THE STANDARD OF LIVING IN PRE-CONFEDERATION ONTARIO AND QUEBEC: THE STORY OF CONVICTS AT THE KINGSTON PENITENTIARY

by

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I. *Introduction: Approaches to Studying Historical Living Standards in Canada*

Concern over economic well-being or 'quality of life' is a mainstay in economic inquiry. In the domain of Canadian economic history it is held that, from the time of the first statistics, incomes in Ontario were higher than those of Quebec, but few attempts have been made to compare living standards before Confederation.[1] A comprehensive study of this period is called for. One question confronted when estimating quality of life in the distant past is: how are living standards measured? There are two main approaches; the traditional method based on income, and a newer interdisciplinary one based mainly on health, although these are not necessarily substitutes.

The traditional approach is to calculate the real wage. The idea is to gauge the levels of consumption, wages, and prices. The newer approach, called anthropometry, is based on biological measures of living standards. In practice two measures are used: average adult height and velocity of growth (time to reach full adult height, and physical development at different ages). The rationale behind these measures is put succinctly by John Komlos, one of the most prolific researchers in this field; "nutritional status (and thus height) is related to real family income which is related to wages and prices which is finally related to the standard of living broadly conceived" (Komlos 1992, 3). Both approaches have been brought to bear on a range of countries, especially in Europe and North America.[2] This paper extends anthropometric analysis to nineteenth-century Canada and compares it to estimates of income and food consumption. The Kingston Penitentiary Prisoner Book, a ledger that contains detailed information on all convicts

[1] For example see McCallum (1980, 3).
[2] For example see Steckel and Nicholas (1991), Steckel (1986), and Komlos (2003).

admitted from the construction of the Kingston Penitentiary in 1835 until 1890 will be used as the source of adult stature. The findings will then be combined with estimates of agricultural income and consumption of food in Quebec and Ontario to shed new light on the quality of life in the two provinces.

A brief overview of the real wage methodology will provide a benchmark with which to compare the anthropometric approach. This method typically has large data requirements: wage histories, price histories, and consumption patterns. Some of the data is beyond reach, with its availability depending on time period and region. For example, data on prices and wages is available for most of England and a broad group of European cities dating back to the middle-ages, but comparable records for other countries do not extend as far back (Allen 2001). Nevertheless, the effort to produce historical real wage series has met some success. Such analyses have been conducted for European countries (Clark 2007; Allen 2001), the Ottoman Empire (Suleyman and Pamuk 2002), and intriguingly the Roman Empire (Allen 2009). This research aims to frame living standards in much the same way as GDP per capita, namely as the purchasing power of agents. The theoretical foundation for using purchasing power or real wage as a measure of living standards is based on consumer theory: given a resource constraint the consumer will purchase the bundles that bring him the greatest utility. Thus, by tracking the time-path of the constraint inferences can be made about the consumer's well-being.

Anthropometry is quite different. It is touted by its adherents as “a remarkably sensitive means of estimating the nutritional and biological standard of living of ancient or modern populations, by measuring the effect of insufficient nutrition or unusually high levels of infection and other environmental stresses upon the mean height of that

population" (Kron 2005, 68). In practice this translates to collecting data on the height of a population and making inferences about its living standards. Although anthropometry is a relatively old concept, dating back to the nineteenth-century works of French doctors René Villermé and Adolphe Quetelet, it became part of the cliometric revolution in economic history in the 1970s.[3] There are two sources of height data: records from living populations and skeletal remains. Military records are the single biggest trove of the former; almost all professional armies since the early nineteenth-century have kept such records (the Confederate army is a notable exception). In addition, data has been collected from other sources such as slave manifests, schools, convict records, and anthropological reports.[4] Taking an anthropometric approach is not merely a short-cut; it can be especially useful when there is no other information available about standards of living, and it can supplement traditional studies of welfare.

Biological measurements allow comparisons between groups for which there may otherwise be a lack of relevant data, such as wages or prices. Steckel and Prince (2001) used this approach to analyze native groups on the North American plains in the nineteenth-century. Most of their economic activity lay outside markets so there is little price and wage data to draw on. Steckel and Prince find that Native Americans were very tall compared to Europeans which could indicate higher living standards. More generally, for any pre- or early industrial society it is difficult to construct sound real wage series. Similar to the case of indigenous groups of the American Great Plains, most agricultural output was for on-farm consumption; and so only prices for staple or marketed crops are

[3] Floud (1994, 11) credits these medical doctors as being pioneers in the use of measurements of human physiology to make inferences about health.
[4] Examples are: military records (Komlos 1995), schools (Komlos 2006), slave manifests (Steckel 1986), anthropologic reports (Steckel and Prince 2001).

readily available. As well, where there is debate about living standards, such as the debate between Lindert-Williamson (1983) and Feinstein (1998) on the experience of British workers during the early Industrial Revolution, it can be useful to consider using biological measures of well-being. Various studies have concluded that during the early industrial revolution (roughly 1770-1815) heights in England declined, with urban workers experiencing a much larger decrease than their rural counterparts (Steckel and Nicholas 1991, 947-49). Exactly how to interpret this finding remains an open question, but the 'pessimist' position that livings standards deteriorated may be bolstered.

The anthropometric research that focuses on European industrialization over the period 1780-1870 has produced interesting findings. For example, rural Europeans were on average taller than their urban counterparts, even though they were mainly subsistence farmers with lower real wages (Komlos 1992, 4). A possible explanation is that in a period of high transportation costs and relatively large mark-ups, farmers faced much lower food prices. Thus, even though their overall purchasing power (or real wage) was less, peasants had better nutrition. Komlos suggests that these findings underscore a serious shortcoming of the real income approach. Since much of the population engaged in economic activity outside the market, price and wage data alone are not useful measures of living standards.

Other notable contributions of anthropometry stem from work with skeletal measurement (forensic anthropology). The idea of using implied height (usually based on the length of the femur) for making inferences about living standards has contributed greatly to our understanding of pre-recorded history. In addition to height, insights about morbidity can be gained as well from scars left by disease on bone and tooth enamel

(Steckel et al. 2002). Perhaps the most notable contribution of this research programme has been the discovery that there was a decline in living standards (reflected in stature, cranial capacity, and morbidity) after mankind gave up its hunter-gather lifestyle and began to practice sedentary agriculture (Cohen and Armelagos 1984).

A. *Heights as a Measure of Living Standards: Food for Thought*

Despite its advantages much of the data on height has its own problems. Military heights, for example, are often truncated, since there is usually a minimum height requirement. This means they are not indicative of the true distribution of the height of a given population. Econometric techniques for analyzing truncated data do exist, but there is currently a debate on which method works best (Jacobs et al. 2008, 44-47). The most popular approach is called Quantile Bend Estimation (QBE). The idea is to assume that the bottom tail of the height distribution is symmetrical to the upper tail and estimate values in place of the missing ones. In cases of minor truncation (when the minimum height requirement is not very restrictive) QBE works quite well, however, when truncation is very pronounced it is difficult to compensate properly. Additionally, cross-country or cross-population comparisons based on heights can be misleading because of possible differences in genetic composition, and hence in potential height. It should be pointed out, however, that most populations have similar ideal or terminal heights; these include Africans, American Blacks, Europeans, and neo-Europeans (North Americans, Australians, and New Zealanders) (Cruff 1995, 5). Exceptions are East and South Asians; there is evidence that the genetic potential heights of these populations is less (DeRose et al. 1998).

Proponents of anthropometry espouse the benefits of this type of measurement: it requires fewer assumptions, less extrapolation, and less interpolation (Cruff 1995,1-2). However, implicit in this methodology is the assumption that improved living standards and stature move in the same direction. This line of thinking does not fully consider optimizing behaviour by agents. Essentially it is argued that agents who maximize utility also optimize the nutrients that they consume. To illustrate, recall Komlos' explanation for greater average heights in rural areas during the early industrial revolution: subsistence labourers did not have to pay transportation costs for food and were therefore healthier. But were they better off? Two arguments based on utility maximizing behaviour suggest otherwise. The first is that an optimizing agent will live where conditions are preferable to them. People who chose to move to the city were essentially revealing their preferences, and may have been better off than those in the country-side. Of course, this analysis ignores the possibility of mobility restrictions or capital constraints, but according to Clark (2007, 162-63) labour was highly mobile in England during this period. Hence, even though biological living standards were lower they regarded themselves as better off. This line of argument is open to the usual sort of criticism levelled at approaches based on revealed preference, such as imperfect information.

The second alternative explanation is proposed by Hansen and Grubb (2002). They argue that a biological measure of well-being does not correspond with utility theory because it ignores relative prices (Hansen and Grubb 2002, 2) . The idea is that a household will view nutritious food for children as an economic good- this means that food is subject to both income and substitution effects. Any increase in real income that

occurs along with a change in relative prices (as is often the case) may lead to countervailing substitution and income effects. The argument has two major components: a child's nutrition is one good among others and rational agents respond to changes in relative prices. It would seem natural then, that any study of anthropometric outcomes should try to explain the driving force behind the outcome. Following the reasoning of Hansen and Grubb, in order to make intertemporal or cross-societal inferences about quality of life, it is necessary to use some type of income measure. To illustrate, consider the case of a consumer who decides how much food, x_f, to consume in order to maximize utility, $u(\boldsymbol{x})$, where $\boldsymbol{x}$ is a vector of all the goods he consumes. He is subject to a budget constraint equal to his income, y, which can be expressed in the following form; $y \leq \boldsymbol{px}$, where $\boldsymbol{p}$ is the price vector. It is clear that in choosing his optimal amount of food the consumer must consider prices and income. But, to maximize nutritional well-being (and thus height) it is only food that matters. This is where the disconnect between utility and anthropometric measures of biological living standards occurs; the quantity of good x_f that is optimal for health is not necessarily the same quantity that is optimal for utility.

II. *Anthropometry and Living Standards: Canada*

There have been two significant attempts to explore the implications of stature as a measure of living standards in Canada. The first is Trevor Dick's (1995) "Heights, Nutrition, and Per Capita Income: Canada, 1870-1915." Dick uses medical records of recruits to the first federal police force in Canada: the *North West Mounted Police* (NWMP). The NWMP was established by the Dominion government in 1873 to police the new territorial additions to Canada that resulted from the purchase of Rupert's Land

from the Hudson's Bay Company. Dick collected data on the heights of recruits for the period 1873-1899, obtaining a sample of 1,553. There was a minimum height requirement (the strictness of enforcement and the cut-off evolved over time), and a maximum weight and minimum chest circumference (Dick 1995, 125). In order to deal with the problem of truncation, Dick presents Quantile Bend Estimates. He finds evidence of a modest increase in height over the period, from 171.5 cm in 1875 to 174.0 cm in 1895 (Dick 1995, 127).[5] However, other economic historians have pointed out significant shortcomings with this data set. First, place and date of birth are missing for most recruits; second, the truncation is quite severe. The estimated average height in 1875 is considerably lower than the minimum height standard of 172.7 cm (68 inches); thus, the efficacy of QBE techniques is doubtful (Cranfield and Inwood 2007, 205) .

Cranfield and Inwood (2007) present a more recent attempt to gauge changes in the Canadian biological standard of living during the nineteenth-century. Their work combines several data sets. They turn to Union Army enlistment records as a source of enlistees born in the Provinces of Upper and Lower Canada and find 829 Canadians who were born between 1800 and 1849. For those born between 1830 and 1870 the Kingston Penitentiary Admission Books (1872-1895) are used. For the latter part of the nineteenth-century they consult South African War Personnel Records, 1899-1901, which includes volunteers from Ontario who fought in the Boer War. And finally they use Canadian Expeditionary Force Personnel Records, 1914-1920, which includes both volunteers and conscripts who fought in WWI.

[5] Dick presents his findings in inches; using QBE he finds 67.5 inches in 1875, 68.1 inches in 1885, and 68.5 inches in 1895.

Military records have drawbacks that make them unlikely to be fully representative of the population. The WWI records are perhaps an exception, as the official minimum height requirement, 63 inches, was low and would not lead to severe truncation (Cranfield and Inwood 2007, 208). The Boer War volunteer data set was not truncated but the recorded heights are probably biased upward due to the nature of the volunteers. As Cranfield and Inwood point out, the upper and middle class is over-represented as are rural men capable of serving in the mounted regiments. These two groups would be expected to be taller than lower-income, non-rural, populations. The Union Army records indicate inconsistent imposition of minimum height standards as well.[6] Although, as noted, there are statistical methods for dealing with truncation, it is difficult to get around the issue of sample selection bias present in the Boer War and NWMP data. We are left with the WWI records, which are useful but limited in their time frame. Certainly, they give no indication of biological living standards in Canada during the first three-quarters of the nineteenth-century.

Cranfield and Inwood, as part of their analysis, present data drawn from the prisoner records of the Kingston Penitentiary. The construction of the Kingston Penitentiary in 1835 marked the introduction of the modern prison system in Canada. The purpose of the facility was to confer a more 'humane' form of punishment on law-breakers, with the expressed aim of rehabilitating them (Correctional Service Canada 2011). Although by modern standards some of the methods were Draconian, the facility was in fact aligned with a reformist movement led by Quakers in Philadelphia who argued for better treatment of criminals, and saw prisons as places of penitence where

[6] For more on the issues with these data sets see Cranfield and Inwood (2007).

convicts could reflect on their crimes and prepare for reintegration to society. Construction on the Kingston Penitentiary began in late 1834 and it was inmates themselves who built it (from quarrying the limestone, to the actual masonry). Thus, beginning in 1835 convict records were kept.

Table 1
Height of the Canadian-born, by birth decade, 1800-1869 (cm)

	Union Army		Convicts		South African War	
Date of Birth	Mean	n	Mean	n	Mean	n
1800-29	171.45	176				
1830-39	171.20	400	172.97	131		
1840-49	170.43	253	172.47	406		
1850-59			172.47	768		
1860-69			171.96	439	173.74	226

***Source*: Adapted from Cranfield and Inwood (2007, 206)**

Convict data on height has certain advantages over military records. The heights of convicts do not appear to be strongly biased, although Cranfield and Inwood point out that the lower-skilled with less command over economic resources are probably over-represented. On the other hand they note that taller men might be more attracted to criminal activity (Cranfield and Inwood 2007, 207). In fact, according to their findings, the average height of convicts was greater than the average height of Canadians fighting in the Union Army (see Table 1).

Cranfield and Inwood's attempt to describe trends in Canadian anthropological standards of living is limited in that their data sources are not fully comparable. In addition, little light is shed on the early nineteenth-century. The period 1800-1829 is covered only by the Union Army sample, and nearly all would have been born no earlier than the 1820s, since the group born in that decade would have been between 31 to 41

years old at the outbreak of the Civil War. Although Cranfield and Inwood restrict their Canadian convict data set to the Kingston Penitentiary Admission Records of 1872-1895, earlier records do exist. The Kingston Penitentiary Prisoner Records Book is a register of all criminals admitted from 1835 until 1890. By consulting these records I have developed a new data set covering birth years from 1800 to 1870.[7]

III. *The Heights of Convicts in Canada: 1835-1890*

A. *The Kingston Penitentiary Data Set*

The Kingston Penitentiary Prisoner Book (KPPB) which was partially explored by Cranfield and Inwood provides a vast trove of information on the characteristics of the convict population. The information includes birthplace, age, name, marital status, occupation, height (measured to the nearest quarter inch), complexion (skin colour), eye and hair colour, religion, crime, term, and county where the individual was tried. Although gender is not recorded, it is fairly easy to deduce because of females' small stature, feminine names, and the fact that no occupation was typically listed for women. For the purposes of this study I collected the relevant variables from the KPPB at Library and Archives Canada for 1835-1876, a period not covered by Cranfield and Inwood. This data set also provides extensive height records for those born in Ontario and Quebec in the nineteenth-century.

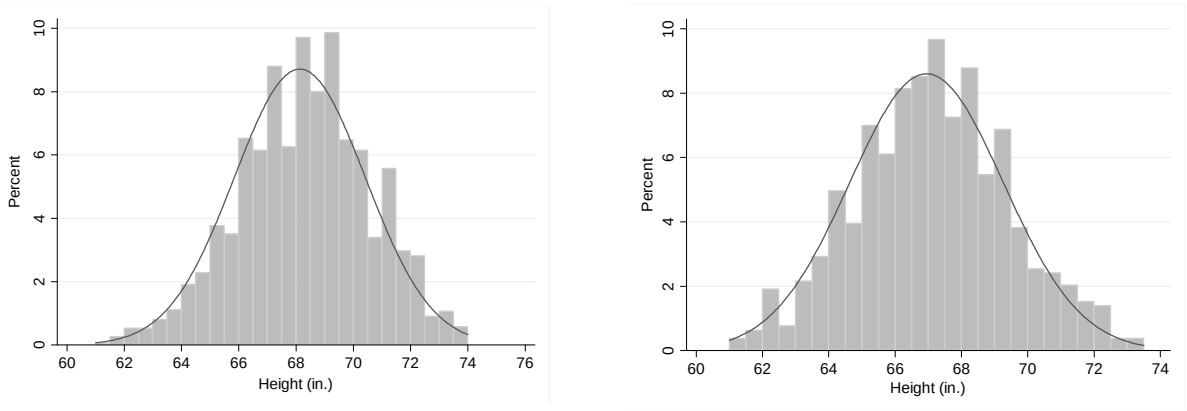
Only adults aged 21-49 are part of this analysis, the reasons being that in times of deprivation the onset of physiological development can be delayed, so it may not be

[7] I would like to thank Kris Inwood and John Cranfield. who provided me with their micro-data of convict heights, covering the years 1877 to 1895.

until roughly age 21 that full adult height is reached.[8] The upper bound of 49 years addresses the onset of shrinkage due to compression of the space between vertebrae that occurs at about 50. This is the cut-off common to much of the anthropometric literature.[9] My sample of entrants to the Kingston Penitentiary from its construction in 1835 to 1890 is 5,437 observations, 95 percent of whom were male.[10]

Figure 1: Height (in.) of Male Convicts

(A) Born in Ontario **(B) Born in Quebec**



***Note*: Using a 0.5 inch bin width**

The histograms in Figure 1 depict the height distribution of convicts from Ontario and Quebec. The unit of measurement is inches because heights were measured to the nearest quarter inch and there is some evidence of 'heaping' on half and full inches.[11] What is clear from Figure 1 is that in both cases the heights of convicts clearly follow a normal distribution with little evidence of truncation. This is in keeping with the expectation for convict data, and suggests QBE or other corrective procedures are unnecessary.

[8] Some historians have used different cut-offs but I follow the lead of Cranfield and Inwood (2007, 206).
[9] See Steckel and Nicholas (1991), Fogel (1986), and Floud et al. (1990).
[10] The sample, which includes Cranfield and Inwood's KPPB records (1877-1890), consists of 5,153 males and 284 females. Some ledger entries were ignored owing to illegible writing, but these were few.
[11] For the distributions using a metric scale see Figure A.1.

Table 2
Share of convicts by county, 1858-1863, and county share, 1861 (percent)

*County/District**	*Share* KPPB Sample	1861 Census	*County/District*	*Share* KPPB Sample	1861 Census
Algoma	0.1	0.4	Nipissing	0.0	0.1
Brant	5.0	2.2	Norfolk	2.5	2.0
Carleton (incl. Ottawa)	2.3	3.2	Northumberland & Durham	6.8	5.7
Elgin	1.7	2.3	Ontario	1.9	3.0
Essex	2.7	1.8	Oxford	3.2	3.3
Frontenac (incl. Kingston), Lennox & Addington	5.9	4.9	Stormont, Dundas, & Glengarry	1.0	4.2
Grey	0.8	2.7	Perth	1.9	2.7
Haldimand	1.7	1.7	Peterborough & Victoria	2.7	3.4
Halton	1.9	1.6	Prescott & Russell	0.4	1.6
Hastings	2.2	3.2	Prince Edward	0.5	1.5
Huron	2.2	5.7	Simcoe	3.2	3.2
Kent	2.3	2.2	Waterloo	1.8	2.8
Lambton	1.4	1.8	Welland	1.3	1.8
Lanark & Renfrew	2.2	3.7	Wellington	2.1	3.5
Leeds & Grenville	3.0	4.3	Wentworth (incl. Hamilton)	9.2	3.6
Lincoln	4.1	2.0	York & Peel (incl. Toronto)	14.1	9.4
Middlesex (incl. London)	6.8	4.3			

Sources: **Kingston Penitentiary Prisoner Book (KPPB); 1861 Census of Upper Canada.**
Note: **The KPPB sample convicts admitted during the period, 1858-1863. 755 observations included.**
***Several were defined as districts in 1861.**

A question that arises when using such a data sample is how representative it is of the overall population. An important anthropometric study using convict records is Nicholas and Steckel's (1991) "Heights and Living Standards of English Workers During the Early Years of Industrialization, 1770-1815." The authors use data on the heights of Irish and British convicts sent to Australia to gauge the biological living standards of workers in the United Kingdom. Nicholas and Steckel suggest their sample is representative by outlining the arguments against the existence of a criminal class in the U.K. during the period. They cite studies of nineteenth-century crime which conclude that convicts were "employable people who supplemented their income by theft in times of

distress" (Steckel and Nicholas 1991, 944). In other words, convicts were not a distinct social under-class. Rather, they were broadly representative of British workers.

In the case of Quebec and Ontario (Canada East and Canada West prior to Confederation) there is, however, reason to suspect that the convict sample is less representative, mainly due to the likelihood that urban centres were disproportionately represented. Table 2 compares the *County/District* breakdown of a sample of convicts from the years 1858-1863, to the population shares found in the 1861 Census of Canada West.[12] The districts that contain the largest urban centres are over-represented. The most dramatic cases are Wentworth which had a 3.6 percent share of the population but a 9.2 percent share of the convict sample and York and Peel which had a 9.4 percent share according to the Census but 14.1 percent of the convict sample.[13] Overall this problem does not appear to be too severe; the snapshot of the prison population seems fairly representative of Canada West.

Table 3 gives the adult height attained by different birth-cohorts of male convicts by place of birth, with the bulk of observations appearing after 1820. Ontarians were quite tall throughout the period (Ontarians and Americans are the tallest groups for every birth cohort from 1810 onwards), while the heights of the Quebecers are low, comparable to those of the English. These findings will be the subject of further discussion.

[12] The same procedure is not feasible for Canada East because of issues with the level of detail found in the ledgers. There is no indication if an entry refers to a county, city, or district for most of the period; this is especially troublesome in the case of Montreal and Quebec. In addition, many of the convicts from Canada East, transferred to the Kingston Penitentiary from the Saint-Vincent-de-Paul Prison, were recorded as coming from Montreal.

[13] Carleton County is the only example of an urban county being under-represented.

Table 3
Stature of male convicts, by place and decade of birth (cm)

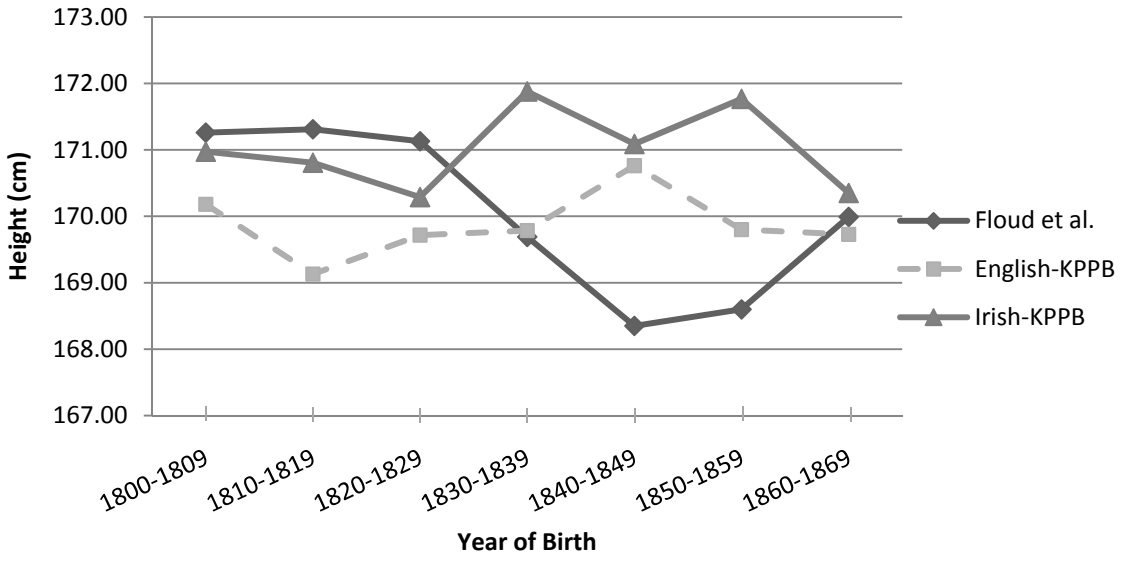
Year of Birth	Ontario		Quebec		England		Ireland		United States	
	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
1800-1809	168.49	3	173.36	2	170.18	2	170.97	8	168.78	5
	(2.93)		(0.90)		(1.80)		(5.26)		(7.51)	
1810-1819	173.45	32	168.99	39	169.13	26	170.81	77	173.94	35
	(5.06)		(5.96)		(7.17)		(6.67)		(5.52)	
1820-1829	172.89	103	169.98	91	169.72	74	170.29	134	172.43	102
	(6.12)		(6.37)		(6.34)		(5.77)		(6.10)	
1830-1839	173.34	318	170.22	217	169.79	172	171.88	250	172.65	148
	(5.67)		(6.16)		(5.77)		(6.37)		(6.35)	
1840-1849	173.20	459	168.94	218	170.76	157	171.09	151	171.78	149
	(6.10)		(5.75)		(5.81)		(5.88)		(5.88)	
1850-1859	173.02	550	170.54	180	169.80	112	171.77	64	172.52	133
	(5.65)		(5.70)		(6.32)		(6.14)		(5.49)	
1860-1869	172.68	383	169.92	47	169.73	73	170.35	26	171.71	89
	(5.79)		(5.01)		(6.41)		(6.34)		(6.08)	
1800-1869	173.04	1,84	169.84	794	170.00	616	171.22	710	172.31	661
	(5.81)	8	(5.90)		(6.07)		(6.16)		(5.97)	

***Source*: Kingston Penitentiary Prisoner Books, 1834-1890. RG 10 DI, vol.1047 (microfilm reel T-2044)**
***Note*: Standard deviations in parentheses.**

B. *Heights of Foreign-born Convicts and Heights in Origin Countries*

In addition to giving new insight into the Canadian biological standard of living, the expanded convict height sample provides information about the nutritional story in other countries. In particular, it allows us to compare the heights of immigrants to their non-migrant counterparts. The KPPB include immigrant convicts born in the United States, England, and Ireland (Table 3, Table A.6). Figure 2 compares heights of English and Irish born convicts with records of the British Military and Royal Marines (Floud, Watcher and Gregory (FWG) 1990, 148-49). A similar comparison was made for Americans, based on Fogel (1986) (see Figure 3).

Figure 2: Heights of English and Irish convicts versus the British Military, 1800-1869 (cm)



***Sources*: Floud, Wachter and Gregory (1990, 148-149); Kingston Penitentiary Prisoner Books.**

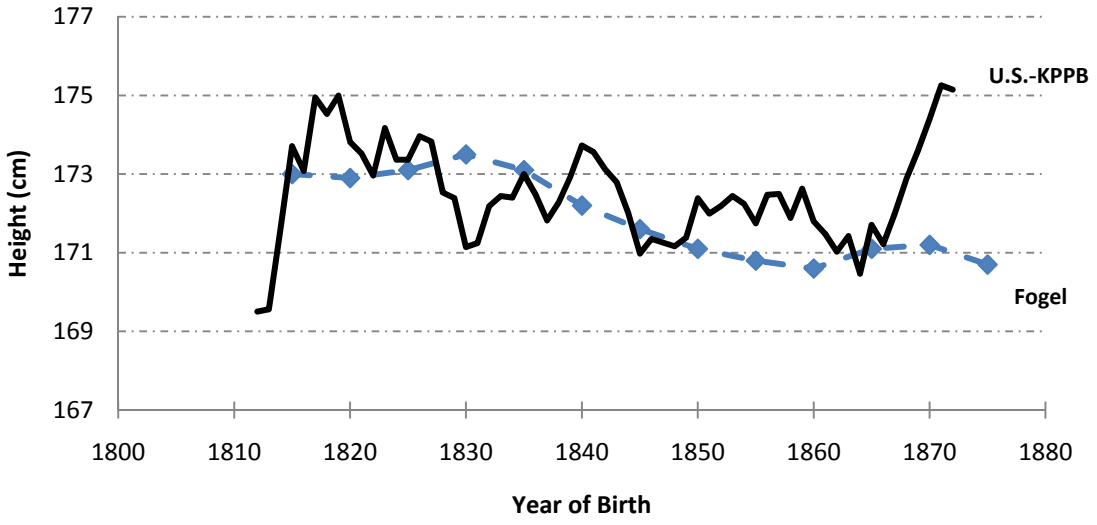
The FWG data is for the British military which includes English, Irish, and Scottish recruits aged 24-29 (as opposed to the convicts who are aged 21-49, see Figure 2).[14] However, for the period in question, England and Ireland, combined, accounted for the vast majority of recruits to the Royal Marines and the Army (Floud et al. 1990, 88-89). One of the findings of the anthropometric literature regarding the British Isles is that the Irish were taller on average than the English in spite of being relatively poor (Mokyr and Ó Gráda 1994).[15] Also, while the heights from military records exhibit a downward trend until roughly 1845 this is not the case with the convict series. Convict heights reveal little trend and are somewhat above the military sample. Any comparison of unrelated data samples is problematic; that said, it seems that the English and Irish immigrants to Canada were a bit taller than their counterparts who stayed behind.

[14] I attempted to create a matching 'British' height series, but there were innumerable difficulties. FWG combine records from the army and the marines (using the *Army and Royal Marine Description Books* and *Army Medical Department reports*), and additionally the shares of the different regions change from year to year for both the Royal Marines and the army.

[15] See Andrew Hallisey (2005) for an interesting treatment of this phenomenon.

One explanation may be that most immigrants were not *the poorest of the poor,* and thus the British who moved abroad were healthier than those who stayed. Anthropometric investigation thus has implications for emigration from the British Isles and possibly other countries. For example, if emigrants were healthier and taller, immigrant records could be biased upwards as a measure of the biological standard of living in the home country. An additional complication is the absence of information in the KPPB on age at immigration. Thus, it is not possible to be sure of the nutritional and disease environment a convict faced during their physiological development.[16] However, this is probably not an important concern as immigrants were typically age 15 or older (Greenwood 2007, 258).

Figure 3: Heights of U.S.-born convicts and white Americans, 1800-1869 (cm)



***Sources*: Fogel (1986, 511); Kingston Penitentiary Record Books.**

Figure 3 depicts Fogel's 5-year averages for American whites aged 25-49 and a five-year moving average of Kingston convicts born in the U.S. The height of convicts

[16] An attempt was made to manually cross-reference immigrant convicts with pre-Confederation census records with the hope of discovering their age at immigration but this proved extremely difficult due to the sheer quantity of observations and the frequency of common names.

born in the U.S. does not exhibit much of a trend, fluctuating around 172 cm. Fogel's U.S. height series combines Union Army enlistment records, Amnesty records of white Southern males, Regular U.S. army records, and other documents (Fogel 1986, 462-63). He finds that height trended downward for the better part of the nineteenth century. This suggests that, although per capita GNP was increasing, a worsening disease environment, due to urbanization, or less access to affordable foodstuffs accompanied the transition to industrial production. While the two series in Figure 3 do not move together they are close in terms of levels, lending further support to the representativeness of convict data. The fact that American convicts in the Kingston Penitentiary are not significantly shorter than Americans further supports the notion that convicts in Upper and Lower Canada did not occupy a distinct social status characterized by nutritional deprivation.

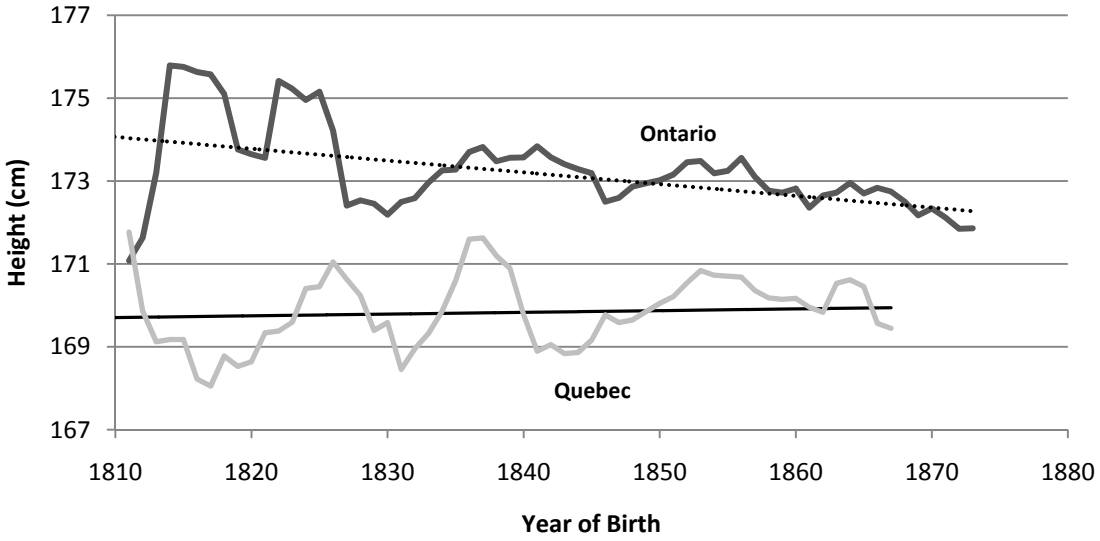
IV. *Heights of Convicts: Ontario and Quebec*

A. *Male Convicts*

The two groups of perhaps greatest interest, given the unique data set, are the convicts born in Ontario and Quebec. Notably, Ontario convicts were considerably taller. See Figure 4, which plots five-year moving averages of convict heights for the two provinces. Although the difference shrinks over time, as late as the 1860s it remains over 2 cm. Further, this gap is statistically significant at the 99 percent confidence level for every birth decade except for 1800-1809 (see Table A.3). This is consistent with the findings of Cranfield and Inwood (2007, 209) who found a one inch difference between WWI soldiers born in the 1870s in Ontario and Quebec. This gap is large; in anthropometric analyses, differences of 1 cm are considered indicative of significantly higher living standards. For example, regarding natives on the American Great Plains in

the mid-nineteenth century, Steckel and Prince (2001, 289) write: "remarkably, these Native American men were about 1 to 2 centimetres taller than European- American soldiers of the same era." The trend lines in Figure 4 show that average height moved in opposite directions in the two provinces. Ontario heights trended downward, dropping noticeably after mid-century (this mirrors the findings on U.S. heights), while Quebec heights have a weak upward trend. Around 1855 the Quebec sample appears to follow the mid-century decline in average height that is apparent for Ontario.

Figure 4: Average height by birth-year for male convicts from Ontario and Quebec (moving five-year averages)



Source: **See Table A.5 in the Appendix**
***Note*: For Ontario the trend line equation is $y = 234.23e^{-2E-04x}$ with $R^2 = 0.0016$; for Quebec the trend line equation is $y = 162.32e^{2E-05x}$ with $R^2 = 0.0788$**
*** The series for Quebec ends earlier because the number of observations drops off steeply after 1867.**

B. *Female Convicts*

An advantage of using prison records for the study of stature is that they typically include information on females, a group that is missing in military and police force records. Although the sample size of women in the KPPB is small, a tentative measure of their biological standard of living can be produced. Table 4 gives the average height of

female convicts by decade of birth for Ireland, Ontario, and Quebec.[17] Women from Quebec were noticeably shorter than those from Ontario. Across the entire period ranging from 1800 to 1869, the difference, 5.37cm, is striking and statistically significant at the 99 percent level.[18] Irish convict women were much closer in height to Quebecers, which is surprising given that by European standards the Irish were quite tall during this period (Mokyr and Ó Gráda 1994). The stature of Ontario women is much greater than that of other groups.

Table 4
Stature of female convicts, by place and decade of birth (cm)

Year of Birth	Ontario		Quebec		Ireland	
	Mean	n	Mean	n	Mean	n
1800-1809					164.47	1
					(-)	
1810-1819	159.60	3	159.39	4	160.02	12
	(8.07)		(5.24)		(6.91)	
1820-1829	161.40	6	156.97	10	157.11	17
	(4.06)		(4.95)		(4.82)	
1830-1839	160.94	18	158.48	7	156.82	56
	(5.82)		(4.66)		(5.45)	
1840-1849	161.09	13	154.26	13	157.14	26
	(5.72)		(6.51)		(7.80)	
1850-1859	162.40	12	153.67	8	164.25	6
	(4.27)		(9.95)		(3.82)	
1860-1869	157.48	2	147.32	1		
	(14.37)					
Total	161.15	54	155.78	43	157.70	118
	(5.57)		(6.71)		(6.23)	

***Source*: Kingston Penitentiary Prisoner Books, 1834-1890. RG 10 DI, vol.1047 (microfilm reel T-2044)**
***Note*: Standard deviations in parentheses**

Although little attention has been paid to female stature in the anthropometric literature, the findings of Nicholas and Shergold (1988) regarding convict workers transported to New South Wales (Australia) are a good basis of comparison. Nicholas and

[17] There are a total of 284 females in the extended KPPB dataset but owing to the small number they are spread thinly in terms of *place of birth*. See Appendix (Table A.7) for a complete list.
[18] See Table A.3.

Shergold collected health indicators including adult height, where their particular concern was worker productivity. They write: "those transported to New South Wales were not of very short stature as compared with their British contemporaries. Rather they were as tall as those workers left at home" (Nicholas and Shergold 1988, 9). Nicholas and Shergold find that rural British women were taller than their urban counterparts (a 1 to 2 cm differential for the early 1800s), with average heights around 155-157 cm for the two groups.[19] Thus, it appears that the KPPB-Irish convict average height of 157.70 cm is comparable to rural British heights; meanwhile Quebec females were closer in height to urban British females. Conversely, the Ontario female convicts are much taller than both groups of British females transported to Australia. The finding that women born in North America are taller than those of the U.K. is not very surprising as this precedent exists in male heights.[20] More surprising is the large gap in stature between the two groups of Canadian-born females in the KPPB records.

It seems that the net nutrition of women born in Ontario was superior to that of women born in Quebec, which may be evidence of a higher standard of living in Ontario. Moreover, the gender gap in average stature over the 1800-1869 period is greater for Quebec than for Ontario (roughly 14 cm compared to 12 cm). This may indicate differences in intra-household allocation of consumption across the two provinces; on average, females in Ontario may have consumed a greater share of the household consumption bundle. A discussion of the greater heights of Ontarians (both male and

[19] See Table A.1 (of this paper) for their findings.
[20] Nicholas and Shergold remark on the large difference in the nutritional value of North American and European diets in the nineteenth-century (1988, 81).

female) relative to Quebecers will be undertaken at a later point. First, the nineteenth-century heights of these groups will be put in a more modern context.

C. *Comparisons to Modern Ontario and Quebec*

My sources of modern heights are the micro-data sets from the *1985 Health Promotion Survey* (HPS) and the *2005 Canadian Community Health Survey* (CCHS), both of which were conducted by Statistics Canada.[21] Table 5 displays the heights of birth-cohorts from 1935-1979. The 1935-1959 averages were calculated using the micro-data from the HPS which did not ask about place of birth or immigration status. Thus, these heights are for *residents* of the respective provinces, some of whom were born elsewhere. The averages for cohorts born from 1960-onward come from the CCHS, which includes information on birth place.

Compared to the convict heights from the nineteenth-century it is notable how small the gap between Ontario and Quebec had become for both genders. Previously, males from Ontario averaged 3 cm taller than those from Quebec, and the difference for females was even greater. By the 1970-79 cohort such differentials had essentially disappeared. Between 1870 and the start of the 1930s a distinct increase in mean stature occurred in both provinces for both genders. Recall that during the mid to late nineteenth century Quebec and Ontario male convicts were on average 170 cm and 173 cm, respectively, yet 60 years later the mean heights of these groups increased (and converged) to around 176 cm. The case of Canadian females also shows a considerable increase in average stature, particularly for females from Quebec; whose mean height increased considerably and closed the very significant gap with females from Ontario.

[21] Any results and views expressed herein are my own and are not endorsed by Statistics Canada.

Unfortunately, the data in Table 5 do not fully cover the period of convergence between Quebec and Ontario heights, but it seems that in the case of Quebec females considerable convergence occurred around the middle of the twentieth-century. This would imply that women born around this time enjoyed a significant change in their biological standard of living, perhaps due to changes in intra-household consumption shares.

Table 5
Average heights of Ontarians and Quebecers over the 20th century, by birth-year (cm)

	Males				Females			
	Ontario		Quebec		Ontario		Quebec	
Year of Birth	Mean	n	Mean	n	Mean	n	Mean	n
1935-49	177.58	66	174.61	93	162.82	95	159.41	119
1950-59	177.41	82	175.61	92	162.15	107	161.75	151
1960-69	176.07	96	176.07	84	164.78	101	163.65	83
1970-79	176.34	96	176.15	70	163.18	108	163.71	97

Sources:
(1) For the period 1935-1959 "Health Promotion Survey 1985"- heights are for *residents* of Ontario and Quebec.
(2) For the period 1960-1979 "Canadian Community Health Survey 2005"- heights are for Canadian born.

While it is interesting to find evidence of converging stature in the twentieth-century, one important question for pre-Confederation Quebec and Ontario is why were people in Quebec shorter? One explanation may be that real wages were higher in Ontario; thus, people in Ontario had greater command over economic resources and accordingly consumed more and higher quality goods - especially food and housing. Another explanation could be consumers in Ontario and Quebec faced different relative prices and so made different substitution decisions when choosing consumption bundles. Thirdly, one must consider the impact of income distributions on average height. There is a limit to human growth; beyond some point, greater consumption of healthy inputs (food in particular) does not have any further impact on human health or height. What actually shows up in historical studies of stature is the shortfall in nutrition (calories, protein,

vitamins and minerals). Thus, two income distributions with the same mean need not lead to the same mean height; the distribution with less density at the bottom end (and more equitable consumption) will have the greater average stature (R. H. Steckel 1983, 4-5).

V. *Real Income and Nutrition: Nineteenth-Century Ontario and Quebec*

A. *Per Capita Farm Income*

Constructing an income series for a pre-industrial society can be difficult. This is particularly true for nineteenth-century Ontario and Quebec when many transactions were outside of markets. In addition, the population share of major urban centres was still quite small, meaning that market prices were not necessarily an accurate reflection of those faced by the average person. The first substantial census of the Province of Canada is for 1851; consequently, this is often the *point-de-depart* for historical studies of the economic character of Canada.[22] Currently no real wage series or comprehensive data on income for pre-Confederation Ontario and Quebec has been produced.[23] Regardless of the difficulties, economic historians have made inroads into understanding the quality of life during this period.

Frank Lewis and M.C. Urquhart (1999) present findings for the late-pioneer period of Upper Canada (before 1851). Drawing on the municipal district assessment records for 1826 to 1851, they produce estimates of agricultural output at five year intervals. In this period over half of the labour-force was involved in agriculture and over 80 percent of the population was rural. Thus, estimating agricultural income provides a good measure of overall living standards (Lewis and Urquhart 1999, 154). Their

[22] In 1840 Upper and Lower Canada were combined to create the Province of Canada which was divided into Canada West and Canada East (roughly Upper and Lower Canada).
[23] Urquhart's *Gross National Product, Canada, 1870-1926* begins in 1870 and does not present a provincial breakdown.

approach comes down to estimating the value of agricultural produce and the quality of housing, and tracing changes in measures of school quality.

Lewis and Urquhart find that per capita farm output was almost unchanged between 1826 and 1851; indeed, living standards were very high in 1826. After correcting their farm income estimates for output not included in the census and for capital accumulation (improvements to land and purchases of livestock), they conclude: "per capita farm income [in 1826] is $27, which is just 12 percent below the value for Canada in 1870" (Lewis and Urquhart 1999, 161).[24] In addition, Lewis and Urquhart (1999, 164) find that there was little change in housing quality over the period. Admittedly, the 1870 Canada value includes other provinces that generally had lower incomes than Ontario; nevertheless the quality of life in Upper Canada was high during this period. This may be part of the explanation for the tall stature of convicts born in Ontario.

While the same type of intertemporal analysis of living standards in Lower Canada has not been carried out, the "agricultural crisis" of the early nineteenth century features prominently in the historical literature. This is a period depicted by economic historian John McCallum (1980, 29) as " the failure of wheat as both a staple crop and basic consumption item... characterized by periodic food shortages, declining living standards, and mounting debt." This period saw *net* per capita supply of wheat (including imports from Upper Canada) fall from 4.4 bushels in 1827 to a low of 2.4 bushels in 1844 before rising to 5.3 in 1851 (McCallum 1980, 30). A similar picture is painted by John Isbister (1977, 678-80) who argues that at mid-century, Ontario farmers were producing

[24] Following the methodology for adjusting farm income per capita (including average annual improvements to farms, $3.78) the figure for 1851 is about $29.

sizable surpluses while their counterparts in Quebec were not producing enough output to obtain sufficient caloric intake.[25] He goes so far as to suggest that malnutrition could have occurred in Quebec.[26] What is clear is that net output per farm was higher in Ontario; McInnis (1992, 78-79) finds a differential of 34 percent, with differences in wheat output being the most significant.[27] McInnis attributes Ontario's advantage partly to chance - Ontario had not been affected by pests to the same degree as Quebec. In addition, Ontario had a better climate for wheat. In particular, parts of the province were suitable for winter wheat, which led to much higher yields (McInnis 1992, 81). Mean stature is especially low for Quebec convicts born around 1820. These would be the individuals whose physiological development would be most affected by low nutritional inputs during the period of "agricultural crisis."

The per capita agricultural income for Quebec in 1851 can be calculated by dividing total farm output ($11,702,000) by the population (890 255). This gives an estimate of $17.[28] As in the case of Upper Canada, annual investment in the capital stock, such as farm improvements and purchases of livestock, needs to be considered. If we assume that farmers in Quebec invested the same amount as those in Ontario towards improvements ($3.78) we arrive at agricultural per capita income of $21 in Quebec. This estimate is biased upward, as it is unlikely that the savings rate of Quebec was higher than that of Ontario. Even so, per capita farm income in Ontario is 38 percent higher than in

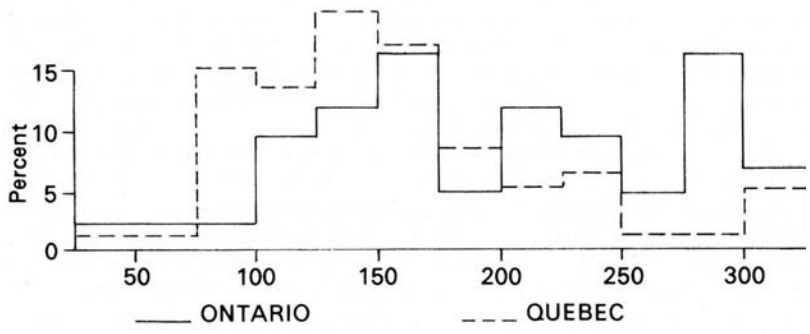
[25] Isbister (1977, 678) assumes the daily requirement was 3,500 Cal for males and 2,500 Cal for females
[26] J.I. Little points out that Isbister did not account for forestry income (Little 1981, 141).
[27] This difference in net output per farm is compounded by the fact that Quebec had a higher fertility rate than Ontario and thus larger average farm family size, 7.1 people compared to 6.2 in Ontario (Isbister 1977, 681).
[28] Total farm output is calculated from Lewis and McInnis (1984, Table III); the population of Lower Canada is from the 1851 Census of Lower Canada.

Quebec. This difference is consistent with the large differential in stature observed for convicts born in the two provinces.

B. *Distribution of Farm Output: Upper and Lower Canada*

In addition to the overall level of income per capita, there is also the possibility that the income distributions in the two provinces were different. In their analysis of agricultural output in Lower Canada in 1851 Lewis and McInnis (1984, 57) note that "the most striking feature of the pattern of agricultural output per worker in Lower Canada is the wide variability from county to county." McInnis (1992) presents a histogram of the distribution of counties in Ontario and Quebec by net agricultural output in 1851 (see Figure 5). The two provinces tell a different story in terms of the distribution of farm output; in particular Quebec has a much higher proportion of low-income farms. It is this distribution that tends to lead to lower average heights. Thus, the distribution of agricultural income may help explain differences in stature.

Figure 3: Distribution of counties by average level of net output per farm, 1851



***Source*: Reproduced from McInnis (1992, 80)**

The impact of differences in relative prices is difficult to determine. Market prices in cities were not necessarily indicative of the prices faced by the majority of Canadians, as they lived in rural areas and engaged in agricultural production for on-farm consumption. Additionally, the greater use of barter in rural economies further

undermines the relevance of city prices. However, according to Lewis and McInnis (1984, 85) prices collected in Montreal in 1855 (by J.C. Taché) are broadly applicable to both Upper and Lower Canada. Clearly, it is difficult to gauge the impact of relative prices on consumption decisions in Ontario and Quebec, but they were probably not the driving force behind a more nutritious average consumption bundle in Ontario.

C. *Diet in 1851: Per Capita Consumption Estimates*

Another approach to living standards is to estimate per capita consumption bundles. The investigations of Lewis and Urquhart (1999) and Lewis and McInnis (1984) into agricultural output and income in Upper and Lower Canada provide a good starting point. They estimate output of a wide range of farm products, which proved invaluable for my efforts to estimate an average consumption bundle and from that nutrition. Table 6 presents estimates of per capita consumption for a simplified bundle of food.[29] It is important to point out that Table 6 gives average per capita consumption and does not take into account intra-household consumption shares; most adult men would have consumed more than these amounts, women and children less. The allocation of these shares may have varied across the two jurisdictions, but there is insufficient information to determine this.

Although the estimates are in many cases crude, and some foodstuffs are omitted, the results in Table 6 are useful for the purposes of comparing nutritional status in the two provinces. Achieving potential adult height requires proper nutrition, which for our purposes comes down to two things: sufficient caloric and protein intake. Caloric input must provide enough energy to cope with energy demands and protein is one of the most important inputs for physiological development (Harvard School of Public Health 2011).

[29] See Appendix for a detailed discussion of the methodology.

Carole Shammas (1990, 135) estimates that early modern men, who engaged in heavy physical work, needed 3,500 to 4,000 Calories per day. The other crucial input for physiological development and health is dietary protein. There is no consensus today about the recommended amount of protein but people who engage in physically strenuous activities require greater amounts, as the amino acids in protein are required for muscular repair and development. In the context of nineteenth-century diets this comes down to "more is better."

Table 6
Per capita consumption of food in Ontario and Quebec, 1851

	Ontario (Upper Canada)			*Quebec (Lower Canada)*		
	Annual Consumption (lbs)	Daily Calories*	Daily Protein (g)	Annual Consumption (lbs)	Daily Calories	Daily Protein (g)
Meat						
Beef	60	180	17.2	34	102	9.8
Mutton	14	51	4.23	10	37	3.1
Pork	94	277	30.7	45	133	14.7
Dairy						
Milk (litres)	363	376	37.3	375	389	38.6
Butter	15	129	0.2	15	134	0.2
Grain						
Wheat (bush.)	*7.1*	-	-	*5.30*	-	-
Flour	309	1,307	50.8	231	975	37.9
Potatoes (bush.)	*2.7*			*2.7*		
Potatoes	162	791	4.2	162	791	4.2
Total		**3,111**	**144.6**		**2,561**	**108.4**

***Note*: See Appendix, Table A.4 for a detailed discussion of the construction of these estimates.**
*** 1 Calorie (Cal) is equal to 1 kcal (1000 calories).**

Most of the population in Upper and Lower Canada was engaged in farming and much of the other employment in the early to mid nineteenth-century involved strenuous work. It seems that the average consumption bundle in Upper Canada of 3,111 Cal was sufficient, whereas that of Lower Canada at 2,560 Cal fell short. The Upper Canadian diet also had 33 percent more protein which would certainly be beneficial for muscular repair and growth. It should be kept in mind that just as Lower Canada included a much higher share of low income farms, it is likely that this characterization applies to food consumption as well. The implication is that many more people in Quebec were undernourished. Whether lower-income workers substituted to less desirable but nutritious foods (such as fluid milk) is difficult to say due to limitations in the available records.

The main purpose of the estimates in Table 6 is to highlight the differences in levels of food consumption across Ontario and Quebec at mid-century. The principle driving force behind the difference in nutritional inputs is consumption of meat; yearly per capita meat consumption in Ontario was over 165 lb compared to less than 90 lb in Quebec. This accounts for almost all the protein intake differential. Quebec did enjoy a small advantage in terms of dairy consumption - the importance of which should not be understated as fluid milk is very nutritious owing to its high protein and calcium content.[30] Consumption of wheat flour, the greatest source or carbohydrates (and calories) in both diets, is significantly greater in Ontario where consumption averaged over 300 lb, which is much more than the Quebec average of 230 lb. Thus, it would appear that the

[30] As explained in greater detail in the Appendix, I have imposed the assumption that in both Upper and Lower Canada half of dairy was consumed in the form of fluid milk. If a greater share of dairy was consumed as fluid milk in Quebec the shortfall in protein would not be as great. Indeed, McCallum (1980, 29) references a French Canadian 'observer' in 1817 (during the Lower Canadian "agricultural crisis") who remarks on the fact that the poor subsist on bread and milk- this suggests that a higher share may be warranted.

relative advantage in income that Ontario enjoyed over Quebec carried over to the consumption of foodstuffs. By 1851 Quebec agriculture was recovering from its period of crisis. Therefore, the average nutritional gap between Ontario and Quebec was likely greater in earlier decades.

There may be an inter-generational component to health, especially if lower average height indicates lower productivity. Given that most consumption was on-farm, it is reasonable to assume that less productive families would generate less food for their children and consequently diminish their future labour productivity. Hence, a feedback mechanism would be set in place such that the lower productivity of the parent generation would increase the likelihood of diminished productivity in the subsequent one. This intergenerational-effect may help explain the persistence of the Ontario-Quebec gap in biological living standards over the nineteenth-century.

VI. *Conclusion: The Differing Fortunes of Pre-Confederation Ontario and Quebec*

The main aim of this paper has been to bring a more rigorous approach to bear on the question of pre-Confederation living standards in Ontario and Quebec. Two distinct but complementary approaches were used, an anthropometric analysis using convict height records and an approach based on income and food consumption. The findings from the Kingston Penitentiary Prisoners Book (KPPB) lend further support to the notion that living standards were comparatively high in Canada but very real differences existed between Ontario and Quebec during the nineteenth-century. The difference in stature between male and female convicts from the two provinces is large and statistically significant. Male convicts from Ontario were taller than their counterparts from Quebec by a margin of over 2 cm for most of the nineteenth-century, a difference that points to

significantly better biological well-being. In addition, the KPPB sheds light on the living standards of women of the period. Averaging over 161 cm, the stature of women from Ontario approached modern heights. Compared to their contemporaries, their height is even more impressive; they stood over 5 and 3 cm taller than female Quebecois and Irish convicts, respectively. These differences are much larger than those found among male convicts and may be evidence of variation in the allocation of consumption goods *within* the household as well as differences in the household consumption basket across Ontario and Quebec.

The estimates of nineteenth-century agricultural income and nutrition are also indicative of higher living standards in Ontario. On average, a farmer in Ontario earned $29, a 26 percent premium over the $23 income of a Quebec farmer. As a consequence of higher output (and thus incomes) the population of Ontario enjoyed better access to food. This is reflected in the estimates of food consumption, particularly meat. In accordance with anthropometric theory, a higher intake of nutrients (both caloric and protein) results in an increased ability to meet the demands placed on the body by physical labour and disease environments. Therefore, one would expect the population of Ontario to have a higher average stature than that of Quebec and this is indeed borne out by the convict records from the Kingston Penitentiary.

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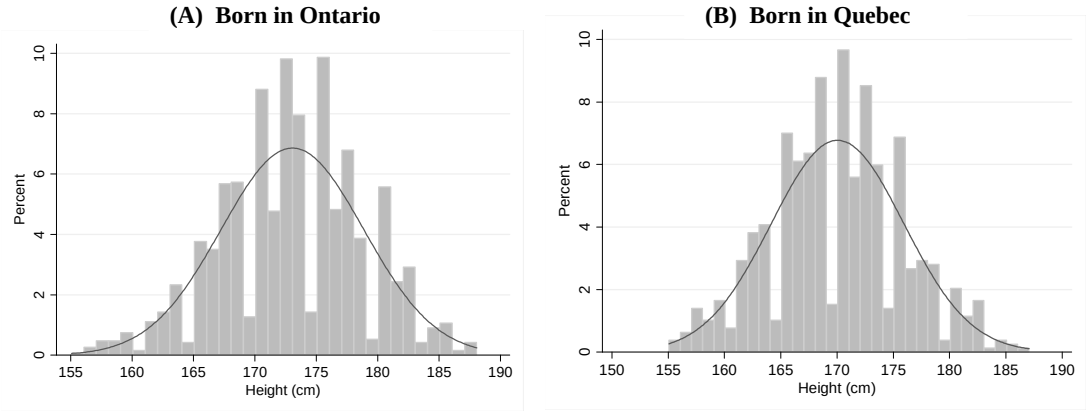
Appendix

Figure A.1: Height (cm) of male convicts (using 1 cm bin width)



Heaping is not a major concern as it does not affect the mean (because it is self cancelling) nor the overall shape of the distribution, but it makes the distribution look peculiar if converted to centimetres.

Table A.1

Stature (cm) of female convicts- Australia (Nicholas and Shergold)

	Urban Irish		Rural Irish	
Year of Birth	Mean	n	Mean	n
1724-89	156	35	156	89
1790-99	155	78	156	174
1800-1809	155	185	157	316
1810-1819	155	159	156	253
Total	155	547	156	832

***Source*: Nicholas and Shergold 1988, 81 (adapted from Table 5.10)**

Table A.2
Stature of male Canadian-born convicts, by decade of birth and occupation, 1800-1869 (cm)

	Ontario						*Quebec*					
Birth Year	Unskilled		Skilled		Professional		Unskilled		Skilled		Professional	
	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
1800-1809	168.49	3					173.36	2				
1810-1819	174.91	18	171.59	14			169.60	23	168.12	16		
1820-1829	173.51	58	172.20	44	167.64	1	170.83	51	168.91	40		
1830-1839	173.45	178	173.10	135	175.64	5	170.51	119	169.86	95	170.39	3
1840-1849	173.73	235	172.87	214	168.13	9	169.37	99	168.55	115	169.76	3
1850-1859	172.87	279	173.20	263	172.72	8	170.13	108	171.25	70		
1860-1869	173.39	161	172.11	219	173.67	2	169.57	26	170.36	21		
Total	173.35	932	172.76	889	171.52	25	170.10	428	169.56	357	170.08	6

***Note*:**
The occupational breakdown of the convicts from Ontario and Quebec is difficult to determine largely because the most frequent entry is *labourer* with little indication as to the nature of the labour. Nonetheless, following the method in Nicholas and Steckel (1991), Armstrong's classification of nineteenth- century occupations is employed here (Armstrong 1972)

Table A.3
Ontario and Quebec convict heights, comparing sample means, two sample t-test

Year of Birth	*Males*		*Females*	
	t statistic	p-value	t statistic	p-value
1800-1809	-2.69 (1)	0.8869		
1810-1819	3.41 (31)	0.0009	0.04 (2)	0.4859
1820-1829	3.23 (90)	0.0009	1.94 (5)	0.055
1830-1839	5.94 (216)	0.0000	1.10 (6)	0.1567
1840-1849	8.83 (217)	0.0000	2.84 (12)	0.0074
1850-1859	5.08 (179)	0.0000	1.88 (1)	0.1556
1860-1869	3.50 (46)	0.0005	1.00 (0)	
Total	12.84 (793)	0.0000	4.22 (42)	0.0001

***Note*: Degrees of freedom in parentheses.**

To test for the statistical significance of the difference in sample means a two sample t-test was used. The null hypothesis is that mean heights were the same in Ontario and Quebec and the alternative hypothesis is that mean height was greater in Ontario, my *a priori* expectation.

Formally,

H_0: $\mu_{Ont} - \mu_{Que} = 0$

H_A: $\mu_{Ont} - \mu_{Que} > 0$

where $t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$

Table A.4

Annual per capita consumption in Ontario and Quebec, 1851

	Ontario (Upper Canada)			*Quebec (Lower Canada)*		
	Consumption (lbs)	Caloric Intake (kcal)	Protein Intake (g)	Consumption (lbs)	Caloric Intake (kcal)	Protein Intake (g)
Meat						
Beef	60	65,589	6,283	34	37,167	3,561
Mutton	14	18,594	1,558	10	13,336	1,112
Pork	94	101,102	11,198	45	48,580	5,381
Dairy						
Milk	363	137,192	13,608	375	141,923	14,077
Butter	15	47,157	56	15	48,784	58
Grain						
Flour	309	476,921	18,530	231	356,012	13,832
Potatoes	162	288,784	1,543	162	288,784	1,543

Note on sources and methodology for Tables 6 and A.4:

For **Ontario** beef and dairy as butter equivalent (Lewis and Urquhart 1999, 160), and wheat (Lewis and Urquhart 1999, 158). For simplicity it is assumed that all surplus field crops (those unused for animal feed) took the form of potato consumption, this results in 2.7 bushels per capita in Upper Canada (Lewis and Urquhart, 159). This amount was assumed for Lower Canada as well. For **Quebec** beef, pork and mutton, dairy as butter equivalent (Lewis and McInnis, 71-74). The remaining goods could not be calculated in a manner consistent with that of Lewis and McInnis. I attempted to reproduce their findings but it appears the 1851 Census data available online from Statistics Canada is different- this may be due to some of the corrections to address minor errors that Lewis and McInnis (1984, 49) mention. Instead, under the assumption that typographical errors are random and self-cancelling I calculated the per-capita ratios of livestock using the 1851 Census records and combined these with the estimates of Lewis and Urquhart (1999) and Lewis and McInnis (1984).[31] The exception to this is per capita wheat consumption because Lower Canada was not self-sufficient and imported wheat substantially from Upper Canada. The figure of 5.3 bushels comes from McCallum (1980, 30).

[31] The 1851 Census supplied by Statistics Canada is reproduced in the Appendix (Table A.5).

It is assumed that half of dairy is consumed as fluid milk (as was found to be the case in the USA in 1840) and the rest is consumed as butter. It is difficult to get data on cheese consumption for this period. Fluid milk is calculated at a ratio of 25 litres of fluid milk to 1 lb butter (Lewis and McInnis 1984,7). Having equal fluid milk to butter ratios for the two provinces is perhaps one of the more contentious assumptions, as fluid milk is particularly nutritious (due to its high protein and micronutrient content), and it is conceivable that, in times of poverty, consumption substitution away from butter (which is essentially devoid of protein) and towards fluid milk would occur. The conversion of bushels of wheat to flour comes from *The 1951 Canada Yearbook*: "1 barrel equals 196 pounds; approximately 4.5 bushels of wheat are used in the production of a barrel of flour." It also states that a bushel of potatoes weights 60 lbs (Dominion Bureau of Statistics 1951, xiv). Finally, the number of Calories and protein content of food used for calculating annual and daily intake come from the USDA's *Nutrient Data Library* (http://www.nal.usda.gov/fnic/foodcomp/search/).

Table A.5
Population and agricultural output in Upper and Lower Canada- 1851 Census

	Upper Canada (Ontario)		*Lower Canada (Quebec)*		*Ratio (UC/LC)*	
	Total	**Per Capita**	**Total**	**Per Capita**	**Total**	**Per Capita**
Lands						
Total- Ac.	9,748,650	10.24	8,113,108	9.11	1.20	1.12
Under Culture - Ac.	3,705,523	3.89	3,605,167	4.05	1.03	0.96
Livestock						
Sheep	967,168	1.02	648,665	0.73	1.49	***1.39***
Swine	571,496	0.60	256,794	0.29	2.23	***2.08***
Horses	201,670	0.21	184,620	0.21	1.09	1.02
Oxen	191,140	0.20	112,028	0.16	1.71	1.60
Cows	296,875	0.31	295,552	0.33	1.00	0.94
Calves	255,249	0.27	183,972	0.21	1.39	1.30
Crops						
Wheat - Bu.	12,688,540	13.33	3,073,943	3.45	4.13	3.86
Potatoes - Bu.	4,973,285	5.22	4,429,016	4.98	1.12	***1.05***
Oats - Bu.	11,395,467	11.97	8,977,400	10.08	1.27	1.19
Peas - Bu.	3,027,681	3.18	1,415,136	1.59	2.14	2.00
Barley - Bu.	625,452	0.66	504,756	0.57	1.24	1.16
Rye - Bu.	472,429	0.50	325,422	0.37	1.45	1.36
Buckwheat - Bu.	679,635	0.71	542,412	0.61	1.25	1.17
Corn - Bu.	1,688,805	1.77	401,284	0.45	4.21	3.94
Turnips - Bu.	3,097,818	3.25	354,250	0.40	8.74	8.18
Hay - Tons	703,727	0.74	755,579	0.85	0.93	0.87
Clover,&c. - Bu.	39,029	0.04	18,873	0.02	2.07	1.93
Flax, Hemp - Lb.	59,680	0.06	1,189,018	1.34	0.05	0.05
Tobacco - Lb.	777,426	0.82	433,129	0.49	1.79	1.68
Hops - Lb.	114,527	0.12	145,735	0.16	0.79	0.73
Population	*952,004*		*890,255*		*1.07*	

Table A.6
Height of Kingston male convicts, by birth year and place of birth (cm)

Birth Year	Ontario		Quebec		United States		Ireland		England	
	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
1804									171.45	1
1805										
1806										
1807			173.36	2			171.03	3	168.91	1
1808	168.49	3			172.30	3	171.45	2		
1809					163.51	2	170.60	3		
1810	173.67	2			168.27	1	176.69	4	173.99	1
1811			170.18	3	176.11	3	169.67	5	176.11	3
1812	172.72	3	169.54	2	167.32	2	170.82	4		
1813	184.79	1	167.64	1	172.59	5	174.63	5	167.96	2
1814	180.98	1	169.33	3	173.78	6	169.16	10		
1815	173.57	3	169.18	7	174.84	3	168.56	9	168.91	2
1816	175.26	5	165.42	4	172.93	3	170.29	6	162.88	2
1817	172.48	8	168.70	6	176.69	4	171.93	8	171.07	5
1818	173.20	4	171.27	7	170.50	4	171.50	13	171.29	8
1819	174.31	4	168.06	6	176.11	3	171.19	12	167.32	2
1820	172.97	5	169.76	6	172.85	10	168.27	9	169.70	4
1821	174.82	13	168.91	6	171.45	5	170.66	12	169.23	6
1822	181.77	4	168.91	7	173.92	9	171.58	15	175.62	7
1823	172.24	4	172.32	8	176.53	6	171.16	13	168.40	5
1824	172.96	8	172.13	14	172.08	8	172.31	14	173.57	3
1825	173.99	14	169.97	3	172.84	11	169.14	14	170.66	8
1826	170.12	11	171.90	14	174.44	7	170.50	20	171.21	8
1827	172.72	7	166.81	10	173.25	12	173.99	7	172.14	11
1828	172.88	16	170.38	13	170.05	20	169.66	16	167.36	9
1829	172.55	19	167.92	9	171.36	14	167.88	13	166.20	11
1830	172.66	11	170.91	14	168.77	9	173.49	14	171.77	16
1831	171.66	15	166.25	16	173.99	15	172.00	30	168.91	20
1832	173.16	33	169.30	21	177.96	8	171.21	16	168.81	20
1833	174.75	44	172.22	19	171.32	15	173.73	24	169.62	16
1834	174.04	26	170.60	26	169.98	16	170.88	31	169.41	14
1835	172.76	35	174.59	16	169.62	16	172.40	30	168.97	23
1836	173.79	50	171.27	25	172.33	18	170.53	27	169.98	16
1837	173.76	30	169.47	33	174.66	20	171.90	24	170.82	16
1838	173.04	36	170.05	20	173.62	12	171.66	21	169.81	12
1839	174.46	34	169.10	24	174.43	16	170.43	30	171.27	18
1840	172.81	35	168.98	28	173.61	15	168.71	16	168.95	17
1841	175.14	37	166.87	23	171.49	15	172.39	19	169.84	15
1842	172.41	37	170.26	16	172.48	8	170.05	10	171.45	8
1843	172.21	44	168.97	20	171.96	20	168.72	24	172.47	15
1844	173.86	50	169.24	21	170.52	15	171.41	15	172.78	20

1845	172.32	27	170.47	20	168.43	8	173.35	11	169.25	15
1846	171.69	48	169.90	23	173.35	11	173.26	13	170.43	15
1847	172.87	55	169.33	18	172.01	18	171.77	14	169.63	15
1848	173.56	64	169.29	20	171.50	12	170.50	16	172.33	21
1849	174.28	55	170.27	22	171.61	27	172.89	11	170.82	15
1850	172.68	53	171.45	26	174.85	14	173.67	8	170.02	16
1851	172.37	42	170.71	24	171.39	11	168.65	12	169.18	14
1852	174.36	62	171.00	24	173.00	18	174.27	9	172.17	15
1853	173.73	59	170.76	24	172.75	21	172.90	7	168.85	11
1854	172.78	60	169.71	19	171.84	13	172.40	4	169.58	17
1855	172.98	58	171.34	17	170.96	13	174.84	9	171.45	13
1856	173.92	57	170.60	18	175.03	14	171.66	3	169.54	6
1857	172.06	58	169.37	11	173.09	12	169.12	3	174.31	6
1858	172.08	50	169.86	6	169.70	8	171.24	3	163.20	3
1859	172.53	48	169.54	10	174.35	7	169.54	5	167.37	7
1860	173.47	40	171.45	12	166.81	10	166.88	5	169.42	5
1861	171.64	40	169.54	6	173.41	12	168.91	3	171.10	9
1862	173.53	48	168.75	8	170.86	14	168.75	4	170.94	5
1863	172.42	32	173.35	2	171.69	13	172.72	3	170.03	13
1864	173.71	46	169.97	6	169.54	6	177.48	2	168.27	9
1865	172.21	37	170.66	4	173.04	8	169.54	1	171.16	13
1866	172.30	35	165.10	1	170.96	9	173.67	2	167.89	5
1867	173.09	36	168.15	5	174.75	5	174.31	4	169.55	2
1868	171.23	43	177.17	2	176.11	6	160.65	1	170.29	6
1869	172.03	25			173.14	6	165.10	1	170.18	5
1870	173.04	10	170.50	2	177.02	9			167.01	6
1871	171.20	18			175.26	2			170.18	1
1872	171.73	23	176.21	2	174.20	6			165.52	3
1873	171.29	4	170.18	1						
Total		1,885		786		672		702		616

Note: These places of birth cover ninety-one percent of male convicts. The remaining nine percent come from Scotland (188 observations), the Maritimes (91 observations), other European countries such as France, Italy, or Germany (191 observations), and the rest of the world (12 observations).

Table A.7
Height of Kingston female convicts, by birth year and place of birth (cm)

Birth Year	Ontario		Quebec		Ireland		United States		England	
	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
1805									162.56	1
1806										
1807										
1808										
1809					164.47	1				
1810	161.93	2			160.66	2				
1811							155.57	1		
1812					163.51	2				
1813										
1814					154.73	3				
1815			154.94	1						
1816			154.94	1	160.02	1				
1817			162.56	1	172.72	1				
1818					162.56	1				
1819	154.94	1	165.10	1	156.21	2				
1820					156.85	1				
1821	161.29	1			153.04	1				
1822					158.33	3				
1823	166.37	1	152.40	1						
1824	157.48	1	153.99	2	157.48	2			166.37	1
1825	166.37	1			155.58	1				
1826			157.48	3	151.13	1	165.10	1		
1827	158.12	1			157.99	5			161.29	1
1828			157.48	3					158.12	1
1829	158.75	1	164.47	1	158.12	3			152.40	1
1830	156.53	2	162.56	1	156.92	8			156.21	1
1831	165.10	1			155.36	3			158.75	1
1832	162.77	3			157.69	3				
1833	157.48	1			153.04	2	162.56	1	156.53	2
1834			161.93	2	160.40	5	160.34	2		
1835	163.20	2	158.12	1	156.77	8	162.56	1	154.94	1
1836	161.71	3			156.14	9	166.37	1		
1837	159.39	2			156.42	6				
1838	163.83	2	156.21	2	157.32	4	158.11	2		
1839	157.48	2	152.40	1	156.53	8				
1840			165.10	1	155.36	3	160.02	1		
1841	170.18	2	149.86	1	159.86	8			163.83	2
1842	157.48	2	152.40	2	166.37	2	168.27	2	167.01	2
1843	160.44	3	139.70	1	161.29	1			158.75	1
1844	154.94	1			151.89	5	152.40	1		
1845	158.75	1	157.48	2	154.94	1	154.94	1	166.37	1
1846	162.56	3	155.36	3						

1847	156.21	1	158.75	1	156.63	3	153.67	1	147.32	1
1848			153.04	2	149.86	1				
1849					156.21	2				
1850	162.98	3	147.32	3	167.64	1	152.40	1		
1851			166.37	2						
1852	163.20	2			161.29	2	147.32	1	149.86	1
1853	157.48	2			160.02	1	160.02	2		
1854	164.04	3			167.64	1	168.91	1	152.40	1
1855										
1856	162.56	1								
1857	163.83	1	154.94	1					160.02	1
1858			152.40	1	167.64	1				
1859			147.32	1						
1860	167.64	1					149.86	1		
1861										
1862										
1863			147.32	1						
1864	147.32	1								
1865										
1866										
Total	161.15	54	155.78	43	157.70	118	159.29	21	159.00	20

***Note*: These places of birth cover ninety-one percent of female convicts. The remaining nine percent come from Scotland (7 observations), the Maritimes (8 observations), other European countries such as France, Italy, or Germany (9 observations), and the rest of the world (2 observations).**