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Wages, prices and living standards in a growing economy. The case of Boston, Massachusetts

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ABSTRACT
This study analyzes the living standards of laborers in Boston, Massachusetts in 1785-1900. Using a linear programming model, I find the food basket that provided a balanced nutrition at the lowest possible cost. Then, I estimate the welfare ratio of laborers. The evidence shows that laborers in Boston earned enough to cover their basic needs, and that their real wages increased in the 19th century. The results also show that the welfare ratio of laborers in Boston was higher than the ratios of several European cities. Boston can be considered a high-wage economy during the late 18th and 19th centuries.

KEYWORDS: Living costs, prices, wages, Boston

JEL CODES: N31, I32, J31, C61

1. Introduction

For a long time, economists and economic historians have analyzed living standards in New England. Some estimates suggest that living standards in colonial New England were relatively high. According to Robert Allen, Tommy Murphy and Eric Schneider, in the 18th century, the welfare ratio in Massachusetts was already higher than the ratios in Continental Europe (Allen, Murphy, and Schneider 2012).[1] Vincent Geloso also showed that laborers in colonial New England had relatively high living standards in the 18th century: the welfare ratio of unskilled workers in this region was higher than the ratios in England, Paris and Quebec (Geloso 2019).[2] In addition, according to Robert Allen, the welfare ratio in Massachusetts was even higher than the ratios in Northern Europe in the 19th century (Allen 2009, 2014).

For the estimation of welfare ratios, it is necessary to make assumptions about the subsistence basket. Some studies have used information on the historical habits of low-income families to make assumptions about the subsistence basket in New England. Allen (2009) and Allen et al (2012) used a food basket that was supposed to resemble the

[1] The welfare ratio is calculated as the ratio between family income and the cost of subsistence.

[2] High living standards, however, were not exclusive to New Englanders in colonial times. In general, Americans had high living standards prior to 1800 (Lindert and Williamson 2016).

consumption habits of poor people in Massachusetts,[3] and that provided the necessary quantities of calories and proteins for subsistence. Geloso (2019) used a similar food basket, but increased the quantity of fuel, to estimate welfare ratios in New England. Allen (2014) made some changes to the composition of the food basket in Massachusetts to reflect changing diets, and increased the quantity of calories.

There are several challenges when making assumptions about the subsistence basket. Information on consumption habits is useful to make assumptions about the subsistence basket if this basket is supposed to reflect diets in the past. However, it is important to be cautious when using historical diets to compute welfare ratios. First, since historical diets did not necessarily provide the exact quantity of nutrients associated to subsistence, an adjustment may be needed. Some adjustments may be arbitrary. Second, if consumption habits vary across countries and across time, the resulting welfare ratios may not be comparable. For example, if consumption habits are affected by real income, the differences in welfare ratios (computed using different diets) may not reflect differences in real income (Zegarra 2022, 2024b). Additional problems may emerge if diets changed over time in response to relative prices. Depending on the selection of the diet, the results may be very different (Zegarra 2022, 2024b). Considering the problems associated with the use of historical consumption habits, some doubts may arise regarding the validity of previous estimations of welfare ratios. Are previous estimations of welfare ratios in Massachusetts valid for understanding the standards of living in this state?

Some studies have used linear programming to find the subsistence basket, and estimate welfare ratios for several economies (Allen 2017, 2020, Zegarra 2021, 2022, 2024b, 2024a). Linear programming is useful to find the lowest-cost basket that provided several nutrients, using information on prices, and the chemical composition of foodstuffs. If the subsistence basket is defined as the basket that secured subsistence at the minimum cost, linear programming will be very useful to estimate the cost of subsistence and welfare ratios. This method has several advantages with respect to the use of historical diets. On one hand, the method does not rely on an arbitrary adjustment of historical diets. In addition, the resulting food basket is not affected by real income. Furthermore, unlike some studies that have assumed the same basket over long periods, linear programming may yield different food baskets in response to changes in relative prices. In 2017, Robert Allen used linear programming to estimate poverty lines in the 21st century (Allen 2017). Other studies used this optimization method to estimate welfare ratios prior to 1900 (Allen 2020; Zegarra 2021, 2022, 2024b). However, no study has used the same method to find the lowest-cost basket in Massachusetts prior to 1900.

In this article, I estimate welfare ratios of laborers in Boston in 1785-1900 using linear programming. I use this method to find the lowest-cost food basket in Boston. As part of the model, some restrictions were made, in terms of a minimum intake of calories, proteins, fat, iron, and some basic vitamins. To estimate the cost of subsistence, the cost

[3] However, as I will show in this article, there were important differences between the average diet of families in Massachusetts and the baskets used by Allen (2009) and Allen et al (2012).

of fuel, clothing, housing, and other basic products was added. The welfare ratio was calculated using information on wages and the cost of subsistence.

In order to estimate welfare ratios in Massachusetts, Allen et al (2012), Allen (2009, 2014) and Geloso (2019) relied on data on prices and wages reported by Carroll Wright in the 19th century (Wright 1885), in addition to some official sources. These studies assumed that the basket of Massachusetts was composed of a large quantity of cereals (corn or wheat flour) and a few kilograms of legumes, meat, and butter or oil. Compared to these studies, I use a different data set, and a different methodology. I use a variety of secondary sources to obtain information on prices and wages in Boston,[4] and a linear programming model to estimate the lowest-cost food basket.

According to my estimations, the welfare ratio of laborers in Boston was usually above 1.5, which implies that working families could cover their basic needs. In addition, real wages increased over time, especially in the late 19th century. After ranging around 2.0 in 1800-60, the welfare ratio increased to 2.9 in the 1890s. My estimates are lower than the welfare ratios from Allen et al (2012), Allen (2009) and Geloso (2019) for the late 18th and early 19th centuries. Compared to Allen (2014), the differences in levels and trends are smaller. The fact that my results are lower than those of Allen (2009), Allen et al (2012) and Geloso (2019) and similar to those of Allen (2014) is not surprising. I assume far higher calorie requirements than the first three studies; the differences in calorie requirements with Allen (2014) are relatively small.

The article contributes to the debates on the Great Divergence. Some studies show that the welfare ratio in Massachusetts was higher than the ratios of several European cities in the late 18th and 19th centuries (Allen, 2009, 2014; Allen et al, 2012; Geloso, 2019). Since the baskets in these studies are supposed to reflect consumption patterns, some doubts may arise regarding their accurateness to measure the standards of living in Massachusetts. However, my results confirm that Boston was a high-wage economy. A comparison of my estimates and previous estimates shows that the finding that Bostonians had relatively high welfare ratios is robust to changes in the methodology. When comparing my results for Boston and welfare ratios in Europe, the present study reveals that families in Boston had higher living standards than important European cities in 1785-1900. Borrowing a phrase by James Lemon, America was the “best poor man's country” (Lemon 2002), or at least one of the best ones.

2. Economic growth and living standards in Boston

By the late 18th century, New England was a mainly agricultural region. Most people lived in rural areas. However, the region experienced important changes over time. In particular, the region witnessed a significant industrial revolution and a rapid process of urbanization; in the second half of the 19th century, most people in the region lived in cities.

[4] I use several sources, including Wright (1885). The appendix lists all data sources.

The region experienced an important transformation in the 19th century from a rural agricultural economy into an urban industrialized economy. Urban population in New England increased from 76 thousand inhabitants in 1790 to 784 thousand in 1850, and 3.8 million in 1900, at an average rate of 3.6% per year.[5] Rural population also grew, but at an average rate of only 0.2% per year. Therefore, the urbanization rate in New England increased from 8% in 1790 to 29% in 1850, and 69% in 1900. In Massachusetts, the urban population grew at 3.6% per year in 1790-1900, and the urbanization rate increased from 13% in 1790 to 51% in 1850, and more than 86% in 1900. In the late 18th and early 19th century, most people lived in the countryside; in contrast, in the late 19th century, most people lived in cities. As New England became industrialized and highly urbanized, the city of Boston grew rapidly. After growing by 1.3% per year in 1700-1800, the population of Boston grew by 3.2% per year in 1800-1900. Boston was a city of 25 thousand inhabitants in 1800; a hundred years later, the city had more than half million people.

The urbanization of New England was associated with the expansion of manufacturing and commerce. Capital flew into the manufacturing sector in the 19th century. In constant dollars of 1840, capital invested in manufacturing in New England grew from 87 million dollars in 1840 to 1.6 billion in 1900 (U.S. Department of Interior 1902; U.S. Department of State 1841). In Massachusetts, capital in the manufacturing sector increased from 42 million dollars in 1840 to 823 million in 1900. On the other hand, the labor force in Massachusetts increased from 209 thousand in 1840 to 485 thousand in 1880, and 745 thousand in 1900; and the labor force in non-agricultural activities increased from 121 thousand in 1840 to 406 thousand in 1880, and 667 thousand in 1900 (Easterlin 1960). Due to the industrialization of Massachusetts, the labor force in non-agricultural sectors increased from 58% of the total labor force in 1840 to 84% in 1880, and 90% in 1900.[6]

Total income in the region increased in the 19th century. In particular, in 1840-1900 total income grew by 2.6% per year in New England and 2.9% per year in Massachusetts. The growth of total income can be explained by the growth of population and the growth of income per-capita. On one hand, the population in New England grew from 1.2 million in 1800 to 5.6 million in 1900, at an annual rate of 1.5%; in Massachusetts, population grew at 1.9% per year in 1800-1900. On the other hand, income per-capita in New England increased in the 19th century, after experiencing a decline in the 18th century. Peter Lindert and Jeffrey Williamson showed that income per-capita in New England declined by 0.3% per year in 1774-1800, and grew by 2.4% per year in 1800-40 (Lindert and Williamson 2013). From 1840, income per-capita in New England maintained an upward trend. For example, Richard Easterlin showed that in 1840-1900 income per-

[5] Population data comes from official sources (U.S. Department of Commerce 1975; U.S. Department of Commerce and Labor 1909; U.S. Department of Interior 1901). Urban population in Massachusetts and New England refers to the population in cities of more than 2,500 inhabitants.

[6] In addition to experiencing a rapid process of industrialization and urbanization, New England enjoyed gains in productivity. In constant dollars of 1840, income per worker increased from 465 dollars in 1840 to 544 dollars in 1880 and 586 dollars in 1900. In Massachusetts, income per worker increased from 379 dollars in 1840 to 585 dollars in 1900. In 1840-1900, income per worker increased by 1% per year in New England and 0.7% in Massachusetts. Income per worker increased in agriculture and in non-agriculture.

capita increased by 1% per year in New England, and 0.6% per year in Massachusetts (Easterlin 1960).

Some scholars have computed welfare ratios to determine the evolution of living standards in Massachusetts (Table 1). According to Robert Allen, Tommy Murphy and Eric Schneider, the welfare ratio of unskilled workers in Massachusetts in the early 17th century was lower than the ratio in London, but similar to the Oxford ratio (Allen et al. 2012). Eventually, the welfare ratio in Massachusetts exceeded the London ratio. For the late 18th century, Robert Allen found that the welfare ratio in Massachusetts was higher than the ratios in London, Oxford, Amsterdam, Florence and Vienna (Allen 2009). In addition, the welfare ratio in Massachusetts increased by almost 100% between 1755-75 and 1835, from around 3.0 to nearly 6.0.

In 2019, Vincent Geloso estimated the welfare ratios of Massachusetts, Canada, England and France in the 17th and 18th centuries (Geloso, 2019). Geloso increased the quantity of fuel in the subsistence basket of Massachusetts. The welfare ratio in this state was around 3.5 in 1688-1700, 3.1 in 1701-25, 3.4 in 1726-50, and 3.2 in 1751-75. These results confirm that Massachusetts was a high-wage economy. The welfare ratio in this state was above 3.0 during this period, which suggests that families in the region could satisfy their basic needs. Moreover, the region had relatively high ratios for international standards, even compared to Northern Europe. The welfare ratio in Massachusetts during this period was higher than the ratios in England, France, and Canada.

In 2014, Robert Allen estimated new welfare ratios in Massachusetts and London, using a food basket that provided more calories (Allen 2014).[7] Since the basket was more expensive, the new welfare ratio of Massachusetts was lower. However, the new findings of Allen still show that the welfare ratio in Massachusetts in the 18th and 19th centuries was far higher than 1.0. In addition, Allen showed that real wages increased rapidly in New England in the 19th century. The ratio increased from around 2.0 in 1800-20 to more than 5.0 in the 1890s. In addition, the welfare ratio in Massachusetts was higher than the ratio in London in 19th century. For example, in 1800-49, the welfare ratio was 2.2 in Massachusetts and 1.7 in London. Compared to London, the welfare ratio in Massachusetts grew more rapidly. In 1800-49, the welfare ratio in Massachusetts was 29% higher than the ratio in London; in 1850-99, it was 44% higher.

[7] Allen et al (2012) and Allen (2009) assumed a subsistence basket that provided around 1,940 calories per day for an adult male, and family expenses equivalent to three adult men. Meanwhile, Allen (2014) assumed a subsistence basket with around 2,100 calories per day for an average person, and family expenses equal to four times the expenses of an average person.

TABLE 1. Welfare ratios, 1700-1899: previous studies

	1700-49	1750-99	1800-49	1850-99
Estimates from Allen (2009) and Allen et al (2012)				
Massachusetts	3,0	4,2	5,2	
London	4,2	3,5	3,8	
Amsterdam	4,2	3,8	2,9	
Antwerp	2,8	2,5	2,3	
Valencia	1,8	1,4		
Leipzig	1,4	1,0	0,7	
Milan	1,8	1,4		
Estimates from Allen (2014)				
Massachusetts		1,5	2,2	3,8
London		1,9	1,7	2,7
Estimates from Geloso (2019)				
Massachusetts	3,3	3,3		
Southern England	2,5	2,2		
Paris	2,0	1,7		

Notes: The table reports welfare ratios from Allen et al (2012), Allen (2009, 2014), and Geloso (2019). Allen (2009) and Allen et al (2012) used the same methodology to estimate welfare ratios. Allen et al (2012) reported the welfare ratios of a variety of cities in 1700-1850. However, for 1800-49, they did not report the welfare ratio of Massachusetts; in this case, I calculated the welfare ratio using wages and prices collected by Allen (2001) for 1805, 1815, 1825, 1835, and 1845, and the same assumptions as Allen et al (2012). Allen (2014) depicted the welfare ratios of Massachusetts and London in his Figure 6, but did not provide the specific figures. In this case, I calculated the welfare ratios using wages and prices collected by Allen (2001), and the same assumptions as Allen (2014). Geloso (2019) depicted the welfare ratios in his Figure 1. The figures reported in this table are approximations from Geloso´s Figure 1.

Therefore, New England experienced important economic transformation in the 19th century, as it became more urbanized and industrialized. However, from the late 17th century, New England was already a high-wage economy. Previous estimations of welfare ratios suggest people in the region could cover their basic needs, and living standards improved over time.

3. Challenges when estimating welfare ratios

Since the early 2000s, economists and historians have estimated welfare ratios for a large number of economies. Most studies have considered consumption patterns in order to make assumptions on the subsistence basket. Several studies have included a large amount of cereals, in addition to legumes, and meat, among other items, in the food basket

of poor people. The basket has been assumed to provide enough calories and proteins to ensure subsistence.

In 2001, Robert Allen relied on information on the diets in modern London in order to make assumptions about a respectability basket in pre-1800 Europe (Allen 2001). This basket included bread, legumes, meat, and other foodstuffs. Later, Allen (2009) modified the 2001 basket in order to obtain a cheaper basket, which he called "subsistence basket". For London, Allen replaced bread with oats, reduced the consumption of meat and legumes, and eliminated some expensive foods. The new basket, which provided around 1,940 kcal and 90 g of proteins per day for an adult man, was supposed to reflect what very poor people needed to consume in order to survive. For other cities, Allen maintained the same basket, or made small adjustments. For example, Allen (2009) included corn in the food basket of Massachusetts instead of oats. To determine the quantity of corn in the basket, Allen assumed that corn provided the same quantity of calories as oats in the basket of London. Several studies used the same basket as Allen (2009) for London, or made small modifications (Allen et al. 2011, 2012; Arroyo Abad, Davies, and Zanden 2012).

However, some scholars have criticized some assumptions of Allen. Some criticisms referred to the nutritional requirements for subsistence, the conversion of food expenses of an adult into expenses for an entire family, and the consumption of fuel (Geloso 2019; Humphries 2013; López-Losa and Piquero-Zarauz 2021; Zegarra 2022). Some scholars have also criticized the assumptions on the number of working days per year, and the number of persons who worked per family (Calderón-Fernández, García-Montero, and Llopis-Angelán 2017; Gary and Olsson 2020; Horrell, Humphries, and Weisdorf 2022; Humphries and Sarasúa 2012; Humphries and Weisdorf 2015; Stephenson 2018). Others have criticized Allen´s baskets under the argument that they do not reflect consumption habits (Horrell 2023; López-Losa and Piquero-Zarauz 2021).[8]

Robert Allen made changes to his methodology in subsequent studies. Allen (2014) increased the quantity of calories to 2,103 kcal/day for an average person. He also modified the method to calculate expenses for a family: he assumed that the expenses of one family were equal to four times the expenses of an average person. Later, he considered requirements of vitamins, in addition to calories and proteins (Allen 2017, 2020). Other studies have also estimated welfare ratios for several countries under new assumptions on nutritional and fuel requirements, workload, and the participation of women. For example, López-Losa and Piquero-Zarauz (2021) assumed calorie requirements above 2,000 kcal/day for an average person in Spain; while Horrell et al (2022) estimated welfare ratios in England for alternative family structures.

Several studies have relied on some consumption patterns to make assumptions about the subsistence basket. Since historical diets did not necessarily provide nutrients at the

[8] The evidence shows that diets were different from the subsistence basket of Allen (2009) (Griffin 2018; Horrell 2023; Oxley and Meredith 2014).

subsistence level, they had to be adjusted in order to obtain a subsistence basket. Some doubts may arise when adjusting historical diets. For example, if historical diets included more than enough calories, the subsistence basket should include a lower quantity of at least some foods. Which foods should be adjusted downward? Should all foods be adjusted downward proportionally? Should only the most expensive items be reduced?

One problem with the use of historical diets is that they could include relatively expensive items. For example, information from the early 1900s shows that families in Massachusetts consumed a large quantity of meat (U.S. Department of Commerce and Labor 1904).[9] On average, an adult man consumed more than 100 kg of meat per year (beef, pork, mutton and poultry), far more than the 5 kg of meat per year assumed by Allen (2009) for this state. Meat was a relative source of calories. Should the subsistence basket include a large quantity of meat even though other products provided calories at a lower cost? Certainly, meat was an important source of other nutrients, such as proteins, fat, and vitamin B12. However, it is not clear that the subsistence basket should include more than 100 kg of meat per year.

Some adjustments made by previous studies seem reasonable. For example, as Allen (2009) did when estimating welfare ratios in Europe, it is reasonable to include relatively cheap sources of calories (such as oats for London) in a subsistence basket. However, other assumptions may seem arbitrary. For instance, Allen (2009) assumed that the subsistence basket of an adult man should include 165 kg of oats per year. Why should the consumption of oats be 165 kg per year? Why not 150 kg? Why not 200 kg? In the same line, why should a subsistence basket include 20 kg of beans and 5 kg of meat per year as Allen (2009) assumed? Why not smaller quantities?

Some problems emerge when considering historical diets and, at the same time, making subsistence baskets comparable across cities. Consider the basket of Allen (2009) for Massachusetts. To some degree, Allen considered consumption habits in order to assume a subsistence basket for Massachusetts.[10] In particular, Allen assumed corn, and not oats, were the main component of the basket of Massachusetts; the quantity of corn was supposed to provide the same quantity of calories as oats in the basket of London. In addition, Allen assumed the same quantities of meat, legumes and butter in Massachusetts and London. If the basket was supposed to reflect consumption habits, it is reasonable to include corn instead of oats. However, it is not clear why the contribution of cereals to the total content of calories should be the same in Massachusetts and London. It is also not clear why the basket should include the same quantities of meat, legumes and butter in both regions. Some might argue that these assumptions are important in order to obtain comparable welfare ratios. However, there seems to be a conflict between the use of historical diets and obtaining comparable welfare ratios, unless people on both sides of

[9] Table 2 shows the average diet of an adult man in 1903.

[10] Only to some degree. In this case, I referred to the inclusion of corn. Allen did not consider other aspects of historical diets, such as the large consumption of meat.

the Atlantic obtained the same quantity of calories from cereals, and consumed similar quantities of meat, legumes and butter.

Later Allen (2014) assumed that the subsistence basket in Massachusetts in the 18th and 19th centuries was composed of 195 kg of flour, 20 kg of beans/peas, 5 kg of meat, and 3 kg of butter per year. The inclusion of wheat flour (instead of corn) was justified by the probable increase of the consumption of wheat flour due to the increase in living standards. The inclusion of wheat flour is reasonable if the subsistence basket is supposed to reflect (at least to some degree) historical diets. However, other assumptions seem arbitrary. In particular, it is not clear why the basket should include 195 kg of flour per year. In addition, it is not clear why the consumption of legumes, meat and butter should be the same as in previous studies of Allen. If flour replaced oats/corn due to the increase in real incomes, an increase in the consumption of meat might be also expected.

Another problem with the use of historical diets emerges from the fact that consumption habits probably depended on the purchasing capacity of families. If diets vary according to income, the differences in welfare ratios may not necessarily capture the differences in the capacity of families to cover their basic needs (Zegarra 2022, 2024b). To illustrate this point, assume that prices are the same in cities A and B, but that family income in A is 100% higher than income in B. Families in city A may consume more expensive items than in B. If the subsistence basket reflects actual diets, the cost of subsistence in city A may be higher than in B, even if the baskets in the two cities provide the same quantity of calories. If the cost of subsistence in A is 100% higher than in B, the welfare ratios will be the same in the two cities, even though families in A have a higher capacity to cover their basic needs.

Some problems may also occur when using changing consumption patterns to determine the evolution of welfare ratios. Changes in consumption habits may occur due to several factors, such as changes in real income and relative prices, the discovery of new products, cultural change, among other factors. As Sara Horrell recently showed, the consumption of soap, candles and lamp oil increased in modern England due to "prosperity, domesticity, and proto-industry" (Horrell 2023:1039). In addition, tobacco, tea and potatoes became part of the diets of British families in modern times. Horrell argues that the calculation of the cost of living and the welfare ratio should consider changing consumption patterns. Should the subsistence basket be allowed to change in response to changing habits? In some cases, information on changing consumption habits can be useful to adjust the subsistence basket. For example, the discovery of new products may allow families to satisfy their needs at a lower cost than old products, and may change consumption patterns. If new products allow families to satisfy their needs at a lower cost, it seems reasonable to include them in the subsistence basket. In addition, changes in relative prices could also influence consumption habits; and it is reasonable to include cheaper products in the subsistence basket. However, in some cases, changes in consumption habits should not lead to changes in the subsistence basket. For example, an increase in real income may lead to variations in consumption patterns, replacing cheap

products with expensive substitutes; but it is not clear that expensive items should be part of the subsistence basket. If the subsistence basket includes more expensive items in periods with higher income, welfare ratios may not capture the actual differences in the capacity of families to cover their basic needs.

It might be argued that baskets should be the same everywhere to make welfare ratios comparable across cities or across time.[11] However, in this case, another problem may emerge. If the differences in diets reflect differences in relative prices, assuming the same basket would make welfare ratios not comparable. To illustrate this point, assume that families can only consume oats and/or beans in cities A and B. Oats are a far cheaper source of calories than beans in city A; the opposite occurs in city B. In particular, assume the price of oats (in grams of silver) in B is twice as much as in A, and the price of beans in A is twice as much as in B. Families in A only consume oats, and families in B only consume beans. Finally, assume nominal wages are the same in the two cities. If the subsistence basket for both cities only includes oats, the welfare ratio will be higher in city A. However, if the basket for both cities only includes beans, the welfare ratio will be higher in city B. Thus, assuming the same basket in two cities with very different relative prices would not allow us to determine the actual differences in the capacity of families to cover their basic needs. The same problem occurs when relative prices change over time. If relative prices change over time, assuming the same basket for long periods may not allow us to determine whether the capacity of families to cover their basics actually improved, declined, or remained constant.

Therefore, it is important to be cautious when using historical diets to make assumptions about the subsistence basket. First, some of the adjustments of historical diets to obtain subsistence baskets may be arbitrary. In addition, there are several challenges when comparing welfare ratios in different cities and in different periods, because of differences in real income and relative prices.

4. Linear programming

Linear programming can be used to determine the lowest cost basket that allowed people to cover their nutrition needs. Linear programming is an optimization method, commonly used for a variety of applications. This method can be used to find the lowest-cost basket that provides a number of nutrients. Linear programming considers the differences in nutrients and prices of foodstuffs to minimize the cost of food, subject to certain restrictions. The restrictions refer to the intake of calories, proteins and other nutrients.[12]

[11] Allen (2001) used the same food basket for Amsterdam, Antwerp, Munich, Leipzig, Krakow, Gdansk, Warsow and Lwow. This basket included the same quantities of rye bread, beans, meat, butter, cheese, eggs, sugar and beer. Allen also used the same basket for Madrid, Valencia, Northern Italy and Naples. This basket included the same quantities of wheat bread, beans, meat, cooking oil, cheese, eggs, sugar and wine. Allen et al (2012) used a single food basket to estimate the cost of subsistence for all cities in the Americas prior to 1800. In addition, Allen (2001, 2009, 2014) and Allen et al (2012) assumed that the food basket did not change over time.

[12] The appendix includes a technical description of the model.

With the lowest cost basket, it is possible to obtain valuable information about living standards. If a family earned enough to pay for such a basket and other basic goods, then such a family could cover their basic needs, including a balanced nutrition.

Some might question the validity of linear programming for the selection of the food basket. Families do not necessarily have complete information on prices and nutrients, and do not rely on a mathematical tool when selecting their diets. In addition, some families may be willing to maintain certain consumption habits even if they are expensive.

These criticisms do not invalidate the use of a linear programming model when estimating welfare ratios. First, linear programming is not intended to estimate the consumption habits of low-income families. The lowest-cost basket is rather useful to determine whether families had the capacity to cover their basic nutrients. Second, although the lowest-cost basket is not intended to reflect the diets of poor people, it may capture some characteristics of the consumption decisions of poor people. In particular, relative prices have an impact on the lowest-cost basket, and may affect the consumption decisions of low-income families. It is likely that high-income families maintained their consumption habits even at a high cost; but poor families probably tried to find a cheaper method of supporting their needs (Allen 2017).

When estimating welfare ratios, there are advantages and disadvantages of using the lowest-cost basket, as there are also advantages and disadvantages of using historical diets. When relying on reasonable assumptions about the historical diets of poor people, the resulting welfare ratios will measure the capacity of low-income families to cover their consumption habits at a subsistence level. In comparison, when relying on the lowest-cost basket, the resulting welfare ratios will measure the capacity of low-income families to cover their basic needs.

The availability of information plays an important role when estimating welfare ratios with either method. A number of studies have made assumptions about the diets of poor people. These assumptions, however, have been constrained by the availability of price information. That is, the baskets only included foods with price information. On the other hand, the selection of the lowest-cost basket may be affected by the set of goods included in the model. If more goods are included in the model, the optimal basket may change, and the cost of food may decline. In this article, I try to minimize the problem of limited information by including as many items in the model as possible.

5. Estimation of the lowest cost basket in Boston

In this section, I find the lowest-cost food baskets in Boston between 1785 and 1900. I assume a person could purchase the following items: wheat flour, rye flour, oatmeal, corn, cornmeal, rice, beans, potatoes, beef, pork, mutton, codfish, eggs, milk, butter, cheese, sugar, onions, turnips, and apples.[13]

[13] I estimate two baskets, one for an adult man, and another for a family of four members. I estimate the basket of an adult man for comparison reasons (other studies have usually assumed a basket for an adult

To calculate the food basket, it is necessary to consider the nutritional needs. Historical studies have usually assumed that food baskets ensured certain levels of calories and proteins. People certainly need calories and proteins for subsistence. A healthy life, however, requires more than calories and proteins. People also need fat, iron and vitamins for a balanced nutrition. Recently, a number of studies considered not only the requirements of calories and proteins, but also those of iron, fat and a number of vitamins (Allen 2017, 2020, Zegarra 2022, 2024b, 2024a). For Massachusetts, however, no historical study has relied on a food basket that provided a balanced nutrition in order to estimate welfare ratios.

Nutritional requirements depend on age, gender and other factors. In order to determine the requirements of calories, I assume a weight of 65 kg for adult men, and 55 kg for adult women.[14] Calorie requirements depend on the type of work. For example, consider a daily energy requirement of 2.2 BMR for men (heavy work) and 1.8 BMR for women (moderate work).[15] According to a report of FAO in the 1980s, a man of 18-30 years with these characteristics would need 3,700 kcal per day, and a woman in the same age range would need 2,350 kcal per day (Food and Agricultural Organization of the United Nations 1985). In the present study, I rely on the calorie requirements recommended by FAO. For proteins and other nutrients, I use contemporary Indian dietary requirements from Indian National Institute of Nutrition (2009) as a proxy for the nutrients´ requirements of pre-1900 Americans.[16] Indian requirements were calculated assuming a weight of 60 kg for men, which is close to the weight of 19th century Americans. According to my calculations, an average adult man doing heavy work in Boston needed at least 3,621 kcal,[17] 60 g of proteins, 41 g of fat, 17 mg of iron, 1.7 mg of thiamine, 21 mg of niacin equivalent (NE), 1.0 µg of vitamin B12, 200 µg of folate, and 40 mg of vitamin C per day.[18]

I allow food baskets to vary over time. In particular, I estimate food baskets for each decade. I assume p_j is equal to the average prices for each decade. All prices were

man). In addition, in the following section, I will estimate the basket of a family of four members in order to estimate welfare ratios.

[14] The average weight of men in Boston during the Civil War was 141.5 pounds or 64 kg (Komlos 1987). In the first half of the 19th century, the height of Americans was around 1.72 m, and the BMI of 18-year-old men was around 21 (Costa and Steckel 1997). For such height and BMI of men, the weight was 62 kg. Thus, the assumption of 65 kg for an adult man is based on historical evidence.

[15] These assumptions will be valid for a basic model. For this model, I will consider a family of four members (two adults and two children), in which the father worked 250 days per year, and the mother stayed at home. In Section 7, I will consider alternative scenarios.

[16] Other studies have also used the Indian requirements to estimate the nutrition requirements in pre-1900 Europe (Allen 2017; Zegarra 2022, 2024b). The use of calorie requirements from Indian National Institute of Nutrition (2009) may be problematic (Humphries 2013). For this reason, I use FAO´s recommendations to determine the minimum requirements of calories.

[17] Due to winter temperatures, Bostonians may require more calories than in locations with less extreme temperatures (Geloso 2019; Milanovic, Lindert, and Williamson 2011). If it is assumed that Bostonians required 10% more calories, welfare ratios would decline by 3.5%. The trend of the welfare ratio will not change, nor will the main differences with European cities.

[18] See the appendix for further information on the estimation of average nutritional requirements.

converted to dollars per kilogram. I consider the requirements of calories, proteins, fat, iron, thiamine, niacin, vitamin B12, folate and vitamin C. Since the lowest-cost basket provided a variety of nutrients, it can be called a "balanced nutrition basket" or simply BN basket.[19]

Table 2 reports the balanced-nutrition (BN) baskets for an average adult man in Boston during 1785-1900. Rye flour and potatoes were always included in the food basket. Wheat flour had an important participation in the basket from the 1810s. Corn, cornmeal and beans also appeared in some decades. Among animal-derived products, mutton and pork were included in the basket in larger quantities than beef and codfish. In addition, the lowest-cost basket never included oatmeal, rice, eggs, cheese, sugar, onions, turnips, and apples.

The composition of the BN food basket can be explained by relative prices and the chemical composition of foodstuffs. Since the constraints of calories, niacin and vitamin B12 were binding, the cheapest sources of these nutrients had an important participation in the food basket. On average, cornmeal and rye flour were the cheapest sources of calories (Table 3). In 1785-1900, one dollar spent on cornmeal provided 65,000 kcal. In the case of rye flour, the provision was 50,000 kcal per dollar. Cornmeal was a cheaper source of calories than rye flour, but did not provide niacin; which may explain why the food basket included a larger quantity of rye flour. Meanwhile, wheat flour, potatoes and turnips were relatively cheap sources of niacin. Even though wheat flour was a more expensive source of calories than cornmeal and rye flour, it was included in the food basket because of its content of niacin. Animal-derived foods were expensive sources of calories, and some of them very expensive sources of niacin as well. However, since animal-derived foods were the only source of vitamin B12, they were included in the food basket.

[19] This term was previously used in other studies (Zegarra 2021, 2022).

TABLE 2. Food baskets for an average adult man in Boston, 1785-1900

	BN baskets for an adult man[1]						USDCL (1904)[2]	Allen et al (2012) & Allen (2009)[3]	Allen (2014) 1720-1900[4]	
	1785-1800	1801-1825	1826-1850	1851-1875	1876-1900	Avg	1903 Adult man	1625-1845 Adult man	Avg person	Adult man
Foodstuffs per year (kg)										
Bread and flour/meal										
Bread							14,4	0,0	0,0	0,0
Flour and meal							82,2			
Wheat flour	0,0	31,9	54,0	77,8	64,3	49,1		0,0	195,0	278,2
Rye flour	67,9	210,3	293,7	148,9	233,6	200,4		0,0	0,0	0,0
Oatmeal	0,0	0,0	0,0	0,0	0,0	0,0		0,0	0,0	0,0
Cornmeal	79,8	59,6	0,0	105,8	41,1	55,5		0,0	0,0	0,0
Other cereals										
Corn	63,6	0,0	0,0	0,0	0,0	8,8	0,0	165,0	0,0	0,0
Rice	0,0	0,0	0,0	0,0	0,0	0,0	2,4	0,0	0,0	0,0
Meats and derived foods										
Beef	0,0	0,0	14,6	0,0	0,0	3,1	60,0	5,0	5,0	7,1
Pork	0,0	41,1	6,8	0,0	0,0	10,3	25,6	0,0	0,0	0,0
Mutton	15,1	0,0	11,0	32,8	29,5	17,9	15,2	0,0	0,0	0,0
Poultry							8,8	0,0	0,0	0,0
Codfish	0,0	3,4	4,0	4,9	6,2	4,0	21,8	0,0	0,0	0,0
Eggs	0,0	0,0	0,0	0,0	0,0	0,0	13,8	0,0	0,0	0,0

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		BN baskets for an adult man[1]						USDCL (1904)[2]	Allen et al (2012) & Allen (2009)[3]	Allen (2014) 1720-1900[4]	
		1785-1800	1801-1825	1826-1850	1851-1875	1876-1900	Avg	1903 Adult man	1625-1845 Adult man	Avg person	Adult man
	Milk	80,5	0,0	0,0	0,0	0,0	11,1	128,2	0,0	0,0	0,0
	Cheese	0,0	0,0	0,0	0,0	0,0	0,0	1,4	0,0	0,0	0,0
	Butter	5,8	0,0	1,2	0,0	0,0	1,1	13,8	3,0	3,0	4,3
	Lard							9,9	0,0	0,0	0,0
Others											
	Beans	0,0	0,0	0,0	5,7	5,4	2,4	0,0	20,0	20,0	28,5
	Potatoes	626,1	259,5	89,4	86,9	87,0	199,0	57,5	0,0	0,0	0,0
	Onions	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Turnips	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Apples	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Sugar	0,0	0,0	0,0	0,0	0,0	0,0	31,3	0,0	0,0	0,0
	Molasses							7,3	0,0	0,0	0,0
	Tea							1,2	0,0	0,0	0,0
	Coffee							3,4	0,0	0,0	0,0
Nutrients (as % of the minimum requirement)											
Calories		100,0	100,0	100,0	100,0	100,0	100,0	73,3	46,1		80,8
Proteins		100,0	134,2	157,7	123,0	146,1	134,7	143,2	25,6		144,9
Fat		100,0	100,0	100,0	100,0	100,0	100,0	277,4	30,5		74,4
Iron		129,4	152,5	169,3	146,9	161,6	153,7	85,1	51,8		163,1
Thiamine		139,6	203,7	215,8	154,6	192,0	184,4	86,8	22,2		207,0

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	BN baskets for an adult man[1]						USDCL (1904)[2] 1903 Adult man	Allen et al (2012) & Allen (2009)[3] 1625-1845 Adult man	Allen (2014) 1720-1900[4] Avg person	Allen (2014) 1720-1900[4] Adult man
	1785-1800	1801-1825	1826-1850	1851-1875	1876-1900	Avg				
Niacin	100,0	100,0	100,0	100,0	100,0	100,0	85,3	5,4		200,9
Vitamin B12	100,0	101,7	100,0	100,0	100,0	100,4	593,2	13,7		19,5
Folate	145,6	169,1	194,7	166,5	204,0	178,3	67,8	142,9		312,4
Vitamin C	709,0	290,4	100,0	100,0	100,0	225,0	77,5	9,6		13,7

Notes: The table reports the BN baskets for an adult man estimated by linear programming, the average diet of an adult man in Massachusetts in 1903 (U.S. Department of Commerce and Labor, 1904), and the baskets of Allen (2009), Allen et al (2012) and Allen (2014). The table also reports the intake of nutrients per day as a percentage of the minimum requirements of an adult man. I consider the following requirements of nutrients per day: 3,620 kcal, 60 g of proteins, 41 g of fat, 17 mg of iron, 1.7 mg of thiamine, 21 mg of niacin equivalent (NE), 1.0 µg of vitamin B12, 200 µg of folate, and 40 mg of vitamin C.

[1] Bread, poultry, lard, molasses, tea and coffee were not included in the linear programming model due to limitations on price information.

[2] USDCL = U.S. Department of Commerce and Labor. The average diet of 1903 included 181.2 lb of flour and meal. I assume the item "flour and meal" was composed of wheat flour, rye flour, oatmeal, and cornmeal in the same amounts. The diet of 1903 also included 33.6 lb of other meats and 48.3 lb of fish; I assume these quantities referred to mutton and codfish, respectively. This source does not report the consumption of vegetables, fruits, vinegar and condiments, even though families consumed these foods; therefore, the reported diet of 1903 underestimates the provision of some nutrients.

[3] Allen et al (2012) used the same basket as Allen (2009) for an adult man.

[4] Allen (2014) assumed a basket for an average person. In this case, the table reports two figures, one for an average person and another for an adult man. The quantities for an adult man were calculated as 1.426 times the quantities for an average person.

The variation in the food basket over time depends on the changes in relative prices. For example, potatoes became relatively expensive over time, especially compared to other cheap sources of calories and niacin. The provision of calories per dollar of potatoes declined from 41,000 kcal in 1785-1800 to 13,000 kcal in 1851-75, while the provision of niacin per dollar of potatoes declined from 570 mg in 1785-1800 to 176 mg in 1851-75. From the first quarter of the 19th century, wheat flour was a cheaper source of calories and niacin than potatoes. Not surprisingly, the participation of potatoes declined over time, while the participation of wheat flour increased.

TABLE 3. Intake of nutrients per dollar in selected products, 1785-1900

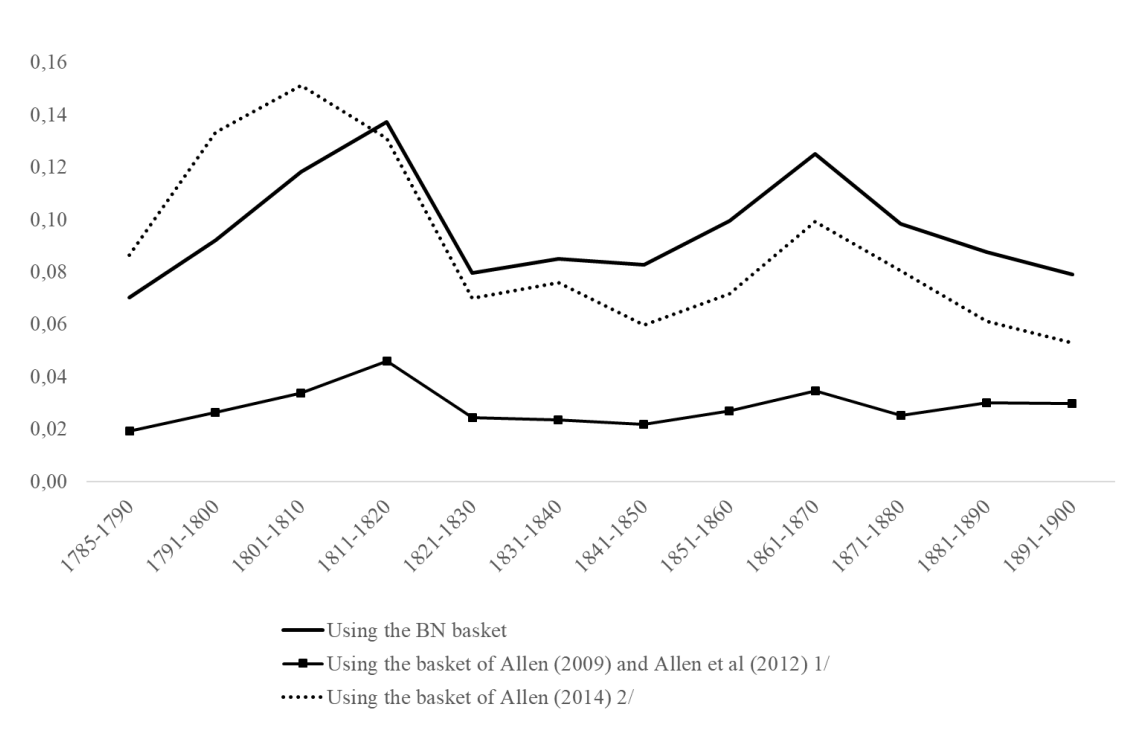
	Calories (kcal)	Proteins (g)	Fat (g)	Iron (mg)	Thiam (mg)	Niacin (mg NE)	Vit. B12 (µg)	Folate (µg)	Vit. C (mg)
Wheat flour	24.277,2	648,9	160,4	222,4	28,5	387,9	0,0	2.077,8	0,0
Rye flour	50.285,1	1.200,8	300,2	405,3	51,0	142,6	0,0	5.854,1	0,0
Oatmeal	16.631,0	498,1	358,1	169,6	20,6	41,2	0,0	2.470,0	0,0
Corn	56.381,6	79,6	111,5	227,8	0,0	0,0	0,0	0,0	0,0
Cornmeal	64.953,9	91,7	128,4	262,4	0,0	0,0	0,0	0,0	0,0
Rice	25.313,7	434,7	70,1	31,6	5,6	105,2	0,0	2.033,5	0,0
Beans	22.195,9	1.432,2	108,6	366,5	46,2	88,2	0,0	35.296,2	475,1
Potatoes	16.303,7	393,5	18,7	140,5	20,6	224,9	0,0	2.623,6	3.560,6
Beef	6.575,7	463,2	524,5	44,4	1,2	111,8	35,5	204,1	0,0
Pork	12.517,8	503,7	1.166,6	33,3	21,5	151,8	37,0	111,1	0,0
Mutton	13.569,8	525,5	1.274,2	43,2	3,2	144,0	36,0	108,0	0,0
Codfish	6.242,6	1.446,1	47,4	31,6	6,3	110,6	158,0	395,1	0,0
Eggs	5.208,4	380,2	393,0	80,8	2,9	2,2	92,7	798,8	0,0
Milk	13.274,3	663,7	744,2	16,1	8,0	16,1	60,3	1.005,6	301,7
Butter	15.383,4	7,8	1.650,9	3,1	0,0	0,0	0,0	0,0	0,0
Cheese	11.303,7	907,3	851,5	7,8	1,5	2,2	52,1	743,7	0,0
Sugar	20.057,8	25,5	0,0	45,3	0,0	0,0	0,0	0,0	0,0
Onions	3.369,9	131,9	0,0	44,0	4,4	29,3	0,0	2.344,3	1.465,2
Turnips	7.189,2	319,5	119,8	147,8	16,0	239,6	0,0	7.988,1	9.985,1
Apples	7.539,3	50,3	0,0	48,6	0,0	0,0	0,0	0,0	0,0

Notes: The table reports the intake of nutrients per dollar spent in each product. These indicators are calculated as the ratio between the content of nutrients in a kilogram of the product and the average price of a kilogram of the product in 1785-1900.

Figure 1 shows the evolution of the cost of the BN food basket in current dollars. The cost of food for an adult man increased in the late 18th and early 19th centuries. The cost of food then declined in the 1820s and increased in the 1830s and 1840s. By 1850-70, the

cost of food in dollars increased rapidly. From the 1870s, the cost of food in dollars declined. In the 1890s, the cost of food was around the same level as in the 1840s.[20]

FIGURE 1. Cost of the food basket of a person per day in Boston, 1785-1900 (current dollars)



Notes: The table reports the daily cost of food for the BN basket and for alternative baskets. The BN basket corresponds to an adult man. 1/ Allen (2009) and Allen et al (2012) assumed the same basket for an adult man. 2/ Allen (2014) assumed a basket for an average person.

The BN basket is the basket that provides a number of nutrients at the lowest cost. There are important differences between the BN basket and the diets of workers in Massachusetts (Table 2). In 1903, the average diet of an adult male worker in Massachusetts was composed of around 130 kg of meat (including red meats, poultry and fish), 130 kg of milk, 82 kg of flour and meal, 58 kg of potatoes per year, in addition to rice, sugar, molasses, tea, coffee, and other foods (U.S. Department of Commerce and Labor 1904).[21] This basket provided a large quantity of proteins, fat and vitamin B12, due to the large quantity of meat. Compared to the BN basket, the diet of a worker in Massachusetts was relatively expensive.

[20] The cost of food in grams of silver followed a different trend than the cost in dollars, especially in the second half of the 19th century. In 1870-1900, the cost of food in silver increased, even though the cost in dollars declined, due to the depreciation of silver with respect to the dollar.

[21] This source reports food expenses for the entire country. The information comes from a sample of 1,043 "normal families" for the entire country, including 62 for Massachusetts. A normal family was composed of a husband at work, a wife, no more than five children, no child of more than 14 years of age, no servants, and with expenditures in rent, fuel, lighting, food, clothing and sundries (U.S. Department of Commerce and Labor 1904:90). The figures do not include information on vegetables, fruits and other foods that were also consumed by families in Massachusetts. Since the reported basket of 1903 in Table 2 does not include the consumption of some foods, it underestimates the provision of some nutrients.

As explained above, the selection of the BN basket depends on relative prices, the chemical composition of foods, and nutritional requirements. The BN basket included a far lower amount of meat than the average diet, because meat was a relatively expensive source of calories. Certainly, meat provided vitamin B12. However, an average adult did not need as much vitamin B12 as the average diet provided. The large quantity of meat in the diets of workers cannot be explained by nutritional needs. Rather, it can be explained by the relatively high incomes in Massachusetts: families probably had the necessary income to consume not only cheap foods that assured subsistence, but also expensive foods they liked.

Cereals, a cheaper source of calories than meat, had a larger participation in the BN basket. This basket included more than 300 kg of flour and meal per year in the late 19th century. In contrast, the average annual diet of 1903 included less than 100 kg of bread, flour and meal. For an adult man who wanted to satisfy his nutritional needs at the lowest possible cost, it would have been convenient to consume far more than 100 kg of cereals per year.

Other studies have used other food baskets to estimate welfare ratios in Massachusetts. Compare the BN basket to those baskets (Table 2). Allen (2009) and Allen et al (2012) assumed a subsistence basket for an adult male composed of 165 kg of corn, 20 kg of beans, 5 kg of meat, and 3 kg of butter per year.[22] Allen (2014) assumed a subsistence basket for an average person composed of 195 kg of wheat flour, 20 kg of beans, 5 kg of meat, and 3 kg of butter per year. Since this basket was intended for an average person, for comparison reasons, I adjusted these quantities to reflect the equivalent consumption of an adult man.[23]

Allen (2009) and Allen et al (2012) included 165 kg of corn in the food basket. In the case of the BN basket, the main cereal was rye flour.[24] Cornmeal was a cheaper source of calories than rye flour, but did not provide niacin. Cornmeal was included in the basket, but in smaller quantities. Allen (2014) included 195 kg of wheat flour in the food basket for an average person, which was equivalent to 278 kg for an adult man. In the case of BN basket, wheat flour was included in far smaller amounts, because wheat flour was a more expensive source of calories than rye flour and cornmeal. On the other hand, Allen

[22] Geloso (2019) included a larger quantity of fuel in the subsistence basket than Allen (2009) and Allen et al (2012), but assumed the same food basket as these studies.

[23] In particular, I multiplied the quantities of the original basket by 1.426, which reflects the ratio between the requirements of calories of an adult man and an average person.

[24] Some might wonder about the consequences of consuming the BN basket instead of the historical diets. What would have occurred if poor people changed their diets in response to relative prices and nutrition requirements? Prices could have changed if a large portion of the population changed their consumption habits. It is hard to know however, if prices would have changed in Boston. If poor people changed their habits and consumed more of rye flour instead of cornmeal, there would have been a higher demand for rye. Rye, however, was tradable internationally; then, it is possible that rye prices did not experience a significant change. It is possible that trade flows changed in response to new consumption patterns. It is also possible that the use of agricultural land changed in response to an increase in the demand for rye. Yet, changes in prices, trade flows and the use of agricultural land also depended on the proportion of low-income families in the total population.

et al (2012) and Allen (2009, 2014) included beans in the food basket, because they provided calories at a relatively low cost. The BN basket includes a smaller quantity of beans. Beans were a relatively cheap source of proteins; but provided calories and niacin at a far higher cost than other foods.

An important difference between the baskets refers to the provision of nutrients. According to Allen et al (2012) and Allen (2009), the basket provided around 1,940 kcal per day for an adult male.[25] Using our assumptions on calorie content, the basket of these two studies provided 1,670 kcal per day. This quantity of calories was insufficient for subsistence. On average, an adult man doing heavy work in Boston required 3,619 kcal per day. In general, this basket provided insufficient calories, as well as inadequate levels of proteins, fat, iron, niacin, vitamin B12 and vitamin C. Considering the insufficient quantity of nutrients, it is not surprising that the cost of the food basket was far lower than the cost of the BN basket (Figure 1).

The differences in the amounts of nutrients between the BN basket and that of Allen (2014) are far lower. The basket of Allen (2014) provided more calories, proteins and other nutrients than the basket of Allen (2009) and Allen et al (2012). However, the quantity of calories, fat, vitamin B12 and vitamin C was not enough to meet nutritional requirements. Considering the smaller differences in the provision of nutrients between the BN basket and the basket of Allen (2014), it is not surprising that the cost of the basket of Allen was not too different from the cost of the BN basket.

6. Welfare ratios

The welfare ratio is calculated as the ratio between family income and the cost of subsistence. If the welfare ratio is greater than 1.0, the family income is higher than the cost of subsistence. If the welfare ratio is less than 1.0, the family income is lower than the cost of subsistence.

I assume a family was composed of four members, two adults and two children.[26] Some studies have assumed that only one adult male worked per family, and that he did so during 250 days per year. However, these assumptions have been widely criticized by economic historians (Calderón-Fernández et al. 2017; Gary and Olsson 2020; Horrell et al. 2022; Humphries and Sarasúa 2012; Humphries and Weisdorf 2015; Stephenson 2018). In the case of Massachusetts, the evidence suggests that the average number of workdays of laborers per year in the 1770s was around 250.[27] On the other hand, women

[25] I computed the quantities of nutrients from the basket. According to my calculations, the basket of Allen (2009) and Allen et al (2012) provided 1,670 kcal/day. The differences in the content of calories can be explained by the differences in the assumption on the quantity of calories in a kilogram of corn.

[26] Since most studies have estimated welfare ratios for families of four members, in this section I do the same for comparison reasons. However, families varied in size in Boston (Wright 1887). Some families had only one member, others two members, other three, and so on. On average, families had 4.9 members in Boston in the 1880s. In the following section, I calculate welfare ratios for alternative family sizes.

[27] On average, the number of workdays of unskilled workers was 255 in 1873 (Bureau of Statistics of Labor 1873:93). In most sectors, on average in 1873 laborers worked more than 200 days per year. For example, on average, city laborers worked 300 days. Meanwhile, railroad laborers worked between 263 and 335 days

could also work for a salary. In Massachusetts, women participated in the labor market. However, women earned less than men; on average, salaries of women were around 50% of men salaries in the 1880s (Bureau of Statistics of Labor 1885:123). In this section, I follow the traditional assumption that only one man worked for a salary per family, and that he did so during 250 days per year.[28] However, in the following section, I will change these assumptions to estimate welfare ratios in several life stages.

I calculate the daily income as the annual labor income divided by 365, assuming that a laborer worked 250 days in a year (Figure 2). Information on wages of low-skilled workers comes from a variety of sources.[29] The daily family income increased from 34 cents of a dollar in the 1880s to 80 cents in the 1810s, but then declined to 62 cents in the 1820s. In the following three decades, wages increased, but remained below the 1820s level. Later, the daily income increased from 73 cents in the 1850s to 1.2 dollars in the 1880s and 1890s.[30]

On the other hand, the cost of subsistence includes the cost of food, housing, fuel, clothing, among other basic goods. The cost of food is calculated as the cost of the BN food basket. I use linear programming to determine the BN food basket for a family. To determine the calorie requirements, I assume the adult man in a family did heavy work (2.2 BMR) and the adult woman moderate work (1.8 BMR).[31] According to my calculations, a family of four members required 9,829 kcal, 188 g of proteins,137 g of fat, 77 mg of iron, 4.7 mg of thiamine, 61 mg of niacin equivalent (NE), 2.5 µg of vitamin B12, 689 µg of folate, and 165 mg of vitamin C per day.[32] In addition, I assume that the subsistence basket of each person includes 3 meters of shirting, 1.3 kg of candles, 1.3 kg of soap, and 1.3 liters of oil per year.[33] I also assume that a family consumed 46.5 M BTU

per year; domestic servants worked between 303 and 332 days per year; and farm laborers worked between 112 and 326 days per year. In the 1880s, the average number of workdays was above 300 (Bureau of Statistics of Labor 1885:120).

[28] In this case, I assume women worked at home, raising children, cooking, and doing other activities; but did not receive a salary.

[29] The appendix indicates the data sources.

[30] In grams of silver, the family income increased more rapidly in the late 19th century.

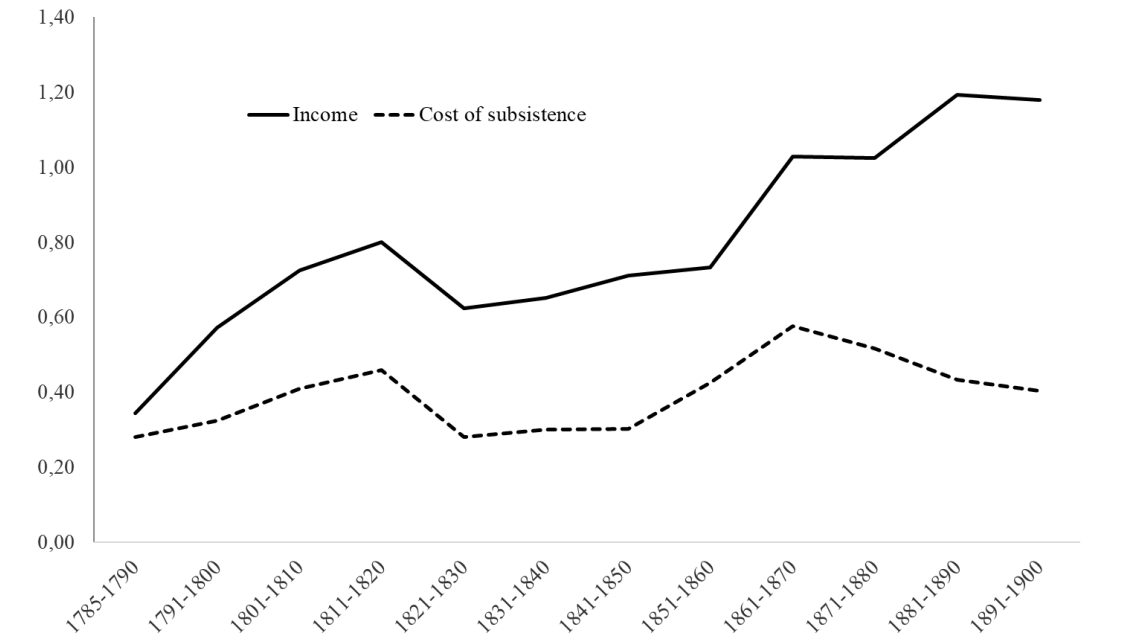
[31] These assumptions are consistent with the assumption that only the adult man worked for a salary. I assume the adult woman did not work for a salary, and that her work at home demanded a moderate effort.

[32] The appendix describes the method to calculate the total nutritional requirements of a family of four members.

[33] Allen et al (2012) made similar assumptions for an adult man in the Americas. Allen (2009) made the same assumption for pre-1900 Europe. The appendix shows the sources on prices. I used prices in Boston for all items, with the exception of shirting. For this item, I assumed that the price in Boston was the same as that of Massachusetts.

of fuel per year (equivalent to 11.6 M BTU per person),[34] and that a family rented two rooms.[35]

FIGURE 2. Income and cost of subsistence of a family per day in Boston, 1785-1900 (current dollars)



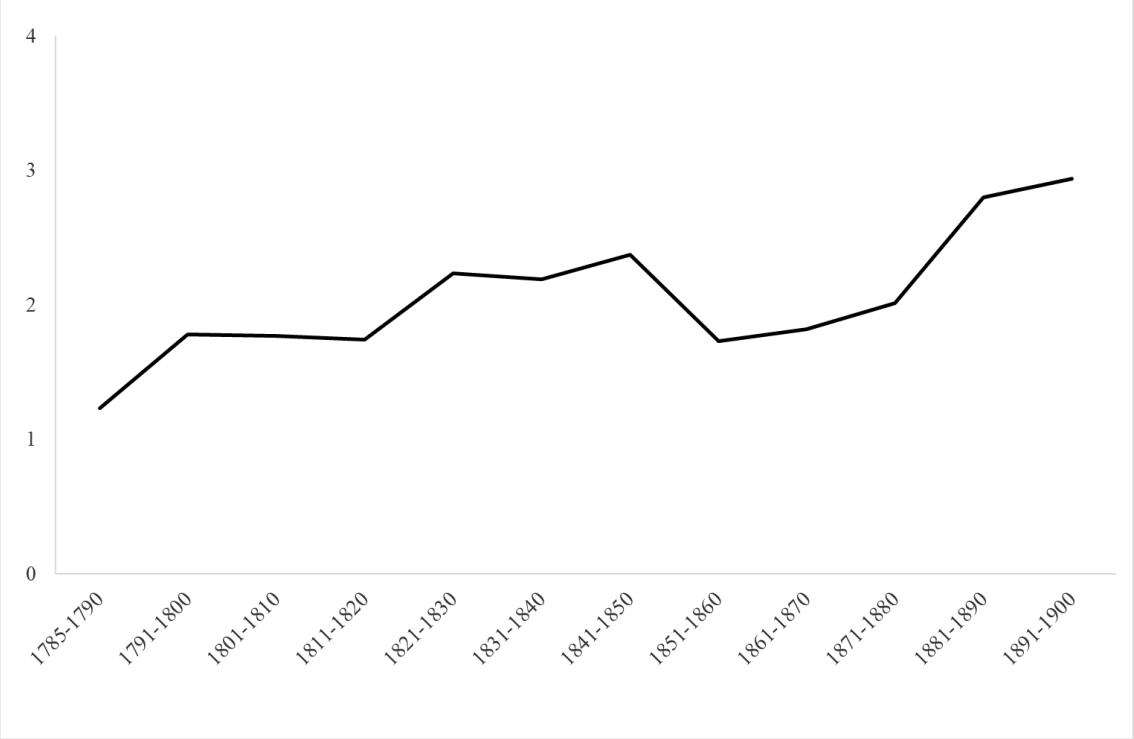
Notes: The figure depicts the daily income and the daily cost of subsistence of laborers´ families in Boston. I consider a family of two adults and two children. Income is calculated as annual wages divided by 365. It is assumed that laborers worked 250 days per year. The cost of subsistence is equal to the cost of food, fuel, clothing, soap, candles, lamp oil and housing.

[34] Fuel consumption was probably related to the consumption of food and housing expenses: the more food a family consumed and the larger the house, the more fuel this family needed. Using information on actual expenses of families in Massachusetts (Bureau of Statistics of Labor 1873:115), the expenses on fuel were equivalent to 14.3% of the total expenses on food and housing. Then, using the cost of the BN food basket, the cost of renting two rooms, and fuel prices, I calculate the implicit consumption of fuel in every year in the 1870s. On average, in 1870-79 a family of four members (two adults and two children) needed to consume 46.5 M BTU per year, which was equivalent to 11.6 M BTU annually per person. Geloso (2019) assumed 20 M BTU per person in Massachusetts in order to estimate the cost of subsistence. Other studies assume 2.0 M BTU of fuel in Europe; but this quantity of fuel may be too low for New England.

[35] According to the Census of Massachusetts of 1895, on average 0.8 persons occupied a room in Boston (Wadlin 1896:535). However, for some families, the ratio was far larger. Some might be inclined to assume that a family lived in one room at a subsistence level, in order to minimize expenses. However, according to Horace Wadlin, two rooms were necessary for a family of four members. In his report of the results of a census of Boston in the 1890s, he indicated that "usually if the family is larger than two in a single-room tenement, there must be overcrowding" (Wadlin 1892:574). Furthermore, according to the United Nations, overcrowding occurs if there are more than three people per habitable room (United Nations. Department of Economic and Social Affairs 2008:301). Therefore, the minimum size of housing for a family of four persons would be two rooms. I do not consider other expenses, which were also important for a healthy life. For example, I do not consider the cost of having proper sanitary conditions. Our estimates of housing costs do not include sanitary expenses: during most of this period, sanitary conditions were poor in Boston, as in other highly populated U.S. cities (Blake 1948; Burian et al. 2000).

According to my calculations, the daily cost of subsistence increased from 28 cents of a dollar in the 1780s to 33 cents in the 1790s and 46 cents in the 1810s (Figure 2). The subsistence cost declined to 28 cents in the 1820s, and remained around 30 cents in the following two decades. The cost increased in the 1850s and the 1860s. In the 1860s, the cost was 58 cents per day. In 1880-1900, the subsistence cost remained below 44 cents per day. Food represented the largest portion of the cost of subsistence. In particular, food represented around 70% of the total subsistence cost.

FIGURE 3. Welfare ratio of laborers in Boston, 1785-1900



Notes: The figure depicts the welfare ratio of laborers in Boston. The welfare ratio is calculated as the annual family income divided by the family´s cost of subsistence.

I calculated the welfare ratio as the total family income divided by the subsistence cost. Figure 3 depicts the evolution of the welfare ratio of laborers in Boston in 1785-1900. The welfare ratio was around 1.2 in the 1780s. The ratio increased in the 1790s, and remained relatively steady in the 1800s and 1810s. In the 1820s, the welfare ratio was around 2.2 and remained steady in the following two decades. Then, the ratio declined in the 1850s to 1.7. However, since the 1870s, the welfare ratio grew rapidly. In the 1890s, the welfare ratio was 2.9.

These results show that families of four members in Boston could cover their basic needs during this period: their incomes exceeded their cost of subsistence. From 1870, living standards increased rapidly. In the late 19th century, family income was around three times the cost of subsistence, much higher than in the middle of the century.

Living standards in Boston increased at a time of economic changes. The evidence suggests that living standards of working families in Boston improved during the Industrial Revolution. Prior to the industrialization of New England, laborers could cover

their basic needs. However, as the economy expanded, living standards grew rapidly. From a macroeconomic point of view, the economy of New England experienced important changes between 1840 and 1900. In this period, urbanization expanded dramatically, and per-capita income grew. My estimates indicate that living standards also experienced important changes during this period, especially since 1870. The welfare ratio remained steady in the first half of the 19th century. The welfare ratio increased rapidly from 1870. In the 1860s, living standards of working families in Boston were around the same level as in the early 19th century. In the 1890s, however, the welfare ratio was around two times its level in the 1790s.

Other studies have estimated welfare ratios in Massachusetts. According to Allen et al (2012), the welfare ratio of laborers followed an upper trend in the 17th and 18th centuries. During 1775-99, the ratio was around 4.0.[36] According to Allen (2009), the welfare ratio remained relatively steady in the 1800s and 1810s, and increased to 5.5 in the 1820s and 6.4 in the 1840s. Meanwhile, according to Allen (2014), the welfare ratio of laborers increased in the 19th century, especially during 1860-1900. The ratio was around 2.0 in 1820 and 3.0 in the 1860s. Then, the ratio increased to more than 5.0 in the 1890s. The evidence from these studies indicates that working families in Massachusetts could cover their basic needs, and that their living standards increased over time.

Some might expect welfare ratios in Massachusetts not to be very different from those in Boston. However, there are important differences between my BN estimates for Boston and the estimates of Allen et al (2012) and Allen (2009) for Massachusetts (Figure 4).[37] Compared to the ratio of Allen (2014), there are also some differences (although smaller) in levels and trends.

It is possible that the differences in welfare ratios between this study and previous studies reflect the differences in living standards between Boston and the state of Massachusetts. However, the differences in welfare ratios could also be explained by methodological differences. For example, I used linear programming to find the lowest-cost basket, while the baskets in Allen et al (2012) and Allen (2009, 2014) were obtained by adjusting the subsistence basket of London in Allen (2009) to partly reflect consumption patterns in New England.[38] In addition, I estimated the cost of subsistence of a family using the nutritional requirements of two adults and two children; in comparison, Allen (2009) and Allen et al (2012) assumed that the cost of subsistence of a family was three times the

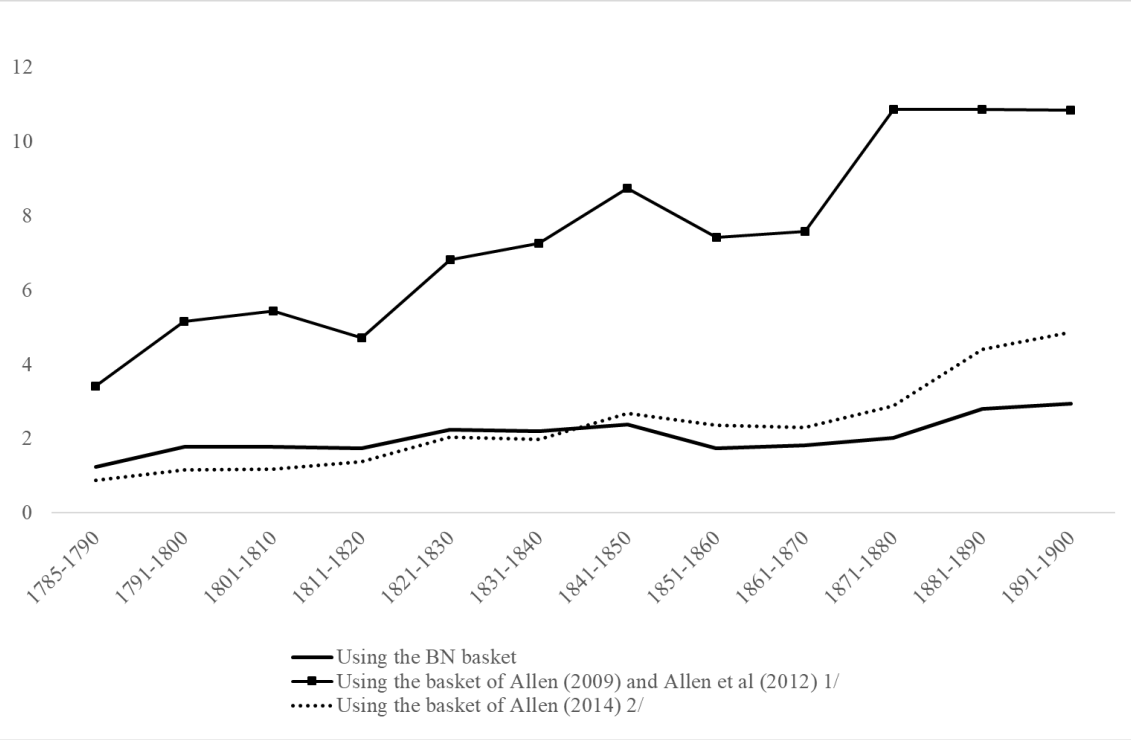
[36] According to Geloso (2019), the welfare ratio in Massachusetts ranged between 3.0 and 3.5 in the 18th century. Geloso found that Allen had made mistakes when converting the wages of Boston laborers taken from Gloria Main. Most of the differences between the results of Geloso and Allen can be explained by the correction of wage data by Geloso. In addition, Geloso assumed a larger quantity of fuel in the subsistence basket of Massachusetts.

[37] I do not depict the estimates of Geloso (2019) in Figure 4, because Geloso´s estimates do not cover the same period of analysis as the present study.

[38] However, notice that the baskets of Allen (2009), Allen et al (2012) and Allen (2014) do not entirely reflect historical habits. For example, as indicated previously, the quantity of meat consumed in Massachusetts in the early 1900s was far larger than the quantity included in the baskets of these three studies. Geloso (2019) used a similar basket as Allen et al (2012) for New England.

cost for an adult male; while Allen (2014) assumed the cost of subsistence of a family was four times the cost for an average person. Furthermore, I collected information on housing costs, while the previous studies assumed housing costs to be 5% of the cost of subsistence. This study has more methodological similarities with Allen (2014) than with Allen (2009) or Allen et al (2012). For example, the differences in calorie requirements are far lower between this study and that of Allen (2014). Since the BN welfare ratios are similar to the ratios of Allen (2014), the differences in the methodology seem to explain most of the differences in welfare ratios between the present study for Boston and the previous studies for Massachusetts.

FIGURE 4. Welfare ratios in Boston: a comparison, 1785-1900



Notes: The table reports welfare ratios in Boston using the BN basket and alternative baskets. 1/ I rely on the food basket of Allen (2009) and Allen et al (2012) for an adult and on the assumption that family expenses are equal to three times the expenses of a male adult. 2/ I rely on the food basket of Allen (2014) for an average person, and on the assumption that family expenses are equal to four times the expenses of an average person.

7. Life stages

In the previous section, I calculated the welfare ratio for a family of four members, assuming that only one adult man worked in the family, and that he did so during 250 days per year. Several scholars have criticized these assumptions. Women and even children could also work for a salary. In addition, men and women may have adjusted their workload according to life circumstances. When men and women did not have children, they had more time to work. Once the family had children, at least one of the parents (most likely the wife) may have reduced the workload.

Recently, Sara Horrell, Jane Humphries and Jacob Weisdorf estimated welfare ratios along the life cycle in England and Wales (Horrell et al, 2022). In addition, two other studies estimated welfare ratios for several life stages in the Netherlands and Spain, respectively (Boter 2020; Zegarra 2024b). These stages varied on the number of people who worked, the work length, and the number of children. In this section, I follow a similar methodology, and estimate welfare ratios for six stages in the adult life of men and women: youth, young-family, peak-family, old-family, post-family, and old-age. I assume that during the first stage (youth), men and women were between 18 and 25 years old. Men and women did not have children during this stage, and worked 250 days per year. I assume that during the young-family stage, men and women started having children. The two parents were between 26 and 35 years old, and had two young children. The father worked 250 days/year, and the mother reduced her workload to 50 days/year. In the peak-family stage, men and women were between 36 and 45 years old, and had three children (two adolescents and one young child). The two parents worked as much as during the previous stage. During the old-family stage, the two parents were between 46 and 55 years old. Two of the children had already left home, the husband worked 250 days/year, and the wife worked 100 days/year. In the post-family stage, the two parents were between 56 and 65 years old, all children had already left home, and both parents worked 250 days/year. In the old age stage, ages were between 66 and 75 years, the husband worked 125 days/year, and the wife did so during 50 days/year.

I estimate welfare ratios for the six life stages. For each stage, I estimate a linear programming model, considering the particular nutritional requirements of the family. The requirements depended on gender, age, and type of work. Energy requirements depended on the workload. I assume energy requirements of 2.2, 2.0 and 1.8 BMR for workloads of 250 days/year, 100 to 125 days/year, and 50 days/year, respectively. I assume the same quantities of fuel, linen, lamp oil, candles and soap per person as in the basic model. I also assume the family lived in one room in stages 1, 5 and 6, and two rooms in stages 2, 3 and 4. Finally, I assume the salaries of women were equal to 50% of the salaries of men.

Table 4 shows the welfare ratios for six life stages in Boston between 1785 and 1900. In all stages, the welfare ratio in Boston was higher than 1.0. However, there were important differences across life stages. In the first stage, the welfare ratio was between 3.0 and 5.0 in 1785-1820. In the following decades, the welfare ratio was usually above 4.5. The welfare ratio experienced an upward trend from around 3.3 in 1785-90 to 7.9 in 1891-1900. In the second stage, as the families started having children, the welfare ratio was lower. The welfare ratio also followed an upward trend over time. However, the ratio was never above 3.4. In the third stage, as the family had three children, the welfare ratio was barely above 1.0 in the 1780s. In the following decades, the ratio increased, but it was never above 2.7. In the fourth stage, the welfare ratio was higher than in the second and third stages. As two of the children had already left home, the family experienced a reduction in the cost of subsistence and an increase in the welfare ratio. During this stage, the welfare ratio was between 1.8 and 4.1. In the fifth stage, the cost of subsistence was

even lower, as the two parents did not have to support their children. In this case, the welfare ratio ranged between 3.4 and 8.1. The ratios were very similar in stages 1 and 5. In the sixth stage, the family had no children. However, the two adults worked fewer hours. Consequently, the welfare ratio was lower. In particular, the welfare ratio in Boston ranged between 1.4 and 3.4.

Therefore, the capacity of Bostonian families to cover their basic needs improved between 1785 and 1900. Single people or families with one or two children never faced difficulties to cover their basic needs. Families with many children could barely cover their needs in the late 18th century.[39] However, in the 19th century, even these families could afford food, housing and other basic needs.

TABLE 4. Welfare ratios in Boston for six life stages in Boston, 1785-1900

	Basic model	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
1785-1790	1,23	3,33	1,47	1,02	1,80	3,43	1,44
1791-1800	1,78	4,68	2,07	1,48	2,59	4,84	2,04
1801-1810	1,77	4,62	2,05	1,50	2,58	4,73	1,97
1811-1820	1,74	4,51	1,99	1,47	2,55	4,62	1,94
1821-1830	2,24	5,87	2,54	1,90	3,31	6,03	2,53
1831-1840	2,19	5,80	2,48	1,88	3,27	5,99	2,52
1841-1850	2,37	6,36	2,68	2,04	3,55	6,54	2,74
1851-1860	1,73	4,64	1,95	1,59	2,46	4,75	1,98
1861-1870	1,82	4,90	2,06	1,65	2,57	5,00	2,07
1871-1880	2,01	5,57	2,29	1,85	2,82	5,65	2,32
1881-1890	2,80	7,47	3,15	2,53	3,89	7,63	3,17
1891-1900	2,94	7,86	3,30	2,65	4,10	8,02	3,34

Notes: The table reports BN welfare ratios for six life stages in Boston. In stage 1, men and women were between 18 and 25 years of age, and had no children. In stage 2, men and women were between 26 and 35 years, and were married. The two adults had two children. In stage 3, the two parents were between 36 and 45 years. The family was composed of the father, the mother and three children. In stage 4, the two parents were between 46 and 55 years of age. In addition, the two children had moved out. In stage 5, the two parents were between 56 and 65 years, and the family was only composed of the two parents. In stage 6, the two parents were between 66 and 75 years of age. The adult man worked 250 days/year in stages 1 to 5 and 125 days/year in stage 6, while the adult woman worked 250 days/year in stages 1 and 5, 50 days/year in stages 2, 3 and 6 and 100 days/year in stage 4. For each stage, the total nutritional requirements of the family were calculated as the sum of the average requirements of each member of the family.

[39] The historical evidence shows that children worked in some families. As indicated by my estimates, families of up to five members had welfare ratios above 1.0. Larger families (with several children) may have recurred to child labor. Families with up to three children did not need that.

8. International comparison

How does the BN welfare ratio in Boston compare to the ratios in other cities and countries? How high were living standards in Boston compared to other economies?

Some studies have compared living standards of New England with those of other countries. Those studies indicate that living standards in the region were relatively high. According to Allen et al (2012), in the early 17th century, the welfare ratio in Massachusetts was below than that of London, but similar to Oxford. Living standards in Massachusetts improved in the 18th century, and became greater than in London. According to Geloso (2019), in the 18th century, the welfare ratio of unskilled workers in New England was higher than in England, Paris and Quebec. Meanwhile, according to Allen (2009), in the early 19th century, the welfare ratio in Massachusetts was higher than in London, Oxford and Amsterdam. Furthermore, according to Allen (2014), the welfare ratio in Massachusetts in the 19th century was as high as in London.

Two problems emerge when making an international comparison of previous estimations of welfare ratios. First, Allen et al (2012), Allen (2009, 2014) and Geloso (2019) relied on food baskets that did not provide enough nutrients. The resulting welfare ratios may reflect the capacity of families to cover the specified subsistence baskets, but do not reflect the capacity of families to have a balanced nutrition. In addition, Allen (2014) assumed the same food baskets for the United States and Europe, despite the differences in relative prices. Thus, the differences in welfare ratios between Massachusetts and Europe may not measure the differences in the capacity of families to cover their basic needs.

To make a correct comparison of welfare ratios across countries, it is necessary to rely on the same methodology. Recent studies have used linear programming to estimate welfare ratios in London, Amsterdam, Paris, Strasbourg, Munich, Leipzig, Toledo and Barcelona (Zegarra 2022, 2024b). Like the present study, Zegarra (2022, 2024b) also minimized the cost of food subject to requirements of calories, proteins and other nutrients, in order to obtain the food basket that assures balanced nutrition. Therefore, it is possible to compare food baskets and welfare ratios using the results in this study and the linear-programming estimates for Europe.

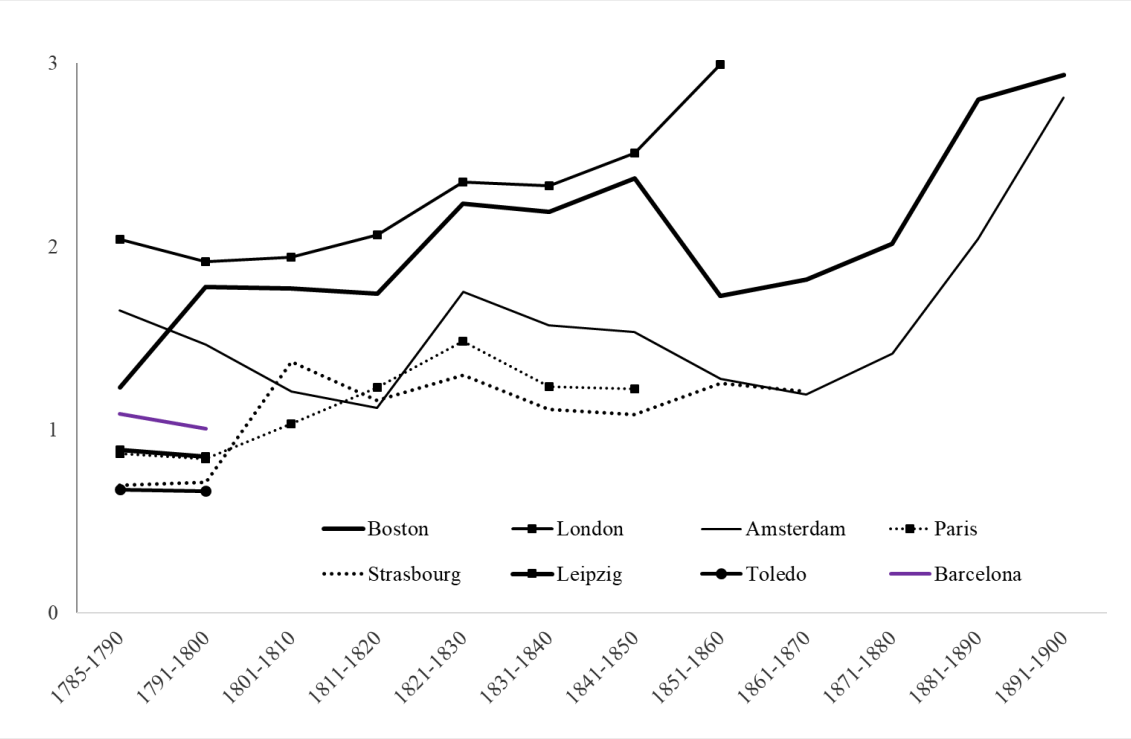
In the 1800-50 period, the BN food baskets in London and Amsterdam were mainly composed of peas and oats; and in Paris, the basket was mostly composed of oats and barley. The BN basket in Boston was not the same as those in Europe. To some extent, the differences in the food basket may be explained by the set of foodstuffs included in the model. For instance, the model for Europe did not include corn.[40] In addition, the model for Europe assumed that families obtained some foodstuffs from the garden, such

[40] The model for Europe in Zegarra (2022) includes peas instead of beans; however, beans and peas had around the same price. The model for Spain in Zegarra (2023) includes beans.

as potatoes and some vegetables.[41] However, the differences in relative prices may also explain the differences in the BN food basket.

Figure 5 shows the welfare ratios for Boston to those for London, Amsterdam, Paris, Strasbourg, Munich, Leipzig, Toledo, and Barcelona. For all cities, the welfare ratios refer to families of four members. Living standards in Boston were higher than in most of those European cities. In the 1790s, the welfare ratio of a family of four members in Boston was around 1.8, so working families in Boston could cover their basic needs. On the other hand, the welfare ratios in Paris, Strasbourg, Leipzig, Toledo and Barcelona were below 1.1; consequently, families in these cities faced severe difficulties to cover their basic needs. The welfare ratio of Boston was similar to the ratios in London and Amsterdam. In the first half of the 19th century, the welfare ratio in Boston increased slowly. The welfare ratios in London also increased slowly. Real wages in Amsterdam declined, so the welfare ratio in Boston was above the ratio of Amsterdam. The welfare ratio in Boston was also higher than the ratios of Paris, Strasbourg, Toledo, and Barcelona.

FIGURE 5. Welfare ratios: an international comparison, 1785-1900



Notes: The figure depicts welfare ratios in Boston and seven European cities. Information for Europe comes from Zegarra (2022, 2024b).

As the Industrial Revolution in New England led to the expansion of the economy and to a rapid process of urbanization in the 19th century, the welfare ratio in Boston increased rapidly. The welfare ratio in Amsterdam also increased in the 19th century, but remained below the ratio of Boston. Unfortunately, I do not have information on the BN welfare

[41] If the same provision of the garden as in Zegarra (2022) were included in the model for Boston, the welfare ratio in Boston would be around 12% greater.

ratio in London for most of the second half of the 19th century. However, the evidence suggests that at least compared to Amsterdam (a city with one of the highest living standards in Europe) and other cities in Continental Europe, the living standards in Boston during 1850-1900 were relatively high.

Therefore, the evidence shows the living standards in Boston were high. Not only could working families in Boston cover their basic needs. In addition, the capacity of Bostonians to cover their needs was higher than in important European cities. Previous studies suggest that Massachusetts was a high wage economy (Allen et al 2012; Allen 2009, 2014; Geloso 2019). My results point in the same direction. The result that Boston was a high wage economy is robust to changes in the methodology.

9. Conclusions

Some studies on New England have made assumptions about subsistence baskets in order to estimate welfare ratios. In this article, I use a different data set and a different methodology to find the food basket and estimate welfare ratios. Linear programming is a useful methodology to find the lowest-cost basket that provided necessary nutrients.

The BN estimates indicate that laborers in Boston could cover the basic needs of their families between 1785 and 1900, as long as they minimized their spending on food. The welfare ratio of laborers in Boston increased in the 19th century. Most of the increase in welfare ratios occurred during 1870-1900. It seems the expansion of the economy of New England offered opportunities to increase the real earnings of working families. Housing prices in Boston increased over time probably due to the increase in population and the consequent higher demand for housing. Food prices also increased over time. However, real wages of laborers increased in spite of the increase in prices.

I rely on a linear programming model to estimate the lowest-cost food basket. Previous studies in Massachusetts did not use linear programming. Due to this and other methodological differences, my welfare ratios for Boston differ from the estimates for Massachusetts, especially from the estimates obtained by Allen et al (2012), Allen (2009) and Geloso (2019). Among previous studies, Allen (2014) reports similar estimates to the BN estimates, both in levels and in trends. In particular, my estimates and those of Allen (2014) indicate that living standards largely increased in the late 19th century.

On the other hand, according to my estimates and those from previous studies, Boston compared well to other economies. Previously, several studies have shown that working families in New England had relatively high living standards. In spite of the methodological differences, my estimates confirm the previous findings on the relatively high living standards of New Englanders. Boston was a high wage economy, not only because the earnings of laborers exceeded the cost of subsistence, but also because the living standards in Boston exceeded the standards of living of important European cities. In particular, Bostonians had higher living standards than people in Amsterdam, and comparable living standards to London. In addition, Bostonians had higher living standards than in France, Germany and Spain. If Boston reflected the general situation in

the United States, this country would be, citing Lemon (2002), "the best poor man's country" or at least one of the best countries for poor people in the world.

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Salaris, preus i nivell de vida en una economia en creixement. El cas de Boston, Massachusetts

RESUM

Aquest estudi analitza el nivell de vida dels treballadors de Boston, Massachusetts, durant el període 1785-1900. Mitjançant un model de programació lineal, obtinc la cistella d'aliments que proporcionava una nutrició equilibrada al menor cost possible. A continuació, calculo la ràtio de benestar dels treballadors. Les dades mostren que els treballadors de Boston guanyaven prou per cobrir les necessitats bàsiques i que els seus salaris reals van augmentar durant el segle XIX. Els resultats mostren també que la ràtio de benestar dels treballadors de Boston era superior al de diverses ciutats europees. Boston es pot considerar una economia d'alts salaris durant finals del segle XVIII i XIX.

PARAULES CLAU: Cost de la vida, preus, salaris, Boston

CODIS JEL: N31, I32, J31, C61

Salarios, precios y niveles de vida en una economía en crecimiento. El caso de Boston, Massachusetts

RESUMEN

Este estudio analiza el nivel de vida de los trabajadores de Boston, Massachusetts, en 1785-1900. Mediante un modelo de programación lineal, obtengo la cesta de alimentos que proporcionaba una nutrición equilibrada al menor coste posible. A continuación, calculo la ratio de bienestar de los trabajadores. Los datos muestran que los trabajadores de Boston ganaban lo suficiente para cubrir sus necesidades básicas y que sus salarios reales aumentaron en el siglo XIX. Los resultados muestran también que la ratio de bienestar de los trabajadores de Boston era superior al de varias ciudades europeas. Boston puede considerarse una economía de altos salarios durante finales del siglo XVIII y el XIX.

PALABRAS CLAVE: Coste de la vida, precios, salarios, Boston

CÓDIGOS JEL: JEL: N31, I32, J31, C61

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Appendix

Wages, prices and living standards in a growing economy. The case of Boston, Massachusetts

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A.1 The linear programming model

I rely on a linear programming model to find the least-cost food basket. I assume a person could purchase the following items: wheat flour, rye flour, oatmeal, corn, cornmeal, rice, beans, potatoes, beef, pork, mutton, codfish, eggs, milk, butter, cheese, sugar, onions, turnips, and apples.

The optimization model can be expressed as follows:

$$Min_{\{q_j\}_{j=1}^{N}} \sum_{j=1}^{N} p_j q_j$$

subject to

$$\sum_{j=1}^{N} \alpha_{jk} q_j \geq F_k^L$$

$$q_j \geq 0$$

where $\sum_{j=1}^{N} p_j q_j$ is the total cost of the food basket, N is the number of items in the food basket, p_j is the price of good j per kilogram, and q_j is the purchased quantity of good j in kilograms. I impose K restrictions on nutrients (k = 1, 2, .., K).

In those restrictions, α_{jk} is the quantity of nutrient k in a kilogram of product j, F_k^L is the minimum quantity of nutrient k that a person should obtain from the market for a healthy nutrition. Importantly, α_{jk} measures the quantity of nutrient k in a purchased kilogram of product j. I used food composition tables to estimate α_{jk}.

A.2 Chemical composition of foods

In the linear programming model, $\alpha_{k,j}$ is the quantity of nutrient *k* in a purchased kilogram of food *j*. To calculate the value of $\alpha_{k,j}$, I collected information on the chemical composition of foods. Table A.1 reports the content of nutrients per purchased kilograms of foods.

I assume people purchased wheat flour and rye flour to make bread. Baking led to the loss of some nutrients. Denote $\theta_{k,j}$ as the relative loss of nutrient *k* due to the baking of *j*-flour *j* (wheat or rye flour) and $\beta_{k,j}$ as the quantity of nutrient *k* in a kilogram of raw *j*-flour. Under the assumption that no portion of flour was discarded when making bread, the quantity of nutrient k in a purchased kilogram of *j*-flour is calculated as $\alpha_{k,j} = (1 - \theta_k)\beta_k$. Recent composition tables do not reflect the composition of some items prior to 1900, especially for flour (Gazeley and Horrell 2013). I then relied on McCance & Widdowson (1946) and Paul & Southgate (1978) to obtain the food composition of wheat flour and rye flour at 100%. Information on calories, proteins, fat and iron comes from McCance and Widdowson (1946). Information on other nutrients and the loss of vitamins due to baking comes from Paul and Southgate (1978).

In addition, in order to estimate the linear programming model, I collected information on nutrients for the following items: oatmeal, corn, cornmeal, polished rice, dried beans, potatoes, roasting pieces of beef, dressed carcass pork, lamb chops, smoked codfish, eggs, milk, cheese, butter, apples, onions, turnips, and brown sugar. In the case of corn, I assume people purchased corn to make cornmeal. I obtained the information from McCance & Widdowson (1946) and Paul & Southgate (1978).

Nutritional information was also collected for wheat bread, poultry, lard, molasses, tea, and coffee from McCance & Widdowson (1946) and Paul & Southgate (1978). I did not use these foods for the linear programming model. I use the chemical composition of these products to calculate the intake of nutrients for the average diet of an adult man in 1903.

Food composition corresponds to raw foods. I consider that a portion of the purchased food was discarded. Bones of beef, pork and mutton, for instance, were also discarded. Denote $\alpha_{k,j}$ as the consumption of nutrient *k* in a kilogram of the purchased food *j*. Then $\alpha_{k,j} = e_j\beta_{jk}$, where e_j is the edible portion of the food *j*, and β_{jk} is the quantity of nutrient *k* in a kilogram of food *j*. For most of those items, food composition and edible portion on most of those items come from McCance and Widdowson (1946) and Paul and Southgate (1978). For dried beans, information comes from FAO (2021).[42]

[42] Cooking reduces the amount of some nutrients, especially vitamins. Indian dietary requirements, however, already take into account possible losses of nutrients during cooking (Allen 2017; Indian National Institute of Nutrition 2009).

TABLE A1. Content of nutrients per kilogram in selected food items per kilogram purchased in the market

	Calories (kcal)	Proteins (g)	Fat (g)	Iron (mg)	Thiam. (mg)	Niacin (mg NE)	Vit. B12 (µg)	Folate (µg)	Vit. C (mg)
Foods for the linear programming model									
Wheat flour	3.330,0	89,0	22,0	30,5	3,9	53,2	0,0	285,0	0,0
Rye flour	3.350,0	80,0	20,0	27,0	3,4	9,5	0,0	390,0	0,0
Oatmeal	4.040,0	121,0	87,0	41,2	5,0	10,0	0,0	600,0	0,0
Cornmeal	3.540,0	5,0	7,0	14,3	0,0	0,0	0,0	0,0	0,0
Corn	3.097,5	4,4	6,1	12,5	0,0	0,0	0,0	0,0	0,0
Rice	3.610,0	62,0	10,0	4,5	0,8	15,0	0,0	290,0	0,0
Beans	3.270,0	211,0	16,0	54,0	6,8	13,0	0,0	5.200,0	70,0
Potatoes	748,2	18,1	0,9	6,5	0,9	10,3	0,0	120,4	163,4
Beef	1.852,5	130,5	147,8	12,5	0,3	31,5	10,0	57,5	0,0
Pork	2.501,2	100,6	233,1	6,7	4,3	30,3	7,4	22,2	0,0
Mutton	3.091,4	119,7	290,3	9,8	0,7	32,8	8,2	24,6	0,0
Codfish	782,1	181,2	5,9	4,0	0,8	13,9	19,8	49,5	0,0
Eggs	1.450,7	105,9	109,5	22,5	0,8	0,6	25,8	222,5	0,0
Milk	660,0	33,0	37,0	0,8	0,4	0,8	3,0	50,0	15,0
Cheese	3.040,0	244,0	229,0	2,1	0,4	0,6	14,0	200,0	0,0
Butter	7.930,0	4,0	851,0	1,6	0,0	0,0	0,0	0,0	0,0
Sugar	3.940,0	5,0	0,0	8,9	0,0	0,0	0,0	0,0	0,0
Onions	223,1	8,7	0,0	2,9	0,3	1,9	0,0	155,2	97,0
Turnips	151,2	6,7	2,5	3,1	0,3	5,0	0,0	168,0	210,0
Apples	346,5	2,3	0,0	2,2	0,0	0,0	0,0	0,0	0,0
Additional foods									
Bread	2.601,6	69,5	17,2	23,8	3,1	41,6	0,0	222,7	0,0
Poultry	1.395,2	120,3	101,8	3,8	0,4	48,0	6,4	44,8	0,0
Lard	9.210,0	0,0	990,0	1,0	0,0	0,0	0,0	0,0	0,0
Molasses	2.660,0	0,0	1,0	47,0	0,4	9,0	0,0	0,0	0,0
Tea	580,0	141,0	0,0	152,0	1,4	1,0	0,0	0,0	0,0
Coffee	3.010,0	128,0	154,0	41,0	0,0	100,0	0,0	0,0	0,0

Notes: The table reports the composition of nutrients in each food item per kilogram purchased in the market. See the text for a description of the procedure to obtain the nutrients.

A.3 Price data

Information on prices comes from several sources. I used secondary sources to obtain retail prices in Boston in 1851-80 (Weeks 1886),[43] and 1890-1900 (U.S. Department of Commerce and Labor 1904). Wholesale prices for some products were obtained from *The New England Farmer* for 1823-43 (Brown 1854; Colman 1839, 1840, Fessenden 1838, 1823, 1824, 1826, 1830, 1834, 1835, 1836).[44] Additional information on wholesale prices is available for 1785-1805 (U.S. Department of Labor 1934).[45] When information was missing for five or fewer consecutive years, I filled in the blanks by interpolation. For some years, I used wholesale prices in Boston and the ratio between retail and wholesale prices to fill the blanks. In some cases, I used the average prices in Massachusetts and the ratio between price in Boston and prices in Massachusetts.[46] Prices in the state of Massachusetts are available for 1780-1860 (Wright 1885),[47] and 1860-1902 (Bureau of Statistics of Labor 1884, 1902; U.S. Department of Interior 1901; Young 1868). For a few products, producer prices were also used to estimate missing prices (Bureau of Statistics of Labor 1909; United States Census Office 1902; Wadlin 1899; Wright 1887).

Prior to interpolation, all prices were converted to grams of silver per kilogram. I relied on Lindert & Deitch (2016) to obtain the quantity of grams of silver per dollar in Massachusetts until 1861. From 1862, I relied on the New York market price of gold and the silver/gold ratio from Officer & Williamson (2021) to estimate the quantity of grams of silver per dollar.[48]

Original prices are in different physical units, such as barrels, bushels, quarts, pecks, and pounds, among others. Following the U.S. Department of Agriculture, I assumed the following conversion rates: 1 barrel of flour = 196 lb, 1 bushel of wheat = 60 lb, 1 bushel

[43] Weeks only reports wholesale prices for wheat flour. For other items, prices are for retail.

[44] The magazine reports weekly prices. Whenever possible, I calculated the average price for the entire year. For some years, information refers to the first half of the year or the second half. I relied on information from other years to obtain the ratio between the prices in the first half of the year and the prices in the second half.

[45] Information is available for 1785, 1790, 1795, 1800 and 1805.

[46] Denote goods B and M as the prices of the same item in Boston and Massachusetts, respectively. I calculated Q as B/M. Whenever it was possible, I interpolated Q to fill in the blanks. When there were missing ratios for more than 10 years, I assumed that the initial value in the missing period was equal to the average ratio in the previous 10 years, and the last value was equal to the average ratio in the latest 10 years. I then interpolated for the missing values. Denote t_0 as the earliest year for which there is information on Q, and t_1 as the latest year. Information was then missing in every year between 1785 and $t_0 - 1$, and in every year between $t_1 + 1$ and 1900. For the period [1785, $t_0 - 1$], I assumed that Q was equal to the average ratio between t_0 and $t_0 + 9$; for the period [$t_1 + 1$, 1900], I assumed that Q was equal to the average ratio between t_1-10 and t_1. I then estimated the price in Boston as the multiplication of Q and the price in Massachusetts. If $t_1 < t_0 + 10$, I calculated the average ratios using the available information, i.e. with less than ten years of data.

[47] Wright (1885) reports prices in Massachusetts in 1780-1860 using records from several locations. Lindert and Deitch (2006) constructed an excel file with the prices of several of those items. When available, I used prices from Lindert and Deitch´s excel file. When not available, I took prices directly from Wright (1885).

[48] I used the market price of gold and the silver/gold ratio to estimate the growth in the quantity of silver per dollar. I then used the quantity of silver per dollar in 1861 to estimate the quantity of silver per dollar from 1862.

of rye = 56 lb, 1 bushel of corn = 56 lb, 1 bushel of potatoes = 48 lb, 1 bushel of beans = 60 lb, 1 bushel of onions = 52.5 lb, 1 bushel of turnips = 50 lb, 1 bushel of apples = 48 lb. I also used the following conversion rates: 1 lb = 0.453592 kg, 1 peck = 8 quarts, 1 peck = 0.25 bushels, 1 cwt (hundredweight) = 100 lb, 1 cord = 24 M BTU.[49]

I considered the differences in prices depending on volume. For example, the price of a barrel of flour was not 196 times the price of a pound of flour, even though one barrel was equivalent to 196 pounds. I assume families did not purchase foods in barrels or bushels. I assume people purchased foods in small quantities, for example in pounds or quarts. If not available, I estimated the retail prices families had to pay when purchasing foodstuffs in small quantities. To estimate these prices for a particular item in Boston, I used information on the relation between prices for small quantities and prices for large quantities for the same item in the state of Massachusetts.[50]

Wheat flour: Retail prices of a pound of wheat flour in Boston were obtained for 1890-1900 (U.S. Department of Commerce and Labor 1904). I estimated the missing values, using prices of flour in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868).

Rye flour: From secondary sources, it was possible to obtain the price of a barrel of rye flour in Boston in 1858-90 (Weeks 1886) and the price of a pound of rye flour in 1900 (Lodge 1910). I converted barrel prices to pound prices. I also estimated the prices of rye flour in Boston 1785-1805, using the price of rye in Boston (U.S. Department of Labor 1934), and the relative price of flour with respect to rye in the state of Massachusetts (Wright 1885). I estimated retail prices for missing years, using retail prices of rye flour in Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868). I also used the prices of rye and rye flour in Massachusetts (Wright 1885), and the U.S. wholesale price of rye (U.S. Department of Agriculture 1939) to fill the blanks.

Oatmeal: I estimated oatmeal prices in Boston, using retail and wholesale oatmeal prices in Massachusetts (Wright 1885), wholesale oat prices in Boston (The New England Farmer), and the relative price of oatmeal with respect to oats in Massachusetts (Wright 1885). I also used producer prices of oats in the state of Massachusetts (Bureau of Statistics of Labor 1909; United States Census Office 1902; Wright 1887) to estimate the prices in Boston. In addition, I used the wholesale price of oats in the United States (U.S. Committee of Finance 1894; U.S. Department of Agriculture 1939) to estimate Boston prices in missing years.

Cornmeal: Retail prices in Boston are available for 1858-80 and 1890-1900 (U.S. Department of Commerce and Labor 1904; Weeks 1886). I used prices in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885) to fill most of the

[49] Most of these equivalences come from the U.S. Department of Agriculture (1939).

[50] In some cases, there is no information on this ratio for the same item. In these cases, I used the average ratio for wheat flour, rye meal, cornmeal, and beans.

blanks.[51] For some years, I relied on prices of corn in Boston in Massachusetts to fill the blanks.

Corn: Prices of corn in Boston are available for 1785-1805 (U.S. Department of Labor 1934) and 1823-39 (*The New England Farmer*). These prices are wholesale. I converted these prices to retail prices, using the ratio between retail and wholesale prices of cornmeal in the state of Massachusetts (Wright 1885). I used corn prices in Massachusetts until 1859 (Wright 1885), as well as prices of cornmeal in Boston and in Massachusetts, to fill the blanks.

Rice: Information on retail prices of rice in Boston is available for 1890-1900 (U.S. Department of Commerce and Labor 1904). There is also information on wholesale prices in 1785-1805 (U.S. Department of Labor 1934) and 1836-43 (*The New England Farmer*). I converted wholesale prices to retail prices, using the ratio between retail and wholesale prices in Massachusetts. I also used rice prices in Springfield to estimate Boston prices in 1851-80 (Weeks 1886).[52] Finally, I used the ratio between Boston prices and average prices in the state to fill the blanks. Average prices in the state of Massachusetts come from a variety of sources (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868).

Beans: I count with the retail prices of beans in Boston for 1851-80 (Weeks 1886) and 1890-1900 (U.S. Department of Commerce and Labor 1904). I used wholesale prices in Boston to fill some of the blanks. Wholesale prices in 1823-39 come from The New England Farmer. For 1842-91, wholesale prices come from official sources (U.S. Committee of Finance 1893). I also used prices of beans in Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868) to estimate the prices in Boston in missing years.

Potatoes: There is information on retail prices of potatoes in Boston in 1860-80 (Weeks 1886) and 1890-1900 (U.S. Department of Commerce and Labor 1904). Wholesale prices are also available for 1785-1805 (U.S. Department of Labor 1934) and 1823-39 (*The New England Farmer*). I estimated retail prices, using information on wholesale prices. I also used average retail and wholesale prices in Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868) to estimate the prices in Boston in missing years. Prices refer to dollars per bushel. I assumed families purchased potatoes per pound. Thus, I converted the price of a bushel of potatoes to the price of a pound of potatoes, using the equivalence between bushels and pounds, and the ratio between prices of small quantities and the prices of large quantities of wheat flour, rye flour, cornmeal, and beans.[53]

Beef: Retail prices of beef in Boston are available for 1851-80 (Weeks 1886) and 1890-1900 (U.S. Department of Commerce and Labor 1904). Prices of beef correspond to fresh

[51] Wright reports prices of Indian meal. I consider Indian meal to be the same as cornmeal.

[52] I estimated Boston prices of rice as Springfield prices of rice times the relative prices of wheat flour in Boston with respect to Springfield.

[53] This ratio was greater than 1.0.

beef, roasting pieces. I used information on wholesale prices in 1785-1805 (U.S. Department of Labor 1934) and 1841-90 to estimate retail prices in missing years. I also used average prices in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868) to estimate retail prices in Boston in missing years.

Pork: Retail prices of fresh pork in Boston are available for 1851-80 (Weeks 1886) and 1890-1900 (U.S. Department of Commerce and Labor 1904). There is also information on wholesale prices in 1823-43 (*The New England Farmer*). For missing years, I estimated the retail prices in Boston using wholesale prices in this city (U.S. Committee of Finance 1893), and prices in Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885).

Mutton: Retail prices of mutton in Boston correspond to 1851-80 (Weeks 1886) and 1890-1900 (U.S. Department of Commerce and Labor 1904). Prices of mutton correspond to mutton, fore quarters. For missing years, I estimated the retail prices in Boston, using wholesale prices in this city in 1823-39 (*The New England Farmer*) and average prices in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868).

Codfish: Retail prices of codfish in Boston are available for 1867-80 (Weeks 1886) and 1890-1900 (U.S. Department of Commerce and Labor 1904). To estimate missing prices, I relied on prices of dry codfish in Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868).

Eggs: Retail prices of eggs in Boston are available for 1851-80 (Weeks 1886), and 1890-1900 (U.S. Department of Commerce and Labor 1904). Wholesale prices are available for 1823-39 (*The New England Farmer*). I converted these prices to retail prices. To estimate the prices in Boston in missing years, I used the average prices in Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885). Prices refer to dollars per dozen eggs. I assume this was the price at which families purchased eggs.

Milk: Retail prices in Boston are available for 1890-1900 (U.S. Department of Commerce and Labor 1904). I relied on the average prices in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868) to fill the blanks. For some years, I estimated the prices of milk using information from other dairy products. In particular, the price of milk was estimated, using the ratio between milk and butter prices, as well as the ratio between milk and cheese prices.

Cheese: Retail prices in Boston are available for 1851-80 (Weeks 1886), and 1890-1900 (U.S. Department of Commerce and Labor 1904). In addition, I relied on the wholesale prices of these products in 1785-1805 (U.S. Department of Labor 1934), and 1829-43 (*The New England Farmer*), to estimate retail prices. I used wholesale and retail prices in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868) to convert wholesale prices in Boston into retail prices, and to fill the blanks. In order to estimate prices in missing years, I also used the ratio between cheese and milk prices, and the ratio between cheese and butter prices.

Butter: Retail prices in Boston are available for 1851-80 (Weeks 1886), and 1890-1900 (U.S. Department of Commerce and Labor 1904). In addition, I relied on the wholesale prices of these products in 1785-1805 (U.S. Department of Labor 1934), and 1829-39 (*The New England Farmer*), to estimate retail prices. To convert wholesale prices into retail prices, I used the information of wholesale and retail prices of butter in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868). Missing observations were estimated, using average prices in the state. In order to estimate prices in missing years, I also used the ratio between butter and milk prices, and the ratio between butter and cheese prices.

Apples: Retail prices in Boston are available for 1899 and 1900 in the Labor Bulletin (No. 10-16). In order to estimate prices for the rest of the period, I used retail prices of dried apples in Boston (U.S. Department of Commerce and Labor 1904, 1906), average retail prices of apples in the state of Massachusetts (Wright 1885), producer prices of apples in Massachusetts (Bureau of Statistics of Labor 1909; Wright 1887), and wholesale prices of dried apples in New York (U.S. Committee of Finance 1893). Original retail prices refer to dollars per peck. I assume people purchase apples in pounds. I do not count with information on the ratio between prices of small quantities and prices of large quantities. I use the average ratio for flour, rye meal, cornmeal and beans (as well as the equivalence between pecks and pounds) to estimate prices of apples in small quantities.

Onions: Retail prices of onions in Boston are available for 1899 and 1900 in the Labor Bulletin (No 10-16). To estimate retail prices for the rest of the period, I recurred to retail prices in the state of Massachusetts in 1768-1859 (Wright 1885) and producer prices in the state (Bureau of Statistics of Labor 1909; United States Census Office 1902; Wright 1887).

Turnips: There is no information on retail prices of turnips in Boston. Thus, I assumed prices in Boston were the same as the average prices in the state of Massachusetts. Retail prices of turnips in this state are available for some years in 1771-1858 (Wright 1885). I estimated missing prices, using producer prices in this state in 1855-1905 (Bureau of Statistics of Labor 1909; Wadlin 1899; Wright 1887). Interpolation was used to fill the blanks. Original retail prices are in dollars per bushel. Families were assumed to purchase turnips in small quantities, not in bushels. I estimated prices of a pound of turnips, using the equivalence of a bushel in pounds, as well as the average ratio between prices of small quantities and prices of large quantities for flour, rye meal, cornmeal and beans.

Sugar: Retail prices of brown sugar are available 1851-80 (Weeks 1886), and 1890-1900 (U.S. Department of Commerce and Labor 1904). To fill the blanks, I relied on the average prices of sugar in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868).

Fuel: Retail prices of wood in Boston are available for 1851-80 (Weeks 1886). For other years, I estimated the prices of wood in Boston, using average prices of wood in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868).

Clothing: I assume retail prices of shirting in Boston are the same as the average prices in the state of Massachusetts. Retail prices in Massachusetts were obtained from secondary sources (Bureau of Statistics of Labor 1902; Wright 1885). I also used the retail prices of cotton cloth in Massachusetts and U.S. wholesale prices of cotton (U.S. Committee of Finance 1894; U.S. Department of Agriculture 1939; Wright 1885) to fill the blanks.

Soap: Wholesale prices of soap in Boston are available for 1842-60 (U.S. Committee of Finance 1893). I estimated retail prices, using the ratio between retail and wholesale prices in the state of Massachusetts (Bureau of Statistics of Labor 1884, 1902; Wright 1885; Young 1868). I also filled the blanks, using candle prices and the relative price of soap with respect to candles.

Candles: Wholesale prices of candles in Boston are available for 1842-91 (U.S. Committee of Finance 1893). Retail prices were estimated, using the ratio between retail and wholesale prices of candles in the state of Massachusetts (Wright 1885). In addition, I used the relation between candles and soap prices to fill in the blanks.

Linseed oil: Retail prices of linseed oil in Boston are available for 1889-91 (U.S. Committee of Finance 1892). For 1840-88, I estimated retail prices in Boston, using wholesale prices in this city (U.S. Committee of Finance 1893), and the ratio of retail to wholesale prices of burning oil in the state of Massachusetts (Wright 1885). I also used retail prices in the state of Massachusetts (Wright 1885) and wholesale prices in the United States (U.S. Department of Labor 1914) to fill the blanks.

Housing: Information on the rent of a room in Boston is available for 1851-80 (Weeks 1886), and 1890-1900 (U.S. Department of Commerce and Labor 1904). Originally figures refer to the rent for four rooms. To calculate the rent of a room, I divided this value by four. I used rent and land prices in Boston in 1785-1805 (U.S. Department of Labor 1934) and land prices in Suffolk in 1850-1900 (U.S. Department of Commerce 1933) to estimate the rent of a room in Boston in 1785-1805 and 1882-96. Interpolation was used to estimate the rent of a room in 1806-50.

A.4 Wage data

Wage data comes from secondary sources. I obtained wages of laborers in Boston from U.S. Department of Labor (1934) for 1780-1805 and 1890-1900, Brown (1854) for 1836, 1840 and 1843,[54] Weeks (1886) for 1871-80,[55] and Wright & Weaver (1898) for 1870-98.[56] I also used annual reports of the Boston and Worcester Railroad and Boston and Maine Railroad to obtain information on laborers in Boston in 1849-65 ((Directors of the Boston and Maine Railroad 1849, 1850, 1851, 1857, 1858, 1861, 1865; Directors of the

[54] Brown (1854) cites information originally reported by Francis Walker.

[55] I calculated the average wages of laborers using Weeks´ information from four companies in Boston.

[56] Most sources report daily wages. For 1890-1900, U.S. Department of Labor (1934) reports hourly wages. The series of hourly wages was used to estimate daily wages in 1899 and 1900, using the ratio daily wages/hourly wages.

Boston and Worcester Railroad Corporation 1853). When information is missing for up to five consecutive years, I filled the blanks by interpolation. When information is missing for six or more consecutive years, I estimated wages in Boston, using the information on wages in the state of Massachusetts and the ratio between the wages in Boston and those in the state of Massachusetts. Information on wages in the state of Massachusetts comes from Wright (1885) and U.S. Department of Labor (1934).

Original data on wages is expressed in dollars. Prior to interpolation, I converted those figures to grams of silver.

A.5 Estimating average nutritional requirements

I calculated the requirements of nutrients for an average adult man, for an average adult woman and for an average minor. To do so, I used the requirements of nutrients for different age- and gender- categories and the distribution of population by age and gender in Suffolk County in 1850. The census of 1850 reports the population in the county of Suffolk for different age ranges of men and women (DeBow 1853). I assumed that the number of inhabitants was the same for each age within every age range. I assumed that the number of pregnant women was equal to the number of births on June 1, 1850 and that the number of lactating women was equal to the difference between the number of births and the number of infant deaths (deaths of children under one year old). Births and mortality data came from (DeBow 1855). In addition, I assumed that the number of pregnant and lactating women had the same distribution as the number of women between the ages of 15 and 39. I also considered that children under six months only obtained their nutrients through lactation. I consider children to be men and women up to 18 years old.

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