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The Problem of Quality Change in Historical Price Statistics: An Illustrative Example Using Baedeker Travel Guides*

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Abstract

The problem of accurately measuring inflation in the face of constant improvement in the quality of goods is a long-standing one in economics. This paper uses a novel dataset on the prices of the travel guidebooks published by the German publishing house Baedeker between 1832 and 1944 to construct a hedonic price index for guidebooks. Comparing these indexes to the list prices of these guidebooks, we show that the failure to adjust for improvements in the quality of the guidebooks over time imparts a substantial upward bias to measured inflation. For example, for German-language guidebooks, nominal prices increased 76 percentage points more than quality-adjusted prices between 1843-1913, suggesting an average upward bias over this period of 1.1 percentage points a year. Similarly, we find substantial average upwards bias of 1.5 and 1.7 percentage points a year for French-language guidebooks over 1859-1913 and English-language guidebooks over 1868-1913, respectively.

Keywords: Inflation measurement, quality change, measurement bias

JEL Classifications: C8, E3, N1

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1 INTRODUCTION

Accurately measuring the rate of inflation is a long-standing challenge in economics in part because the quality of the basket of goods and services can change substantially over time. Failure to correctly adjust for these changes can impart a bias to measured price indexes, usually upward. Economists and statisticians have long been aware of these problems. The Stigler Commission Report (Stigler et al. (1961)) is an early summary of some of these problems. The information technology revolution in the 1980s and 1990s revived concerns about biases in price statistics due to rapid advances in technology, lowering the effective price of many goods such as computers, electronics, televisions and other information technology intensive products. Cole et al. (1986), Dulberger (1989), Berndt, Griliches, and Rappaport (1995), Pakes (2003), Aizcorbe (2006), Erickson and Pakes (2011), and Byrne, Oliner, and Sichel (2018) all demonstrated that adjusting for quality of goods over time results in lower real prices using various examples. The Boskin Commission Report (Boskin et al. (1996)) estimated that the U.S. Consumer Price Index probably overstated the true rate of inflation in the U.S. by between 0.8 and 1.6 percentage points a year, in part because of these quality adjustment problems. Importantly, this quality adjustment issue can apply to all goods, even those considered to be technologically stable as originally noted by Waugh et al. (1929) and more recently by Greenlees and McClelland (2011).

One way to deal with the quality adjustment problem is to construct hedonic price indexes first proposed by Court (1939) and popularized by Griliches (1961). Aizcorbe (2014) provides a definitive textbook treatment. These methods, simply put, view goods and services as bundles of characteristics, which have some value. Hence, the price of a good or service is the sum of the value assigned to all its characteristics.

This paper utilizes hedonic techniques to provide an illustrative example of the importance of quality adjustment in constructing price indexes. We exploit a unique dataset of the prices and characteristics of Baedeker travel guidebooks which were published and sold during the nineteenth and early twentieth centuries. These guidebooks were precursors to contemporary Frommers or Lonely Planet guidebooks. Over our sample, the characteristics and the process used to make the guidebooks dramatically changed — largely due to advances in printing and book binding technology. We construct and compare price indexes for the list prices and quality-adjusted prices of the guidebooks, and demonstrate that the failure to adjust for quality change results in a large overstatement of inflation.

The remainder of this paper is organized as follows: Section 2 reviews the data including the Baedeker guidebooks, Section 3 outlines the hedonic methodology and resulting price indexes, Section 4 assesses the robustness of the hedonic indexes, and Section 5 discusses the results.

2 DATA

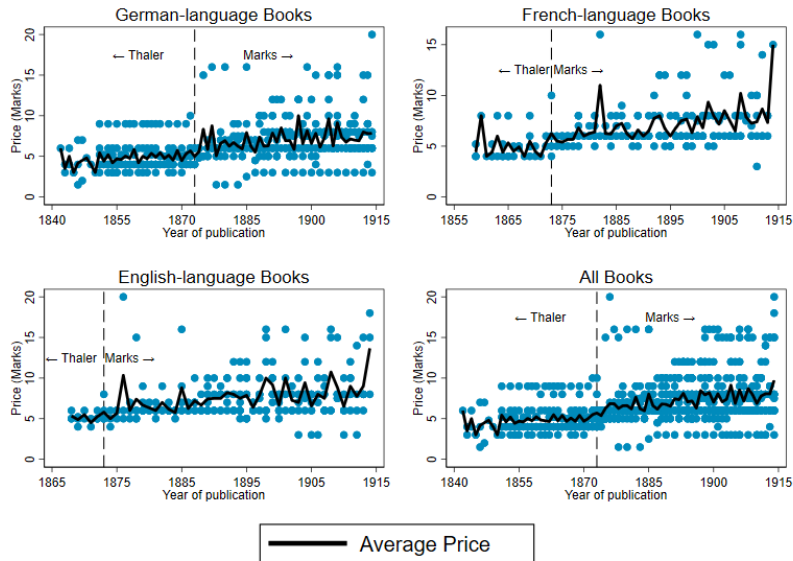
Our primary source of data is the catalog of Baedeker guidebooks compiled by Hinrichsen (1981). Hinrichsen reports the publication dates and various characteristics of every guidebook published in German, French and English between 1828 and 1944. The guidebooks include extensive information on how to get to various (mainly Western European) destinations, where to stay, where to eat, details on various tourist attractions and much more. The guidebooks were published between 1828 and 1944, but, before the mid-1840s and after World War I, publication was sparse. Thus, for our empirical analysis we focus on the prices of books published between 1842 and 1914.

2.1 PRICE OF BAEDEKER GUIDES Hinrichsen (1981) only reports the prices of the German language books. We obtained the prices of the English- and French-language guidebooks from advertisements on the inside covers of the guidebooks themselves. Most of the prices are reported in Marks. Prior to 1873, prices of guidebooks were reported in Vereinsthaler and Silbergroschen. In 1873, Germany officially transitioned to the Mark as a result of German unification and the adoption of the gold standard. We converted these prices to Marks using the official exchange rate of 3 Marks to 1 Vereinsthaler.

Figure 1 plots the publication date and price in Marks of all of the books we include in our analysis. Simply eyeballing the plots there appears to be a general upward trend in the prices of the books over time. Of course, these scatter plots are not comparing like with like over time. The regional coverage of the books increased over time. For example, in the 1850s the books mainly covered Germany and northwest Europe. By the 1910s there were books covering France, Italy, the United Kingdom, and even Egypt and the United States. And for those regions that were covered continuously over our sample period, the level of detail included in the various editions of the books increased over time.

2.2 CHARACTERISTICS OF BAEDEKER GUIDES Many characteristics of the guidebooks, like the prices, changed over time. Some of these characteristics, like the number of pages or maps, can be quantitatively measured – Hinrichsen (1981) reports data on seven quantitative characteristics (number of introduction pages, number of main text pages, number of maps, number of plans, number of groundplans which are not available for French books, number views and number of panoramas). Examples of some of these characteristics are shown in the appendix. Additionally, Hinrichsen (1981) further qualitatively described certain books in relationship to each other using words like “erweiterte” (extended) or “verbesserte” (improved) for the German-language books, “refondue” or “augmentee” for the French-language books, or “revised” or “augmented” for the English-language books, which we coded as dummy variables – we consider eleven qualitative characteristics.

Figure 1: Prices of New Books Published by Year

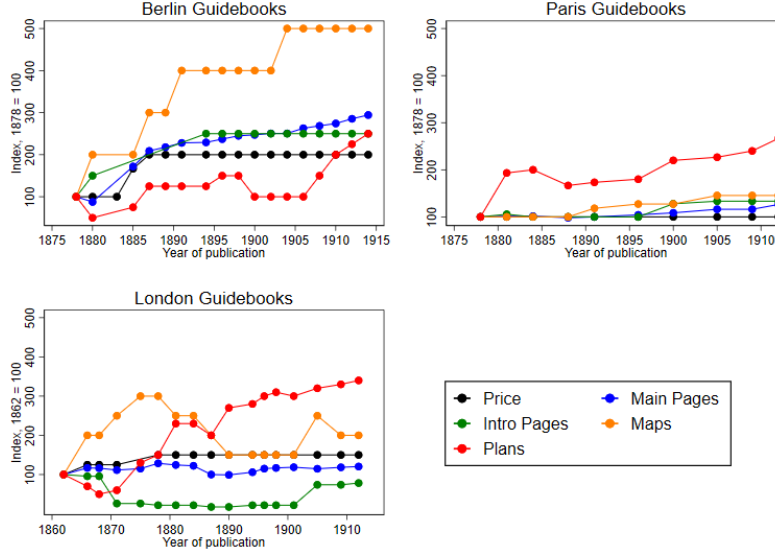


Notes: Only books with price data are counted. The average price is the arithmetic average of all prices in each year. Source: Hinrichsen (1981); Baedeker Guidebooks.

Figure 2 focuses on three series of German-language guidebooks that covered the same city over time. The first guidebook to Berlin was published in 1878 and sold for 1.5 Marks. The 18th edition of the Berlin guidebook, published in 1914, sold for 3 Marks, twice the price of the first edition. However, the 18th edition included 10 pages of introductory text, 262 pages of main text, 5 maps, 10 plans and 17 groundplans. By comparison, the first edition included only 4 pages of introductory text, 89 pages of main text, 1 map and 4 plans. By any reasonable metric, the more expensive 18th edition was in many ways a better (higher quality) book than the first edition. The first guidebook to London was priced at 1 Thaler 10 Silbergroschen in 1862 (the equivalent of 3.3 Marks) and contained 332 pages of main text. The 17th edition published in 1912 and priced at 6 Marks contained 400 pages of main text and had improved along all other dimensions of quality as well (except number of introductory pages). The prices of the Paris guidebooks were constant at 6 Marks for every edition published between 1878 and 1912, but the quantitative characteristics changed greatly. For example, the number of main pages increased from 372 to 470 and the number of plans increased from 15 to 40 between the 9th (in 1878) and 18th (in 1912) editions. In general, across all guidebooks, the quantitative characteristics, like the nominal price, tended to increase over time. For example, the simplest measure of quality—the number of main pages in each book—increased by 194 and 16 percent between 1878–1914 for Berlin and Paris guidebooks, respectively, and by 20 percent between 1862–1914 for London guidebooks. This, taken with Hinrichsen (1981)’s continual use of qualifiers, indicates that the quality of the guidebooks also

increased over time.

Figure 2: Evolution of the Price and Characteristics of the German-language Guidebooks



Notes: Markers indicate a new edition. Values are indexed to the first year of available data.
Source: Hinrichsen (1981)

3 A HEDONIC PRICE INDEX

The traditional hedonic price model expresses the (log of the) nominal price of a good as a function of the characteristics of the different models of the good sold at each point in time and time dummy variables (see for example Triplett (1986), Berndt (1991) and Aizcorbe (2014)). Let $P_{v,t}$ denote the price of volume v sold at date t , where $v = 1, \dots, V_t$ and V_t is the total number of different volumes sold at date t . We don't have sales data on the sales of different volumes at different points in time, so we simply assume that all volumes sold in the first year of their publication. Let $X_{k,v,t}$, $k = 1, \dots, K$ denote the quantitative characteristics of volume v sold at dates t . Let $D_{j,v,t}$ denote dummy variables for certain qualitative characteristics of the different volumes, and $D_{l,v,t}$ denote dummy variables for volumes in languages other than German ($D_{1,v,t} = 1$ if volume v published at date t is in English, = 0 otherwise; $D_{2,v,t} = 1$ if volume v published at date t is in French, 0 otherwise). $D_{v,t}$ denotes the time dummies. We estimate the following regression:

$$\ln P_{v,t} = \alpha + \sum_{k=1}^K \beta_k X_{k,v,t} + \sum_{j=1}^J \gamma_j D_{j,v,t} + \sum_{l=1}^L \lambda_l D_{l,v,t} + \sum_{t=1}^T \delta_t D_{v,t} + \epsilon_{v,t} \quad (1)$$

While it has become standard in the literature to estimate hedonic regressions using weights

based on units or expenditure shares, we estimate unweighted regressions as we have no information on sales of the different volumes. By construction, the influence of product characteristics on the price (the β_k coefficients) are assumed to be constant over time, which may or may not be a reasonable assumption. The results of the Equation 1 regressions are in Table 1.

Table 1: Hedonic Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	German	German	English	English	French	French	All	All
Pages - introduction	0.005*** (0.000)	0.005*** (0.000)	0.003*** (0.000)	0.004*** (0.000)	0.005*** (0.001)	0.003*** (0.001)	0.004*** (0.000)	0.004*** (0.000)
Pages - main text	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)
Maps (Karten)	-0.002* (0.001)	-0.002** (0.001)	0.002 (0.001)	0.002** (0.001)	0.003*** (0.001)	0.005*** (0.001)	0.001 (0.001)	0.001 (0.001)
Plans (Pläne)	0.004*** (0.001)	0.004*** (0.001)	0.005*** (0.001)	0.005*** (0.001)	0.005*** (0.001)	0.006*** (0.001)	0.004*** (0.001)	0.004*** (0.001)
Groundplans (Grundrisse)	0.004 (0.003)	0.004 (0.003)	-0.024 (0.024)	-0.033 (0.023)				
Views (Ansichten)	-0.003 (0.003)	-0.003 (0.003)	0.003 (0.003)	0.004 (0.003)	-0.000 (0.003)	0.004 (0.003)	0.001 (0.001)	0.000 (0.001)
Panoramas (Panoramen)	0.010** (0.005)	0.012** (0.005)	0.002 (0.006)	-0.002 (0.006)	0.018 (0.033)	-0.010 (0.029)	0.005* (0.003)	0.005 (0.003)
Observations	433	433	231	231	205	205	869	869
R-squared	0.812	0.819	0.789	0.812	0.761	0.832	0.772	0.781
Quality Dummies	No	Yes	No	Yes	No	Yes	No	Yes
Language Dummies	No	No	No	No	No	No	Yes	Yes

Notes: The dependent variable is the log price of the respective-language guidebooks in Marks. Quantitative variables include maps, plans, intro and main pages, views, panoramas and ground plans. Qualitative dummies are all text dummy variables. For each language and for all of them together, there are versions of the model with and without the qualitative dummies. All regressions are run with year dummies which are used to construct the price indexes. Standard errors are in parentheses. *** denotes significance at the 1 percent level; ** denotes significance at the 5 percent level; * denotes significance at the 10 percent level.

We fit the regression in Equation 1, by book language, using various combinations of $X_{k,i,t}$ and $D_{j,v,t}$. That is, raw price models, for which all of these are omitted and quality-adjusted models where $X_{k,i,t}$ and $D_{j,v,t}$ are included. We also fit versions of these models by pooling data across languages. For the pooled specification of the quality-adjusted model, we add language dummies, $D_{l,v,t}$. Some of the signs on the coefficients are counter-intuitive, but, as Pakes (2003) notes, it is the significance, not the sign, of the characteristics coefficients that matters. We also fit an alternative model specification with edition fixed effects, which yields qualitatively equivalent results.

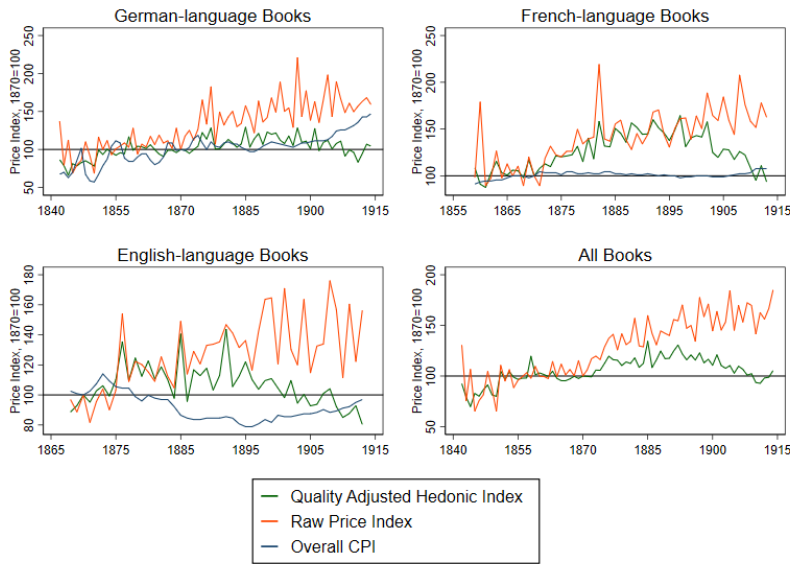
As noted in Aizcorbe (2014) in regressions such as these the intercept term α gives the average price for some reference group. In the exercises below we will take 1870 as the reference year and use the time dummies, $D_{v,t}$, to determine relative price levels of the other periods. In this

case $\hat{\alpha}$ gives us the average constant-quality price of the guidebooks for 1870, and the estimated coefficient on the 1871 time dummy variable, $\hat{\delta}_{1871}$, gives us the average constant-quality price in 1871 relative to 1870. Finally, there is the well-known need for a bias adjustment to convert the logged measure of the price index into a price index in levels. We use the bias adjustment suggested by Wooldridge (2013), since his procedure does not require normally distributed error terms. Thus, we define a dummy variable hedonic price index, I_t^{DV} , at each date t relative to the base year 1870 as,

$$I_t^{DV} = \frac{\exp(\delta_t)}{N} \sum \exp(\epsilon_{v,t}) \tag{2}$$

where N is the total number of observations used in the regressions. These price indexes are in Figure 3 along with historical CPI in each of the countries.

Figure 3: Hedonic Price Indexes



Notes: Historical CPI is from Mitchell (1992). The raw price index is the index recovered from regressing the log price on only the time dummies for each period. The coefficients on the time dummies are then converted into an index. The quality adjusted index is produced by adding quantitative and qualitative variables to the regressions as covariates. Each panel contains the results of separate estimations for German, French, and English guidebooks and an estimation with all books together. Indexes are plotted through 1913.

Sources: Hinrichsen (1981), Jordà, Schularick, and Taylor (2017), Authors' Calculations.

For each country, the raw price increases over time and tends to be noisy. In Germany, this is consistent with historical CPI, but, in France and Great Britain, historical CPI is flatter, even showing decreases in Great Britain during earlier portions of the sample. However, the quality adjusted indexes are less noisy and exhibit deflationary trends in the second half of the samples. These decreasing trends in the early 20th century are counter to what historical CPI indicates. More-

over, by the end of each sample, the quality-adjusted indexes imply real prices that increased 35.8 percent for German-language guidebooks between 1842-1913, but decreased by 14.2 percent between 1859-1913 and 13.6 percent between 1868-1913 for French-language and English-language guidebooks, respectively. Contrarily, the raw price indexes imply price increases of 111 percent for German-language books between 1842-1913, 66 percent for French-language books between 1859-1913, and 61 percent for English-language books between 1868-1913. These findings, indicate substantial upward bias in the measurement of guidebook prices, which is consistent with the long-standing belief that failure to properly adjust for quality changes leads to overstating the level of inflation.

4 ROBUSTNESS

4.1 STABILITY OF COEFFICIENTS The validity of the indexes in Figure 3, to some extent, relies on the assumption that the coefficients on the characteristics of the guides are constant over time. To test this assumption using the data on German guidebooks, we split our data into two samples across time for each year in 1855-1900, fit the quality adjusted hedonic model on each subsample, and test if the coefficients on the characteristics are the same using an unadjusted Wald test. Though we would like to execute this exercise for French- and English-language guidebooks as well, those subsets of books often have too little observations in the cross-section to split up the sample period.

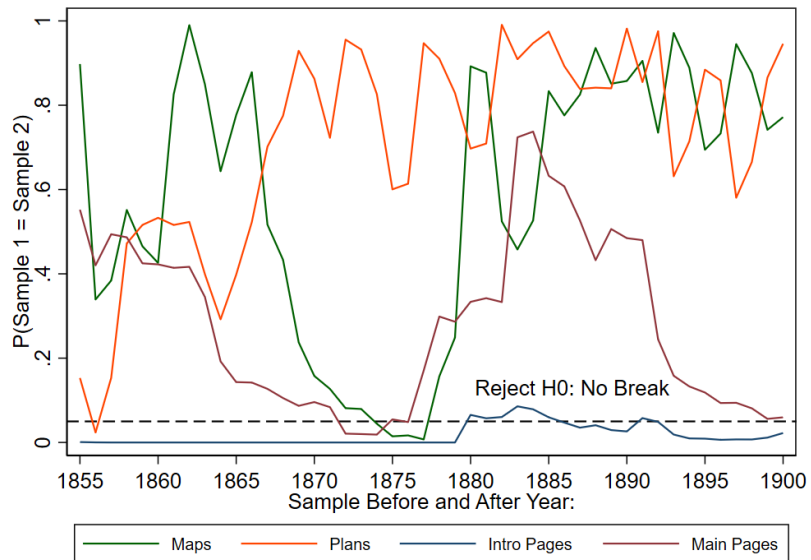
Figure 4 shows the results of these Wald tests for each split in the data. In most cases, there is no evidence of a break in the equivalence of a coefficient across subsamples, but, between 1873-1878, a few of the coefficients show evidence of differences across subsamples. Therefore, to ensure that this does not have a drastic impact on the resulting price indexes, we constructed a quality adjusted hedonic price index using only data from 1880 onward and compare that index to the full-sample quantitative-qualitative adjusted price index. This comparison is in Figure 5 and shows that time-variation in the coefficients on some of these characteristics do not bias the price indexes for guidebooks.

4.2 A CHARACTERISTICS PRICE INDEX Alternatives to the hedonic methods used in this paper so far are cross-sectional methods that produce characteristics price indexes which were originally developed by Gorman (1980). Essentially, we fit a separate regression for each year of data, yielding a time series of coefficients. These regressions are of the following form,

$$\ln P_v^t = \alpha^t + \sum_k \beta_k^t X_{v,k}^t + \epsilon_v \quad (3)$$

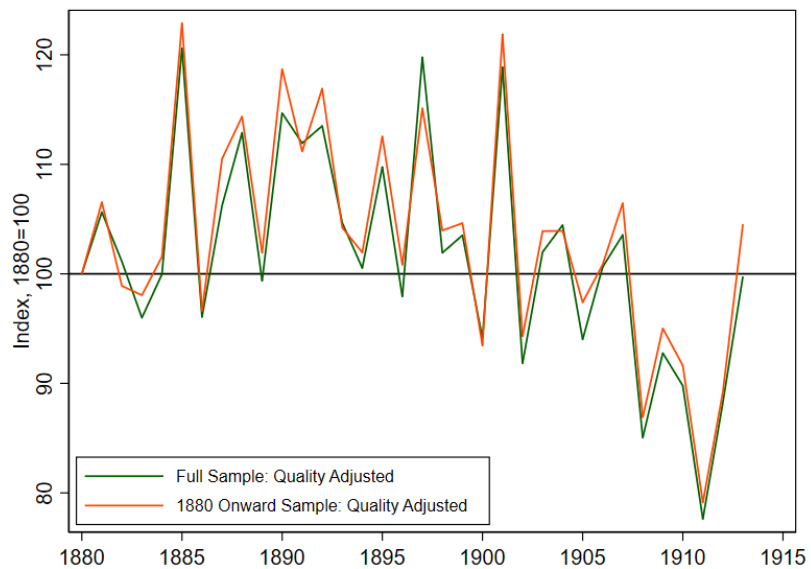
where t denotes the year and k denotes the characteristic. To contend with degrees of freedom

Figure 4: P-Values of Various Wald Tests



Note: Values are p-values of an unadjusted Wald test that the coefficients are consistent across time. This test is done separately for each characteristic reported in the chart using data on German guidebooks.
 Source: Hinrichsen (1981) and authors' calculations.

Figure 5: German Imputed Indexes - Post Break

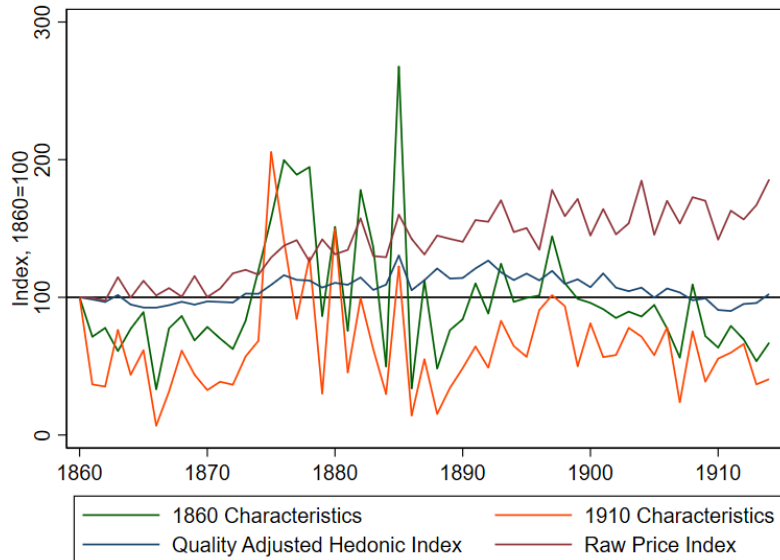


Note: Indexes are adjusted with both quantitative and qualitative variables and constructed using time dummies. Post-break indicates that the series was constructed using data from only 1880-1913.
 Source: Hinrichsen (1981) and authors' calculations.

issues, we pool all data across German, English, and French guidebooks and only use some of the quantitative characteristics – the number of intro pages, the number of main pages, the number of

maps maps, and the number of plans – as regressors. Using the resulting time series of coefficients, we predicted the price of guidebooks in each year by fixing the quantities of the characteristics to an average across all editions in a particular year. We then indexed these imputed prices and compare them to the hedonic methods in Figure 6.

Figure 6: The Characteristic Price Indexes for Books in Two Periods



Note: The lines indicate the price that a book with the average characteristics of an 1860 and 1910 book would have been in each year. These prices are imputed by multiplying the characteristics by the regression coefficients of the cross-sectional regressions. The hedonic indexes are calculated using pooled data as well. Sources: Hinrichsen (1981), Author's Calculations.

The characteristics price indexes are much noisier than their hedonic counterparts which is likely due to the small size of the cross-sections from which we derive the characteristic coefficients. Thus, we have less confidence in these indexes compared to the hedonic methods, but these indexes still reflect the importance of adjusting for quality change in price indexes and indicate that adjusting for the quality of guidebooks could result in deflationary or flatters tendencies in prices.

5 DISCUSSION

This paper demonstrates the problem of quality adjustment for price indexes, using a novel dataset of prices and characteristics of Baedeker guidebooks. After adjusting for quality, the price indexes for guidebooks increase just slightly or decreases over our period of observation, which is in contrast to the unadjusted price series that increases substantially over the period. In fact, over their respective periods, inflation in the prices of German-language, French-language, and English-language guidebooks would be overstated by an average of 1.1, 1.5, and 1.7 percentage points per year, receptively, if the changing quality of the guidebooks is not considered. Though

our hedonic methodology could fall short, in that it may not include all important characteristics that determine the price of the guidebooks, our results are robust to using a characteristics price index methodology as well. Recently, Crawford and Neary (2023) argued that hedonic techniques do not sufficiently capture quality adjustments due to the addition of new features to a product, but the guidebooks rarely experience such changes.

The existence of the quality adjustment issue in price indexes has potential ramifications for overall price indexes. If similar quality adjustment issues persisted across goods and services other than guidebooks, then the 113 and 18 percentage point increases in CPI for Germany from 1842-1913 and France from 1859-1913, respectively, and the 5 percentage point decrease in CPI for England from 1868-1913 could be overstated as well.

Such logic can easily be extended to the U.S. CPI. Indeed, the Stigler and Boskin commissions of the 1960s and 1990s, respectively, found evidence of bias in U.S. price indexes and sought to quantify it (Stigler et al. (1961) and Boskin et al. (1996)). Following these commissions, various processes in constructing U.S. price indexes were improved, processes that are reviewed by Gordon (2006) and Moulton (2018). Despite these improvements, there is still potential for quality adjustment bias in today's price indexes. The U.S. Consumer Price Index (CPI) includes things similar to the Baedeker guidebooks (RG022: books purchased at retail outlets other than book clubs). The CPI does not adjust for quality in any of its book prices. Albeit a tiny part of the CPI, there are many other components of the CPI that are not adjusted for quality. Guidebooks are an example of just one technologically stable item that still undergoes quality changes.

Constantly assessing quality changes to the goods and services people consume is crucial for understanding how the cost of living evolves over time. Future research ought to focus on improving how aggregate price indexes are adjusted for quality, allowing more goods and services to be quality adjusted without overcompensating.

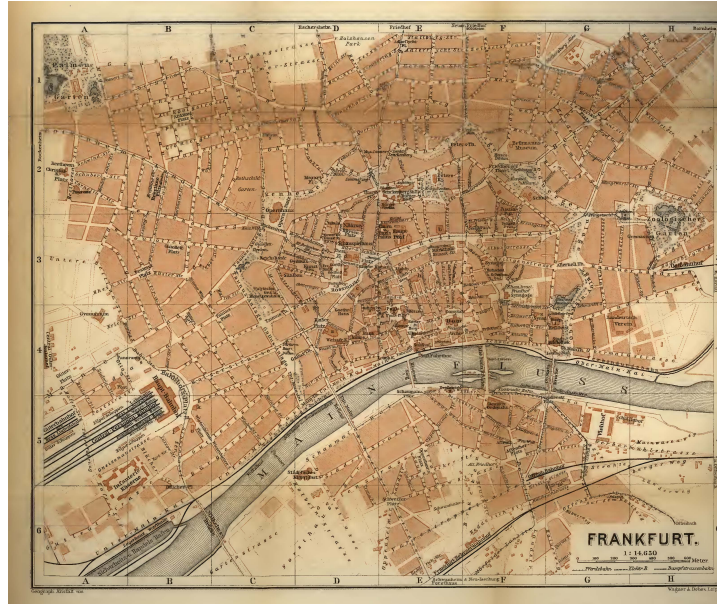
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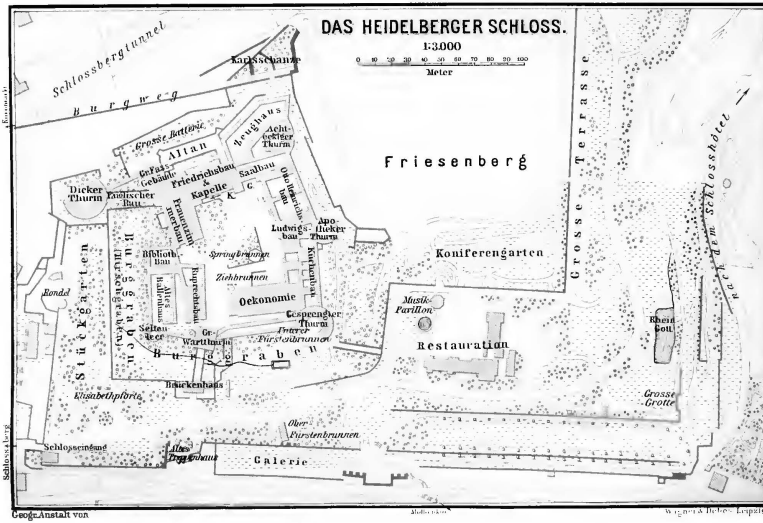
APPENDIX

Figure A.1: An Example of a Baedeker Map



Source: *The Rhine from Rotterdam to Constance. Thirteenth Revised edition*

Figure A.2: An Example of a Baedeker Plan

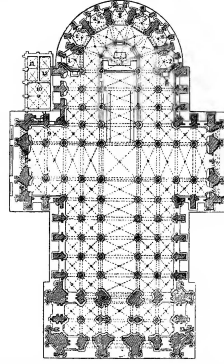


Source: *The Rhine from Rotterdam to Constance. Thirteenth Revised edition*

Figure A.3: An Example of a Baedeker Groundplan

Cathedral. COLOGNE. 3. Route. 31

Frederick William III. and IV., kings of Prussia, at length rescued the desecrated edifice from total destruction. The former, at the suggestion of Sulpice Boisserée, caused it to be examined by the eminent architect Schinkel in 1818, and gave instructions for its restoration. The work of renovation, however, was not begun till 1823. It was at first carried on under the superintendence of Albers (d. 1833), and afterwards under that of the talented Zwirner, a thorough master of the Gothic style (d. 1861). On Zwirner's death Herr Voigtel (b. 1826) succeeded to his office, and carried the work to completion. Zwirner was the first to form the project of com-



1. Engelbert Chapel. 2. Materous Ch. 3. Ch. of St. John. 4. Ch. of the Three Kings. 5. Ch. of St. Agnes. 6. Ch. of St. Michael. 7. Ch. of St. Stephen. 8. Ch. of the Virgin. 9. Treasury. 10. Sacristy. 11. Chapter House. 12. Library.

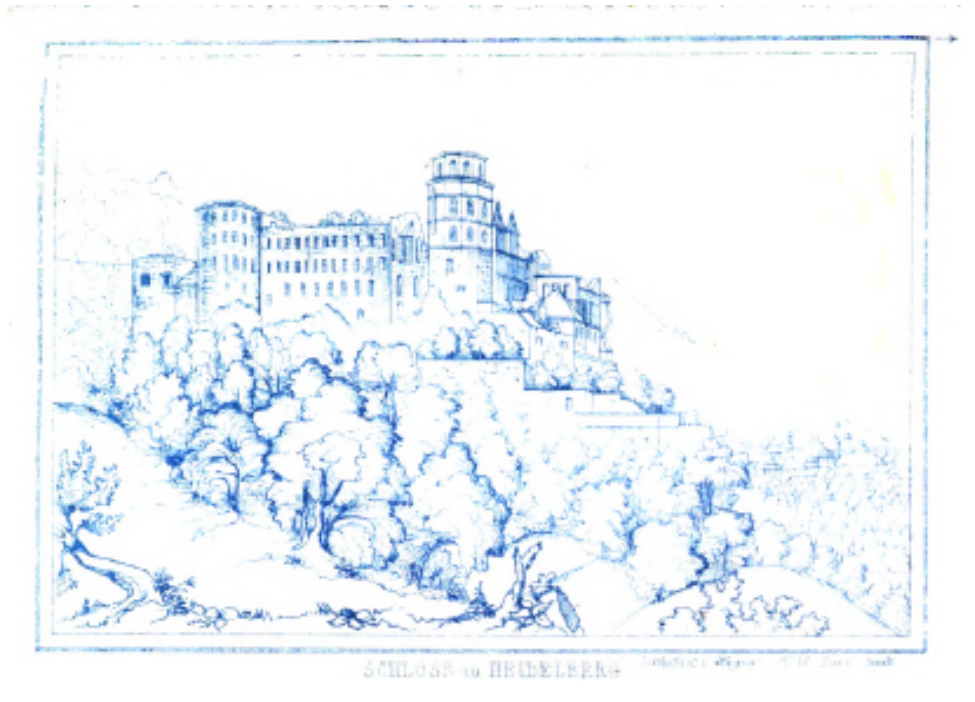
Source: *The Rhine from Rotterdam to Constance. Thirteenth Revised edition*

Figure A.4: An Example of a Baedeker Panorama



Source: *Palestine and Syria, Fifth Edition*

Figure A.5: An Example of a Baedeker View



Source: *Die Rheinlande von der Schweizer bis zur Holländischen Grenze, Ninth Edition*