

Infant Formula Appendix for: “Gender Roles and Medical Progress”*

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Abstract

This document contains additional information on the history of infant formula and a detailed description of the construction of the price series of Similac discussed in “Gender Roles and Medical Progress.” It also presents additional data on the price of earlier products - Mellin’s and Nestle’s baby formulas - which are not used in the paper.

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1 History of Infant Formula

The availability of satisfactory infant formulas is a comparatively recent development. Until the 20th century there was virtually no safe and reliable alternative to breast feeding. Available statistics from the early 19th century reveal that improper feeding of babies who could not be breast fed was a leading cause of infant mortality.¹

During the second half of the 19th century, discoveries in biology and medicine provided the basis for development of substitutes to human milk. Causes of various infectious diseases, need for sanitation and milk pasteurization were also recognized. These discoveries led to a variety of initiatives to improve public health and to the development of the infant formula industry.

Table 1 lists the main developments in the area of public health.² Initiatives were targeted to two main concerns: the quality of milk and drinking water supplies, and sewage treatment. Urban areas were the first to act. Various cities introduced milk certification at the end of the 19th century, but by 1920 milk regulations had reached every part of the country, with regulations beginning to appear in state statutes. Pasteurization became a primary milk purification device during this period. By 1939, the U.S. Public Health Service had drafted the Model Milk Health Ordinance and was actively promoting it at the local level (Weisbecker, 2007). The purification of water supply underwent a similar revolution. By the 1940s most major metropolitan areas had developed drinking water treatments and sewage disposal systems.

The development of safer milk and drinking water supply had a fundamental role for the development and the diffusion of baby formula products as an effective and safe alternative to mother’s milk.

Table 1: Timeline in Public Health Initiatives

1838	First chemical analysis of human and cow’s milk.
1854	Cholera first demonstrated to spread via water supplies in London.
1892	First US city to treat sewage waters with chlorine.
1893	Bureau of Milk Inspection established in Chicago.
1906	First Federal Pure Food and Drug Act passed by Congress.
1908	First Bureau of Child Hygiene established in New York City.
1912	US Children’s Bureau established.
1921	Sheppard-Towner Maternity and Infancy Protection act enacted by Congress.

The first breakthrough in infant nutrition was the realization that cow’s milk was a very poor alternative to mother’s milk. In 1838, the first chemical analysis showed that cow’s milk contains a much higher level of proteins and a lower amount of fat and carbohydrates than human milk (see columns 1 and 4 in Table 2). Following this discovery, the infant formula industry developed in the late nineteenth century as physicians, biologists and chemists collaborated to develop a substitute for breast milk for infants whose mothers had died or could not breastfeed.

Early research on infant formula was conducted in hospitals in Boston, Cleveland and Chicago. Medical researchers and chemists developed many of the early formulas, later licensing the production to commercial firms. This development process established an early connection between the medical profession and formula manufacturers.

The first generation of infant formulas, developed between the 1870s and the 1890s, were offered on the market primarily by food manufacturing companies. These products, such as Liebig’s, Nestle’s and Mellin’s infant food, were essentially cow’s milk modifiers made of malt, wheat flour and sugar which had to be mixed with hot cow’s milk and diluted with water. Although better than cow’s milk, the resulting infant food was still nutritionally inferior to maternal milk “since most of them contained little more than concentrated carbohydrate” (Cone, 1976).

During roughly the same time period many physicians developed and prescribed a method of infant feeding called the “percentage feeding method” which entailed mixing specific proportion of fat, protein

¹See Packard and Vernal (1982), Apple (1987) and Schuman (2003) for a detailed account of the history of infant formula. See Powell (1997) for an history of the infant formula industry in the United States.

²Sources: <http://www.sewerhistory.org/chronos/roots.htm> and Wolfe (2001).

and sugar, with the proportion varying by month with the baby age. This method was so complex that it was mostly prepared in milk laboratories and distributed through pediatricians.³

Independently, much research was devoted during the early nineteenth and early twentieth centuries to finding a single food formula to replace this complicated feeding method. The most important innovation in infant feeding occurred in the mid 1910s when nutrition scientists succeeded in creating a so-called “humanized” infant formula that exactly matched the composition of maternal milk in terms of its fat/proteins/carbohydrates content. The first two formulas with this property, SMA (for “simulated milk adapted”) and Similac (for “similar to lactation”), were created in 1914 and 1920, respectively, and are still sold in stores today. Similac was developed by two Boston based scientists, Alfred W. Bosworth, a milk chemist, and Henry Bodwidtch, a pediatrician. The formula, marketed by the Moores and Ross Milk Company in 1924, was initially sold only through physicians, who would place their own label on the plain cans. By 1926, it was commercialized under the name Similac. We focus on Similac because it was the first commercially available “humanized” formula to become popular. In 1975, 52% of infants receiving commercially available milk-based formulas were fed Similac. The formula remains very popular today. In 1987, Ross still retained 54% of the US market. SMA did not achieve great popularity: in 1975, it accounted for less than 12% of the market for commercially prepared formulas, and by the 1987 its market share had dropped to 6%. Alternative scientific infant formulas, such as Enfamil, were launched on the market much later, in 1959. In 1987, Mead Johnson, the producer of Enfamil, had 35% of the market.⁴

Table 2 reports differences in the composition of human and cow’s milk and of first and second generation infant formulas.⁵ Entries are percentages of grams of fat/proteins/carbohydrates per 1,000 grams of milk/formula. We use the composition of SMA for the 1920s as a proxy for Similac’s. This is a reasonable assumption since, according to all accounts, the two products were very similar along these dimensions. This is still true today as different brands of infant formula are nutritionally identical, making infant formula a nearly homogeneous product.⁶ Entries in columns 3 and 4 show how early progress in this area was strictly linked to the idea of matching exactly the composition of human milk. By 1977 nutritional scientists realized that it was wrong to design the formula to exactly match human milk. As a consequence there was a drastic change in the composition of these formulas relative to those created in the 1920s (see last two columns of the table; entries in these columns also show the homogeneity of infant formula products.)

Table 2: Percentage composition of different types of milk

	Cow’s Milk	Nestle, 1929	SMA, 1914	Human Milk	SMA, 1977	Similac/Enfamil, 1977
Proteins	3.4%	2.3%	0.9%	0.9%	1.5%	1.5%
Fat	3.6%	2.3%	4.6%	4.4%	3.5%	3.6%
Carbs	4.8%	5.7%	6.5%	6.6%	7%	6.8%

The “humanized” formulas were initially intended for use in hospitals if mothers encountered problems breastfeeding or in case mothers died. However, it was soon realized that bottle feeding was a more effective and efficient way to control the nutritional intake of each feeding even for babies who could be regularly breastfed. In addition, the pharmaceutical-based companies that produced them used the “medical detailing” technique of direct marketing to physicians and hospitals (typical of most medical products) to market baby formulas (Powell, 1997). Consequently, as the number of births that took place in hospitals and of new mothers discharged with a few days supply of baby formula and having being taught how to use the product effectively rose, so did bottle feeding.

³The formula could also be made at home through a complicated and time and labor intensive process. Newspapers from the time include a very large number of classified ads for nurses specialized in making formula according to Rotch’s percentage method, one of the most popular at the time.

⁴See Fomon (1975, Table III) and Powell (1997).

⁵Data on human and cow milk are from Packard and Vernal (1982, page 140). Data for Nestle are from Apple (1987). Data on the more contemporary formula are from Hambraeus (1977).

⁶What product differentiation exists in the industry today results from specialty formulas for lactose intolerant babies that are based on soy milk. See Powell (1997).

The unintended consequence of technological progress in infant feeding was to induce a dramatic change in breast feeding practices. In 1930, 90% of newborn babies were breastfed. By 1956, the in-hospital breastfeeding rate had dropped to 37%, further declining to 25% by 1971. This revolution had persistent effects. Although recently there has been a resurgence in breastfeeding, this has mostly occurred at shorter duration and for non-exclusive breastfeeding. Today, less than 15% of babies are still exclusively breastfed at 6 months. (See Figure 6 in the paper and the discussion therein.)

2 Price of Infant Formula

In “Gender Roles and Medical Progress” we posit that progress in infant feeding technologies is embodied in infant formula and measure it by using a series for the price of Similac. For the most recent years (post-1985) we use data from Oliveira and Davis (2006) and Oliveira, Prell, Smallwood, and Frazão (2004). These studies use data from the AC Nielsen Scan Track records to show how the Special Supplemental Food Program for Women, Infant and Children (WIC), a program started in 1974 to improve nutrition for poor women, and its infant formula rebate program (which currently accounts for half the sales of the infant formula industry) significantly raised the infant formula prices faced by non-WIC consumers. For earlier periods we use historical data sources to build our price series. The next two sections discuss details related to the construction of the price series of Similac (1935 to 1985) as well as earlier formulas (1893 to 1936).

2.1 “Humanized” Formula: Similac

We measure technological progress embedded in infant formula based on a time series for the real price of Similac. We collect the data from advertisements from the Chicago Tribune, the Los Angeles Times and the Washington Post.⁷ The historical ads provide information on price, quantity and type of formula in drugstore chains such as Walgreens and Stineway. For each year between the 1935 and the mid 1985 we have monthly information on price, quantity and type (powder, concentrated liquid, ready-to-feed) of Similac products on sale in drugstore chains in Chicago, Los Angeles and Washington.

In order to compare prices across product types, we express them in the same unit of measure (one ready-to-feed liquid ounce of formula) using the following conversion rules. According to the instructions reported on the current Similac labels, 25.6 ounces of powder can make approximately 196 fluid ounces of formula, whereas 13 ounces of concentrated liquid Similac can make 26 fluid ounces of formula. Therefore, the price of one unit (i.e., one liquid ounce) of formula in real terms is obtained by dividing the (real) price of the can by the quantity of formula (in liquid ounces) that can be obtained by using the content of the can.⁸ Figure 1 to Figure 3 display the monthly data for the unit price of Similac thus obtained by city and product type.

As shown in the figures, there is no record on the price of Similac in the Los Angeles Times from July 1936 to March 1948 and in the Washington Post from October 1942 to May 1948. Hence, for some of the early years our series is based on the price of Similac for the Chicago area alone.

Since there are very few observations on ready-to-feed formula, we only use information on the price of powder and concentrated liquid Similac. These products did not differ in terms of their chemical composition. The only differences between powder and liquid formula were (and still are) related to the proportion of water that needs to be added in order to obtain one ready-to-feed liquid ounce of formula and in the differential amount of time required to effectively mix powder or concentrated liquid with water. Since this difference is negligible, we consider the two products as equivalent in terms of their quality and we average their prices to construct a single data series. Figure 4 shows the monthly city-level data for the unit price of Similac thus obtained. Interestingly, there is little price variation across cities before 1970.

⁷This information is available from ProQuest Historical Newspapers Chicago Tribune (1849-1985), Los Angeles Times (1881-1985) and The Washington Post (1877 - 1990). We are grateful to Claudia Goldin for suggesting this data source.

⁸Nominal prices are deflated by using the U.S. Bureau of Labor Statistics All Urban Consumers Price Index (CPI-U) with base 1982-1984. This index is an average of prices for all items in the CPI and across all major U.S. cities. We deflate monthly data by using the monthly CPI-U.

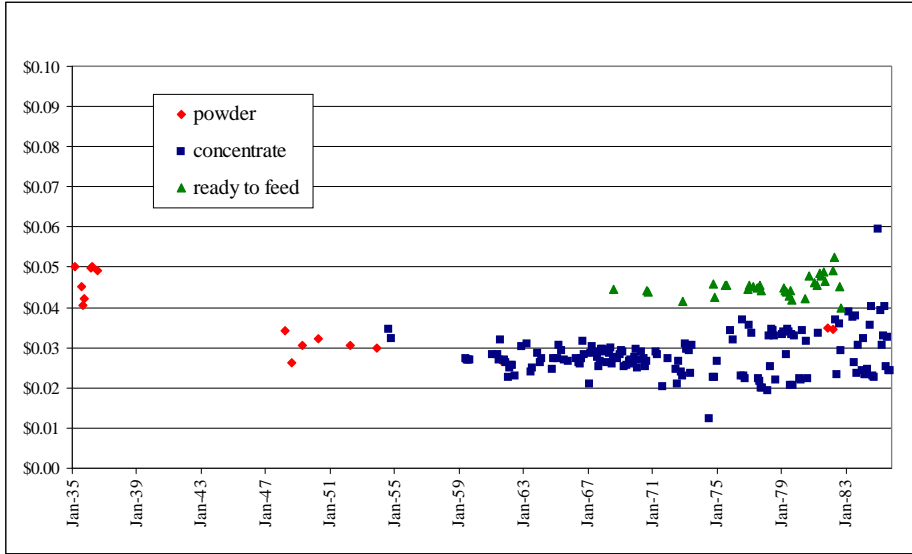


Figure 1: Unit Price of Similac by Product Type: Los Angeles

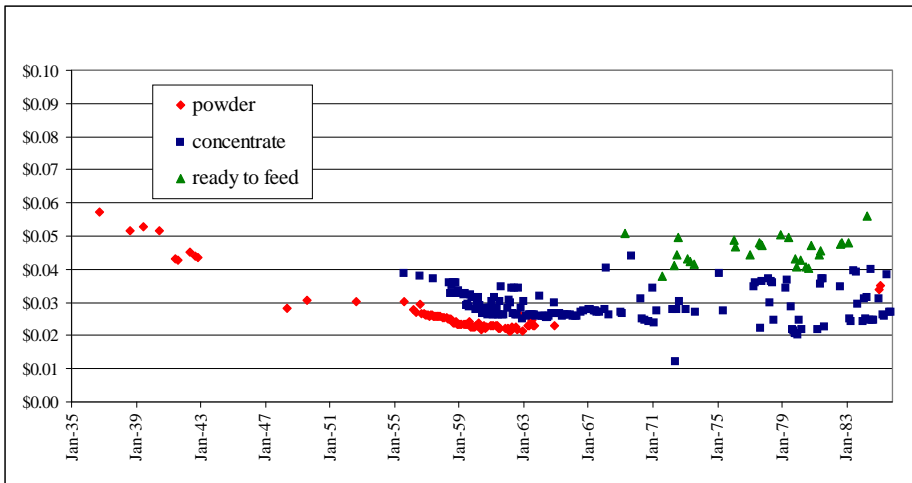


Figure 2: Unit Price of Similac by Product Type: Washington

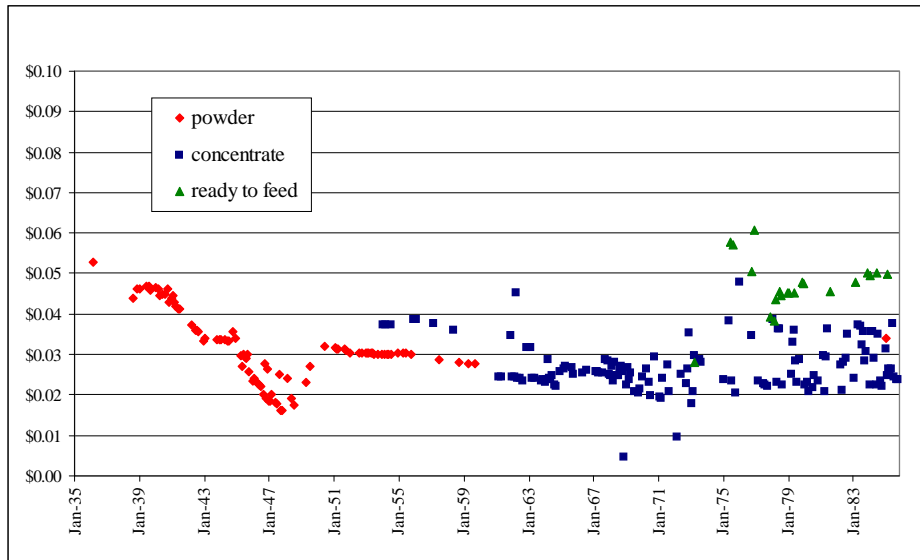


Figure 3: Unit Price of Similac by Product Type: Chicago

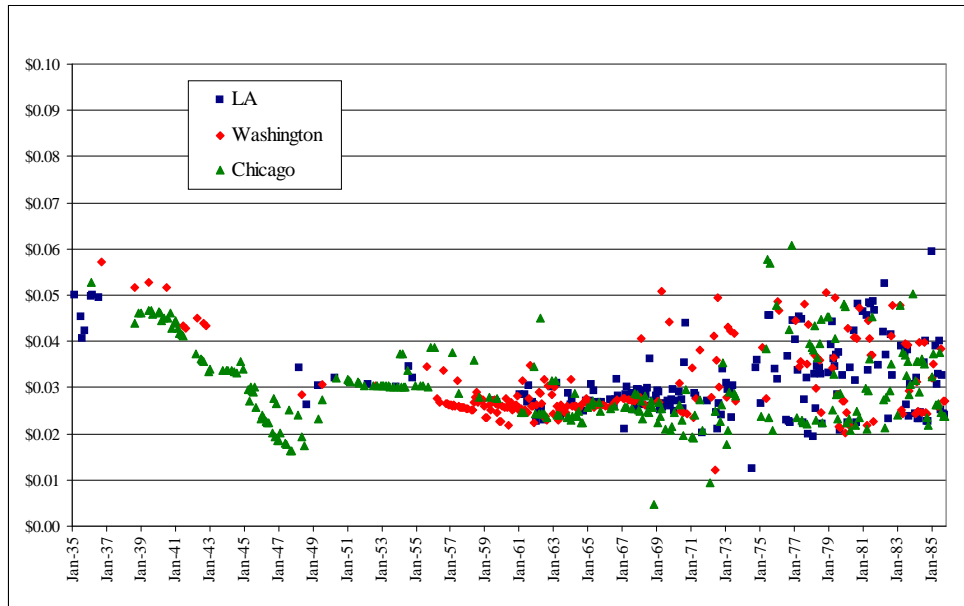


Figure 4: Unit Price of Similac by City (Powder+Concentrate)

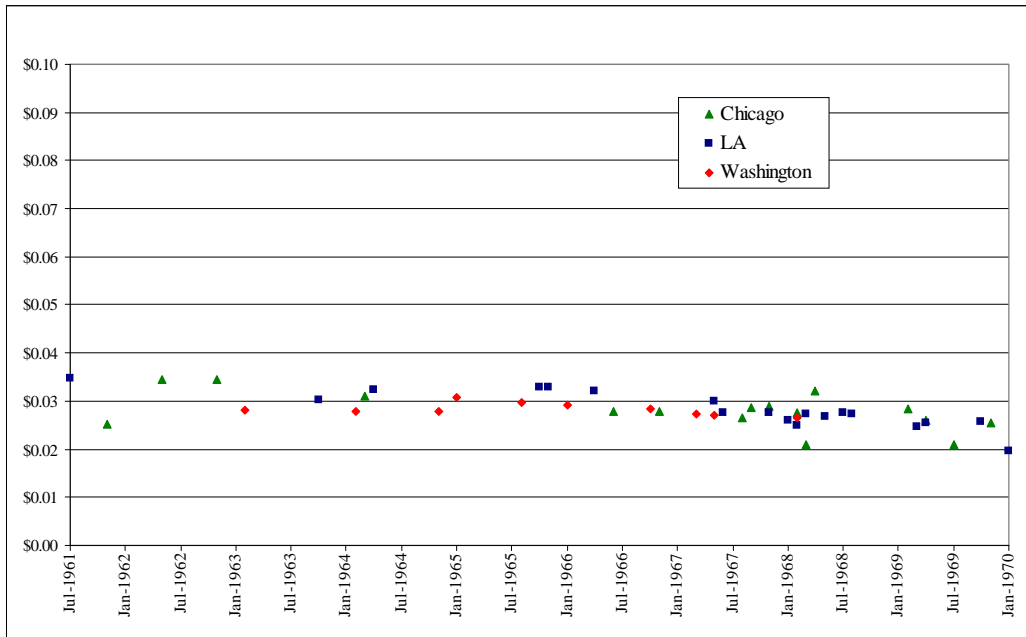


Figure 5: Unit Price of Enfamil by City (Concentrate)

The annualized version of these series, averaged across the three cities, is reported in Figure 7 in the paper as a *time price*, that is, deflated by hourly wages in manufacturing, and is used in our quantitative analysis (see Section 4 in the paper). If the information for one year is missing we interpolate prices across the adjacent years.

For some months/years we also have information on the regular (non sale) price of the product. However, this information is very limited and cannot be used to obtain a consistent price series. Nonetheless, it is interesting to note that a 16 ounces can was often referred to as the ‘\$1.25 Similac’ and not by its weight. This seems to suggest that the non-sale price of the product was \$1.25 for a long time (from 1935 to the late 1940s/early 1950s). Over time we find more and more ads of the ‘\$1.25 Similac’ at discount prices suggesting that the price of the formula was closer to its sale price in the early 1950s than it was in the mid 1930s. It follows that we are probably underestimating the decline in the price of Similac over this period.

The nutritional content of Similac has improved over time with the introduction of iron-fortified formulas in 1959 and of the ready-to-feed version of the product in the 1970s. Since we are using sale prices, we actually have very few observations for these improved products. Hence, we have excluded them from our calculations. We also have data for Enfamil, a formula that became available in the late 1950s/early 1960s. However, we have excluded Enfamil from our analysis since, as shown in Figure 5, data on it are only available since 1961 and we have few price observations. We would not observe any change in the price series if we were also to include Enfamil in our calculations.

2.2 Milk Modifiers: Nestle’s and Mellin’s

We have also extended the price series backward by collecting the prices of the first generation of milk-based formulas (Mellin’s and Nestle’s) that were commercially introduced in the late 19th century. These formulas were milk modifiers, that is, they were mixed in given proportions to cow milk. The information collected from the ads, however, did not include quantities only prices. We obtain estimates for the quantities of these products by using a variety of sources - figures from Apple (1987) and histor-

ical ads, labels and bottles sold on eBay.⁹ Below we describe our procedures for computing the sizes of Mellin’s and Nestle’s products and the calculations that we used to obtain the price of one liquid ounce of “ready to feed” formula. Since the powdered formulas had to be mixed with milk (and water) in given proportions, we add to our calculations the price of cow milk. To this aim we use the series of retail price of “delivered” fluid milk (series 195 from the Statistical Abstract of the United States: Bicentennial Edition). The price reported in this series is an order of magnitude higher than the one reported in the wholesale price series from the NBER. However, the retail price is reasonable when compared with a more recent series on the retail price of milk sold in stores (and not ‘delivered’ milk) available from the University of Wisconsin Dairy Marketing and Risk Management Program (http://future.aae.wisc.edu/data/monthly_values/by_area/307?tab=prices&grid=true) for the period 1980-1997.

Nestle’s Sizes: Nestle’s infant food came in different sizes:

1. The size sold for \$0.5 at regular price would correspond to 1lb of powder formula. We find this information from historical ads on eBay.
2. The “hospital size” can of powder Nestle’s weighted 4.5lb. This information is reported in Figure 3.3, Apple (1987).

There seem to be also additional, unknown, sizes of the Nestle’s cans. Since we do not have this information we drop these price observations from our sample. Size and type may have changed in the 1920s. Therefore, non-hospital size packages sold at a regular price of more than \$0.5 (essentially all non-hospital packages after about 1919) are excluded from the series.

Conversion factor: We use the following calculations in order to obtain the price of one liquid ounce of “ready to feed” formula: 6 table spoons + 20 oz of cow’s milk + 15 oz water = 38oz of liquid (where 2 table spoons are equal to 1 liquid oz). This information is taken from page 12 in the August 1929 issue of the Journal of the American Economic Association. The calculation above assumes that 1 table spoon of powder is equal to 9 gr of powder, based on current package descriptions (where, generally, 1 scoop = 9 gr, approximately). The conversion factor that we use to go from table spoons to liquid oz is as follows: 1oz = 28.35 grams = 3.15 tbsp = 0.53 servings of 6 tbsp.

Figure 6 shows the monthly series, by city, for the unit price of Nestle’s-based formula thus obtained. As shown in the figure, we only have a limited number of observations for this product.

Mellin’s Sizes: There were only two sizes for Mellin – small and large bottles. The large bottle had a net weight of 10oz (Figure 5.6, Apple (1987)), an approximate volume of 16oz (authors communication with eBay seller), and approximate dimension of 6” to 6 $\frac{3}{4}$ ” height and 3” diameter. The small bottle’s approximate dimensions are 5 $\frac{1}{2}$ ” height and 2 $\frac{1}{2}$ ” diameter (authors communication with eBay seller). Based on dimensions, we can estimate that the small bottle should contain 60% to 64% as much formula as the large bottle. If we use 60%, it’s net weight is 6oz and it’s volume is 9.6oz.

Type: Data for Mellin do not report whether the product was sold in powdered or liquid form. The mixing directions for Mellin’s formula call for use of “level tablespoons.” Combined with information on types of formula generally available in the relevant time period, we assume that Mellin sold only powder formula.

Conversion factor: We use the following calculations in order to obtain the price of 1 liquid oz of “ready to feed” formula (assuming that the large size corresponds to a 16oz bottle and the small one corresponds to a 9.6oz bottle): 6tbsp + 16oz cow’s milk + 12oz water = 31oz of liquid. This information is taken from Figure 5.4 in Apple (1987). Since 6tbsp = 3 oz by volume, this implies that 1oz of powder = 10.33 liquid oz of usable ready to use formula.

Figure 7 shows the monthly series, by city, for the price of one liquid ounce of Mellin’s-based formula thus obtained.

⁹See <http://americanhistory.si.edu/collections/object.cfm?key=35&objkey=110> for an example.

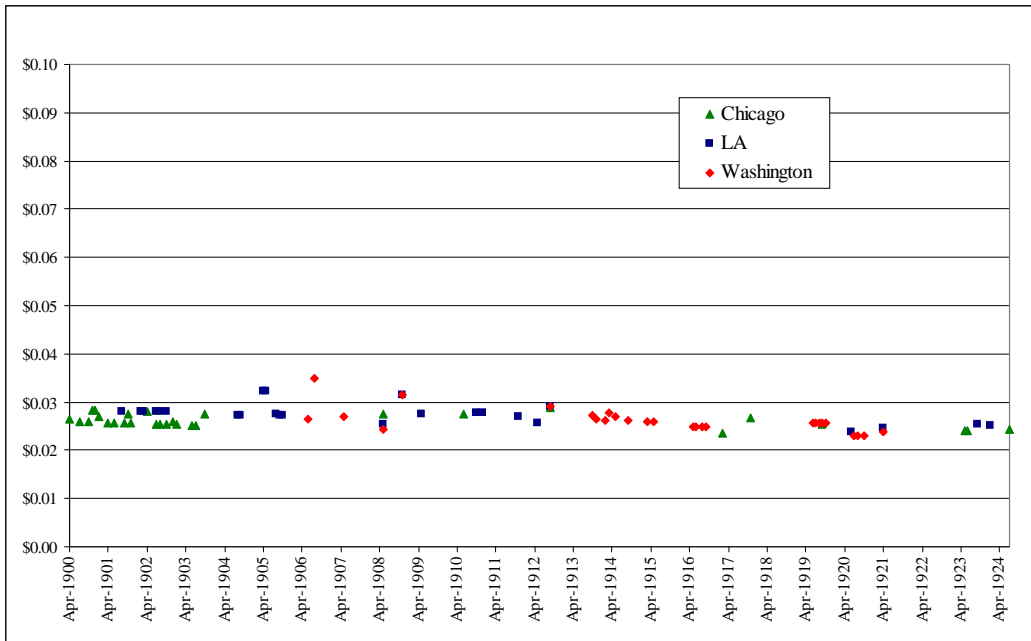


Figure 6: Unit Price of Nestle's by City

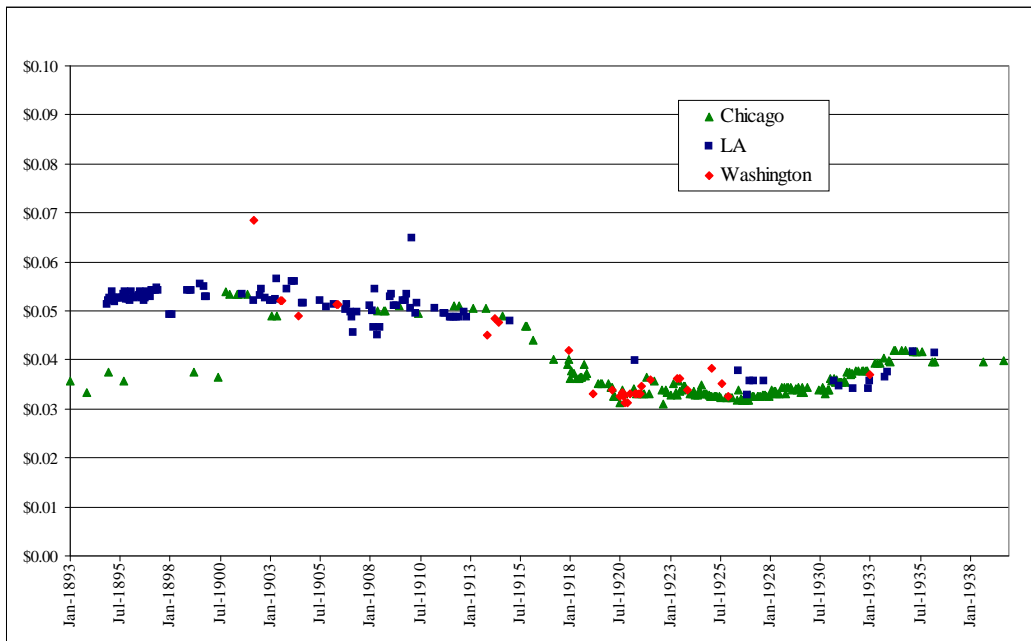


Figure 7: Unit Price of Mellin's by City

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