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Silver Circulation Worldwide:

Initial Steps in Comprehensive Research¹

Abstract

Published data on silver flows and stocks, gathered in volumes published by Moneta, provide a basis for initial steps in documenting flows of silver production and commerce from the sixteenth through the nineteenth century. Collection and publication of comprehensive data on silver flows will generate the first comprehensive study of flows of a commodity in the world economy of recent centuries, and will facilitate advances in global economic history. This article presents estimates from 1400 through 1900, showing annual flows of production, cumulative stocks (accounting for various levels of wear and tear), and the long-term rate of growth in silver stocks.

Recent economic historical study of silver in the world economy, from the 15th century onward, has stopped short of comprehensive quantitative analysis. This group uses recently published data from the nineteenth-century silver boom and the international meetings associated with the gold standard to begin such comprehensive analysis. Results indicate that, while world population grew at an annual rate of 0.45% per year, 1700–1900, silver stock rose at an approximate 0.7% per year in the same period. To support this confirmation of rapid monetization of the world economy, the article describes the procedure of estimating global flows and stocks out of competing estimates of silver flows.

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World-historical research is moving incrementally toward documenting historical production and exchange of major commodities. Rapid recent growth in study of global economic history has generated need for coherent time series on production and exchange of major commodities.² The purpose of the present study is to announce a major research project, identifying it as a comprehensive project for assessment of global output and global exchange of silver during the past half-millennium. Great quantities of data have been assembled on enterprise-level or national-level production and trade for numerous commodities, especially cotton, silk, wheat, rice, textiles, and iron. One can imagine that documentary study of leading commodities would lead to information on industries, as well as analyses of economic integration and transformation worldwide. Up to now, however, time-series figures for these commodities remain disaggregated and incommensurate, since scholars lack the research strategy and funding necessary to assemble data into coherent series that trace flows across space and time. Cotton in particular has attracted several major surveys. Nevertheless, great differentiation in stages of cotton production and huge varieties of cottons make it difficult to develop consistent time series data.³

Among leading commodities, silver has been of central importance in the global economy for the past five centuries. Silver presents particular benefits as object of a comprehensive research campaign because of availability of historical resources and the nature of new technologies that make documentation of its quantitative history relatively feasible. Silver is relatively well documented, so there is hope for preparing thorough and consistent datasets on its production and exchange. Andre Gunder Frank and the team of Dennis O. Flynn and Arturo Giráldez have argued that worldwide silver flows, from the sixteenth into the nineteenth centuries, facilitated formation and growth of a genuinely global economic system. Akinobu Kuroda has traced flows of silver from eleventh-century Eurasia to twentieth-century Ethiopia and Arabia. John TePaske tallied official records of production by the Spanish-controlled mines in the Andes.⁴

Debates on silver in world history stretch back for centuries, notably including emphasis on price inflation in seventeenth-century Europe as having been stimulated by Spanish imports of silver.⁵ Especially since the 1995 work of Flynn and Giráldez, it has become clear that large quantities of silver went through (not just to) Spain and also across the Pacific from Mexico to Manila, and then mainly to China—silks, in exchange, went to the Americas in large quantities.⁶ Of silver sent to Spain, it has become clear that much of it spread through Europe and was forwarded to buyers in Russia, the Ottoman Empire, and India. African imports of silver long remained at a low

level, but with time silver flowed from La Plata to Southeast Africa in exchange for slaves.⁷ Periodic efforts to summarize flows of silver have made significant headway, but have come to a halt well before developing definitive series. Nineteenth-century efforts by British and American analysts focused only on major industrial countries, generally downplaying such major producers and consumers as Mexico, China, and India.⁸

A Strategy for Documenting Silver Output and Exchange

At a recent meeting in Virginia City, Nevada—the city built above the Comstock Lode, which dominated world silver production from 1859 to 1874—scholars with several types of expertise on history of silver met and agreed to collaboration aimed at detailed documentation of silver flows. Dennis O. Flynn, an economist who has written widely on the role of silver in the world economy, convened the meeting. Georges Depuyrot, senior researcher at the Centre National de la Recherche Scientifique in Paris and editor of the *Moneta* series of numismatic and monetary history publications, has assembled substantial quantities of published data on silver flows. Saul Guerrero, an affiliate of Universidad Metropolitana in Venezuela with PhD degrees in chemistry and history, has recently completed a near-definitive study of the history and technology of silver mining in Zacatecas, the main mining province of Mexico. Patrick Manning, of the World History Center at the University of Pittsburgh, has led in coordinating efforts to create a world-historical data resource, with emphasis on silver as a key commodity.

These four, each able to call upon additional colleagues, agreed to the design of a research agenda to document silver extraction, exchange, and end-market locations for the period since 1500. It envisions collaborative, world-wide research linking many types of data and multiple analytical perspectives to analyze processes of silver production (both technical and social) and to document flows and stocks of silver in the world economy from 1540 to 1900—and ultimately to the present. Three lines of research will be pursued at once, using multiple methods and resources to triangulate plausible estimates of silver flows and stocks. In all three approaches, it is emphasized that quantitative data collected must be attributed with margins of error. The three approaches are:

- **Secondary research, to provide a low-end estimate of silver output and flows.** This approach will work with published accounts, including descriptions of processes, as well as official estimates of silver mine production and flows and stocks of silver across the globe. This strategy will yield low-end estimates, in that secondary accounts may fail to report on levels of production or purchase of silver for key regions and key periods of time.
- **Primary research, to provide a middle-level estimate of silver output.** This approach relies on exhaustive analysis of primary records: records of output and exchange from mines, tax receipts, and documents on exchange of silver.⁹ In addition, proxies and simulations will document processes of production to estimate likely flows of silver output based upon necessary absorption of estimated quantities of inputs such as ore extracted, ore quality, timber fuels, water, lead, salt, copper sulphate, and mercury. After establishing an inventory of installed production infrastructure by region and period, a percentage usage of known refining capacities can also be used to estimate actual bullion output.
- **Primary research on inventory demand for silver, to provide a high-end estimate of silver flows.** This method relies on a theory of inventory demand: that is, the end-market locations and levels of silver holdings required by participants in the world economy in order to satisfy monetary and non-monetary needs—and the annual purchases of silver necessary in order to sustain desired holdings.¹⁰ Estimates will be made for stocks of silver required by populations and institutions in specific regions throughout the

world, based upon probate records, court cases, and other primary sources that specify quantities of wealth held in the form of bullion, specie, and other objects of silver wealth held by people, businesses, and governmental units of various categories. Wear and tear estimates—at levels commonly estimated—can then help to identify quantities of silver imports required to sustain silver-stock requirements for each location at every point in time. This methodology is useful for estimation of flows of contraband, as well as unrecorded overland flows (above and beyond official silver flows reported in the ‘low estimate’ mentioned above that are based upon secondary literature).

The three approaches rely on significantly different methods of tabulation and estimation, each sustaining attention to the margin of error appropriate to the analysis. While it will be laborious to carry out three parallel types of analysis, benefits will appear if results of the various methods tend to reinforce one another. That is, if successive approximations by the various methods yield a result in which the three curves of aggregate silver flow (accompanied by their error margins) show clear parallels, this would indicate that our varying methods are closing in on revealing the underlying reality of past silver output and exchange. Details of this strategy are being developed by the research team in proposals for funding.¹¹

Secondly, we present results of our initial foray into our first approach: surveying secondary research on silver production and exchange. We focus on analysis of three volumes of data, edited by Georges Depeyrot and published by Moneta, providing an extensive survey of estimates of silver production and exchange that were constructed in the late nineteenth century and that extend back to the fifteenth century.¹² We tally estimates of production and exchange made available in these volumes, and conduct an elementary analysis of these data. Our results show that estimates of silver production and flows by this method are larger than those previously reported, especially for the period 1870-1900, even though ours are sure to be minimal estimates. As we argue below, these estimates based on secondary sources will give indications on where additional primary research on silver production is necessary (for instance, regarding Mexico); they will also indicate instances for which studies of inventory demand will reveal likelihood of large-scale imports of silver (for instance, regarding China). In these ways, the strategy of relying on interplay of three types of estimates of silver quantities will advance data collection through each method.

Secondary Research—Methods for an Initial Foray

La Collection Moneta has published nearly two hundred volumes on numismatics and monetary history: the three volumes on silver and gold in recent centuries thus build on the editor’s long experience in assembling such data.¹³ The purpose of these three volumes is to republish and analyze the documents of the international monetary conferences held by France, Great Britain, Germany, and the United States, notably those of 1867 in France, 1878 in Paris, 1881 in Paris, and 1892 in Brussels.¹⁴ In the first volume, Depeyrot provides a detailed introduction, surveying quantities and types of currency from the Classical era forward, then focusing on the era 1700-1900, as silver and bimetallic systems gave way to a global gold standard, yet with monetary instability in that time as in others. The introduction refers to factors of industrialization, imperial expansion, and shifts in European national power structures.¹⁵ Volume 2 includes comprehensive data on production of gold and silver, principally for the years 1870-1900, summarized from contributions to the international monetary conferences. Volume 3 includes data from the same conferences on import and export of silver and gold, again principally for 1870-1900. Data begin with annual global totals of production; most data on production are presented as annual series for individual nations or territories; data on imports and exports are presented as flows between select pairs of territories.

Our initial analysis addresses data on silver production, published in Volume 2, and data on silver import and export, published in Volume 3. We began by electronically scanning most tables in Volume 2 and select tables in Volume 3.¹⁶ Tables include numerous, apparently independent reports on volumes of silver production: for silver production worldwide (Vo. 2, pp. 4-33), silver production by nation or territory (Vol. 2, pp. 34-238), and for import and export of silver and gold (Vol. 3, pp 4-489). Tables report data in various dimensions: weights in kilograms or ounces, values in dollars or pounds. We assembled and compared all series on global silver production, all series for each territory, and select series for trade among territories.¹⁷ We report these comparisons and other analysis in graphical form. In this way we are able to convey the general magnitude of flows of silver, but we do not disclose precise data used in the analysis, in order to respect the copyright and conditions of use of data set by Moneta and the DAMIN project of CNRS.¹⁸

Global Estimates of Silver Production, 1870 - 1900

Figures 1 and 2 display several related estimates of annual global silver production, based on documents for the period 1870-1900. First, Figure 1 shows a historical summary that we have selected as the best single estimate of global silver production given in Documents and Studies.

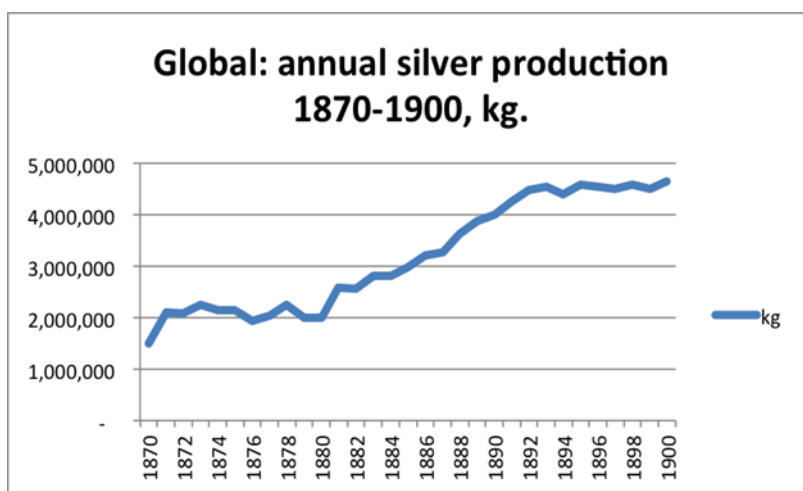
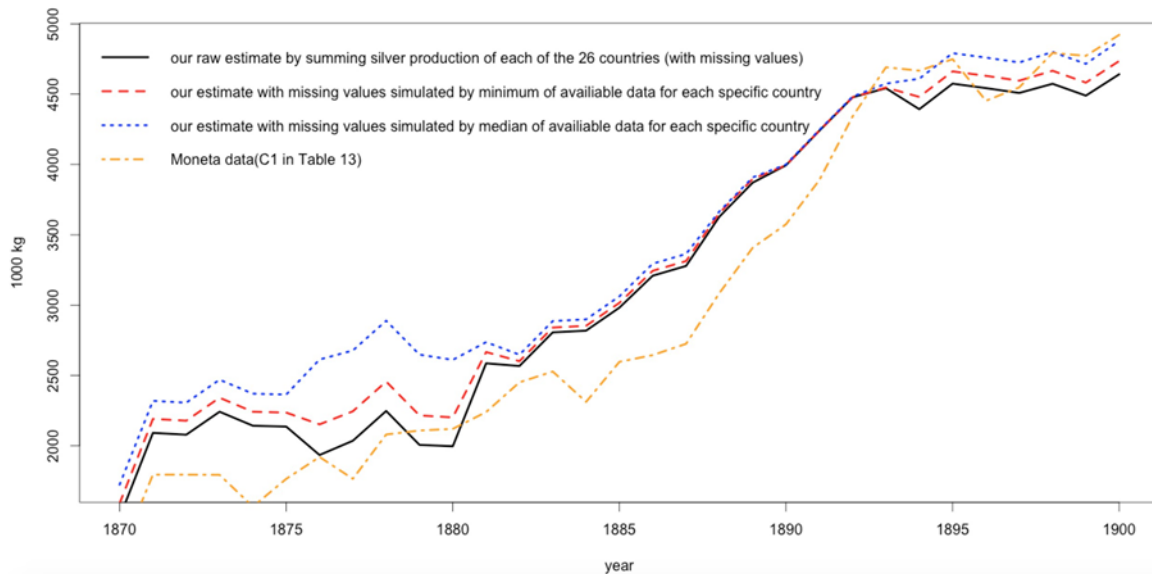


Figure 1: “Historical estimate” of Global annual silver production in kg, 1870-1900.¹⁹

To compare with these historical estimates, we developed “territorial-sum estimates” in three stages: 1) we began with the mean of multiple estimates for production by year in each territory; 2) we excluded outliers from calculation of the mean;²⁰ 3) we initially accounted for missing values by locating estimates for the same variable in other regions, transforming dimensions as necessary;²¹ 4) further, missing values were estimated with attribution of the minimum value of the variable over the range of years under consideration; and 5) in a higher approximation, missing values were estimated with attribution of the median value over the range of years under consideration.

Figure 2 displays results of these three estimates as compared with “historical estimates.” These are our effort to replicate historical production estimates by summing estimates of production by territory for three versions of a “territorial-sum estimate.” The legend describes various types of estimates.



Legend to Figure 2:

Curve A (bottom). Global annual silver production, 1870 to 1900, from historical records: the “historical estimate,” as shown in Figure 1.

Curve B (second up). Total annual silver production from 1870 to 1900, based on data for 28 territories (selected out of the 43 listed)—this is our “territorial-sum estimate” of global silver production, based on mean estimate for each territory, excluding outliers.²²

Curve C (third up). Territorial-sum estimate, estimating missing data at minimum.²³

Curve D (top). Territorial-sum estimate, estimating missing data at median.²⁴

Figure 2. Related estimates of global silver production, 1870-1900.

A major aspect of our analysis is comparing the reported “historical estimate” of global silver production with the “territorial-sum estimate” that we construct from reported data on nations and territories. The overall result is that the sum of territorial estimates generally exceeds the global historical estimate. Thus, researchers of the nineteenth century did a credible job of estimating global totals in silver production, but they generally did not succeed in gathering data from all regions of the world. Indeed, we have identified still further regions neglected in “territorial-sum estimates” that can be made from the Moneta volumes.

Next we explore in more detail the silver output of leading reported producers as compared with total production. Our data sets lead us to select the U.S., Mexico, and Germany as the top 3 suppliers. According to the stacked plot in Figure 3, we can see that, overall for 1870-1900, U.S. silver production was approximately 30% of global totals; the sum of U.S. and Mexican production came to just over 50% of the global total; and the sum of output from the U.S., Mexico, and Germany came to about 70%; all

other countries provided the remaining proportion, up to 30%. The total is the territorial-sum estimate shown in Figure 1.

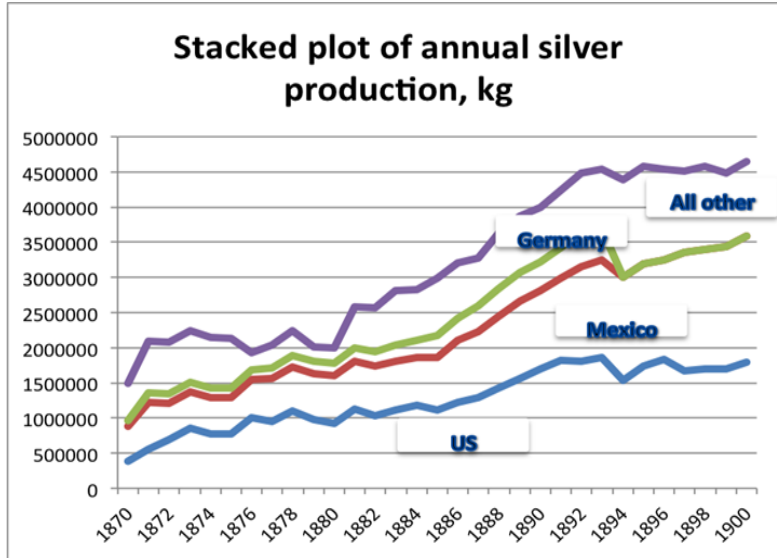


Figure 3: Annual silver production, 1870-1900: total and major contributors

Further, we can calculate cumulative silver production from 1870 by assuming that there was no silver production before that year. In addition, we adjust each year's cumulative total by assuming varying annual wear-and-tear loss of the accumulated silver stock, at rates of 0% (no loss), 1%, 2%, and 5%. Figure 4 reports these results in kilograms, showing that all four assumptions yield parallel patterns of growth at a steadily decreasing rate: 0% loss (territorial-sum data) yields the curve with largest values, while 5% yields the smallest values; differences among these four curves are more apparent at later times. For territorial-sum data, the cumulative total of silver stock in 1900 is estimated at near 100 million kilograms.

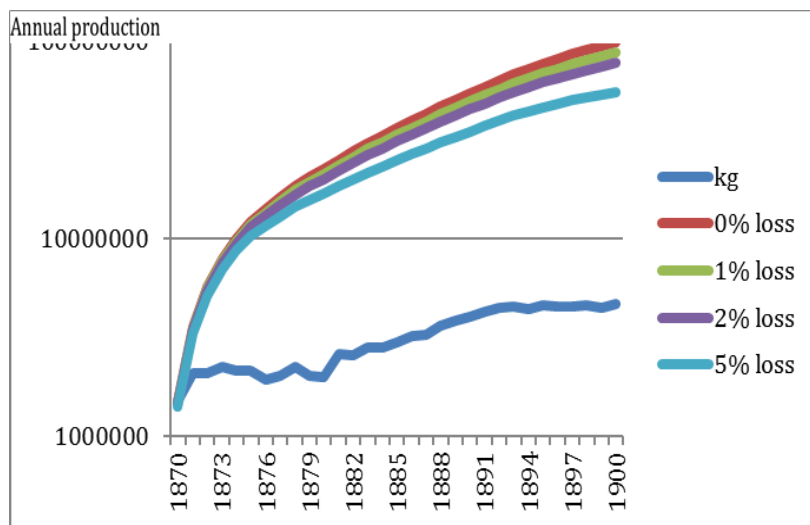


Figure 4: Cumulative silver production, 1870-1900

To give an idea of the implicit per-capita holdings of silver, one can divide the estimated 100 million kilograms of silver in 1900 by 1900 global population of 1.6 billion. The result is .0625 kilograms or 62.5 grams of silver per person—or roughly US\$ 1.34 per person at current (1900) prices.²⁵ Even in those days of silver boom, silver holdings per person were modest.

We conclude this section with an observation on data inconsistencies in our published sources. Original data in the *Moneta* books, because they are based on reports from various nations to the 1870–1900 international conferences, are not always consistent. For instance, Figure 5 shows that global silver production, presented in kilograms and ounces, was relatively consistent through 1891, but totals in ounces were well below totals in kilograms from 1892 to 1900.²⁶ Attention to detail in analysis should make it possible to resolve most inconsistencies.

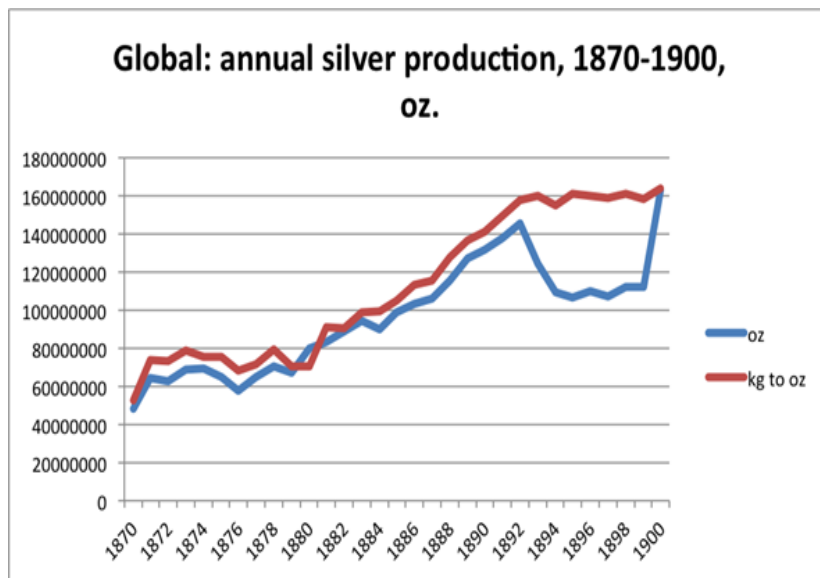


Figure 5: Global annual silver production in kg and oz, 1870-1900

Global Silver Production, 1403 - 1903

For global silver production from 1403 to 1903, we extend our method for “preferred” estimates to the longer period.²⁷ Results are given in Figure 6, but with quantities recorded in ounces. The curve shows a relatively steady rate of increase in global silver production from the sixteenth century to the nineteenth century (though with an era of slower growth in the seventeenth century), except for a decline in output during the Napoleonic Wars. By 1851 silver production increased to 38 million ounces; by 1903 annual production reached 160 million ounces.

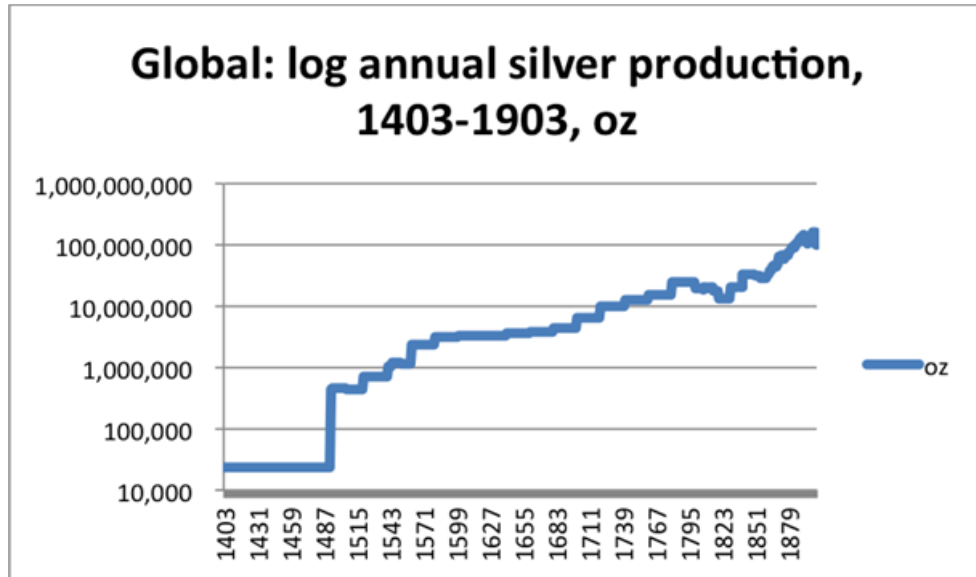


Figure 6: Global annual silver production in oz, 1403-1903

Next, working with data in Figure 6, we calculate the cumulative stock of silver produced over time. Figure 7 shows estimates of cumulative stock of silver, assuming zero stock in 1403 and accounting for annual losses of silver stock of 0%, 1%, 2%, and 5%, from 1403 to 1903. Figure 7 (1403 to 1903) is parallel to Figure 4, which presents similar calculations for a shorter period (1870-1900). Figure 7 shows an ongoing, cumulative increase in silver stock 1403 to 1733.

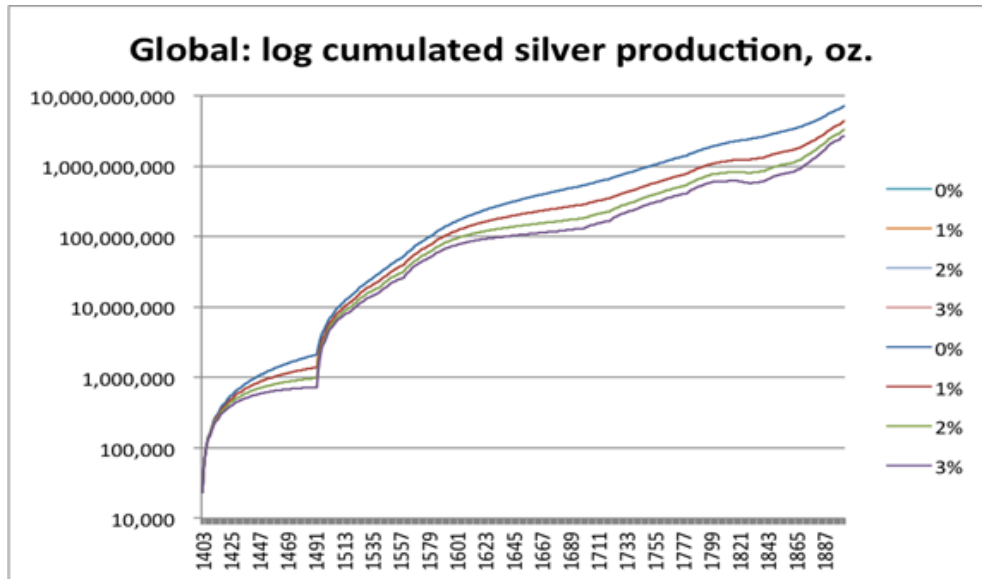


Figure 7: Global annual silver production in oz, 1403-1903

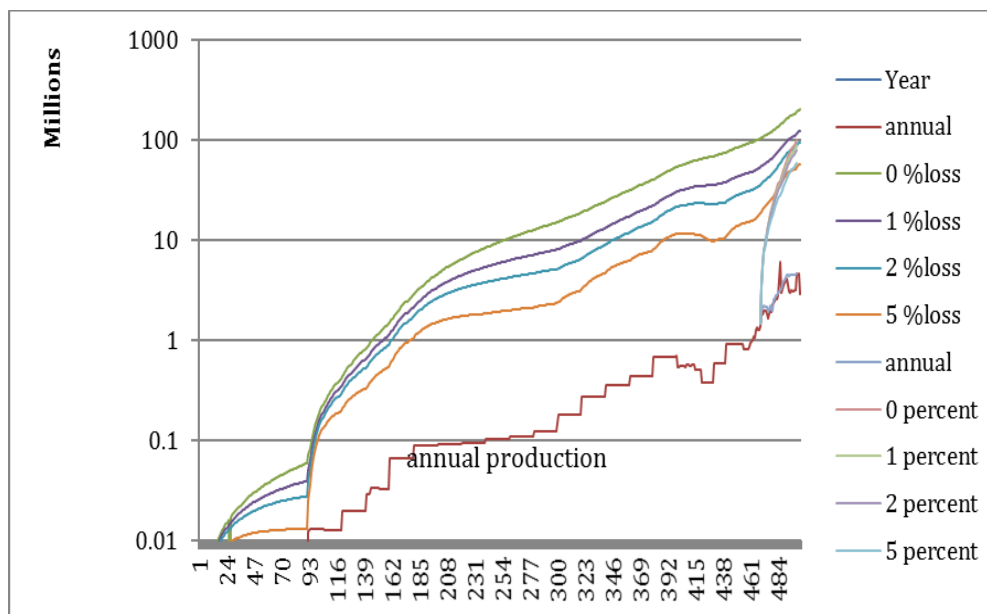


Figure 8: Global annual silver production in oz, 1403-1903 and 1870-1900

Next we extend discussion of cumulative global silver stock, comparing long-term and short-term perspectives, as indicated in Figure 8. As global population grew from roughly 640 million in 1700 to 1.6 billion in 1900, the silver stock rose from 500 million ounces to 5 billion ounces (assuming a 1% annual loss in silver stock).²⁸ In that case, per capita silver holdings rose from 0.78 ounces per person in 1700 to 3.1 ounces per person in 1900. That is, population grew at a rate of 0.45% per year while the silver stock grew at a rate of 0.7% per year over those two centuries—close to double the rate of population growth and an impressive rate of average global silver holdings, which may mean expanding monetization. In the sixteenth century, population grew at a slower rate (perhaps declining overall), while silver stocks grew at a greater rate. In sum, these estimates are consistent with a very high rate of global monetization during the fifteenth and sixteenth centuries, declining to a slower but still high rate in the eighteenth and nineteenth centuries. These are, of course, preliminary estimates: we look forward to considering further implications of these estimates and to seeing what new research results bring modification of estimates.²⁹

Figure 8 also shows that, by 1900, a very substantial proportion of the world’s current silver stock had been produced in the years after 1870—even if one assumes no loss of silver over time. That is, at any time, a significant proportion of the production of silver went to replacing silver that had been lost in recent years. Since Figure 8 shows a cumulative 1900 total of silver production since 1403 at a 2% loss was no more than a cumulative total of silver production since 1870, it suggests that the entire world’s supply of silver would have been replaced in the period from 1870 to 1900.³⁰

International Silver Exchange, 1870 – 1900 (from Volume 3)

Volume 3 of the Moneta collection includes a section with tables mixing gold and silver imports and exports for 39 nations and territorial units, followed by a section limited to silver imports and exports.³¹ Our objective is to transform these series of bilateral exchanges into a visualization of overall global flows in silver. We begin with some idea of the overall contours of the global flows of silver. For instance, in the era from 1870 to 1900, we can be certain that most silver had its origin in Mexico and the United States, followed by Europe and South America.

Second, we can assume that silver went next to centers of distribution, principally in England and the United States. From these centers, silver went in many directions to other purchasers. How are we to visualize these three (and perhaps additional) levels of silver flow? It may be that researchers working in marketing and flows of commerce have developed visualizations that can be useful in displaying the historical flows of silver.

In the meantime, we present a few illustrations of levels of silver import and export for England and the United States in the period from 1870 to 1900.

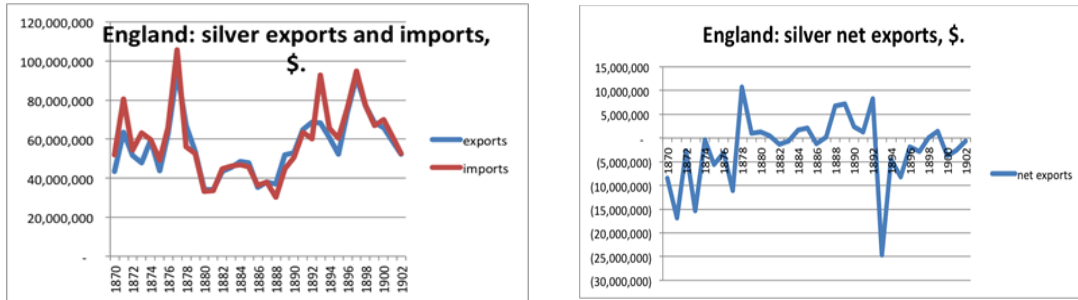


Figure 10. England: silver imports, exports, and net exports

Figure 10 shows English foreign trade in silver. While levels of import and export fluctuated substantially, they remained close enough together that net exports were close to zero. For the United States, which was producer as well as merchant of silver, the picture was quite different. Imports and exports both rose, roughly in parallel, and net exports were substantially positive, although with occasional troughs.

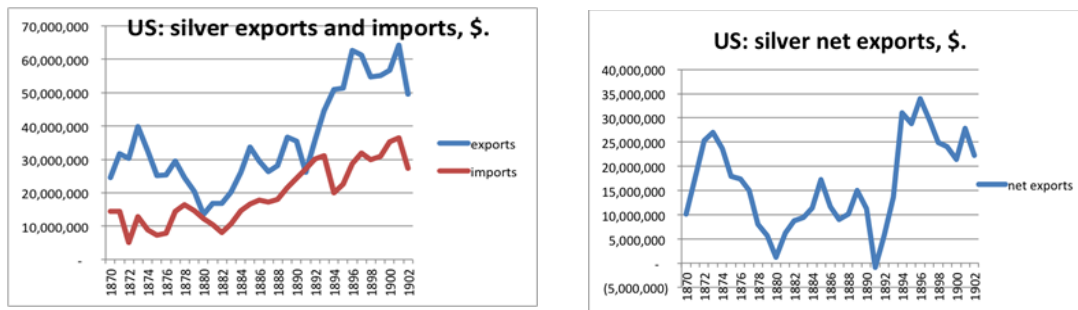


Figure 11. United States: silver imports, exports, and net exports

Work is proceeding on the representation of multi-destination flows of silver: initial efforts in Figures 12 and 13 show an underlying pattern but complex details. Figure 12 shows principal sources of England's imports of silver and the principal destinations of English silver exports; Figure 13 shows parallel data for the United States. The totals for imports and exports in each case remain stable, but the specific directions of the flows vary widely.

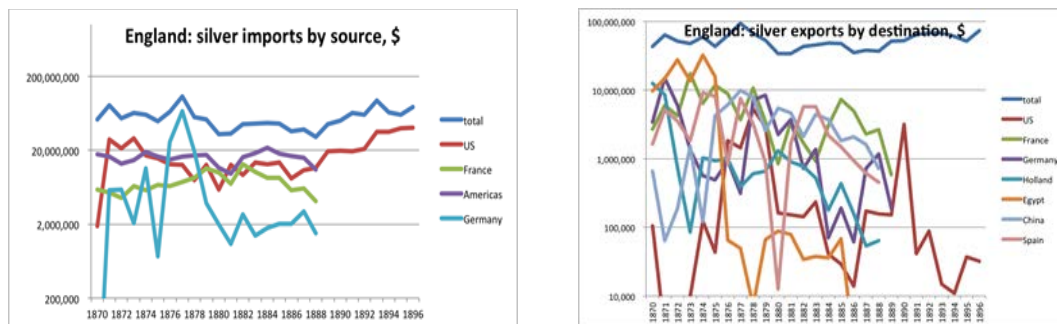


Figure 12. England. Imports by Source; Exports by Destination



Figure 13. United States. Imports by Source; Exports by Destination

Further Frontiers in Secondary Research

The quantity and quality of secondary data on silver production vary greatly by place and especially by time. The focus in this paper has been the era from 1870 to 1900, probably the most intensive era of analysis of silver flows because of rapid industrial expansion and tumultuous change in monetary systems. We have demonstrated that published data from that era are highly valuable but also inconsistent even in great economic centers and that they are incomplete in addressing important areas of production and demand.

We conclude with a brief look at sources available for analysis of earlier periods, by listing major secondary sources on silver production and exchange for four periods: Table 1 lists sources by period for 1200-1550, 1550-1800, and 1800-1870. We have left out periods after 1870 for two different reasons. For the period 1870-1910, sources are voluminous and Georges Depuyrot has done an excellent job of listing them in the bibliography of *Moneta* volumes. For the period after 1910, sources are also voluminous, but we have not yet focused on assembling them systematically.

For periods before 1870, it is clear that most evidence awaits us on the period from 1550 to 1800, for which many works involve partial analyses that can be combined into an overall analysis of secondary materials. The period from 1800 to 1870, in contrast—the period of the Napoleonic wars, independence of Mexico, the Comstock Lode in Nevada, and rise of American silver shipping—has been studied to a lesser degree, and is ready for detailed

analysis. Third, the period before 1550, while documented much more sparsely than later periods, can still provide indications on the significance of Old World silver mining and exchange, in order to provide a baseline for studies of later periods.

Secondary Sources on Silver Production, by Era. Many scholars have proposed estimates of silver production and flows for various flows and regions, drawing on various primary sources and principles for estimation. Listing these secondary works will be the object of two types of research. First, the estimates of these authors can be assembled to provide the secondary, low-end estimates of silver stocks and flows described above. Second, the primary sources listed in these works will be included in the middle-level, primary-research dimension of the overall research project.

1200-1550

Day, J. 1978. "The Great Bullion Famine of the Fifteenth Century." *Past and Present* 79: 3-54.

Depeyrot, G. 1995. *Histoire de la monnaie, des origins au 18e siècle. II. Du 14e au 16e siècles*. Wetteren: Moneta.

Kuroda, A., 2009. "The Eurasian silver century, 1276-1359: commensurability and multiplicity." *Journal of Global History* 4: 245-269.

1550-1800

Atwell, W. S. 1986. "Observations on the 'Seventeenth-Century Crisis' in China and Japan." *Journal of Asian Studies* 45, 2: 223-244.

Atwell, W. S. 1990. "A Seventeenth-Century 'General Crisis' in East Asia?" *Modern Asian Studies* 24, 2: 661-682.

Atwell, W. S. 2002. "Time, Money, and the Weather: Ming China and the 'Great Depression' of the mid-Fifteenth." *Journal of Asian Studies* 61, 1: 83-113.

Bailey, W. B., and B. Zhao. 2009. "Familiarity, Convenience, and Commodity Money: Spanish and Mexican Silver Dollars in Qing and Republican China." <http://dx.doi.org/10.2139/ssm.1424070>.

Boxer, C. R. 1970. "Plata es Sangre: Sidelights on the Drain of Spanish-American Silver in the Far East, 1550-1700." *Philippine Studies* 18, 3: 457-478.

Boyer-Xambeu, M-Th., Gh. Deplace and L. Gillard. 1995. "Bimetalisme, taux de change et prix de l'or et de l'argent, 1717-1873," *Economies et Sociétés* 29, 7-8: 1-377.

Brading, D. A. 1970. "Mexican silver-mining in the eighteenth century: The revival of Zacatecas." *Hispanic American Historical Review* 50, 4: 665-681.

Brading, D. A. 1972. "Colonial Silver Mining: Mexico and Peru." *Hispanic American Historical Review*, 52, 4: 545-579.

Chaudhuri, K.N. 1963. "The East India Company and the Export of Treasure in the Early Seventeenth century." *Economic History Review*, NS 16, 1: 23-38.

- Chaudhuri, K.N. 2003. "The inflow of silver to Bengal in global perspective, c. 1650-1757." *Global Connections and Monetary History, 1470-1800*, eds. D.O. Flynn, A. Giraldez, R. von Glahn (Aldershot: Ashgate), 159-168.
- Depeyrot, G. 1996. *Histoire de la monnaie, des origines au 18e siècle. III. Les 17e et 18e siècles*. Wetteren: Moneta.
- Fisher, J. 1975. "Silver Production in the Viceroyalty of Peru, 1776-1824." *Hispanic American Historical Review* 55, 1: 25-43.
- Flynn, D. O. 2009. *A Price Theory of Monies: Evolving lessons in monetary history*. Wetteren: Moneta.
- Flynn, D.O. and A. Giraldez, 1995. "Born with a 'Silver Spoon': World Trade's Origin in 1571." *Journal of World History* 6, 2: 201-221.
- Flynn, D. O. and A. Giraldez. 1995. "Arbitrage, China, and World trade in the Early Modern Period." *Journal of the Economic and Social History of the Orient* 38, 4: 429-448.
- Flynn, D.O. and A. Giraldez. 2002. "Cycles of Silver: Globalization as Historical Process." *World Economics* 3, 2: 1-16.
- Flynn, D.O. and A. Giraldez, eds. 2010. *China and the Birth of Globalization in the Sixteenth Century*. London: Ashgate.
- Flynn, D.O., Arturo Giraldez, and Richard von Glahn, eds. 2003. *Global Connections and Monetary History, 1470-1800* (Aldershot: Ashgate).
- Frank, A. G. 1998. *ReOrient, Global Economy in the Asian Age*. Berkeley: University of California Press.
- Garner, Richard L. 1988. "Long-Term Silver Mining Trends in Spanish America: A Comparative Analysis of Peru and Mexico." *American Historical Review* 93, 4: 898-935.
- Lees, W. N. 1864. *The drain of silver to the East and the Currency of India*. London: W. H. Allen & Co.
- Lin, M. H. 2011. "Latin America Silver and Early Nineteenth-century China," *Third European Congress for World and Global History*, 2011.
- Miyamoto, M. Shikano, Y. 2003. "The Emergence of the Tokugawa monetary system in East Asian international perspective," in *Global Connection and Monetary History*, eds. Flynn, Giraldez & von Glahn, 169-186.
- North, M. 1991. "Bullion transfer from Western Europe to the Baltic and to Asia, 1550-1750." Van Cauwenberghe, E. H. G., ed., *Money, Coins, and Commerce: Essays in the Monetary History of Asia and Europe* (Leuven: Leuven University Press), 185-195.
- Prakash, O. 2003. "Precious Metal Flows into India in the Early Modern Period." *Global Connections and Monetary History, 1470-1800*, eds. Flynn, Giraldez, von Glahn (Aldershot, 148-158).
- Von Glahn, R. 1994. "Myth and Reality of China's Seventeenth-century monetary crisis." *Journal of Economic History* 56, 2: 429-454
- Von Glahn, R. 1996. *Fountain of Fortune. Money and monetary policy in China, 1000-1700* (Berkeley: University of California Press).

Von Glahn, R. 2003. "Money use in China and changing patterns of global trade in monetary metals 1500-1800." *Global Connection and Monetary History, 1470-1800*. 187-205.

Vries, J. de. 2003. "Connecting Europe and Asia: A Quantitative Analysis of the Cape-route trade, 1497-1795." *Global Connections and Monetary History 1470-1800*, 35-106.

1800-1870

Irigoin, A. 2009. "Gresham on horseback: the monetary roots of Spanish American political fragmentation in the nineteenth century." *Economic History Review* 62/3: 551-575.

Irigoin, A. 2009. "The End of the Silver Era: The consequences of the breakdown of the Spanish peso standard in China and the United States, 1780-1850." *Journal of World History* 20, 2: 207-244.

Salvucci, R. J. 1991. "The Origins and Progress of U.S. – Mexican trade, 1825-1884: "Hoc opus, his labor est." *Hispanic American Historical Review* 71, 4: 697-735.

Schell, W. 2001. "Silver symbiosis: ReOrienting Mexican Economic History." *Hispanic American Historical Review* 81,1: 89-133.

1850-1910

We leave aside the very dense bibliography for this period of rapid monetary change and intense study. For details, see the bibliography in Depeyrot, *Documents and Studies*.

1910 – 2000

Resources for this era are to be collected.

Conclusion

We conclude this introductory exploration of our research into silver circulation worldwide by reaffirming our belief that documenting flows of major commodities is an important and feasible topic in global economic history. These elementary results point to more detailed documentation of silver production and flows that can be achieved through continued work at the current pace. Further, we will continue to seek funding for expanded work on published data, for expanded primary research of the sort that has been achieved for the mines of Zacatecas, and for the conceptualizing and documenting of inventory demand by consumers of silver. An essential objective of our work is display of silver documentation via an online repository to make data accessible to all researchers.³²

We are impressed to see that source materials used in the Moneta reference work, mostly compiled in the late nineteenth and early twentieth century, included thorough estimates of silver production all the way back to the fifteenth century. We have compiled, cumulated, and displayed those estimates, and believe that they provide a good preliminary estimate of global silver flows and stocks. Further research should draw together all estimates of silver production and exchange, by time and place, and compare those results with these preliminary estimates.

NOTES

¹ The authors express appreciation to Saul Guerrero and Georges Depeyrot for their helpful commentary.

² For a comprehensive overview of economic history by region and topic, see Pat Hudson and Francesco Boldizzini, eds., *Routledge Handbook of Global Economic History* (London: Routledge, 2016).

³ Prasannan Parthasarathi, *The transition to a colonial economy: weavers, merchants and kings in South India, 1720-1800* (Cambridge: Cambridge University Press, 2001); Giorgio Riello, *Cotton: the fabric that made the modern world* (Cambridge: Cambridge University Press, 2013); Sven Beckert, *Empire of cotton: a global history* (New York: Alfred A. Knopf, 2014); Richard Bulliet, *Cotton, Climate, and Camels in Early Islamic Iran: A Moment in World History* (New York: Columbia University Press, 2011).

⁴ Andre Gunder Frank, *ReOrient: Global Economy in the Asian Age* (Berkeley: University of California Press, 1998); Dennis O. Flynn and Arturo Giráldez, "Born with a 'Silver Spoon': World Trade's Origin in 1571," *Journal of World History* 6 (1995): 201-221; Akinobu Kuroda, "The Eurasian silver century, 1276-1359: commensurability and multiplicity," *Journal of Global History* 4 (2009), 245-269; Kuroda, "The Maria Theresa dollar in the early twentieth-century Red Sea region: a complementary interface between multiple markets," *Financial History Review* 14 (2007): 89-110; John Jay TePaske and Kendall W. Brown, *A New World of Gold and Silver* (Leiden: Brill, 2010).

⁵ David Hackett Fischer, *The Great Wave: Price Revolutions and the Rhythm of History* (New York: Oxford University Press, 1996); Earl J. Hamilton, *American Treasure and the Price Revolution in Spain, 1501-1650* (New York: Octagon, 1965); R. B. Wernham, *The Counter-Reformation and Price Revolution, 1559-1610* (Cambridge: Cambridge University Press, 1968).

⁶ Flynn and Giráldez, "Born with a 'Silver Spoon'"; Flynn and Giráldez, "Silk for Silver: Trade via Manila and Macao in the 17th Century," *Philippine Studies* 44 (1996), 52-68.

⁷ Pedro Machado, *Ocean of Trade: South Asian merchants, Africa and the Indian Ocean, 1750-1850* (Cambridge: Cambridge University Press, 2014).

⁸ For estimates of twentieth-century silver production, see the summaries prepared by the United States Geological Survey, available at <https://minerals.usgs.gov/minerals/pubs/commodity/silver/>.

⁹ Guerrero, Saul. "The Environmental History of Silver Refining in New Spain and Mexico, 16c to 19c: A Shift of Paradigm." PhD Dissertation, Dept. of History and Classical Studies, McGill University, March 2015.

¹⁰ For a development of the concept of inventory demand, see Dennis O. Flynn, "Accumulation: Theory from History" (forthcoming).

¹¹ For secondary research, the approach described in the next section of this text will be pursued through resources including those listed in Table 1. For primary research, the approaches applied in Guerrero's dissertation will be applied further, distinguishing dry smelting of silver (relying on burning of large quantities of wood and charcoal) from wet amalgamation of silver (relying on mercury at cold temperatures); estimates of

output capacity for individual mines will permit estimates of output at roughly 60% of capacity. For inventory demand, algorithms for demand in various social situations will be based on levels of population and consumption of selected commodities.

¹² Georges Depeyrot, *Documents and Studies on 19th C. Monetary History*, 3 vols. (Wetteren, Belgium: Moneta, 2015).

¹³ DAMIN, *La Dépréciation de l'argent monétaire et les relations internationales* (ANR 2011 BSH3 008 01). Published as Georges Depeyrot, *Documents and Studies on 19th C. Monetary History*, 3 vols. (Wetteren, Belgium: Moneta, 2015). They are volumes 189, 190, and 191 in the overall Moneta series.

¹⁴ Depeyrot, *Documents and Studies*, I:3-4.

¹⁵ Depeyrot, *Documents and Studies*, I:5-60. The remainder of Volume 1 includes graphic summaries of national data on gold and silver production, coin production, monetary stocks, and a detailed bibliography.

¹⁶ the relevant pages of Depeyrot, *Documents and Studies*, are scanned into PDF files. Then for each PDF file, an online OCR software is utilized to convert it to an Excel file. Through this process, we can get access to all corresponding data in our laptops. If appropriate permissions can be obtained, we will make our data files available online as comma-separated values.

¹⁷ For example, Volume 2 of *Documents and Studies* includes six estimates of global silver production from 1873 to 1880: in column 1 of Table 8, column 2 of Table 10, column 1 of Table 13, column 4 of Table 13, column 5 of Table 13, and column 1 of Table 14.¹⁷ And for the year of 1873, the six values in ounces are 63,317,014; 63,316,210; 63,267,187; 63,317,014; 63,267,000; 63,267,000; 63,267,000; and 63,288,346.43.

¹⁸ DAMIN, *La Dépréciation de l'argent monétaire et les relations internationales* (ANR 2011 BSH3 008 01). Published as Georges Depeyrot, *Documents and Studies on 19th C. Monetary History*, 3 vols. (Wetteren, Belgium: Moneta, 2015).

¹⁹ In Figure 1 we selected, as a valuable estimate from the historical records, column 1 in Table 13 of Vol. 1, pp. 18-19, from United States annual reports, 1890-1903. This time series, without corrections except that it is converted from ounces to kilograms at a ratio of 35.274, is labeled here and elsewhere as the "historical estimate" of global silver production, 1870-1900.

²⁰ We use the global silver production of 1873 again as an example. If the six values are 63,317,014, 63,316,210, 63,267,187, 63,317,014, 63,267,000, 63,267,000, 63,267,000 and 83,288,346.43, then we will ignore the outlying value 83,288,346.43 and use the remaining five to calculate the mean estimate.

²¹ To be more specific, suppose that, for France, we know its silver production in dollars from 1870 to 1900 and its silver production in kilograms within this time period except 1880-1885. In order to fill in the missing kilogram values for 1880-1885, we first go through all other producers in the book, noticing that we have production data in both dollars and kilograms for Russia. Then annual rates between kilogram and dollars can be achieved easily, which are then used to impute the missing kilograms silver productions for France from 1880 to 1885.

²² Covering both huge suppliers, such as the United States, Mexico, Chile, Bolivia, Germany and so forth, and tiny producers, such as Finland, Norway, and Sweden.

²³ In this case, missing values are estimated as the minimum positive value reported in the interval 1870-1900

²⁴ Missing values are estimated as the median value reported in the interval 1870-1900.

²⁵ 60 cents per ounce 1900; 28 grams per ounce. So 62.5 grams of silver is $62.25/28 = 2.23$ ounces per person. At 60 cents per ounce that would yield $2.23 * .60$, or \$1.34 per person in US Dollars of 1900.

²⁶ Calculation of data for Figure 5: In order to visualize this clearly, we first transform all kilogram estimates to ounce by a ratio of 35.274, and denote it as 'kg to oz'. The other ounce estimates are denoted as 'oz'. However, for 1892-1900, 'oz' are significantly smaller than 'kg to oz'.

²⁷ The source tables are in Depeyrot, *Documents and Studies*, II:13-20.


²⁸ Populations from Angus Maddison, *The World Economy* (Paris: OECD, 2006). Revisions to Maddison totals need to be developed, but these figures are sufficient to compare the rates of growth of population and silver stock.

²⁹ The estimates will have implications for the important question of the changing distribution of silver stocks among continents and nations.

³⁰ This simple result is complicated, however, by the fact that the 1403-1903 estimate for annual and cumulative silver production is lower by about 10%, for the period 1870-1900, than the estimates restricted to the period 1870-1900. While we stand by our overall statement on the impact of a 2% loss rate, we also reaffirm our point that more thorough analysis of existing estimates is necessary.

³¹ For tables on regional silver and gold tables, see pp. 179-317 for the United States and pp. 18-178 and 318-320 for 37 other regional units. For tables on import and export of silver alone, see pp. 401-488 for the United States and pp. 321-400 and pp. 489-490 for other regions.

³² The CHIA project is working to expand its world-historical data repository to encompass data on silver production and flows. Publication of such data, however, requires agreements on rights of all owners of the data, and may require time and new institutional arrangements in order to take place.

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