Long-Term Silver Mining Trends in Spanish America: 
A Comparative Analysis of Peru and Mexico

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When Spain conquered the Aztec and Inca empires, it acquired territories so rich in silver that Spanish America became the world’s leading supplier. From the middle of the sixteenth century to the end of the colonial era, it produced between 3 and 3.5 billion ounces, or a hundred thousand tons, of silver. Scholarly opinion has long held that silver mining had a profound impact on the development of the colonial economies and, because so much silver was exported, on the development of the economies of Spain and Europe. But scholars have been handicapped in testing hypotheses about economic development from American treasure because they have lacked long series of data on silver production in Peru and Mexico. In the last two decades, that void has been filled.1 It is possible now to determine when

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silver production increased or decreased, by how much, and for what length of time in Spanish America, in each viceroyalty (Peru and Mexico), and in several of the larger mining camps or districts. These calculations show that during the first half of the colonial period (circa 1560–1685) Spanish American mines provided between 25,000 and 30,000 tons of silver to the Atlantic World and beyond; during the second half (1686–1810), that amount more than doubled. Although the Spanish American silver curve does not rise steadily or gradually upward, the "upward trend always predominates." Since the Spanish colonial silver industry helped to drive both the American and European economies, more knowledge of the secular trends in mining and the factors that influenced those trends would shed further light on how the Atlantic economy performed. Although Peru had at Potosí the richest silver mining camp, Mexico boasted two important advantages for long-term growth—higher ore grades and lower operational costs—that Peru lacked. Because of these advantages, merchants, who controlled much of the capital market in the New World, had more incentive to invest in expensive re rehabilitations of mines in Mexico than in Peru. But, despite a severe depression in Potosí during the seventeenth century and a more costly and less profitable industry throughout Peru, mining did not die out in Potosí or across the viceroyalty. There were bursts of activity, from opening new camps to rehabilita ting old ones, throughout the colonial period, and in the eighteenth century an impressive recovery was engineered at Potosí and several other camps. Although Potosí did not regain its former preeminence, it remained one of the largest producing camps in Spanish America as late as two centuries after its founding. Faced with a low return per unit of processed ore, Peruvian mining came to have a marginal character, in contrast to Mexican mining. The survival of the often condemned draft-labor system (miuta) in Peru may be explained in part because owners could pay miuta workers less than voluntary laborers and thereby reduce their operating costs. Mexican miners had to be cost-conscious, too, but with higher profit margins they could attract the long-term financing that was crucial to keep the industry healthy.

Economies of Mexico and Peru, 46–60. I have converted all the silver series to pesos on the basis of 8 pesos per mark (8 onces) of silver.

2 Pierre Chaunu and Huguette Chaunu's massive study, Seville et l'Atlantique (1501–1650), 8 vols. (Paris, 1955–59), concerns a conjuncture between Europe and the New World in the sixteenth and seventeenth centuries. A recent important study, based on sources from Holland, is Morincongale, zezettes et fabuleux métaux, 42–119, 220–350. The debate over the value of the study of the longue durée is treated in Peter Burke, ed., Economy and Society in Early Modern Europe (London, 1972), especially in Burke's "Introduction," 1–9. Essays by Carlos Cipolla (43–46) and Alexandre R. E. Chabert (47–54) offer different interpretations on the impact of the flow of silver to Europe, primarily with reference to Italy. In setting up his differences with Cipolla over how to describe the price movement after 1550 in Italy, Chabert acknowledged cyclical dips but asserted that "the upward trend always predominates" (50). The same language, I would argue, could describe the silver-production trend in the Spanish New World.

3 For a wide-ranging discussion of the mining industry in Peru and Mexico, see David Brading and Harry Cross, "Colonial Silver Mining: Mexico and Peru," Hispanic American Historical Review, 52 (1972): 345–79.
The total output of the Spanish colonial mines between the middle of the sixteenth century and the end of the colonial period reached between 2.9 and 3.1 billion pesos (each peso of 272 maravedís). That total represents an annual average production of between 11.5 and 13.5 million pesos.\(^4\) The trend line, as shown on

\(^4\) John TePaske has come up with a total of just over 3 billion from the 1580–1810 period, whereas my total of just under 3 billion is for a longer period, 1559–1810. Such differences will occur because of the several steps required to convert the tax receipts into silver-production series. TePaske’s data will be published in a forthcoming book on Peru’s and Mexico’s economies. To save space, I have not included tables of annual silver production for the colonies or the camps in this essay. I will make these available, with relevant sources and statistics, on computer printouts to anyone interested. The dates for the various series differ slightly in that Potosí’s series begins in 1549 and the others in 1559.
Figure 1, yields an annual growth of 0.6 percent. At that rate, more than a century would have passed before output doubled. The fact is that output did not rise automatically in steps of one-half of 1 percent per year but instead moved rather erratically up and down. According to the annual production figures, output had risen 300 percent by 1600, dropped a third by 1700, and climbed another 300 percent by 1810. Despite numerous and frequent shifts in direction, which included some sustained declines, the long-term trend in production was unmistakably upward. Such growth signifies a capacity to overcome recurring problems related to undercapitalization, heavy taxes, and ineptitude.

I have divided the long colonial curve into three periods: 1559-1627, 1628-1697, and 1698-1810. In the first phase, 1559-1627, the rise in the curve represents a yearly growth of about 2.3 percent. In the seventeenth century from 1628 to 1697, the curve follows a downward course at an annual rate of 0.3 percent. In the final century of the colonial period, the trend reverses itself, and output grew by 1.1 percent annually. The high growth rate in the first period can be attributed mostly to easy accessibility to the ores and the mid-sixteenth-century invention of the mercury process that made refining medium and low-grade ores, especially Potosi’s tailings, profitable. The downturn in production of silver at Potosi was the chief cause of the declining curve in the seventeenth century. Also contributing to the downturn was a readjustment and consolidation that inevitably took place in the industry as miners had to find the resources to dig deeper shafts and longer tunnels to reach the ore. Still, halfway through the colonial period, Potosi’s share of the total output in Spanish America was so large that it could almost dictate the shape of the New World silver curve. The third period can be described as one of both revival and expansion throughout Spanish America: not only were old camps in both Peru and Mexico being rehabilitated but new ones were also being established.

In the sixteenth and early seventeenth centuries, a substantial part of the silver mined in America was exported to Europe. This fact has led some historians to contend that the shipment of treasure from America caused an inflation in Europe during the second half of the sixteenth century and the early seventeenth century.

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I have used 1810 as the terminal date, although mining continued throughout the insurgency. The impact of the insurgency on mining is a topic for another inquiry.

To calculate the regression coefficients, I have used Econpack, developed by Dr. Milton Hallberg of Penn State. Unless followed by a figure in parentheses, all growth rates have r-values of a 99 percent confidence level. I have corrected for autocorrelation wherever the Durbin Watson statistic does not fall within an acceptable range. In plotting trend lines and calculating growth rates, I do not wish to imply that time, as the independent variable, is the only factor that explains production, the dependent variable. How much to produce depends on many different factors that cannot always be related to time. I have tried in all cases to find the best fitting line to describe each curve. In analyzing segments of trends, I have used essentially a “dummy-variable” approach. This has the effect of treating each segment as unconnected with all other segments with no assurance that the points where they meet are actually joined. My colleague, Dr. Spiro Stefanou, has been analyzing the silver series in terms of linear splines, that is, a technique that eliminates the discontinuities at the points where the segments join. This allows for the plotting of a continuous line rather than a broken one; it may also generate slightly to moderately different growth rates. We will examine these techniques and the findings that they yield in a forthcoming manuscript on Mexico’s eighteenth-century economy. Growth rates are calculated according to the standard equation: \( \log P_t = \log P_0 + r \log (1 + r) \), with the logarithm of the equation being

\[ \log P_t = \log P_0 + r \log (1 + r) \]
Other historians disagree, contending that there was not much inflationary impact at all. Scholars have compiled and searched numerous price and production series from the Mediterranean to the Baltic for conclusive evidence of the impact of the inflation but without reaching any agreement. When the series for total colonial Spanish American silver output is compared with the European series, they follow similar paths: they rise sharply until the early seventeenth century after which they level off and turn downward. But the lack of precise information about how much silver was produced in America and was exported to Europe has been a handicap to resolving how much inflation there was. It can now be shown that, up to 1600 or 1610, between 375 million and 400 million pesos worth of silver were produced in the New World. Nearly all the production of silver occurred in the second half of the sixteenth century, so the annual average output from 1550 to 1600 or 1610 was from 6.5 to 7.5 million pesos per year. The rate of growth in production of silver during that half-century meant that output doubled about every thirty years, and that rate of growth may also hold for exports, which constituted half or more of what was produced. 6

The debate over the economic impact of silver from America on Europe also concerns the proposition that a slump in production of silver pushed America and Europe into a depression. A contraction in the Spanish American silver industry did occur, with the average production falling by as much as a quarter compared to the average for the whole colonial period. A loss of that magnitude would certainly affect the economies of Europe and America, although with respect to America Peru suffered much more than Mexico. What is important to understand, however, is that the downturn in total colonial production was confined primarily to the second quarter of the seventeenth century and that it had bottomed out by the third quarter. 7 The link between New World silver production and Old World economic activity had grown more tenuous in part because the colonial economies were less dependent on Europe. Exporting less silver to Europe during the seventeenth century may have set the conditions for a shorter, milder depression in America than in Europe. 8


7 For a survey of the statistical profiles of the European economies from 1500 to 1800, see Charles Wilson and Geoffrey Parker, eds., An Introduction to the Sources of European Economic History 1300-1800 (Ithaca, N.Y., 1977).

8 I have not tried here to resolve the "century of depression" controversy. Clearly, one result of this research is that in terms of mining Peru had a serious depression and Mexico had almost none in the seventeenth century. See Woodrow Borah, New Spain's Century of Depression (Berkeley, Calif., 1951), 18-29; Bakewell, Silver Mining and Society, 226-28; Jonathan Israel, "Mexico and the 'General Crisis' of the Seventeenth Century," Past and Present, 63 (1974): 38-39, and passim; TéPaske and Klein, "Seventeenth-Century Crisis," 116-35, with rebuttals by Henry Kamen and Israel and rejoinders by Té Paske and Klein in Past and Present, 97 (1982): 144-61; Richard Boyer, "Mexico in the Seventeenth Century,"...
were broken in the 1720s and quickly surpassed again in the 1740s. There were lapses in the steady climb of the production curve during the eighteenth century (early 1720s and early 1740s) but no serious or prolonged interruptions. These observations about a seventeenth century less depressed and an eighteenth century more expansive than earlier thought point to the conclusion that silver was far more abundant in the Atlantic World than has heretofore been appreciated.9

Peru’s curve closely resembles the curve for total colonial production but with some important distinctions (see Figure 2). For the whole colonial period, the trend line is almost flat, with an annual growth rate of only 0.1 percent (98 percent confidence level). The shifts within the secular movement are fairly dramatic. The early successes at Peru were spectacular. Climbing at an annual rate of 3.6 percent, output doubled about every twenty years. By 1610 (half a century later), the rise had peaked, and a contraction had begun. Production fell at a rate of 1.7 percent per year until 1715. So great was the fall that output in the early eighteenth century was not much higher than it had been in the middle of the sixteenth century. But, severe as the contraction was, it did not extinguish mining activity. In almost every decade between 1630 and 1690, production shot up for a year or two only to lapse once again. Until the eighteenth century, none of these spurts was powerful enough to bring about a permanent recovery. After the long descent of the seventeenth century, Peruvian mining made an impressive recovery, growing at an annual rate of 1.2 percent during the eighteenth century. Despite this strong performance, the record output of the early seventeenth century was not surpassed until the 1780s. In the following two decades, at least until 1810, production turned downward again.

Mexico’s silver curve differs significantly from Peru’s. From the second half of the sixteenth century to 1810, Mexican output followed a much stronger upward course at 1 percent per year, ten times the rate for Peru (see Figure 3). To be sure, the Mexican curve turned down during the second quarter of seventeenth century and again during the second quarter of the eighteenth century. These were

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9 Two factors—contraband trade in silver bullion and missing ledgers—can affect the shape of the curve in any century but bear most directly on the seventeenth century. Illicit commerce certainly flourished in seventeenth-century Peru, but neither the extent of such commerce nor whether the silver involved was registered or unregistered is yet well understood. Unregistered silver would not appear in the treasury ledgers and, therefore, would not be counted. Moreover, not all the known treasury ledgers have been consulted. If some of the gaps in the seventeenth-century treasury series should ever be filled, the seventeenth-century contraction may become less pronounced. There is the possibility that future research will alter the appearance of the curve in the sixteenth and eighteenth centuries, too. Morineau, Incroyables gazettes et fabuleux métaux, treated fraud on the European side, 258–49, as well as the impact of American treasure on seventeenth and eighteenth-century Europe, 218–549.
short-term lapses; but, on each occasion, within a few years or at most a decade, the downturn was halted and growth resumed. The Mexican curve also falls into three periods of varying lengths: 1559–1627, 1628–1724, and 1725–1809. In the first phase, which coincided with its earliest discoveries, Mexico posted a growth of 2.5 percent per year. Although the first phase peaked in the 1620s, it may have begun to level off at the turn of the seventeenth century, as was also true in Peru. Downward pressure on the production curve is evident in the 1630s and 1640s, but it does not signal a prolonged depression. During the century-long second phase, while suffering some periodic reverses, the Mexican silver industry still posted a yearly growth of 1.2 percent. During the last decade of the seventeenth century, a new record high was achieved, the first since the 1620s. In the final phase, production grew at a rate no less than 1.2 percent each year and perhaps

\(^{10}\) Because of so many missing ledgers, this is at best a very tentative rate.
as high as 1.4 percent. At the end of the eighteenth century, the expansion may have begun to slow as it had done off and on during the century, although to what extent remains unclear.

How can we account for the different curves in Peru and Mexico? Peter J. Bakewell, who has studied camps in both Peru and Mexico, argued that Peru’s seventeenth-century depression was largely the result of “ore depletion (and the consequent extra costs of new exploration and more difficult extraction).” The decline in the quantity and the quality of ore affected production in both colonies but probably more so in Peru than in Mexico. In either place, ore depletion

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11 The discrepancy arises because total production based on silver-tax receipts (from TePaske) is lower and the growth rate slower than output based on mint registrations (from Humboldt). When miners were granted tax exemptions, the taxes at the treasury would be affected (reduced) whereas the registrations at the mint would not. Other problems such as currency devaluations and bookkeeping errors may affect both total silver taxes and total mint registrations.

translated into greater risks and higher costs for miners and investors. By the eighteenth century, a unit of Peruvian ore may have cost on average from 10 to 20 percent more to extract and process than a similar unit in Mexico. If a Mexican mineowner could expect a 10 percent profit on 1,000 ounces, a Peruvian mineowner could at best expect revenues just to cover expenses.

A second difference can be attributed to generally higher operational costs in Peru than in Mexico, in part because the Crown had long taxed more heavily in Peru. Mineowners paid a variety of royalties, fees, and taxes; in addition, they had to buy mercury, powder, salt, and other items from the government at fixed prices. In 1504, the Crown decreed that all mineowners should pay at least one-fifth of their silver (quinto real) for the privilege of mining it. In 1548, Mexico won a concession from the Crown by which the fifth was dropped to a tenth (diesmo), and by the seventeenth century the tenth had become the standard. In Peru, however, the fifth remained in effect (with a few exceptions) until 1736, when the tenth was authorized. Thus, for more than half of the colonial period, Andean mineowners paid twice the royalty that Mexicans did. Mercury also represented another major government-imposed expense. On average, mineowners (or refiners) expected a quintal (100 pounds) of mercury to produce 100 marks (800 ounces) of refined silver. The higher the yield per quintal, the lower the cost of refining to the producer. Peruvians paid a higher price than Mexicans for their mercury and obtained less silver per quintal because both their silver and mercury were of lower grades. While in Mexico all the government-related costs (from the pit to the mint) may have added up to about 20 percent of the value of the silver, in Peru they may have reached as high as 35 percent. Since these amounted to fixed costs over which the individual producer had little control, they could only be compensated for through better quality ores or greater operational efficiencies, which were harder to come by in Peru than in Mexico, at least after 1600.

A third explanation for why the Peruvian and Mexican curves differ has to do with how the mining industry developed in each viceroyalty. In Peru, the mountain of silver at Potosí was so rich that it dominated Andean mining until the first decade of the nineteenth century. Although other camps opened up in the seventeenth century, they were not as rich as Potosí, and they had trouble competing with Potosí for the limited capital and labor resources of the Andean economy. At least until the early eighteenth century and perhaps as late as the viceregal reorganization in 1778, the viceregal production curve largely reflected what was happening at Potosí. When production at Potosí fell off sharply during the late seventeenth and early eighteenth centuries, other camps had not developed sufficiently to compensate. For example, Oruro, founded in 1606 about 150 miles northwest of Potosí, enjoyed a promising start in the first quarter of the seventeenth century and a brief revival in the eighteenth century, but for the colonial period as a whole its

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13 This is no more than a rough estimate, based on the comparative yield of silver in the amalgamation (or mercury) refining process.
15 Bakewell, "Mining in Colonial Spanish America," map on 106; and Orlando Capriles Villazón, Historia de la minería boliviana (La Paz, 1977), 58–59.
curve was downward. Mining opportunities did improve in the eighteenth century because the general Andean economy was on the upswing (even Potosi was expanding), and the Crown had reduced its share of the producers' costs. Pascoc, a camp founded in 1630 more than 800 miles north of Potosi (in what was known as Lower Peru), produced little silver until the second half of the eighteenth century, when it eventually matched Potosi. To be sure, Mexico lacked a Potosi, but from the late sixteenth through the seventeenth century it could boast the existence of a half-dozen major camps. All these camps experienced the normal cycles of boom and bust, yet they often engineered recoveries that transformed contractions into expansions. The data that exist for individual districts and for the colony as a whole point to long-term growth rather than decline. In the eighteenth century, output from six of Mexico's major mining districts (that is, groups of mining camps served by a single branch of the royal treasury) grew in the range of 0.3 to 2.8 percent yearly: San Luis Potosi, 2.8 percent; Sombrerete, 2.4 percent; Guanajuato, 1.8 percent; Durango, 0.7 percent; Guadalajara, 0.5 percent; and Zacatecas, 0.3 percent. Since the cycles varied from camp to camp, a contraction in one or two large camps was offset (beyond the near term) by continuing or expanding production at other camps. Over the long run, then, as recovery followed recovery from camp to camp, the Mexican silver curve could maintain its upward movement.

Potosi continued as the premier camp in South America almost until the end of the colonial period, but Zacatecas lost its ranking as Mexico's preeminent camp to Guanajuato in the early eighteenth century. Both were founded about 1550, but during the next two and a half centuries Potosi registered nearly two and a half times more silver than Zacatecas: 950 million pesos worth of silver compared to 425 million pesos. Potosi may have accounted for 80 percent of Peru's colonial output, but Zacatecas probably contributed under a quarter of Mexico's output. As late as 1776, when Potosi was only a shadow of its former self, Peru's viceroy, Manuel de Amat y Junient, reported the district of Potosi still registered 41 percent of Peru's total, followed by Oruro with 14 percent and Pasco with 13 percent. By the middle of the eighteenth century, Zacatecas's share of Mexico's output had fallen to a tenth, although in the beginning of the nineteenth century it rose to between 12 and 15 percent. Having ranked first from the late sixteenth through the early eighteenth centuries, Zacatecas dropped to second or third during the eighteenth century. Zacatecas's fall was offset by Guanajuato's rise to preeminence during the middle of the eighteenth century and the periodic successes at other camps such as Bolaños, Charcas, and Pachuca. Peru's mineowners and officials were aware of the need to broaden the search for ore beyond Potosi. Potosi's greatest mineowner, Antonio López de Quiroga, urged Peru's viceroy, Conde de Lemos, to encourage other owners to explore the mid-seventeenth-century opportunities

in camps like Puno, yet for López de Quiroga in particular and other mineowners in general Potosí remained the center of their interests and activities.\footnote{Guillermo Lohmann Villena, \textit{El Conde de Lemos, virrey del Peru} (Madrid, 1946), 271–72.}

Potosí's production curve does not harmonize with its legend of wealth and fame, for the trend over the whole colonial period is unmistakably downward (Figure 4). Its curve rose sharply until the first quarter of the seventeenth century, after which it began a slide that did not end until the middle of the eighteenth century. A late colonial upswing was sustained through the second and third quarters of the eighteenth century, after which it began to weaken. By the end of colonial rule, output had sunk to levels comparable to those recorded during the nadir of its depression. For the whole colonial period, growth was negative at an annual rate of between 0.3 and 0.4 percent.

Potosí's production curve reveals a pattern of growth (1549–1605), decline (1606–1723), revival (1724–1783), and finally decline (1784–1810). The first
The period was Potosi's most spectacular, when production grew at just under 3 percent annually. This growth rate should not disguise the fact that Potosi's initial years were less than auspicious. Between 1549 and 1572, Potosi's output climbed to 3.2 million pesos and then dropped to 1 million pesos per year. The decline resulted from the rapid depletion of rich, surface ores that were mined mostly by Indians under contract to the Spanish. To exploit underground ores required technical expertise that Indians lacked. Mining did not long remain in a moribund state or, for that matter, in the hands of the Indians. Two events around 1572 paved the way for Potosi's emergence as the premier camp. First, the government established the mita system that was designed to assure Potosi an adequate supply of cheap labor, and, second, the local industry introduced the amalgamation process that was developed in Mexico to refine low-grade ores economically. To refine the ore by amalgamating it with mercury and other ingredients required a substantial investment in plants and equipment. Only the Spanish could afford these investments, and consequently they came to assume a dominant role in both extracting and refining ores. Much of the initial capital invested in the refining operations came from processing the tailings piled around mine entrances. Those piles contained ores too poor to be smelted but rich enough to be amalgamated, and since the extraction costs of these discarded ores had already been paid for, according to Bakewell, the huge profits that they brought in could be used to pay off the loans needed to build the plants as well as to repair and expand the mines. In response to these changes, output rose from less than 1 million pesos in 1572 to 7.5 million pesos in 1592, an all-time record. Between 1593 and the end of the first decade of the seventeenth century, when the boom came to an end, production was still very high but no longer rising.

During the second period, which encompasses most of the seventeenth century and the first quarter of the eighteenth century, Potosi's output shrank at an annual rate of between 1 and 2 percent. From 1610 (when the boom began to fade) through 1735, the decline was 1.4 percent per year, and from 1650 (when the decline became unmistakable) through 1735, it was 1.6 percent per year. Despite efforts toward and predictions of a recovery in seventeenth-century Potosi, that recovery never materialized. The mountain that rose above the camp and city contained four main veins that ran "more or less south to north vertically on the eastern flank." The early miners dug away the top of the mountain, but, as later miners worked their way down, they had to find a way to extract the ore from the interior. During the late sixteenth and early seventeenth centuries, as many as nine horizontal tunnels—six feet high and eight feet wide—were cut into the mountain to reach the ore and to drain the water. The government placed a limit on the size of each mine along a vein, with the result that an unusually rich vein could have several dozen mines (one allegedly had seventy-eight different mines). In 1640, at

20 Bakewell, "Technological Change in Potosi," 75–77.
least one tunnel reached 400 yards into the interior, and by 1810 another one had reached 2,200 yards at a cost of 560,000 pesos. The owners of the mines and the tunnels were often different persons, and conflicts inevitably arose over who should pay and how much should be paid to maintain the tunnels. In short, as miners worked their way through and down the mountain, the cost of cutting tunnels and draining mines increased sharply.\textsuperscript{22} The long seventeenth-century downward trend at Potosí is symptomatic of the effect of mounting costs and declining grades, a combination that few mineowners were prepared or qualified to deal with. What kept Potosí's silver registrations from tumbling further and faster in the seventeenth century was the founding of new camps such as Sicasica (1600), Tatasi (1612), and Padua (1652) within the Potosí district but beyond the city itself. In the last half of the seventeenth century, these other camps may have provided as much as one-quarter of the silver registered at Potosí. Even so, that left Potosian mines with an annual average output worth about 1.9 million pesos.\textsuperscript{23} The dilemma for the industry and the government was real. Potosí still produced far more silver than any other camp but at a cost that was growing and eroding profits. In the early seventeenth century, profits from mining at Potosí helped to finance a general economic expansion; in the late seventeenth century, as profits dwindled, Potosí may have become more of a burden than a benefit for the general economy. To sustain or to curtail mining at Potosí entailed difficult choices for industry and government, but to let economics dictate Potosí's future was probably never a practical alternative, at least, not for the Crown. Recovery, not abandonment, remained the goal for Potosí.

Potosí experienced a modest rise in output in the late third and early fourth quarters of the seventeenth century, after which it entered a half-century of plummeting silver production. For 1690–1699, Potosí's output (for the whole district) dropped by 26.1 percent, for 1700–1710 by 30 percent, and for 1710–1719 by 23.2 percent. In the 1720s, when Potosí's production reached its nadir, annual output averaged only 1.3 million pesos, the lowest since the mid-sixteenth century. When a recovery at Potosí finally took hold in the late 1720s or early 1730s, the upward climb proceeded at a snail's pace compared to the leap forward in the second half of the sixteenth century. If dated from 1724, when the depression bottomed out, through 1783, the recovery had an annual growth rate of 1.8 percent. The strongest decades were the 1750s and the 1770s, when output shot up by one-third and one-fifth, respectively. The recovery lost momentum in the two or three decades before 1810, as production peaked in the 1780s and then turned down in the 1790s. Output was as high in the last quarter of the eighteenth century as at any time since the middle of the seventeenth century, but it was still only half of what it had been at the end of the sixteenth century and the beginning of the seventeenth century. The surge in output came largely in response to long-overdue reforms that lowered operating costs through cuts in silver taxes and

\textsuperscript{22} Purser, \textit{Metal-Mining in Peru}, 29–31; Brading and Cross, "Colonial Silver Mining," 550–51; and Bakewell, \textit{Miners of the Red Mountain}, 26, 30.

\textsuperscript{23} Bakewell, \textit{Miners of the Red Mountain}, 65.
mercury prices. Additional savings accrued to the owners because with the continuation of the mita they could pay draft laborers less than voluntary workers.24 As the prospect for making a profit improved at Potosi, the expansion there had a wider impact by stimulating business activity, capital investment, and local growth across the Andean region.25 Without Potosi’s eighteenth-century revival, both the mining economy and the general economy might have remained stalled down to the end of the colonial period or, at the very least, until the reorganization of the viceroyalty in 1778. Even in its twilight, Potosi’s role, although diminished, was crucial.

Zacatecas followed a different path. Although it suffered numerous setbacks for many of the same reasons that Potosi did, the mine industry there managed to avoid a long-term slump and instead put together a series of recoveries that resulted in an overall upward slanting production curve (Figure 5). To be sure, compared to Potosi, Zacatecas was only a minor player on the silver stage. In the 1580s, when Potosi was at its zenith, it registered seven times as much silver as Zacatecas, and in the first decade of the nineteenth century, when Zacatecas’s production broke all previous records, it was still not producing much more than Potosi, whose output by then was about a million pesos below its colonial average.

In the sixteenth century, despite major discoveries at Zacatecas, Durango, and Parral in the northern provinces of Mexico, the mining boom was more directly linked to discoveries in Taxco and Pachuca, camps not far from the capital, where their silver was registered and taxed.26 In the 1580s and 1590s, more than half of all silver-tax receipts were collected in Mexico City, an indication that the central region was more productive than the northern provinces during the late sixteenth century. By the early seventeenth century, the shift from the center to the north was irreversibly underway.27 During the eighteenth century, the core of the Mexican silver industry was found in the area that extended from Guanajuato north to Zacatecas and from Guadalajara east to San Luis Potosí.

Zacatecas’s production curve is both different from Potosi’s and more complicated to describe. From 1559 to 1810, Zacatecas’s rate of growth was 0.5 percent per year.28 Along with this rising curve, however, Zacatecan mining had a highly


25 Fisher, “Mining and the Peruvian Economy in the Late Colonial Period,” 46 and 56–58, citing the works of Assadourian, et al., Tandeier, and Rose Marie Buechler as well as his own studies.

26 There was no standard or uniform size for mining districts and their rentes cajas. Some districts encompassed hundreds of square miles, and others were small and compact. It was even possible to register silver in a real caja outside the district in which the silver was mined. Still, the differences in their registrations cannot be explained in terms of the differences in their jurisdictions.


28 When silver taxes instead of silver marks are used, the rates are a few tenths of a percent lower per year. Data on silver taxes begin in 1580, but data on silver marks start in 1559. For the discussion of Zacatecas’s production curve, I have used growth rates calculated from silver marks, although I have converted marks to pesos. For silver taxes, consult TePaske and Klein, “Seventeenth-Century Crisis in New Spain,” 124–28; and John J. TePaske, “Economic Cycles,” Bibliotheca Americana, 1 (1983): 198–203. For silver marks, 1560–1700. see Bakewell, Silver Mining and Society, 241–45; silver marks, 1700–1821,
cyclical character. Figure 5 illustrates the difficulty that one faces in trying to analyze the production trend. Generally, output tended to rise for fifty to sixty years, after which it declined for twenty to forty years. The dates for the cycles are 1559–1664 with the boom ending around 1622, 1665–1763 with the boom beginning to fade about 1716, and 1764 to 1810 or 1821. The long cycles are of interest because, at the end of the first century of mining in Zacatecas and again

were compiled from the Clements Library, University of Michigan, Zacatecas Collection: Quinato y diezmo, 1700–14, 1716–29, 1734, 1756–49, 1763–67; Cargo y data, 1730–34, 1736–37, 1750–62, 1769, 1771–72, 1774, 1776–78, 1780–82, 1784–87, 1790–93, 1790, 1801–21; and Treasury Records and Correspondence, 1715. For years not in the Clements Library, consult Archivo General de Indias (hereafter, AGI), Guadalajara, leg. 477, 478, 480, and 482.

29 If growth rates are calculated for the obvious rises and declines, the results are: 1559–75, 2.7 percent; 1576–98, -1.0 percent; 1599–1622, 3.5 percent; 1623–61, -2.1 percent; 1662–80, 7.3 percent; 1681–98, -2.4 percent (94 percent confidence level); 1699–1724, 3.4 percent; 1725–63, -2.1 percent; 1764–1810, 2.4 percent.

30 Under this scheme, the peak that can be identified during the 1670s must be treated as a temporary aberration. A major strike was made in the camp of Sombrerete about that time. Until a branch of the treasury was set up there in 1681, Sombrerete’s silver was presented for taxation at Zacatecas. For a few years, this arrangement inflated Zacatecas’s silver registrations. Such reorganizations took place throughout the colonial period and could not help but affect the silver curves of individual camps.
at the end of the second century, output had dropped to or below the level for the initial year, 1559. Not only did Zacatecas recover from each downturn but it also raised production during the next long cycle. In the first century, output averaged about 1.2 million pesos per year, and during the second that average rose to about 1.5 million pesos per year, a change of 23.2 percent. The third cycle, of course, must remain incomplete because of the independence movement, but the cycle's growth phase up to 1810 or even up to 1821 is indisputable. In the boom phase of the third cycle, output reached an average annual level of about 2.2 million pesos, but if a contraction had followed the boom, the figure would surely be lower.

The pattern of development in early Zacatecas was similar to the pattern in early Potosí. Zacatecas fell into a slump after the easily accessible ores had been extracted and processed. The introduction of refining with mercury effectively ended the slump and began a boom that peaked in the early 1620s, a decade or so after Potosí had peaked and turned downward.\(^\text{31}\) The contraction that encompasses the second quarter of the seventeenth century and half of the third quarter is significant, although it did not turn into a prolonged depression. When Francisco de Rojas y Oñate, a senior officer of Mexico City's high court of justice, the Audiencia, visited Zacatecas in 1644, he discovered how bleak the prospects were for a quick revival of the local industry. He found the local mining economy in disarray: abandoned mines, scarcities of labor and mercury, and owners so deeply in debt that few could maintain or expand their operations.\(^\text{32}\) With many of Zacatecas's mines now fifty to one hundred years old, they had reached the stage at which, without expensive repairs, they had become unprofitable.

Despite all these problems, Zacatecas did eventually recover. Rising costs and sagging profits did not discourage a new group of owners and investors from undertaking the repairs. Growth resumed, although it was highly volatile and erratic. Output as measured in Figure 5 appears to skyrocket in the 1670s and the early 1680s and then to plummet in the late 1680s and the 1690s before rising again after 1700, in large part, because high-grade silver was discovered in Sombrerete (one hundred miles north) but registered in Zacatecas until a separate real coja was opened in Sombrerete in 1681. Hence this sharp rise followed by an equally sharp decline has more to do with administrative changes than mining operations. If Sombrerete's silver could be factored out, Zacatecas's curve would be less extreme. It would probably show a rise in output at Zacatecas during the 1660s and the 1670s followed by a downward movement through the 1690s before recovery at the beginning of the eighteenth century. Of the nearly 20 million pesos registered in Zacatecas during the 1670s, under 10 million pesos came from Sombrerete. That would make Zacatecas's share more than 10 million pesos, an amount that was higher than the output of the camp during the 1660s. Indeed, Zacatecas's recovery was strong enough to prompt from the leader of the Audiencia of Nueva Galicia in 1681 a statement that both camps were prospering.\(^\text{33}\) In the first quarter of the

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\(^{31}\) Bakewell, _Silver Mining and Society_, 188; and "Notes on Mexican Silver Mining," 593.

\(^{32}\) Bakewell, _Silver Mining and Society_, 197–99. The government had made matters worse by trying to collect on past-due accounts for purchases of mercury.

\(^{33}\) Bakewell, _Silver Mining and Society_, 193–94.
eighteenth century, as a result of these periodic recapitalization efforts, Zacatecas was riding the crest of another successful recovery that finally peaked in the mid-1720s, sixty years after the last major contraction. During the next forty years (into the early 1760s), however, output shrank until all the gains of the previous boom had been lost. Many heavily capitalized mines could not be operated profitably and were abandoned in the 1740s and 1750s. The decline in output was so great that by 1760 the number of refineries needed to process the ore had dropped from about thirty to six.34

The third cycle began in the 1760s when a new generation of miners with their merchant backers started to claim and to rehabilitate many of the camp’s abandoned mines. Especially impressive was a fifteen-year period (1764–1779) when their efforts, supported by the Bourbon mining reforms, resulted in a virtual quadrupling of output (at an annual rate just over 9 percent). Over the final thirty years before Hidalgo’s Rebellion, although output fluctuated, it eventually broke all previous records. The new highs in the early 1800s were preceded, however, by a mercury shortage (1798–1801) that caused the curve to dip to near-record lows.35

By the eighteenth century, ore yields in Spanish American mining were no higher on average than one to two ounces of silver per hundredweight of ore.36 This meant that Andean miners had to process several times more ore to achieve the same yields as Mexican miners. Zacatecas’s yields of two to three ounces of silver per hundredweight of ore, enough to make but not to guarantee a profit, were close to the Mexican average; Potosí’s yields of one ounce or less were also probably close to the Andean average.37 Some camps did better than Zacatecas and some worse than Potosí. Understanding how silver mining in Spanish America accommodated itself to these conditions requires a closer examination of the industry’s structure.

Silver mining was a special colonial business in that all the product, bullion, was turned into currency, except for the small amount that jewelers and artisans needed for their work. The government determined how many coins could be cut from a bar of silver, and the coins entered the general economy as the owner of the silver used them to cover taxes, wages, supplies, or loans. Not all the currency entered the economy, of course, for a substantial part (perhaps more than half) paid for imports and various governmental transfers. As in any other business venture, to stay in business, silver producers had to receive enough currency from their bullion to cover costs and provide a return on capital that justified further investment in the operation. Costs were dependent on what

34 Clements Library, Zacatecas Collection, Treasury Records and Correspondence, 1760–69, Box A.
36 Enrique Tandeter, Trabajo forzado y trabajo libre en el Potosí colonial tardío (Buenos Aires, 1984), 5 and n. 4.
37 Tandeter, “Forced and Free Labour in Late Colonial Potosí,” 100, n. 4. Calculations for Zacatecas are derived from yields quoted in several documents. AGI, Guadalajara, leg. 192; and Archivo General de la Nación (hereafter, AGN), Minería, leg. 4.
producers had to pay for labor and material, on the efficiency of the operation, and the quality of the ore. Silver producers had no direct control over the quality of the ore in the ground, but they could try to compensate for less than average grades by being more efficient, at least in theory. Although the break-even point in terms of ore quality varied from camp to camp and from period to period, it ranged from 40 to 60 ounces of silver per ton of ore refined with mercury.

The quality of ore declined during the colonial era, yet rich lodes remained to be discovered and exploited even in established camps. Predicting yields of silver from ore in flooded and abandoned works was a favorite pastime of owners and investors, and many of these predictions were duly reported in mining surveys conducted by royal officials. In Zacatecas, for example, during the contraction of the 1740s, a survey reported that a group of flooded and largely abandoned mines, if recovered, would yield from 80 to 160 ounces of silver per ton of ore, estimates that were considerably higher than the average.\(^8\) When one of those mines, Quebradilla, was finally recovered by José de la Borda late in the third quarter of the eighteenth century, the yields, although high by colonial standards, were less than half those predicted a half-century earlier.\(^9\) On average, a ton of Andean ore yielded less silver than a comparable ton of ore in Mexico, and Peru's miners had to do more to cut costs or to introduce efficiencies in order to offset the lower quality. But the two major imports, mercury and labor, usually cost more in Peru than Mexico, and Andean miners were no more efficient and may well have been less efficient than Mexican miners. While one part of the history of Spanish colonial mining is the long-term success in Mexico, another part is the long-term effort to support a more marginal Peruvian industry.

Without the invention of the amalgamation process and the mercury that the process required, few Spanish-American camps could have stayed in business very long. Once mercury's importance was established in the second half of the sixteenth century, the Crown moved to create a monopoly to control the production, sale, and distribution of mercury in the viceroyalties. How well the monopoly functioned remains a matter of debate, although most historians agree that the high prices and undependable supplies hardly served the interests of the producers. The mineowners believed that lower prices and larger stockpiles of mercury would possibly increase the production of silver enough to make up for the loss of income from the mercury, and such growth would benefit equally the Crown and the industry.\(^10\) For the Crown, however, the monopoly functioned not only to protect a valuable commodity but also to generate revenue for the government. Although from time to time the government acceded to requests for lower mercury prices or other changes in the administration of the monopoly, it always had to weigh these actions against the conflicting needs of the industry for lower costs and the state for greater revenues. Disbanding the monopoly as some,

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\(^8\) AGI, Guadalajara, leg. 190.

\(^9\) AGN, Mineria, leg. 115, exp. 4.

\(^10\) Sterling Library, Yale University, Latin American Collection, 5–E.
like Alexander von Humboldt, a staunch free trader, had urged was probably too risky financially for the Crown to consider seriously.\footnote{Humboldt, \textit{Political Essay on the Kingdom of New Spain}, 3: 284–87.}

Year-to-year shortages of mercury in individual camps or for entire colonies were frequent and probably unavoidable, given the great distances of mercury mines from the silver camps and a primitive transportation system. While a sudden drop in the mercury supply could curtail production almost immediately, a rise in supplies did not necessarily mean an increase in output of silver, at least in the short term. Other factors, such as the quality of ore, the cost of draining and opening new tunnels, and the availability of labor and capital, had to be taken into account before operations could be expanded to match the supply of mercury. We do not yet know how much mercury was mined in or shipped to Spanish America. A mercury camp, opened at Huancavelica in Peru during the sixteenth century, was to serve Potosí, while mines in Spain and Europe were to supply Mexico and any additional amount that was needed in Peru. The operation and administration of the government-owned mines were often inefficient and inept. Despite these problems, the volume of mercury available for distribution in Peru and Mexico doubled from the seventeenth to the eighteenth century. With the quality of ore on the decline, such an increase was required to support the expansion of mining during the eighteenth century.\footnote{For 1571–1724, several sets of figures exist, and I have used a set taken from an early eighteenth-century viceregal report. Marqués de Casa Concha, \textit{Relación del estado que ha tenido y tiene la Real Mina de Huancavelica ...} [1726 copy]. Clements Library, Miscellaneous Latin American Collection. These figures agree closely with Set 1, published by Guillermo Lohmann Villena, in \textit{Las Minas de Huancavelica en los siglos XVI y XVII} (Seville, 1949), 452–55. Lohmann Villena’s set ends in 1700, but Casa Concha’s runs until 1724; although the annual figures become less precise in the eighteenth century. See Fisher, \textit{Silver Mines and Silver Miners}, 76, for 1759–1812.}

The production of mercury at Huancavelica can be reconstructed for two periods, 1571–1724 and 1759–1812 (Figure 6).\footnote{For 1571–1724, the rate is negative at 0.2 percent per year with a confidence level of 70 percent, and for 1759–1812, it is negative at 1.8 percent per year with a 100 percent confidence level.} During these two periods, Huancavelica’s production was at least 950,000 quintales, and, if the figures for the second quarter of the eighteenth century were known and included, it would probably reach 1.1 million quintales. A rule-of-thumb measure for silver to mercury was 100 marks of silver per one hundred pounds of mercury. The ratio of Potosí silver to Huancavelica mercury (assuming that all of Huancavelica’s mercury was shipped to Potosí) is about 97 marks for each one hundred pounds. Huancavelica’s curve has a slight downward tilt during the colonial period.\footnote{Humboldt, \textit{Political Essay on the Kingdom of New Spain}, 3: 284–87.} Huancavelica’s mercury production declined more slowly than Potosí’s silver production, and this suggests that the supply of mercury was not a crucial factor in causing or sustaining the long depression at Potosí. For shorter intervals, to be sure, a decline in the supply of mercury could have an adverse impact on the silver curve. On the viceregal level, however, Potosí’s monopoly over Huancavelica’s mercury may well
have retarded the growth and development of other Andean camps. At Potosí, the long-term supply of mercury was not the most serious problem.

The Mexican mercury series (Figure 7) is somewhat more complete than the Peruvian series. It includes all shipments to Mexico from 1559 to 1805 with a sixth of the years missing. The Mexican series has a distinct advantage over the Peruvian series in that it encompasses the whole colony and not just a single camp. The crucial linkage between mercury and silver is evident when the growth rates for mercury supply and silver production are compared: mercury grew at an annual rate of 0.8 percent from 1559 to 1805, silver at 1 percent. Mexico's yearly

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45 Yearly mercury data for 1559-1700 are drawn from Chaunu and Chaunu, Seville et l'Atlantique, 82:2, 1958-60; Bakewell provides quinquennial data in Silver Mining and Society, 253-57, for 1565-1700, and although the Chaunus' and Bakewell's totals are not always in agreement, I have used the Chaunus' data for the basic series and filled in the gaps with Bakewell's figures, which, it must be understood, are averages rather than precise annual figures. Yearly data from 1709 through 1805 are drawn from Antonia Heredia Herrera, La Rentia del ataque en Nueva España: 1709-1751 (Seville, 1978), 277-33; and John TePaske's current research. I am indebted to Professor TePaske for these data to complete the series.
totals of silver production include smelted silver, which by the late eighteenth century amounted to less than 20 percent and perhaps no more than 10 percent of total silver registrations. Until the eighteenth century, silver registrations grew nearly twice as fast as mercury imports, a sign of a rough parity between smelted silver, which did not require mercury, and refined silver. In the eighteenth century, however, silver and mercury grew at about the same rates, because more ore was being refined and less smelted. Mexico may have received as many as 1.7 million quintales of mercury between the middle of the sixteenth century and 1810. At 100 marks per quintal, Mexico produced about 1.4 billion pesos worth of refined silver in a total of 1.8 billion pesos of refined and smelted silver. More important than the ratio between refined and smelted silver is the fact that the yield of silver to mercury stabilized at a level that could yield a profit. In several major camps, the yield may have improved to 110 or 125 marks per quintal during the second half of the eighteenth century.\textsuperscript{46} Mexico's mercury curve, like Huancavelica's

\textsuperscript{46} Fabián Fonseca and Carlos de Urrutia, \textit{Historia general de Real Hacienda}, 2 vols. (Mexico City, 1845), 1: 383.
curve, rose sharply in the last half of the sixteenth century in response to the introduction of the mercury process that made refining low-grade ore economical. The volume of mercury shipped to Mexico fell modestly in the seventeenth century and then rose markedly in the eighteenth century. The decline in mercury shipments coincided with the rise (also modest) in silver registrations. These contradictory trends could coexist in the seventeenth century but not in the eighteenth century, when smelting became less profitable. Miners also had other ways to deal with mercury shortages: they could try to save mercury by using less or recapturing more of what they did use, and they could try to supplement their supply by buying mercury from merchants and dealers outside the royal monopoly. In retrospect, one could argue that increasing the supply of mercury during the seventeenth century (especially at the prevailing prices) would not have permanently reversed the downward trend in Peru, and adding to the supply of mercury would probably have strengthened the upward trend in Mexico.

What the Crown did in the seventeenth century, however, was the reverse: it increased the supply in Peru by shipping less to Mexico. Beginning in the 1620s and continuing into the 1650s, large quantities of mercury from Almadén and Idria were shipped to Peru instead of Mexico with the result that Mexico's supply shrank. This decision may well have been a miscalculation that contributed to a slump in Mexican mining during the second quarter of the seventeenth century. Tables 1 and 2 show that the amount of mercury available in Spanish America (from all sources—Almadén, Idria, and Huancavelica) fell in the period 1630–1670 from more than 100,000 quintales to just slightly more than 60,000 quintales. During the second and third quarters, Peru had two and a half times more mercury than Mexico. With less total mercury available, Mexican miners and refiners had to make choices about curtailing operations, firing up the smelters, or stretching supplies. Mexican miners were largely successful in making the necessary adjustments because, although the supply of mercury in Mexico did not grow and may have fallen during the second half of the seventeenth century, the output of silver began to rise again. On the Peruvian side, the need for mercury may have been legitimate. The decline in Peru's total registrations (starting about 1610) eased in the second quarter, after which came a brief recovery before the final descent. That the recovery was only temporary was not so apparent to the government, which still regarded Peru's mines and particularly Potosí's as the colonies' most valuable mining properties. By the 1660s, however, the government, recognizing the need to accommodate the demand for mercury in Mexico, reversed its priorities. At a time when Almadén failed to boost its output, the government authorized the shipment of mercury from Huacavelica in Peru to Mexico to supplement the supply of mercury in Mexico, although only a few thousand quintales of Peruvian mercury were actually delivered.

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47 Bakewell, Silver Mining and Society, 189–95.
48 M. F. Lang, “New Spain's Mining Depression,” Hispanic American Historical Review, 48 (1968): 632–41. While Lang did not demonstrate that Mexican mining was depressed in the seventeenth century, he offered a general picture of the controversy over shipping mercury from Mexico to Peru and vice versa.
TABLE 1
Mercury Supply in Spanish America, 1571–1700
(By Decades and in Hundredweights)

<table>
<thead>
<tr>
<th>Date</th>
<th>Chaunu Totals</th>
<th>Percent Change</th>
<th>Date</th>
<th>Bakewell Totals</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1561-1570</td>
<td>8,715</td>
<td></td>
<td>1571-1579</td>
<td>49,912</td>
<td></td>
</tr>
<tr>
<td>1571-1580</td>
<td>56,463</td>
<td>547.9</td>
<td>1580-1589</td>
<td>96,764</td>
<td>93.9</td>
</tr>
<tr>
<td>1581-1590</td>
<td>94,471</td>
<td>67.3</td>
<td>1590-1599</td>
<td>96,303</td>
<td>-0.5</td>
</tr>
<tr>
<td>1591-1600</td>
<td>94,887</td>
<td>0.4</td>
<td>1600-1609</td>
<td>68,056</td>
<td>-29.3</td>
</tr>
<tr>
<td>1601-1610</td>
<td>70,711</td>
<td>-25.5</td>
<td>1610-1619</td>
<td>103,873</td>
<td>52.6</td>
</tr>
<tr>
<td>1611-1620</td>
<td>106,676</td>
<td>50.9</td>
<td>1620-1629</td>
<td>106,332</td>
<td>2.4</td>
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<tr>
<td>1621-1630</td>
<td>108,389</td>
<td>1.6</td>
<td>1630-1639</td>
<td>104,529</td>
<td>-1.7</td>
</tr>
<tr>
<td>1631-1640</td>
<td>95,818</td>
<td>-11.6</td>
<td>1640-1649</td>
<td>96,850</td>
<td>-7.3</td>
</tr>
<tr>
<td>[110,194]</td>
<td>[1.7]</td>
<td></td>
<td>[94,767]</td>
<td>[-14.0]</td>
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</tr>
<tr>
<td>1641-1650</td>
<td>68,174</td>
<td>-28.9</td>
<td>1650-1659</td>
<td>94,297</td>
<td>-2.6</td>
</tr>
<tr>
<td>[93,281]</td>
<td>[-1.6]</td>
<td></td>
<td>[68,952]</td>
<td>[-26.1]</td>
<td></td>
</tr>
<tr>
<td>1661-1670</td>
<td>68,952</td>
<td>-26.1</td>
<td>1660-1669</td>
<td>63,528</td>
<td>-32.6</td>
</tr>
<tr>
<td>1671-1680</td>
<td>81,701</td>
<td>18.5</td>
<td>1670-1679</td>
<td>78,271</td>
<td>23.2</td>
</tr>
<tr>
<td>1681-1690</td>
<td>44,848</td>
<td>-45.4</td>
<td>1680-1689</td>
<td>61,941</td>
<td>-21.5</td>
</tr>
<tr>
<td>1691-1700</td>
<td>70,990</td>
<td>58.3</td>
<td>1690-1691</td>
<td>74,476</td>
<td>20.2</td>
</tr>
<tr>
<td>Totals</td>
<td>1,064,075</td>
<td></td>
<td>1,095,132</td>
<td></td>
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<tr>
<td>[1,105,044]</td>
<td></td>
<td></td>
<td>[78,932]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Decade Average: 76,005

Note: For the decades 1631–1640 and 1641–1650, the Chaunu's totals are incomplete. The figures in brackets show totals based on aggregating Chaunu's Peruvian totals with Bakewell's Mexican totals. Sources: P. Chaunu and H. Chaunu, Seville et l'Atlantique, 8.2.2: 1974–75; Bakewell, Silver Mining and Society, 254, 256.

During the course of the eighteenth century, Almadén (and Idria) became the chief source of mercury for both Mexico and Peru. During the second half of the eighteenth century, Huancavelica probably supplied less than half of what the Andean miners required on average each year to maintain or expand their operations. In that period, Huancavelica's mercury production was falling at about the same rate that Peru's silver output was rising, so the gap between what was needed and what was locally available was widening. The difference was made up through imports. During the last half of the eighteenth century and the first

Fisher provided data on Huancavelica's output from 1759 to 1812 in Silver Mines and Silver Miners, 76.
TABLE 2
Mercury Exported to Mexico and Distributed to Zacatecas, 1600–1700
(By Decades and in Hundredweights)

<table>
<thead>
<tr>
<th>Date</th>
<th>Mexico</th>
<th>% Change</th>
<th>Zacatecas</th>
<th>% Change</th>
<th>Total Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600-1610</td>
<td>30,402</td>
<td></td>
<td>1,353</td>
<td></td>
<td>4.5</td>
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<tr>
<td>1610-1619</td>
<td>40,697</td>
<td>33.9</td>
<td>15,037</td>
<td>1,011.4</td>
<td>37.0</td>
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<tr>
<td>1620-1629</td>
<td>40,754</td>
<td>0.2</td>
<td>16,248</td>
<td>8.1</td>
<td>39.9</td>
</tr>
<tr>
<td>1630-1639</td>
<td>22,909</td>
<td>-43.8</td>
<td>9,197</td>
<td>-43.4</td>
<td>40.2</td>
</tr>
<tr>
<td>1640-1649</td>
<td>27,593</td>
<td>20.5</td>
<td>10,993</td>
<td>19.5</td>
<td>39.8</td>
</tr>
<tr>
<td>1650-1659</td>
<td>23,170</td>
<td>-16.0</td>
<td>5,600</td>
<td>-49.1</td>
<td>24.2</td>
</tr>
<tr>
<td>1660-1669</td>
<td>16,433</td>
<td>-29.1</td>
<td>3,685</td>
<td>-34.2</td>
<td>22.4</td>
</tr>
<tr>
<td>1670-1679</td>
<td>23,428</td>
<td>42.6</td>
<td>7,692</td>
<td>108.7</td>
<td>32.8</td>
</tr>
<tr>
<td>1680-1689</td>
<td>18,327</td>
<td>-21.8</td>
<td>8,340</td>
<td>8.4</td>
<td>45.5</td>
</tr>
<tr>
<td>1690-1699</td>
<td>16,942</td>
<td>-7.6</td>
<td>5,040</td>
<td>-39.6</td>
<td>29.8</td>
</tr>
<tr>
<td>Totals</td>
<td>260,655</td>
<td></td>
<td>83,185</td>
<td></td>
<td>31.9</td>
</tr>
</tbody>
</table>

Note: Data for Zacatecas, 1600–1610 is incomplete. Bakewell, Silver Mining and Society, 251–57.

decade of the nineteenth century, a total of 200,000 quintales or more of mercury arrived from Europe. To supply Peru with several thousand quintales a year and Mexico with 10,000 to 20,000 quintales meant that Almadén (and Idria) had to produce annually from 15,000 to 25,000 quintales. With such heavy dependence on imports, and given the perils and delays of the Almadén operations and the Atlantic crossings, shortages were bound to occur. But there were no long-term shortages in either Peru or Mexico, and, at times, such as the 1790s, the supply of mercury was ample. In the Viceroyalty of Peru (formerly Lower Peru), the treasury had 11,000 quintales on hand in 1790 and received 40,000 quintales through 1797 from Huancavelica and Almadén. Even after this abundance of mercury sparked an explosion in output that totaled more than 30 million pesos, or 4.5 million pesos per year, the treasury still had in 1797 a balance of about 16,000 quintales, enough mercury for approximately two years.50 Similarly, in Mexico during the 1790s, when its silver refineries were consuming 20,000 to 25,000 quintales per year, Mexican imports were not only keeping pace but were also providing year-end balances of 15,000 to 25,000 quintales, enough for at least a year's operation.51 Still, the mercury supply system was vulnerable. When the British blockade of the Spanish Peninsula was in effect from 1798 through 1801, the flow of mercury from Spain to the New World slowed to a trickle, with the

51 The figures in the mercury-distribution accounts were difficult to reconcile and were constantly being reworked. These are estimates based on three different reports from the Marqués de Branciforte, Viceroy of Mexico, to Diego de Cardoqui, with various dates from 1794 and 1795. AGI, México, leg. 1566.
consequence that silver output in Spanish America dropped by more than a third.\textsuperscript{52} Although surpluses existed in both Peru and Mexico, they were quickly drawn down during the shortage and not rebuilt after imports resumed in 1802. Supply was only part of the mercury equation, however. Peruvians paid more for mercury than Mexicans, and, since they normally had lower yields, they had a harder time, no matter the level of supply, making a profit. Without a downward adjustment in mercury prices and other financial incentives, expanding mercury supplies would have contributed little to the long-term growth and development of the Peruvian silver industry.

The price of mercury actually moved downward during colonial times, but it did so slowly and to the advantage of the Crown.\textsuperscript{53} As a general rule, mercury prices were lower in Mexico than in Peru even though the Mexican price started at a higher level than Peru's. In Mexico, prices dropped from 180 pesos per quintal to 82.5 pesos in the early seventeenth century and then to 41 pesos in the last quarter of the eighteenth century. In Peru, the price of mercury from Huancavelica was set at 104 pesos per quintal in the late sixteenth century, and for the last half of the colonial period prices fluctuated between the high 90s and the low 70s per quintal, although miners lacking capital might pay the equivalent of 100 pesos per quintal to their creditors (aviadores). In 1809, Peru's price dropped to 50 pesos per quintal, the lowest official price ever. Almadén mercury, which Peru came to depend on more and more in the late eighteenth and early nineteenth centuries, was normally set at a price that reflected the cost of operating the mine at Huancavelica. As a result, Andean miners paid about twice the price that Mexican miners paid for Almadén mercury (in part, to cover higher transportation expenses), despite repeated requests by the Peruvians to be granted the same price that Mexicans paid.\textsuperscript{54} Higher mercury prices translated into higher mining costs at a time when the ore yielded on average no more than the customary ratio of 100 marks of silver per quintal of mercury and may have fallen below that level.\textsuperscript{55} Mercury was the single most expensive item in the refining operation. In Mexico, after the final price reduction in 1778, Almadén mercury accounted for one-fifth of the total refining costs, and Idria mercury, used when none other was available, accounted for one-quarter of those costs.\textsuperscript{56} In Peru, one-third or more of the total refining costs went for mercury. Peruvian producers had to find a way of raising yields or streamlining operations to make up for higher mercury costs. Neither was easy.

\textsuperscript{52} Regulations required that during shortages mercury be reserved for the largest refineries with the most ore ready to be amalgamated. Fisher, \textit{Silver Mines and Silver Miners}, 81; and AGN, Mexico, Historia, leg. 92, esp. 40.

\textsuperscript{53} Bakewell, "Mining in Colonial Spanish America," 2: 122.

\textsuperscript{54} Fisher, \textit{Silver Mines and Silver Miners}, 81-82, 83-84. In 1800, the price of Peruvian mercury was raised from 73 to 85 pesos per quintal in order to stimulate production at Huancavelica and reduce demand for Almadén mercury during the British blockade (81-82). The purchaser usually paid the cost of transporting the mercury from a central warehouse to the mining camp. But the cost of transporting the mercury overseas was included in the price fixed by the monopoly.

\textsuperscript{55} Fisher, \textit{Silver Mines and Silver Miners}, 74.

\textsuperscript{56} David Brading, \textit{Miners and Merchants in Bourbon Mexico, 1763-1810} (Cambridge, 1971), 152-56; and Garner, "Silver Production and Entrepreneurial Structure," 177, n. 58. In that footnote, gross profits should read 4-20 percent instead of 20-40 percent.
and, because of the thin profit margins, the producers often had to buy mercury with cash borrowed from aviadores or on credit from the local treasury. Aviadores added a steep charge for advancing cash, while the treasury, with a growing portfolio of unpaid mercury debts, could refuse credit or confiscate silver or other property until all indebtedness was removed. Price, more than supply, worked against a profitable industry over the long term.

Among the most costly items for Peruvian and Mexican mineowners were wages and salaries. They constituted a larger part of the total cost in the extracting than in the refining of the ore. How much a silver producer had to pay in wages and salaries (either in cash or kind) had a major impact on the profitability of the operation. In the first decades after the major silver discoveries, draft labor had to be used in both Peru and Mexico. In the late sixteenth and early seventeenth centuries, voluntary labor began to supplement draft labor but did not completely replace it. Peru’s draft-labor system (mita) remained in effect at both Potosí and Huancavelica until the end of the colonial period, although the majority of Peru’s workers were hired rather than drafted. Some historians have argued that the continued reliance on the mita system, even for a minority of the laborers, became an obstacle to the development of mining in Peru because it disguised what would have been the real labor costs if the draftees had been hired at prevailing rates. But others have argued that it was precisely the high cost of mining in Potosí (and in Huancavelica) that led both the mineowners and the public officials to defend continuation of the mita. Without it, many mines would not have shown any profit, even after the Crown cut silver taxes and mercury prices in the eighteenth century, and the treasury would have lost revenue. No Spanish institution provoked as much condemnation as the draft-labor system—mita in Peru and repartimiento in Mexico—because of its cruel and exploitative character. But differing economic conditions may explain why Peru’s system not only survived but evolved while Mexico’s virtually disappeared.

Finding enough workers for the widely scattered and remotely located camps was difficult at any time, and labor shortages, especially under the pressure of Indian depopulation in the sixteenth and early seventeenth centuries, were unavoidable. By 1600, the colonial mining industry needed between 20,000 and 25,000 workers, a number that was greater than could be supplied through

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60 Tandeter, “Forced and Free Labour in Late Colonial Potosí,” 100–04, 110–17. Certainly, Brading and Cross raised the same issue when they wrote that, “without this source of cheap labor the cerro Rico, with all its rich ores long since exhausted, could not have continued to work minerals which on average yielded no more than 3 3/4 ounces of silver per hundredweight,” in “Colonial Silver Mining,” 560. See also Cole’s concluding chapter that incorporates Tandeter’s study in The Potosí Mina, 125–36.
voluntary labor.\textsuperscript{61} In 1600, Peru and Mexico had about the same proportion (half and half) of draft and voluntary laborers.\textsuperscript{62} After 1650, labor shortages moderated as the colonial population began to grow, but they remained a factor in Peru because its population was smaller and grew more slowly.\textsuperscript{63}

The institutionalization of the \textit{mita} in Peru extends beyond the simple demographic issues. The \textit{mita} was organized in the 1570s to provide a pool of about 13,500 workers at Potosí, of which only one-third were supposed to be working in any given week. By 1600, the camp needed 11,000 to 12,000 workers, and the difference between what the \textit{mita} provided and what the camp needed was made up by \textit{mingas}, workers hired from among the “off-duty” \textit{mitayos} and other Indians in search of work. Thus, within a quarter of a century of the founding of the \textit{mita}, \textit{mingas}, many of whom may have come to Potosí under the \textit{mita}, outnumbered \textit{mitayos} three to one. Both government and industry expressed a preference for hiring workers rather than drafting them, but their overall concern was not just having enough workers but having enough at a reasonable wage. Since \textit{mitayos} were paid less than \textit{mingas}, the continuation of labor drafts had a strong financial incentive. The insistence on preservation or expansion of the \textit{mita} at the same time that the number of \textit{mingas} was growing was derived in part from an effort to control labor costs.\textsuperscript{64} Without the \textit{mita}, Potosí would have had trouble attracting workers under the wages and conditions that \textit{mitayos} had to accept, and many mineowners would have had trouble staying in business. The \textit{mita} did supply a scarce commodity at a bargain price on a temporary basis, but, equally important, it served as a source for the hiring of permanent workers at higher wages than \textit{mitayos} earned though not as high perhaps as a free market would have dictated.

With mine labor frequently in short supply, Potosian miners learned quickly how to buy, sell, lease, and swap labor despite the state’s persistent efforts to regulate and allocate the supply. Potosi’s labor market became a hybrid. It was shaped but not dominated by either the coercive or the voluntary system. The market showed itself to be remarkably inventive and constantly changing even as Potosí moved from expansion to contraction. In one arrangement, some miners sold or leased the services of their assigned \textit{mitayos} to other producers rather than use them in their own operations; in another, which became popular, some communities, unable to meet their quotas, negotiated with owners to substitute cash payments for drafted workers, the cash to be used, presumably, to hire


\textsuperscript{62} Bakewell, \textit{Miners of the Red Mountain}, 111–13, 185–86. In \textit{The Potosí Mita}, 56, Cole estimated that the ratio of one drafted worker to one voluntary laborer was maintained during the seventeenth century at many small operations, and he also discussed (48–50) how competition for draft labor intensified because the number willing or able to work as \textit{mitayos} was dwindling. Although draft labor was used in camps besides Potosí, such as Ovuro, and in farming and manufacturing, it did not become such an integral part of these local and regional economic developments as it did in Potosí. For further comments on the labor force within the general demographic history, see Noble David Cook, \textit{Demographic Collapse: Indian Peru, 1520–1620} (Cambridge, 1981); and Nicolás Sánchez-Albornoz’s \textit{Indios y tributos en el Alto Perú} (Lima, 1980).

\textsuperscript{63} As late as the eighteenth century, epidemics and famines could induce temporary labor shortages with attendant declines in silver registrations in Mexico (1737, 1760, 1779, and 1784), but they were generally manageable. Garner, “Silver Production and Entrepreneurial Structure.”

\textsuperscript{64} Cole, \textit{The Potosí Mita}, 51–52.
replacements. Trading in mitayos apparently grew as mining costs rose and profits plummeted during the first half of the seventeenth century. Holders of mitayos paid them 2.5 to 3.5 reales per day, but they could earn several times that amount by selling or leasing their services. The buyer probably paid no more than the prevailing rate in the open market, and the mitayo, regardless of his employer, received no more than the mita-prescribed wage. For the seller, trading in mitayos could bring more profit than operating the mine or refinery to which the mitayos were assigned. The government estimated that a single mitayo could fetch 235 pesos a year. If the services of a third or a half of the several thousand mitayos on duty in Potosi were sold or leased for the period of one year, those transactions would generate between a quarter and a half-million pesos for the original holders of the labor obligations. The cash-substitution plan followed two basic forms. Indian communities could hire and pay substitute workers (usually mingas) or transfer the money for them directly to the mineowners. Either way, the miners could shift a percentage of their operational costs to the Indian communities without having to share any of the savings or profits with them. In an unexpected (and illegal) twist, the miners, who received cash in lieu of workers, could opt to pocket the money rather than use it to hire replacements, hence the phrase indios de faltriquera, or Indians in the pocket. From time to time, royal officials reported that only one-third or one-half of the mitayos actually showed up to work in Potosi, the rest having been paid for in cash. As much as a million pesos could flow from the Indian communities to the Potosi miners each year, although such an amount must be treated as the exception rather than the rule. In 1659, one royal inquiry turned up the fact that the delivery of silver in place of workers amounted to 580,000 pesos, a figure said to be much higher than what the treasury collected in silver taxes. Some cash was used to hire mingas, and some was certainly pocketed, but the exact division was seldom documented. Despite much criticism on economic, administrative, and moral grounds, the mita survived because it evolved from a short-term labor-supply system into a financial service that helped to subsidize Potosi’s miners as mining itself grew more costly and less profitable.

66 Bakewell, Miners of the Red Mountain, 156–60. The selling or leasing of mitayo services was more complex and subtle than the above description suggests. In one case, Bakewell explained that refinery owners piled up mercury debts with the treasury in order to win approval to lease their plants and the mitayos assigned to them because they could make more money from the leases than from the refineries.
67 The figure was arrived at by assuming that there were approximately 3,000 mitayos on duty in Potosi each year in the seventeenth century and by multiplying the annual wages of the local mingas (7 to 9 pesos per week, or 400 to 425 pesos per year) times one-half to two-thirds of the mitayo population. Bakewell, Miners of the Red Mountain, 161–62.
68 Cole, The Potosi Mita, 92. Cole’s source, a report by Francisco de la Cruz, the bishop-elect of Santa Marta, stated that the royal fifth at Potosi was only 300,000 pesos in 1659. Bakewell and Lamberto de Sierra showed silver registrations that should have yielded taxes in the range of 600,000 to 700,000 pesos, but TePaske and Klein showed silver revenues at Potosi of about 500,000 pesos. This discrepancy raises the possibility that, if de la Cruz’s figure for the royal fifth is inaccurate, his estimate of the mita deliveries could also be suspect. It is often difficult to reconcile several sets of figures, such as silver marks versus silver revenues, in any given year.
In the eighteenth century, economic forces combined to resuscitate the *mita* at Potosí and to lead some to call for it to be extended beyond Potosí. The forces at work were a revival in mining, spurred in part by cuts in silver taxes and mercury prices, and a scarcity of labor. The underlying cause of the labor shortage in the Andean camps was the slow rate of the population growth, although some regions posted greater gains than others. The Spanish also believed that Indians would not work in the mines unless “forced” to do so, which in a sense was true; many Indians refused to work because they had other job choices. The imbalance between the supply of and demand for labor boosted wages and costs. In Potosí, a high-cost and low-profit camp to begin with, *mita* labor was one way to cut expenses in order to raise profits, since *mitayos* were paid less than free laborers. During the seventeenth century, the number of all workers needed annually in Potosí had fallen from 10,000 to 4,000. The number of *mitayos* had declined as well and may have dropped even further in the first quarter of the eighteenth century. After the revival began in 1720s and 1730s, the demand for labor surely rose. For the end of the eighteenth century, when Potosí’s mining was on the wane again, Enrique Tandeter reported that the camp had about 5,000 laborers of whom just under half (2,376) were *mitayos*. As in the past, *mitayos* held the least desirable jobs, such as hauling and grinding ore, jobs that could not be easily or cheaply filled by wage labor. Potosian mineowners had long tried to exact more work from the *mitayos* than the regulations permitted (another way of getting more output for the daily wage). In the eighteenth century, some of the regulations were rewritten so that the *mitayo*’s daily quotas (thirty bags of ore instead of fifteen, for example) increased, while his wages did not. *Mitayos* had to work longer hours and enlist family members to fulfill their obligations, all of this at no higher cost to the owner. The difference between what *mitayos* were paid and what *mingas* had to be paid ended up as miners’ profits. The continuation of *mita* labor and the revision of its work rules may have contributed substantially to Potosí’s recovery in the second half of the eighteenth century, although this remains to be spelled out in detail. In short, mining became profitable once again at the expense of the Indian communities that had long subsidized the *mita* system.

By the late eighteenth century, Upper Peru and Potosí had been attached to the Viceroyalty of Rio de la Plata, but *mita* quotas earlier defined for Potosí remained in force for certain provinces in the newly reorganized Viceroyalty of Peru (Lower Peru). Apart from the financial gain through the continued use of the *mita*, the need for labor may have been as real in Upper Peru as it was becoming in Lower Peru, especially at Pasco, the viceroyalty’s premier camp. Moreover, Indians in Lower Peru were disinclined to seek or to accept work in the mining camps, and miners, expressing their exasperation, often demanded labor drafts to relieve

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71 Cole, *The Potosí Mina*, 120.  
shortages and moderate wages. Some “voluntary” drafts were permitted but were seldom successful. At Pasco, the shortages were so severe and constant that workers could earn as much as 3 pesos a day, a wage that was several times higher than what miners thought that they should pay or could afford. Competition for workers even led to poaching, which the government tried to ban.\textsuperscript{73}

In the long and controversial history of the mita, certain developments make some economic sense. Bakewell argued, correctly I believe, that, despite the protestations of royal officials and later historians, the selling and “pocketing” of mita services could be economically useful because they introduced a degree of flexibility into a system whose quotas were normally revised each decade.\textsuperscript{74} But, as Potosí slid more deeply into a mining depression, that economic rationale became less valid because sustaining the industry rather than shifting the labor of that industry was the chief concern. The delivery of mitayos whether in person or in silver became a way to help to keep Potosí’s financially beleaguered miners in business, a goal, it should be stressed, that the Crown often shared.\textsuperscript{75} If wages had been allowed to rise to reflect the imbalance in supply and demand, many Potosian mines would have gone bankrupt, with losses not only to the industry but to the Crown as well. Subsidies were preferable to abandonments, even though the miners had to mount active campaigns to persuade increasingly skeptical viceroys that the mita in various forms had to be preserved. The miners lost a few battles—periodically, the Crown approved reforms—but won the war because, as Potosí’s production turned upward in the 1730s, the mita both provided scarce labor and subsidized costly operations. Its survival was assured until the end of the colonial period.

Although the mita endured in Andean mining until independence, its Mexican counterpart, repartimiento, did not survive the seventeenth century.\textsuperscript{76} The question that needs to be raised, even though we may not be able to answer it yet, is whether the emergence of free labor in Mexico contributed positively to the development of the mining industry in contrast to the dual system of free and forced labor in Peru. That Mexico’s population was larger, may have recovered more quickly in the seventeenth century, and was located closer to the major mining centers than Peru’s were distinct advantages. It may be equally significant that, as the silver industry took root and the employment regimen took shape, no single Mexican camp had a demand for labor comparable to Potosi’s. In the late sixteenth and early seventeenth centuries, when the pressure of Indian mortality was the heaviest, draft and slave labor were used primarily to alleviate local shortages. David Brading and Harry Cross cited the example of Pachuca, which drafted 1,108 Indians from surrounding villages during 1576–1579 but only 57 by 1661.\textsuperscript{77}

According to a survey of the industry in the 1590s, the number of mine workers

\textsuperscript{73} Fisher, Silver Mines and Silver Miners, 90–97.
\textsuperscript{74} Bakewell, Miners of the Red Mountain, 162–63.
\textsuperscript{75} Cole reported that Potosí’s miners would “literally kill” to protect the practice of indios de faltriquera. The Potosí Mita, 124.
\textsuperscript{76} Fisher, Silver Mines and Silver Miners, 92–94; and Bakewell, “Mining in Colonial Spanish America,” 2: 128.
\textsuperscript{77} Brading and Cross, “Colonial Silver Mining,” 557.
had reached over 9,000 for the whole colony (compared to more than 10,000 in the single camp of Potosí in Peru); of the 9,000, 68.5 percent were naborias, or free Indian workers, 17.7 percent were repartimiento Indians, and 13.8 were slaves. Naborias tended to be concentrated in the north, where the natives were less populous and repartimiento labor in the central areas, where the natives were more numerous. Because northern miners lacked access to the Indian communities in the central areas, the probable location of the colony's major boom in the late sixteenth century, they had to find other ways (slavery, wages, or peonage) to bring workers to their camps. Had northern Mexico, where the population was small and scattered, sprouted a Potosí, the colony would probably have created a draft-labor system. By the time the mining industry had shifted from the center to the north, a wage-labor system was already in place. Although never widespread in the northern camps, repartimiento did on occasion account for a third of the workers in Zacatecas, which had become the colony's premier camp.78

During the Indian depopulation from the middle of the sixteenth century to the middle of the seventeenth century, competition for labor in Mexico could be intense. Three strikes—two in the 1630s and one in the 1650s—at Parral may have severely depleted the pool of workers in Zacatecas and other nearby camps. Many mestizos and mulattos, who were often the skilled workers, migrated to Parral because their skills commanded a higher wage there than in Zacatecas.79 An intermediate form of labor between the compulsory and voluntary systems was peonage, which Indians accepted to earn money for tribute and other obligations. In Zacatecas, Bakewell found instances in which money may have been advanced, although he could not always ascertain whether this was done to attract or retain the workers. It was widespread enough to cause the viceregal government to issue rules limiting the time of indebtedness, usually four to eight months. No doubt peonage inspired abuse but not uniformly so. Many workers had no debts, and many others may have been influenced to stay whether in debt or not because of the attractiveness of the wage, the pepena (worker's ore allotment), and the general living conditions.80 Despite the falling population, Bakewell concluded that the terms of employment often played a larger role in creating labor shortages than did the demographic factors. In his view, "the availability of Indian labour [in Zacatecas] depended on the prosperity of mining, [rather] than the prosperity of mining on the availability of labour."81

Periodic labor shortages and the absence of a large-scale, state-run labor system notwithstanding, wages for Mexican mine and refinery workers do not appear to have been as high as or higher than wages for voluntary laborers in Peru. Comparing wages of mine workers within the same colony or between two colonies is risky because the evidence is scant and because wages were paid in cash, in kind,

80 Bakewell, “Notes on Mexican Mining,” 398; and Silver Mining and Society, 126.
81 Bakewell, Silver Mining and Society, 128–29, 200–01.
in ore shares, or in combinations of all three. During the seventeenth and
eighteenth centuries, Mexican workers were paid, on a weekly basis, between 2 and
4 pesos, a wage that, if paid in cash, was more than the average minga received but
not as much as the average mituyo received in Peru. An arrangement for a share
of the ore (called both pepena and partido) could earn the worker two to three times
his wage. Not all categories of mine or refinery workers qualified for ore shares,
and the rates varied from camp to camp and from mine to mine. Although the
pepenas made mine and refinery workers Mexico's highest paid workers in an
industry in which labor accounted for better than half of the total production costs,
it did not become over the long term a prohibitive financial burden. Future
research may show whether tying workers' wages to pepenas made the labor force
more efficient and productive than relying solely on wages. In the eighteenth
century, some miners complained that high labor costs, in particular, the pepenas,
in combination with rising costs for repairs and expansions, rendered mining less
and less profitable. Some mine and refinery owners succeeded in reducing labor
costs, although they were greatly aided in this by population growth that increased
the competition among the workers for the jobs. In general, the cost of labor to
the employer on a daily or weekly basis held steady and may have even decreased
in eighteenth-century Mexico, while it edged up in Peru.

Peru's lower ore qualities and higher mercury and labor costs made
long-term financing less attractive there than in Mexico and further handicapped
the Andean silver industry. Clearly, the trends, whether or not investors fully
comprehended their significance, favored a more cautious approach in Peru. Since
the early seventeenth century, the main source of capital for mining had been the
merchant community. Merchants could become involved in different ways: they
could advance cash or credit (avios) to pay for wages and supplies; they could
underwrite the cost of building adits and shafts, repairing tunnels, and erecting
refineries; and they could purchase shares or partnerships in mining companies.
Extending avios was widely practiced in both colonies. It entailed the least risk over
the shortest time for the merchant, since he offered avios only to producers who
agreed to sell their refined silver to him. The merchant-avizador paid less for the
silver than the mint did and considered the difference as his profit or commission.
In Mexico, however, financial arrangements between producers and merchants
evolved beyond avios. In addition, we must recognize that the long mining

82 Bakewell, Silver Mining and Society, 125; Bernard Bobb, The Viceroyalty of Antonio Maria Bucareli
of New Spain, 1771-1779 (Austin, Tex., 1961), 177-78; and Brading, Miners and Merchants, 147-49, 184,
186, 193, 199, 201, 204, 277-78. There is little evidence that a system of pepenas to supplement wages
developed in Peru, although in the late eighteenth century some miners began to offer a share of ore
in order to attract new workers. Fisher, Silver Mines and Silver Miners, 94.
83 As Bakewell, Brading, and Fisher have all pointed out, there were risks, in that workers tried to
reserve the best ores for themselves and might resort to cutting out the pillars (which supported the
roofs) in order to get ores.
84 Brading, Miners and Merchants, 148-49.
85 For brief discussions of mining capital, see Bakewell, "Mining in Colonial Spanish America," 2:
136-38; and Brading and Cross, "Colonial Silver Mining," 566-68. For an extended discussion of how
capital was raised in late colonial Mexico, see Brading, Miners and Merchants, chap. 4.
depression had reduced Peru's capital resources (for mineowners and merchants alike) and limited its economic growth. Peruvian merchants may have more readily accepted long-term risks in the flush times of the late sixteenth and early seventeenth centuries than later. In the former period, merchants allowed miners to roll over their loans at increasingly higher interest rates. The worsening depression made that practice less popular. Conversely, expansion in Mexico had replenished the capital pool and enhanced business in general. Mexican investors exhibited an entrepreneurial spirit, which Peruvians as late as the 1790s complained that Peruvian investors lacked: "The Kingdom of Mexico has always prospered on account of its Mines: Peru, whose mines are richer and more numerous, is barely kept alive by hers. This contrast arises solely from differing attitudes towards Mining in the two countries. There a rich merchant will advance 50,000 or 100,000 pesos for the working of a Mine, simply on the word of the Miner, and remain unmoved when he learns that the vein has been lost: here there is hardly an habilitador [backer] who advances 10,000 or 12,000 pesos (if, indeed, any provide so large a sum) without seeking to squeeze the Miner and his Mines until he has the piña [silver not yet cast into bars] in his hand, and his profit is thus assured." 

Less is known about how mining was organized and financed in Peru than in Mexico. It is plausible that, after the installation of the amalgamation process in the late sixteenth and early seventeenth centuries, the structure of the viceregal mining industries followed different patterns: the scale of Peru's mining and refining operations became smaller as Mexico's became larger. A single comparison from the late eighteenth century is instructive but not definitive. For (Lower) Peru, John Fisher estimated that the average mine employed under twenty workers, while Pasco, its largest camp, had about thirty. No colony-wide ratio for late colonial Mexico exists yet. In Zacatecas, however, the average was fifty workers per mine. Pasco and Zacatecas had almost the same number of workers (2,500 versus 2,700), but productivity was higher in Zacatecas, with 40 percent fewer mines that averaged two to three times more silver than Pasco. One result of the increasing participation of Mexico's merchant community was the establishment of many large, heavily capitalized, and vertically organized mining companies. Mexican producers and investors had discovered the benefits of large-scale operations perhaps as early as the second half of the seventeenth century, whereas Peruvians had initiated few such operations by the late eighteenth century. The remarkable entrepreneur López de Quiróga was an exception to the long-term

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86 Andrien, Crisis and Decline, 92–93.
87 From Mercurio Peruano, 3 (January 9, 1791): 21–22, quoted in Fisher, Silver Mines and Silver Miners, 98; also see Fisher, "Mining and the Peruvian Economy," 52.
88 Fisher stated in "Mining and the Peruvian Economy," 52, that "about a dozen" employees made up the average work force. In his Silver Mines and Silver Miners, 95, the ratio of mine workers to productive mines in 1799 is between sixteen and seventeen to one. For Zacatecas, a list of mines and the number of workers per mine for 1790 can be found in Archivo Municipal de Zacatecas, leg. 29, exp. 22.
89 Braden's Miners and Merchants, chap. 4, remains the best overall treatment of the organization of Mexico's important camps and of the operations in those camps.
Peruvian pattern. Potosí had had other wealthy miners, such as Hernán Carrillo de Córdova and Pedro de Mondragón, but they were beneficiaries by and large of the original Potosian boom during the late fifteenth and early sixteenth centuries, when the processing of the tailings was so profitable. According to Bakewell, while these and other Potosians exhibited capitalistic traits, López de Quiroga represented a “new phenomenon,” “the first capitalistic miner” in Potosí and perhaps in Spanish America. His wealth may have grown to tens of millions of pesos over the course of his career in mining, commerce, and ranching. What set López de Quiroga apart from other miners of his and earlier generations was the scale of his operation and the extent of his success at a time of few investments and numerous bankruptcies at Potosí. He possessed enormous capital resources with which he built a huge enterprise of mines, refineries, and the businesses that provided the products needed to keep the mines and refineries operating. With his knack for finding ways to streamline his operations and increase his profits, he proved to be an able and effective manager of an extensive financial empire.90

Impressive as his achievements were, López de Quiroga did not become the model for other Potosian or Peruvian miners. Continued reliance by most on short-term avies both reflected and reinforced the development of small-scale operations.

During the last quarter of the eighteenth century, Pasco’s success as a mining center was in part the result of a departure from the avies system. Silver was first discovered in Pasco around 1567. Production data, based on treasury receipts, exist only from the 1670s to the end of the colonial period. After posting figures in the range of 500 to 1,000 marks per year during the last quarter of the seventeenth century, output began to grow in the early eighteenth century.91 In the early eighteenth century, few of Pasco’s pits exceeded “30 varas [yards] in depth.” The presence of underground springs and the lack of drainage facilities made the mines prone to flooding and costly to operate. It was not until the middle of the eighteenth century that an adit for drainage was installed so that miners could move beyond the water line. By the last quarter of the eighteenth century, Pasco miners faced once again the need to construct a new drainage system, which in 1780 some fifty miners agreed to support. Fisher reported that the “new ores were not exceptionally rich, but [were] plentiful,” plentiful enough, it would appear, to persuade the miners in 1794 to build a larger adit. Miners in Pasco had known of the need for adits to drain the mines since the seventeenth century, and the technology was fairly well understood. Several projects for building or enlarging adits were undertaken at Pasco, with some success between 1750 and 1850, but, because they were so costly, they were seldom finished on time or as designed. Such projects required a level of financing that few Peruvian miners individually could afford and, in the absence of mercantile capital, Pasco miners pooled their funds or tapped revenues available through the miners’ guild to build the adits. From time to time, they had access to cheap Indian labor (with official approval), which kept costs down. Large import-export merchants, who could

91 TePaske and Klein, Royal Treasuries of the Spanish Empire in America, 1: 524–62.
have provided long-term financing, continued to prefer short-term avías, which
entailed less risk, a quicker return, and more profits. Late eighteenth-century
Peru was not as poor as it had been a century earlier, and yet Lima merchants, who
were among Peru’s wealthiest, continued to plead insufficient funds arising in large
part, they argued, from losses incurred in the dismantling of the commercial
monopoly. Among the merchants themselves, critics charged their colleagues with
being provincial and inept in adapting to the changing commercial economy. It
is little wonder that they found investment in mining so daunting. Without the
broad participation of the colony’s principal moneylenders, mining in Peru (in
comparison to Mexico) was, according to Fisher, organized and financed as a
“subsistence activity.”

In Mexico, silver entrepreneurs began to tap merchant capital for both
long-term and short-term ventures in the seventeenth century, and they continued
borrowing on an even greater scale in the eighteenth century. Although avías
remained the conventional financial mechanism, the merchant’s role grew as
production increased. In contrast to Peru, joint ventures between merchants and
miners became commonplace. In the early eighteenth century, Zacatecan mining
merchants joined miners as partners in enterprises, some of which were formed
to rehabilitate but not to operate the mines, while others were formed to do both.
In the second half of the eighteenth century, merchants and miners formed
companies in which shares of stocks were issued and profits distributed. Zacatecas’s
Veta Grande Company was organized in the early 1780s and spent nearly 1.2
million pesos over the next twenty years before striking it rich. Brading described
its stockholders as a “small group of Mexico City merchant-capitalists and finance
houses which had dominated entire sections of the mining industry throughout
the eighteenth century.” The company had trouble paying its bills in some years,
but it continued to invest in acquiring, consolidating, and rehabilitating its
properties until the early 1800s, when it yielded dividends for the remaining
stockholders of more than 3 million pesos. Capital was also raised in many ways:
from family members, from religious orders, or from the miners’ own resources,
but the merchant as aviator, rescator (independent refiner), partner, or stock-
holder remained the primary source for capital or credit. Zacatecas, which suffered
the longest slump of all the major districts during the eighteenth century,
continued to attract enough capital to carry out some large ventures, although at
times it needed more than it could raise. Quebradilla was counted among
Zacatecas’s richest mines, but it was only productive for about a dozen years
between 1700 and 1810. Still, at least three companies were organized to drain and
repair the mine during the mid-century slump (before José de la Borda
successfully rehabilitated the mine in the 1770s). In all these ventures, which lost

93 British Library, Manuscript Division, Additions 15, 981, fols. 22–34; and Fisher, Silver Mines and
Silver Mines, 98. How much capital these merchants actually controlled remains undetermined. It is
probable that, in part because of the long mining depression, Peru’s merchants were by comparison
poorer than Mexico’s.
94 Brading, Miners and Merchants, 204–07; and Garner, “Silver Production and Entrepreneurial
several hundreds of thousands of pesos, merchants were the principal underwriters. One could argue that, on the basis of the roster of miners and refiners in mid-eighteenth-century Zacatecas, the number of merchants extending loans and acquiring mines was growing rather than decreasing as the camp’s silver registrations continued to plummet. As risky as investing in Zacatecas may have been, it paid off for some, and that was enough to encourage others to try.95

Mexico’s silver-production curve made risk-taking more tolerable. The rise in output over time made the slumps and depressions, some of considerable magnitude, appear less serious and more manageable. While many mining operations failed to make any profits and probably bankrupted their owners and backers, enough of them succeeded to add to the colony’s overall wealth, particularly in the eighteenth century, when merchants poured capital into the opening and rehabilitation of mines, not only in Zacatecas but also in Pachuca, Bolaños, and Catorce. One characteristic that owners and backers shared was a willingness to plow profits back into the operations to make them more efficient and productive. The rising silver curve reinforced the expectation of success.

An important feature in the evolution of the industry was the emergence of more large-scale, efficient, and capital-intensive companies. In seventeenth-century Zacatecas, according to Bakewell, Bartolomé Bravo de Acuña found a way to combine operations of four different mines, and, as a result, he “improved the mines by linking them . . . and in due course he made a fortune from them.”96 A half-century later, Pedro Salazar, an avíador, won the support of mineowners who worked the same vein to create a fund by assessing each owner. The money was used to repair and maintain the shaft and adit that served all their underground workings. The plan continued in effect for nearly ten years (1715–1725), even though Salazar himself did not live to see it implemented.97 This pattern culminated with the late eighteenth-century mining company, which had miners and merchants among its stockholders, which worked clusters of mines along the same veins, and which might even enjoy special concessions.98 Of course, Mexico still had weaknesses and defects to overcome. Capital was scarce and during the last quarter of the eighteenth century almost completely dried up, as the Crown began to implement an aggressive policy of “voluntary donations” and forced loans.99 The long-term success of mining was crucial in this regard, for while it consumed capital, it also generated capital. By contrast, Peru, except for the late

95 The government also had a role in terms of granting credit and exemptions from taxes for the purchase of mercury to help to stimulate investment by cutting operating costs. For a general discussion of the economic role of the eighteenth-century Mexican merchant, see Brading, Miners and Merchants, 95–128. On the role of the church as a lender, see Linda Greenow, Credit and Socioeconomic Change in Colonial Mexico: Loans and Mortgages in Guadalajara, 1720–1820 (Boulder, Colo., 1983), 160–62, 203–9. For the applications of royal concessions in Zacatecas, see Garner, “Silver Production and Entrepreneurial Structure,” 173–85.
96 Bakewell, Silver Mining and Society, 135.
97 AGI, Guadalajara, leg. 174.
sixteenth and perhaps the late eighteenth or early nineteenth centuries, was predominately a consumer of capital.

The role of the merchant, who controlled so much of the flow and distribution of capital in Spanish America, differed sharply between the Andean and Mexican mining economies. The recovery of mining in eighteenth-century Peru as a result of new strikes and lower costs did not alleviate merchants' skepticism or fears to the extent that they changed their investment practices. In Mexico, on the other hand, the role of the merchant grew significantly in the eighteenth century. In 1761, Francisco Xavier Gamboa, an attorney for the Mexico City merchants' guild, published his famous _Comentarios de las ordenanzas de minas_. He painted, perhaps purposely, a bleak picture of the Mexican mining industry to show why the industry needed capital and how the joining of merchants and miners into a single organization would help to raise that capital and spur production. But the condition of the industry was not as bleak as Gamboa indicated. Production had been rising steadily since the seventeenth century, and the downturn around 1760 was both temporary and selective. Gamboa and his merchant clients were interested in a revised legal code that would directly enhance the position of the merchant in the industry. His approach amounted to an endorsement of the industry's economic potential.100 But Gamboa's proposal had little chance of succeeding in Mexico, where, despite the long-accepted role of the merchant in mining, fear of the total domination of the industry by the merchant guild remained strong. Given the attitude of Peru's merchants, it is hard to imagine such a plan ever being adopted there.

I have made no attempt to treat the full range of topics that might be considered within a comparative framework for the mining economies of the two viceroyalties of Peru and Mexico. Rather, I have chosen to describe and analyze long-term production trends and growth rates as a first and necessary step to any full-scale comparative analysis. I have also tried to suggest the ways in which the three crucial factors of mercury, labor, and capital may have influenced the movement or the shape of the various silver curves. The production trends for total colonial output, total Peruvian output, and total Mexican output rose over the 250 years of rule by Spain in the New World. But the growth rates for the two viceroyalties, the principal components of total colonial production, were significantly different, and, while the long decline in the seventeenth century was largely the result of a plummeting trend in Peru, it was tempered by modest growth in the output of Mexico's mines. In the last quarter of the seventeenth century, as Peru's production continued to slide, Mexico became and remained the chief silver producer in the Spanish New World. In the eighteenth century, recovery and

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100 Francisco Xavier Gamboa, _Comentarios de las ordenanzas de minas_ (Madrid, 1761), 160–72; and Brading, _Miners and Merchants_, 149–52. After the third-quarter boom was well underway, Gamboa pressed the Mexican viceroy, Antonio Bucareli, to reconsider the merchant-miner guild, which the Crown had not yet approved (and did not ever approve). At this stage (with mining profits rising), the Consulado had even more reason to invest in mining. Sterling Library, Yale University, Latin American Collection, E-6.
expansion in the camps of Peru and Mexico caused total colonial output to climb slowly but steadily until 1810. New discoveries helped to boost output in the eighteenth century, but more impressive was the application of financial and technical resources to permit rehabilitation of many poorly maintained but still potentially profitable mines in older camps.

Once Potosí’s tailings were exhausted, mining costs became generally higher in Peru than in Mexico, and this difference may explain why Peru’s mining problems proved to be intractable. The great surge in production of silver at Potosí during the late sixteenth and early seventeenth centuries may have distorted the view of both the mining industry and the Crown as to what would arrest and reverse the seventeenth-century depression. Just as the surge in mining had enlarged the capital base of the Andean economy (or economies), the contraction shrank it. For more than a century, Peru lacked an engine to drive the economy. By contrast, in Mexico, silver mining, which became more broadly based in geographic terms, grew over time, and in so doing it continually replenished the capital pool that was needed in the mining sector and the general economy. The main engine of the colonial economy slowed down and even went into reverse on occasion but never for extended periods. The eighteenth-century expansion may have resulted from infusions of merchant capital, as some have argued, but it was capital that was originally formed in the mining sector and then recycled through the general economy.