

Do Institutions Matter in Extractive Industries? The Case of Mexican Mining, 1900-1929

Noel Maurer, Stephen Haber, and Armando Razo

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Abstract: Mining investment should be expected to be highly sensitive to the security of property rights, due to the industry's high sunk costs. This paper uses the historical case of Mexico in 1909-29 to argue that when most of a country's mining output is exported to a single market, this relationship no longer holds, since the importing country can cheaply enforce property rights by the simple expedient of prohibiting "stolen" imports. As long as the importing nation can be relied upon, producers will disregard threats to their property rights.

Introduction

In 1908, Mexico produced 31 percent of the world's silver, 11 percent of its lead, and 5 percent of its copper. Over the next two decades, the country experienced an attempt by an aging dictator to confiscate foreign-owned mines and re-allocate them to his cronies (1909), a revolution that overthrew that dictator (1911), a counter-revolution (1913), a counter-counter-revolution (1914), a civil war among the winners of the counter-counter-revolution (1914-17), a new constitution that deliberately gave the government the right to confiscate and reallocate land and subsoil rights (1917), one successful coup (1920), three coup attempts (1921, 1927, and 1929), a presidential assassination (1928), and two more bouts of civil war (1923-24 and 1926-29). Two decades later, in 1929, Mexico produced 42 percent of the world's silver, 14 of the world's lead, and 6 percent of its copper. In absolute terms,

silver output had risen 40 percent, lead output had doubled, and copper production had risen by two-thirds. This is not the result that one might have expected.

Investment and production in mining should, in theory, be highly sensitive to the specification and enforcement of property rights. The reason is that mining operations involve large sunk costs. Mines need to be dug, drained, and lit. Rails need to be constructed. Engineers need to be paid. If there is a significant chance that the government might seize the mine, or transfer it to a third party, then investors would be expected to be very reluctant to invest in mining.

The large sunk costs involved in mining make it a tempting target for expropriation. A government can take control of the mine and hire professionals to run it without bearing the cost of the initial investments. Investors in mining operations presumably understand that their operations are tempting targets, and should therefore be extremely sensitive to the security of their property rights. Changes that increase the insecurity of property rights would then be expected to have strong negative effects on investment in the mining industry, and, after a lag, on output.

Violent changes of government should also negatively affect mining, since unstable governments can not credibly commit to protect property. First, since their expected lifespan is short, they have few incentives to forego revenues now for more in the future. Second, when governments change hands at the barrel of a gun, constitutional government has broken down (by definition) and private investors can

no longer depend on the judicial system to protect their property rights. Third, unstable governments (or the factions seeking to overthrow them) have every incentive to reward their followers and punish their opponents by redistributing property rights.

In Mexico, neither Porfirio Díaz's attempt to redistribute mines to his cronies in 1909, the violent instability of 1911-1929, nor the Constitution of 1917 had little long-term impact on mining. There was a short-term decline in output during 1913-1917. That downturn, however, was short-lived. By 1918, when the railways returned to operation and international prices recovered, Mexico's mining companies got back to work. They quickly resumed their pre-1911 growth path and Mexico ended the 1920s producing more copper, silver, and lead (its three most important mineral exports) than it had produced in any year before 1911.

Why were Mexican miners apparently unfazed by threats against their property rights? First, mining taxes were already relatively high. Raising them would have caused marginal mines to cease operation, and done little to raise government revenue. (The government discovered this in the 1920s.) Second, American companies, which represented three-quarters of the capital invested in Mexican mining and smelting, could (and did) call on the U.S. government to protect them against confiscation. The U.S. could do this at very low cost because virtually all of Mexico's industrial metals were exported to the U.S. The Customs Service simply blocked the entry of "stolen" ores. In short, because Mexico's exports went to one

market, that market's government could cheaply, easily, and credibly enforce property rights.

One counter-hypothesis is that only foreign owners possessed the technical knowledge to run the industry. This is unlikely for two reasons. First, Mexican-owned mines and smelters were prominent in all of the country's major mineral products. Foreign assets could be transferred to them. Second, the Mexican government could hire foreigners to run the mines, much as the Soviet Union did. It was far important that learning to run a mine took time, time in which a faction or government facing violent opposition could not afford to be without revenues.

Mexico's Mining Industry in the 19th Century

Mining had been an important economic sector in Mexico since the early colonial period. At independence in 1821, it was common knowledge that Mexico possessed considerable mineral wealth. Moreover, the precise location of the major mineral bearing areas was well known. Nevertheless, the mining industry went into severe decline in the 19th century. The exact causes of this collapse have not been systematically studied. High mining taxes may have been a contributing factor. In 1868, for example, taxes on mining output were on the order of 24 to 26 percent *of revenues*. At this rate, existing mines might continue to operate, but few would have

been profitable.¹ For whatever reason, virtually all of the British companies that had invested in Mexican mining in the early 19th century failed by 1850.²

Changes in markets and technologies in the last decades of the nineteenth increased the returns from Mexico's mineral wealth. There now existed demand not just for Mexico's traditional products (silver and gold), but for industrial metals like zinc, copper, lead, and antimony. Since many industrial minerals also existed in the same ores that held precious metals, their joint exploitation was potentially profitable. New developments in refining technologies made low grade ores (which had not been worked in the past) profitable. In addition, the vertiginous growth of Mexico's railroad network reduced transport costs and made it feasible to export industrial metals, which had a much lower value-to-weight ratio than gold or silver.³

Technology enabled the growth of the mining industry, but capital still needed to be raised. Most of Mexico's mining sites were characterized by low grade ores at substantial depths. Exploiting those ores required sinking deep shafts, continually pumping out floodwaters, and constructing smelters that could reduce the ore to metal. Domestic capital markets were not capable of rapidly financing these investments. In order to quickly revive the industry, foreign capital was needed.

¹ Cleland (1922), p. 269.

² Cleland (1922), pp. 264-68.

³ Trackage expanded from 640 kilometers in 1877, to 10,000 kilometers in 1893, 16,000 kilometers by 1903, and 27,000 kilometers by 1910. See Coatsworth (1981), pp. 36, 40.

Property Rights under the Porfiriato

President Díaz needed foreign firms to extract, refine, and market the country's mineral wealth. The mining and smelting companies needed President Díaz to guarantee their property rights and access to the stream of rents produced by those property rights. For investment and production to take place, there had to be a commitment mechanism to constrain the government from behaving opportunistically. The end result was a system of property rights designed by the miners, and underpinned by relatively high taxes on the industry. As long as Porfirio Díaz expected to be in power, he had very little incentive to renege on this arrangement.

In 1883, the government created the Sociedad Mexicana de Minería, composed of representatives of the mining companies and the government. In 1883, the Sociedad drafted an amendment which would take away the right of state governments to regulate or tax mining. In 1884, it drafted a federal mining code.⁴

The mining laws of Porfirian Mexico—contrary to the standard textbooks—did not award the miners fee simple ownership of the subsoil, except for water, oil, and building materials.⁵ In fact, the miners preferred the separation of surface and

⁴ Velasco Ávila, Flores Clair et al. (1988), p. 344-53. The constitutional reform had to be approved by congress. The 1884 mining code, however, was put into effect by presidential decree.

⁵ Many standard works in Mexican history strongly suggest that because the 1884 mining code did not explicitly state that the subsoil was national patrimony that it somehow conveyed to the miners the

subsoil rights. In a fee simple system, a landowner can appropriate most of the value of a mine by charging a high rental rate or sales price for his land. In addition, neighboring property owners can charge high rental rates to allow miners to run power lines, tram or cable-ways, railroads and aqueducts across their property.

Mexico's mining code of 1884 therefore made the Mexican government the residual claimant on subsoil property. This meant that miners, acting through the federal government, enjoyed the right of "denouncement." This included the right to prospect for ore, mine an area, and expropriate rights of way on adjoining properties. Landowners were entitled to compensation, but the amount only had to reflect the value of the surface land and improvements, not the value of the minerals underneath the surface. If the miner and the landowner could not agree on this level of compensation, the law stipulated that a federal official would simply set the price.

The new laws also removed the possibility that state governments would predate upon the miners, prohibiting state regulation of subsoil rights and capping state mining taxes at two percent of the gross value of production..⁶

In return for laying down property rights, the federal government received taxes from the miners. The 1884 code gave federal government a surtax of 25

impression that they had been awarded fee simple ownership of the subsoil. See, for example, Meyer, Sherman et al. (1999), p. 431. In point of fact, the 1884 mining code explicitly stated that if a miner did not work his claim the government could reallocate it to another miner, without compensation. By logical extension, the government was implicitly the owner of the subsoil: You cannot reallocate the usufruct rights to something you do not own. The 1909 reform to the mining code explicitly stated that the subsoil was national patrimony, but changed nothing in practice.

percent of the mining revenues earned by the states.⁷ The 1892 mining code imposed a 10 pesos per hectare tax on all mining claims.⁸ The federal government also levied an assay tax on output (on a sliding scale, depending on the product), an excise tax on gold and silver (three percent of value) a coinage tax (two percent on gold and silver), and a stamp tax on the documents necessary to transfer bullion or ore (0.6 percent of value). We estimate that in 1905 total federal and state taxes on mining output came to 7.7 percent of the gross value of production. The combined federal and state tax rate on gold and silver production was a good deal higher (10.4 percent), because of the special excise tax and the coinage tax on these two products.⁹ Our estimates square with contemporary observers, who placed the tax

⁶ These provisions did not dispense with the problem of opportunism by the federal government, but at least it created safeguards against state governments.

⁷ México. Secretaría del Estado y del Despacho de Fomento (1885).

⁸ In order to register the parcel, an initial payment of 10 pesos per hectare was also required. México. Secretaría del Estado y del Despacho de Fomento (1893). This is not quite the same as saying that Mexico's system approximated a fee simple system of property rights. The possession of a mining claim gave the owner no rights to the surface ground. In theory, the mining claim owner held a "primary right" to the subsoil and the surface owner held a "secondary right" to the surface. The owner of the primary right had priority over the owner of the secondary right. In addition, the owner of the subsoil did not have absolute perpetual ownership. Technically, the residual claimant on the subsoil was the government. The miner had a lease on the underground, which would be automatically forfeited for failure to pay the parcel tax. Engineering and Mining Journal, 11/15/1902.

⁹ We estimated these taxes in several steps. First, we estimated the value of production. For gold and silver, we took the value of output directly from Mexican Yearbook, 1908, p. 505. For zinc, copper, lead, and antimony, we took the volume of output figures from Bernstein (1964), pp. 128-29, and multiplied them by the average price per pound of those commodities as reported in the Anuario de Estadística Minera, 1929-30, p. 365. To this result, we then added the two percent coinage tax and the three percent export tax on gold and silver (under the assumption that all silver and gold was coined and exported). We obtained these rates from the Engineering and Mining Journal, 4/6/1905, pp. 663-64. To this result, we then added the stamp tax revenues from the transfer of bullion or ores (0.6 percent) on the assumption that ore would be transferred only one time. We obtained these rates from the Engineering and Mining Journal, 4/6/1905, pp. 663-64. We then computed the value of the parcel tax by multiplying the tax per hectare (as reported in the Engineering and Mining Journal,

burden on gold and silver production at 9.5 to 11 percent of the gross value of output.¹⁰

In response to complaints by miners that these tax rates prevented them from profitable operation, particularly because of the declining price of silver, the federal government reformed the tax system in March 1905. The government reduced the parcel tax to 3 pesos per hectare for claims exceeding 25 hectares, and 6 pesos per hectare for smaller claims. It also capped state taxes at 1.5 percent of the gross value of production. The federal government eliminated the coinage tax, and the special excise on gold and silver was set on a sliding scale (from 1.5 to 3.5 percent) depending on the state of the metals prior to refinement.¹¹ We estimate that in 1907 total federal taxes on mining output came to 2.8 percent of the gross value of production. State taxes took another 1.5 percent, yielding an average tax rate of 4.3

4/6/1905, pp. 663-64) by the total number of hectares in mining claims (as reported in Bernstein (1964), pp. 28-29). In order to estimate the fees for the registration of new parcels, we took the number of active parcels in 1905, subtracted the number in 1892 (from Bernstein (1964), pp. 28-29), and then divided by the number of years between the two dates. This almost certainly underestimates new registrations for 1905, but our estimates are not sensitive to changes in the number of new claims registered, as this represented a very small percentage of total tax revenues. Finally, we computed the value of federal assay taxes by taking the rates published in México. Secretaría de Hacienda (1895). We estimated state taxes by assuming that all states taxed at the 2.0 percent rate, the maximum allowable under the law. We note that estimates of actual state tax rates for 1910-11 made by Velasco and co-authors indicate this to be a reasonable assumption. Of the 16 states they studied, 13 taxed at the maximum allowable rate. (Velasco Avila, Flores Clair et al. (1988), p. 332). We then estimated the federal surtax on state taxes by simply multiplying the state tax rate by the federal surtax rate (25%). We summed all taxes, and then divided our estimates of the total value of output. In order to calculate the taxes on gold and silver mines separately, we assumed that they paid parcel registration fees and taxes in the same ratio as their value of production to the total value of mining production. All other estimates were made exactly as above.

¹⁰ Engineering and Mining Journal, 4/6/1905, pp. 663-64.

¹¹ Engineering and Mining Journal, 1/27/1906, p. 180; Mexican Yearbook, 1908, pp. 503-507.

percent.¹² The combined federal and state tax rate on gold and silver mines was somewhat higher (6.0 percent), because of the special excise on these two products. These estimates are in rough agreement with figures reported by gold and silver mines at the time. The Mexico Mines of El Oro, Ltd., according to its 1908-09 annual report, paid taxes worth 5.3 percent of its gross revenues.¹³ The Santa Gertrudis mine reported paying taxes worth 7 percent of its gross revenues in the same year.¹⁴

Mining in Porfirian Mexico was not, therefore, a low-tax industry. We have been able to estimate profit margins for six large, publicly traded, gold and silver mining companies in 1907. These firms accounted for 14 percent of gold and silver

¹² We estimated tax rates in several steps. First, we estimated the value of production. For gold and silver, we took the value of output directly from the Mexican Yearbook, 1908, p. 505. For zinc, copper, lead, and antimony, we took the volume of output figures from Bernstein (1964), pp. 128-29, and multiplied them by the average price per pound of those commodities as reported in the Anuario de Estadística Minera, 1929-30, p. 365. We then calculated assay tax revenues by applying the rates per kilogram reported in Mexican Yearbook, 1908, p. 504. To this result, we then added the stamp tax revenues on gold and silver, as reported in Mexican Yearbook, 1908, p. 503. We then computed the value of the parcel tax by multiplying the tax per hectare (as reported in Mexican Yearbook, 1908, p. 504) by the total number of hectares in mining claims (as reported in Mexican Yearbook, 1908, p. 507). We assumed that most mining claims were held in parcels of more than 25 hectares, and thus paid the lowest per hectare tax rate (3 pesos). We make this assumption because contemporaries (and subsequent governments) noted that most claims were held by very large companies that did not actively work the entire claim. We estimated the number of new claims registered by subtracting the number of claims registered in 1905 (from Bernstein (1964), pp. 28-29) from those registered in 1907 (from the Mexican Yearbook, 1908, p. 507), and divided by two. To obtain the value of the registration tax, we then multiplied the result by 5 pesos per hectare (the registration tax rate). State tax rates were taken directly from Velasco, et. al., (1988), p. 332. We calculated the federal surtax of 25 percent directly from information on state taxes. We summed all taxes, and then divided our estimates of the total value of output. Some states levied an additional tax on refined ores that we were unable to compute. In order to calculate the taxes on gold and silver mines separately, we assumed that they paid parcel registration fees and taxes in the same ratio as their value of production to the total value of mining production. All other estimates were made exactly as above.

¹³ Engineering and Mining Journal, 11/6/1909, p. 911.

output in Mexico in that year. We estimate that the (weighted) average before tax profit margin for these firms in 1907 was 46 percent, and ranged from 27 percent (Batopilas) to 59 percent (La Esperanza).¹⁵ The weighted average, implicit tax rate was therefore 13.1 percent of profits. Had the 1905 tax reform not taken place, the implicit tax rate would have been 21.2 percent of profits.¹⁶

Taxes were even higher for copper-producing firms. The Greene-Cananea Consolidated Copper Company accounted for, on average, 40 percent of Mexico's copper output in 1904-1911. (In 1908, a one-two punch of a crippling strike and a 50 percent decline in copper prices briefly dropped their share to 10 percent.) Cananea's pre-tax margins never exceeded 33 percent, and averaged 24 percent.¹⁷

For most mines, the implicit tax on profits would have been even higher than the 12.3 percent we estimated for these five firms. The reason is that mining taxes were assessed as specific fees or a percentage of revenues. The lower the profit

¹⁴ Engineering and Mining Journal, 2/5/1910, p. 320.

¹⁵ We calculated these profit margins from direct data on cost and revenue per ton in Mexican Yearbook, 1908, pp. 482-83; 485, 486, 491-92, Mexican Yearbook 1909-10, pp. 494 and 498, and the Engineering and Mining Journal. The companies we included in this analysis were: the El Oro Mining and Railway Company, Ltd., The Mexico Mines of El Oro Ltd., La Esperanza Ltd., San Rafael y Anexas, S.A., Dolores S.A., and Batopilas.

¹⁶ We calculated these implicit profit tax rates in several steps. First, we calculated the total value of production of the firms from data in the Mexican Yearbook, 1908, pp. 482-83; 485, 486, 491-92, and from the Mexican Yearbook, 1909-10, pp. 494 and 498. We then assumed that, on average, these firms paid the same percentage of their gross value of production as did the gold and silver industries as a whole in 1905 and 1907 (10.4 percent and 6.0 percent respectively) in order to estimate the total state and federal tax paid by these firms. We then divided the total estimated taxes paid by the total before-tax profits of the firms, as calculated from data in their financial statements reprinted in Mexican Yearbook, 1908, pp. 482-83; 485, 486, 491-92, and from the Mexican Yearbook, 1909-10, pp. 494 and 498.

¹⁷ Moody's Manual of Investments, various.

margin of the mine, the higher the implicit profit tax. The seven companies that we have looked at were among the most profitable in the country. Unless a mine was able to earn a (before tax) double digit profit margin, its after tax profits—*even after the 1905 tax reform*—would have been negative. Balance sheets and dividend payments published in the Engineering and Mining Journal and Economista Mexicano allowed us to calculate returns on assets for 28 mining firms. These firms accounted for 36 percent of all invested capital in mining.¹⁸ Five of these firms, accounting for 12 percent of the sample, lost money in every year for which we have data.¹⁹ (See Table 1.)

These estimates match the observations of contemporaries. “Taxation of this type is very severe on mines, the ores of which carry only small margins of profit. Where the profit is not greater than 20 to 25 percent of the gross output, as is the case with many splendid mining properties ... a government tax of this character would take a big share of the profits; it tends inevitably to discourage that kind of mining which is based on low grade ores.”²⁰ In short, the claim in the literature that the tax rate was “minimal” is without empirical foundation.²¹

¹⁸ Invested capital from Bernstein (1964), p. 75, table 4.

¹⁹ Presumably these companies were able to cover their variable costs.

²⁰ Engineering and Mining Journal, 3/14/1903, p. 398.

²¹ Meyers (1991), p. 342.

The tax rate was, however, not set so high that it discouraged investment.²² Circa 1888, American miners had invested only 20 million dollars in Mexico. By 1897, this figure had more than trebled, to 68 million dollars.²³ By 1911, the total capital invested in mining had grown roughly 16-fold, to 323.4 million dollars. U.S. investment accounted for 77 percent of this figure, with British (13%), Mexican (5%), French (2%), and other countries (3%) accounting for the rest.²⁴

This wave of investment was accompanied by a phenomenal increase in mining claims. In 1892, when the parcel tax was created, mining companies registered 34,999 hectares. By 1905, total mining claims covered 256,243 hectares, an eight-fold increase in just 13 years.²⁵ Circa 1911, the total number of hectares under concession had most grown an additional 75 percent, to approximately 450,000.²⁶

Mexico's refining capacity grew as well, rivaling that of the United States. In 1913, of the 129 silver-lead blast furnaces in North America, 49 were in Mexico. These 49 smelters had a total annual capacity of 2,297,000 tons, which was 31

²² For a discussion of the growth of the foreign mining companies, and an analysis of the labor relations system in those firms, see Cárdenas García (1988), especially Chapters 2 and 3.

²³ Bernstein (1964), p. 72.

²⁴ Calculated from data in Bernstein (1964), p. 75, table 4.

²⁵ Bernstein (1964), p. 28-29.

²⁶ In 1919 there were 446,549 hectares under concession. It is highly unlikely that the number of hectares under concession increased dramatically between 1911 to 1919.

percent of total North American capacity.²⁷ Much the same was true in copper smelting. In 1913 there were 220 blast or reverberatory copper smelting furnaces in North America, 41 of which were in Mexico. These 41 furnaces had an annual capacity of 3.9 million tons, 14 percent of total North American capacity.²⁸

Output rose commensurately with investment. Between 1890 and 1911 the output of gold increased from 2,718 kilos to 37,111 kilos, the output of silver increased from 1.07 million kilos to 2.3 million kilos, and the output of lead increased from 30 million kilos to 117 million kilos. The rate of growth of copper output dwarfed even these impressive leaps: Copper output increased by a full order of magnitude, from 5.6 million kilos to 56 million kilos.²⁹ By 1911, Mexico accounted for 32% of world silver, 11% of world lead, and 7% of world copper production.

While there were literally hundreds of mines and mining companies spread across the republic, a small number of foreign mining companies in silver, lead, and copper. The largest of these mining companies vertically integrated into refining. Foremost was the Guggenheim's American Smelting and Refining Company

²⁷ Canada had less than 2 percent of total North American capacity. Calculated from data in Engineering and Mining Journal, 1/10/1914, p. 67; Capacity for one firm, the Compañía Fundidora y Afinadora de Monterrey was not reported in the 1913 census. We therefore estimated it from 1919 data in Engineering and Mining Journal, 1/17/1920, p. 119, under the assumption that the firm did not increase its capacity during the period 1913-19. This assumption is supported by the fact that capacities for other firms (both in Mexico and the United States) did not vary much between 1913 and 1919. Thus, our reported total number of smelters and capacities is slightly different than that reported in the 1913 census.

²⁸ Calculated from data in Engineering and Mining Journal, 1/10/1914, p. 63.

(ASARCO). ASARCO owned or leased ten mines in the states of Aguascalientes and Chihuahua. Its furnaces smelted 165,000 tons of ore from these mines every year.³⁰ In fact, most of its business came from smelting silver, lead, and copper ore for other mining firms. Asarco's 20 silver-lead furnaces and 14 copper smelters made up 43 percent of Mexico's silver-lead blast furnace capacity and 27 percent of Mexico's copper smelting capacity in 1913.³¹

ASARCO, in fact, had a virtual monopoly in the custom smelting business because most of its competitors' furnaces were dedicated to refining their own ores. In silver-lead refining there were only five major firms: ASARCO, the Compañía Metalúrgica Mexicana, the Compañía Metalúrgica de Torreón, the Compañía Minera de Peñoles and the Compañía Fundidora y Afinadora de Monterrey. The four firm ratio was 90 percent.³² Copper smelting was also extremely concentrated. In addition to ASARCO (and its subsidiary, the American Smelter's Security Corporation) there were only five other major firms, of which only two of which were not American: the Cananea Consolidated Copper Company, the Mazapil Copper Company Ltd., the Teziutlán Copper Mining and Smelting Company, the

²⁹ México. INEGI (1994), pp. 539, 540, 542, 544.

³⁰ Mexican Yearbook, 1909-10, p. 492.

³¹ Calculated from data in Engineering and Mining Journal, 1/10/1914, pp. 63, 67.

³² Calculated from data in Engineering and Mining Journal, 1/10/1914, p. 67; Capacity for one firm, the Compañía Fundidora y Afinadora de Monterrey was not reported in the 1913 census.

French-owned Compagnie du Boleo and the Mexican-owned Compañía Metalúrgica de Torreón. The four firm ratio in copper smelting was 86 percent.³³

Díaz's Failed Opportunism

Ex ante, the Mexican government had every incentive to give generous concessions to firms in order to get them to invest. Ex post, however, the government had every incentive to abrogate those concessions or raise taxes—and the mining companies knew it.

Tax rates were constrained by the broad spread of mining returns. Had the government raised the tax rate much further, it would have pushed the producers who worked low grade ores (the majority of the industry) out of business. The Batopilas mines, for example, were 20 years old in 1907. In that year, tax payments amounted to 42 percent of their net revenues after maintenance, depreciation, and interest expenses. In 1908 and 1909, that figure rose to 62 and 61 percent respectively.³⁴ It is not likely that this mine, one of Mexico's largest, would have remained in operation had taxes been hiked. In fact, of the 21 companies that published balance sheets in the *Engineering and Mining Journal* or the *Economista Mexicano* between 1899 and 1910, five of them lost money. Four of those, representing 12 percent of the sample by value of assets, lost money in every year for

³³ Calculated from data on installed capacity of blast and reverberatory furnaces in Engineering and Mining Journal, 1/10/1914, p. 63.

which balance sheets and dividend payments were available. (See Table 1.) The frail financial situation of so many of Mexico's mines probably explains why Díaz lowered taxes in 1905: lower tax rates produced higher output and a larger stream of revenues.

Confiscation was an unlikely threat. It took knowledge of engineering, geology, hydrology, chemistry and metallurgy to run a deep shaft mine and accompanying smelter. It would take time to learn this knowledge (or hire willing foreigners), during which the mine would produce no revenues.

The government could, however, reallocate the property rights of foreign miners to those who did know how to operate modern mineral operations: Mexico's domestic miners and refiners. What better way, after all, to reward domestic political supporters than to hand them mines that had been developed by foreigners?

From 1907 to 1909 the Díaz government and foreign miners faced off over an attempt by the government to alter the property rights system in a way that would prejudice the rights of foreign miners. A committee appointed by Development Minister Olegario Molina published the first draft of the proposed law in February 1907. Molina worked on it for another year, and the 1908 draft prohibited foreign individuals from acquiring mining properties in the northern border states, while foreign companies would be prohibited from acquiring mining properties *anywhere* in the Mexican republic. Not even Díaz, according to the draft of the law, could

³⁴ Engineering and Mining Journal, various.

authorize foreign companies to operate in Mexico, although he was authorized to grant exemptions to foreign individuals in border states.³⁵

The law met stiff opposition. The Chamber of Mines protested vigorously, sending a delegation directly to meet with Treasury Secretary Limantour.³⁶ Díaz called a meeting of the Cabinet on June 25, 1908 to discuss the law and the opposition to it.³⁷ After the meeting, Díaz dropped the article of the proposed law that made it unlawful for foreign companies to acquire mines in Mexico.³⁸

Díaz then chose not to enact the revised bill by decree, but instead introduced it into Congress.³⁹ Díaz travelled to El Paso to meet with President Taft.⁴⁰ We don't know what was said at this meeting, but the bill did not go into effect until January 1, 1910, minus the clauses limiting foreign activities. The only restriction was an 80 kilometer exclusion zone along the border. Foreign individuals could hold titles in this zone only with the permission of the president. This restriction, however, dated back to 1856.⁴¹ Claims in the zone without presidential permission

³⁵ Mexican Year Book, 1908, pp. 510-11; Engineering and Mining Journal, 6/13/1908, pp. 1210, 1214.

³⁶ That delegation included Federal Deputy José Luis Requena and Senator Ramón Alcaraz. Engineering and Mining Journal, 6/20/1908, p. 1267; Engineering and Mining Journal, 10/23/1909.

³⁷ Engineering and Mining Journal, 8/1/1908, p. 252.

³⁸ Engineering and Mining Journal, 10/24/1908, p. 833. The revised law only restricted their activities to an 80 kilometer strip along the border. Individual miners could obtain concessions within this strip, but only after receiving the approval of the president. Foreign companies could not hold mines in this area, even with presidential permission. This was, in fact, a continuation of previous restrictions that dated back to 1856. Engineering and Mining Journal, 11/21/1908, p. 1025.

³⁹ Bernstein (1964), pp. 79-80.

⁴⁰ Engineering and Mining Journal, 10/23/1909.

⁴¹ Mexican Yearbook, 1909-10, pp. 520-21; Engineering and Mining Journal, 6/13/1908, p. 1214.

could now be auctioned off, but the government never put a single mine on the block.⁴²

The miners could call upon a very powerful protector: the U.S. government. Virtually all of Mexico's industrial metal production was exported to the United States. This meant that all the U.S. government had to do to sanction Mexico was apply a retaliatory tariff, killing the industry and taking the tax revenues of the Mexican government with it. The threat of such action was very real. In point of fact, in 1907 the United States imposed a 20 percent ad valorem duty on Mexican zinc. The tariff effectively killed the Mexican zinc mining industry until World War I.⁴³

The Revolution

Porfirio Díaz sailed to exile in 1911. He was succeeded by a series of unstable governments, all of which confronted serious credible threats to their power. Governments, and factions that aspired to be governments, had strong incentives to raise taxes or predate on the property rights of the miners. They were blocked, however, by the same features that had blocked Díaz. They found that they could not raise taxes much above Porfirian levels without causing the mines to shut

⁴² Mexican Yearbook, 1909-10, pp. 520-21. Engineering and Mining Journal, 2/19/1910, pp. 416-419.

⁴³ Engineering and Mining Journal, 1/5/1907; Engineering and Mining Journal, 3/13/1909; Engineering and Mining Journal, 10/2/1909. Zinc output figures (see Table 7.1) indicate that in 1911 zinc output was only 7 percent of its 1907 level.

down. Confiscation was not an option, because they could not run the mines themselves. Even if they got someone to run it for them, they needed the smelting companies to refine the ore. Even if they could coerce (or confiscate) the smelting companies, they could not export the refined ore anywhere but the United States, and the U.S. government could (and did) refuse to permit the importation of "stolen" ore.

The overthrow of Díaz by Francisco Madero in 1911 and General Victoriano Huerta's bloody coup against Madero in 1913 caused barely a ripple in the mining industry. Rail service was interrupted, causing temporary shortages of fuel and ore at smelting plants. Some paymasters or company offices were robbed. For the most part, however, Mexico's mines and smelters worked without interference.⁴⁴ As Table 2 shows, Mexico's output of lead and copper in 1910, 1911, and 1912 was higher than the average for the decade 1900-09. Its output of silver over 1910-12 actually set an all time production record.

[TABLE 2 HERE]

⁴⁴ Meyers (1991), p. 346; Engineering and Mining Journal, 1/28/1911, p. 243; Engineering and Mining Journal, 3/11/1911, p. 536; Engineering and Mining Journal, 3/18/1911, p. 584; Engineering and Mining Journal, 4/1/1911, p. 680; Engineering and Mining Journal, 4/8/1911, p. 731; Engineering and Mining Journal, 4/15/1911, p. 780; Engineering and Mining Journal, 5/20/1911, p. 1033; Engineering and Mining Journal, 6/10/1911, p. 175; Engineering and Mining Journal, 10/7/1911, pp. 685-690; Engineering and Mining Journal, 1/6/1912, pp. 77-79; Engineering and Mining Journal, 11/30/1912, p. 1017-18; Engineering and Mining Journal, 1/11/1913, p. 136-39; Engineering and Mining Journal, 11/2/1912, p. 832; Engineering and Mining Journal, 3/15/1913, p. 582; Engineering and Mining Journal, 12/7/1912, p. 1096.

Once the battle against Huerta began, and the victors of that fight turned to fighting among themselves, governments and factions tried to treat the mines they way they treated cattle ranches, beer breweries, or banks. They quickly found out that they could not do so. The first Mexican politician to learn this lesson was Victoriano Huerta, who attempted to extort funds for his government from foreign miners in Durango, under pain of death. The American miners responded by shutting down their mines and leaving the state en masse.⁴⁵

Francisco “Pancho” Villa, who controlled most of Mexico’s major mining regions from 1913 to 1915, learned a similar lesson—over and over and again. Villa's began by to insuring good conditions for mine owners so that they could produce revenues that he could tax—not unlike Porfirio Díaz.⁴⁶ This explains why American mining interests urged the Wilson Administration to back Villa and some mining companies covertly provided financial support.⁴⁷

Villa failed for two reasons. First, transport costs rose substantially during the 1914-17 civil war, since railroads thus were strategic targets for demolition.⁴⁸

⁴⁵ Engineering and Mining Journal, 10/18/1913, p. 763.

⁴⁶ Meyers (1991), p. 346.

⁴⁷ Meyers (1991), p. 347.

⁴⁸ Engineering and Mining Journal, 2/15/1913, p. 394; Engineering and Mining Journal, 11/15/1913, p. 916; Engineering and Mining Journal, 1/8/1916, p. 95.

Mexico's mines and smelters did not cease operations in 1914-17, but worked on an intermittent or curtailed basis.⁴⁹

Even without the civil war, the industry would have been hammered by the sharp decline in demand for copper and lead that was caused by the onset of World War I. The price of copper, 16.3 cents (U.S.) per pound in 1912, fell to 15.3 cents in 1913, and to 13.6 cents in 1914. Lead prices dropped from 4.5 cents per pound in 1912 to 3.9 cents in 1914. (See Table 3.)

[TABLE 3 HERE]

Some of Villa's officials believed that the mining companies could be forced to resume production. In May 1914, for example, Tomás Urbina, the Villista governor of Durango, ordered foreign mining companies to resume work or face confiscation. Other local leaders seized a number of Mexican-owned mines.⁵⁰ Two months later (July 1914) General Fidel Ávila, governor of Chihuahua, and Silvestre Terrazas, Villa's Secretary of State, gave companies one month to renew "mining, industrial, and other operations which might have been closed by war" and threatened confiscation "if they persist in the continued closure of their operations."⁵¹

⁴⁹ Engineering and Mining Journal, 1/10/1914, pp. 137-139; Engineering and Mining Journal, 5/2/1914, p. 928; Engineering and Mining Journal, 1/9/1915, pp. 122-123; Engineering and Mining Journal, 1/8/1916, pp. 116-118; Engineering and Mining Journal, 6/24/1916, p. 1123; Engineering and Mining Journal, 1/6/1917, pp. 76-78; Cleland (1922), p. 277; Cárdenas García (1998), p. 94.

⁵⁰ Meyers (1991), p. 349.

⁵¹ Meyers (1991), pp. 350-51.

This strategy was doomed from the start. Virtually all of the smelting capacity in Villista Mexico was in the hands of ASARCO, and ASARCO simply refused to buy or smelt ore believed to have come from a confiscated mine.⁵² The Villistas tried on one occasion to fire up one of Asarco's smelters, but quickly realized that they lacked the knowledge to do so.⁵³ The U.S. government blocked attempts to export raw ore for smelting by establishing special offices to warn customs officials when "stolen" ore reached the border.⁵⁴ In short, ASARCO and the Customs Service could effectively enforce the property rights of miners.

Villa continued to try and fail to squeeze the miners. In mid-March 1915, losing the war and desperate for revenue, Villa decreed that mines that were not being worked would be subject to forfeiture. The Miners and Smelters Owner's Association (MSOA) and the State Department swung into action, and Villa backed down.⁵⁵ In July 1915, Villa needed funds to purchase a shipment of 250,000 cartridges in El Paso. Lacking the cash, he demanded a loan of \$300,000 dollars from the MSOA representative in Chihuahua. The miners refused. Villa responded by decreeing that all mining companies in Chihuahua had to resume operations at once and turn over their ore to his administration. The MSOA, predictably, cabled

⁵² Meyers (1991), p. 350.

⁵³ This experiment took place in September 1915, when the Villistas were losing the war against Obregón and were desperate for any source of revenue. Meyers (1991), p. 358; Engineering and Mining Journal, 1/8/1916, p. 116.

⁵⁴ Meyers (1991), p. 351.

⁵⁵ Engineering and Mining Journal, 4/10/1915, pp. 668-669; Meyers (1991), p. 356.

the State Department, which dispatched General Hugh Scott to see Villa. We do not know what Scott told Villa. We do know, however, that Villa dropped all of his demands in exchange for a thousand tons of coal.⁵⁶

In the end, Villa went back to working with the miners in exchange for taxes. All Villa extracted was a one-time, extraordinary war tax of five percent of revenues. Even this extraordinary tax was later reduced, who declared, under pressure from the U.S. State Department, that it would not be collected “where impracticable.”⁵⁷

Villa's main opponent, Venustiano Carranza, also attempted to increase taxes. In 1915, Carranza doubled the parcel tax on small properties and increased the parcel tax on large properties eight-fold (the exact rate depending on the size of the mining claim). He accompanied the increase in the parcel tax with an export tax of 6.5 percent on bullion and 8.5 percent on ore. On April 16, 1916, Carranza slightly lowered the parcel tax (on a sliding scale), and lowered the export tax on industrial metals to five percent, but he simultaneously raised the export tax on gold and silver to ten percent. Moreover, he increased the tax that states could charge from 1.5 percent to 2.0 percent of revenues, and he raised the federal surtax from 25 percent to 60 percent.⁵⁸ The Buena Tierra Mining Company calculated that the tax hikes quadrupled the total tax rate over 1912 levels.⁵⁹

⁵⁶ Meyers (1991), pp. 357-58.

⁵⁷ Meyers (1991), pp. 355-56.

⁵⁸ Under Díaz and Madero, the parcel tax had been 3 pesos per hectare for claims exceeding 25 hectares and 6 pesos for smaller claims. Under the new decree, the parcel tax was 18 pesos per

These taxes, however, generated little revenue, because the mining companies shut down their operations in the areas under Carranza's control. Some firms continued working on a limited basis with their Mexican employees only.⁶⁰

Carranza followed the same course as Villa. First, he appealed to the miners "to please come back and reopen their mines and metallurgical works."⁶¹ When that failed, he threatened expropriation.⁶² The State Department immediately protested. On November 14, 1916, Carranza gave the miners an extension until February 14, 1917 to resume work.⁶³ Ultimately, he beat a strategic retreat: he did not rescind the law, but he did not enforce it either. The reports about conditions in Mexico by the

hectare for properties of 21 to 50 hectares and 24 pesos per hectare for properties above 50 hectares. Thus, the rate was 6 to 8 times its Porfirian level. Even small properties were hit with a tax increase: parcels of 10 hectares or less paid 12 pesos per hectare (double the earlier level) and parcels of 11 to 20 hectares paid 15 pesos per hectare (2.5 times the earlier level). Engineering and Mining Journal, 5/6/1916, p. 827; Cleland (1922), pp. 277-78.

⁵⁹ Engineering and Mining Journal, 11/3/1917, p. 810.

⁶⁰ Engineering and Mining Journal, 1/8/1916, p. 95; Engineering and Mining Journal, 6/24/1916, p. 1123; Engineering and Mining Journal, 9/16/1916, p. 529.

⁶¹ Engineering and Mining Journal, 7/15/1916, p. 151.

⁶² The decree specified that any mine that had been idle for two consecutive months, or that was idle at various times for a total of three months in one year, could be denounced or confiscated and worked by the government. Engineering and Mining Journal, 10/14/1916, p. 729; Engineering and Mining Journal, 3/3/1923, p. 403; Bernstein (1964), pp. 112-113.

⁶³ Later events provide us with two natural experiments to test the proposition that the Carrancistas could not actually run a mine profitably. The first occurred in early 1917 when the managers of the Chispas mine in Arizpe, Sonora refused orders from the government to raise wages, employ more men, and increase production. Carranza's government jailed the manager and seized the mine. The government soon found, however, that without the foreign managers it could not run the mine at a profit, and had to close down the operation entirely. The government also found out that it could not effectively imprison the mine's manager, who escaped from jail and fled to Arizona. The second experiment occurred later that same year, in the state of Coahuila, when, as a result of a labor dispute, the federal government decided to take over the state's coal mines and work them on its own account. The government quickly found out, however, that it could not drain the mines and restart production—unless it had the cooperation of the mining companies' skilled staff, which was not

EMJ, which portrayed Carranza in the most negative light imaginable, do not mention a single case of confiscation under this law.⁶⁴ By 1917 the entire issue was moot, because many of the major mining companies were back at work, attracted by astronomically high metals prices.⁶⁵ (See Table 3).⁶⁶

Institutional Reform

The credible threat of enforcement by the United States meant that the reform of property rights in the Constitution of 1917 was a dead letter. On paper, Article 27 of the Constitution severely reduced the property rights of the foreign companies that dominated the mining industry. It followed the mining code of 1909 by stating that the ownership of all minerals in the subsoil belonged to the federal government. It departed from Porfirian legislation, however, in three crucial respects. First, Article 27 bluntly stated that miners had to work their entire claims in order to maintain their property rights. It was the case, of course, that most companies only worked a small portion of their claims, and had done so since Porfirian times. Article 27

forthcoming. The government therefore dropped its plans to confiscate the mines. Engineering and Mining Journal, 5/19/1917, p. 909; Engineering and Mining Journal, 11/27/1920, p. 1056.

⁶⁴ See, for example, Engineering and Mining Journal, 1/11/1919, pp. 112-113; Bernstein reaches a similar conclusion: "It appears that no property was declared forfeit under the law of 9/16/1916." Bernstein (1964), p. 114.

⁶⁵ There continued to be interruptions of output, particularly in the state of Chihuahua, because of the ongoing guerrilla war against Villa and because of the perceived danger to Americans that had been caused by Pershing's punitive expedition against Villa, but for the most part operations began to return to normal by the middle of 1917. Engineering and Mining Journal, 11/24/1917, p. 940; Bernstein (1964), p. 113-114.

⁶⁶ Bernstein (1964), p. 114.

therefore implied that they could be expropriated. Second, Article 27 stated that only Mexican citizens and Mexican companies had the right to mining concessions. The government might grant this right to foreigners only if they agreed to be considered Mexican in respect to such property and to therefore not invoke the protection of their governments. Third, Article 27 stated that all contracts and concessions that resulted in the monopoly of lands, waters, and natural resources of the nation were subject to revision or nullification by the president.⁶⁷

Neither Carranza nor Obregón promulgated enabling legislation to Article 27. The Constitution of 1917 was nothing more than a wish list. In 1926, however, President Plutarco Calles finally enacted a new mining law. First, it stated that, instead of being perpetual, mining concessions had a duration of 30 years. Second, paying a parcel tax would no longer be sufficient to maintain a claim. Concessionaires would have to produce a specific amount of ore per hectare, the exact amount depending on the product being mined, distance from a railroad, and surface area. Third, the law required that 90 percent of mining engineers be of Mexican birth.⁶⁸ Fourth, the law stated that smelting and refining companies could not dismantle their works without government permission. Fifth, the “forbidden

⁶⁷ Bernstein (1964), Appendix 1, p. 288; *Engineering and Mining Journal*, 3/3/1923, pp. 401-403.

⁶⁸ The intent of the law was obvious. Unless there was a trained cadre of Mexican mining engineers, who could actually run the mines and refining works, it would not be possible to threaten foreign companies with confiscation. The government had learned this lesson throughout the 1910's and early 1920's, and wished to deny foreign companies the ability to resist future tax increases and institutional reforms by shutting down production.

zone” was expanded from 80 to 100 kilometers wide along the border and 50 kilometers of the coast. Finally, the law stipulated that foreigners and foreign companies could only obtain concessions in Mexico if they renounced all protection of their own governments.⁶⁹

Calles knew that he could not actually enforce the 1926 mining law.⁷⁰ Calles knew that in a showdown the miners would curtail production, depriving him of the tax revenues he desperately needed to fight the Cristero War (a civil war against Catholic rebels which devastated the Bajío region of Mexico in 1926-29) and maintain the loyalty of the army. Calles therefore did what any rational politician would have done under the circumstances: he grandfathered in all of the existing mining claims under whatever set of institutional arrangements had been made before the law went into effect.⁷¹ The only clauses of the law applied to existing operations were the requirements that a proportion of the engineering personnel had to be Mexican and that mining and refining operations had to obtain the permission

⁶⁹ Engineering and Mining Journal, 10/31/1925, p. 683; Engineering and Mining Journal, 3/19/1927, pp. 486-87.

⁷⁰ Sariago, Reygadas et al. (1988), p. 70.

⁷¹ Engineering and Mining Journal, 1/23/1926, p. 180; Engineering and Mining Journal, 9/25/1926, p. 509.

of the government to shut down their operations.⁷² Even these clauses of the law were eventually dropped. In August 1930 the entire law was abolished.⁷³

In short, in post-revolutionary Mexico the government and the mining companies came to an agreement much like to the one they had reached under Díaz: the government would not interfere with the property rights of the companies and the companies would agree to pay the government a reasonable tax for the right to work their concessions. From the point of view of the mining companies, the changes in Mexico's formal institutions were, during the 1910's and 1920's, easily mitigated.

Investment

One implication of our analysis is that the mining and smelting industry survived the revolutionary violence intact. Fortunately for us, the Mexican government carried out a census of all mining, smelting, and chemical refining operations in Mexico in 1922, and inquired as to the physical state of each and every enterprise. The 1922 census of mines canvassed 425 mining companies, which controlled 3,669 mining claims. Of these, 221 companies (with 1,398 claims) reported themselves as paralyzed. The census does not indicate whether this was the consequence of

⁷² Engineering and Mining Journal, 5/8/1926, p. 777; Engineering and Mining Journal, 5/14/1927, p. 815; Engineering and Mining Journal, 2/12/1917, p. 300; Engineering and Mining Journal, 1/22/1927, p. 163; Bernstein (1964), chapter 14.

⁷³ Sariago, Reygadas et al. (1988), p. 71.

physical destruction, low mineral prices, or the exhaustion of a mine's ores.

Whatever the reason, the paralyzed mines tended to be small operations. The average size of the paralyzed firms' claims was only 18 percent that of working mines—71 hectares compared to 385 hectares. The result was that the 21 percent of the country's total mining area had been withdrawn from production in 1922: 15,600 hectares of paralyzed claims out of a total of 75,675 hectares included in the census. (See Table 7.3).

[TABLE 4 HERE]

One might argue that the 1922 underestimated the extent of physical damage caused by the revolution because it covered only 75,675 hectares of the 370,220 under concession in 1911. (Of course, we don't know how many of the concessions were actually worked before 1911.) We can use the data on smelter survivorship to check the mining data. The 1922 census revealed 112 cyanide reduction works in Mexico, with a total capacity of 24,229 tons per day. Only 7 firms listed their capacity as "destroyed," and their capacity totaled 320 tons—1.3 percent of total capacity. Another 14 firms listed their reduction works as being in "bad condition," but these represented only an additional 1,170 tons, 4.7 percent of capacity. An upper bound estimate of damaged capacity would only be six percent. (See Table 5.)

[TABLE 5 HERE]

The 1922 census covered 57 firms operating 125 copper and lead smelters. Only 2 smelters were reported as "destroyed." Their combined capacity of 50 tons

was equal to only one-quarter of one percent of the industry's total capacity if 19,506 tons per day. Even if we consider firms that listed their smelters as being in "bad condition" as destroyed, the highest estimate we can produce of revolutionary loss was 4.2 percent of the industry's total capacity. (See Table 6.)

[TABLE 6 HERE]

We can cross check these results on the survivorship of Mexican smelting operations with data from U.S. sources. In December 1913, and again in December 1919, the Engineering and Mining Journal (EMJ) published a census of the major lead and copper smelting operations in North America. The EMJ reported that in 1913 there were five silver-lead smelting companies operating in Mexico. These firms controlled 49 blast furnaces, with a total capacity of 2,297,000 tons per year. In 1919, there were now 52 smelters with 2,424,000 tons per year in capacity. All of the 1913 smelting works were still in operation. (See Table 7.)

[TABLE 7 HERE]

The 1913 four firm ratio in lead-smelting was 0.90. In 1919 it was 0.96. The ownership structure had scarcely changed: ASARCO, the Compañía Metalúrgica Mexicana, and the Compañía Metalúrgica de Torreón were still the dominant players. The only difference was that the Compañía Minera de Peñoles was now a subsidiary of a new firm, the Compañía de Minerales y Metales. (See Table 7.)

An analysis of EMJ data on copper smelters gives similar results. At the end of 1913 there were six companies in Mexico, operating 38 blast furnaces, with a total

capacity of 3,676,000 tons per year.⁷⁴ All six of those companies still operated in 1919. Many, such as ASARCO, Cananea Consolidated Copper, and the Compagnie du Boleo, had increased their capacity since 1913. In addition, companies entered the market. The industry's total blast furnace capacity grew 21 percent during the revolution, to 4,464,000 tons per year. (See Table 8.)

[TABLE 8 HERE]

The ownership and industrial structure of the copper smelting industry was little altered by the revolution. In 1913 the four firm concentration ratio was 0.86. In 1919 it was 0.83. The same firms that had dominated the industry in 1913 were still the industry leaders: ASARCO, Cananea Consolidated, the Compagnie du Boleo, Mazapil Copper, and Teziutlán Copper. (See Table 7.7).

Investment

One implication of our analysis of survivorship is that there was considerable new investment in plant and equipment in the years during and after the revolution. This hypothesis is consistent with a broad range of evidence.

Table 9 presents estimates of the real value of mining equipment and machinery imported into Mexico from the U.S. and U.K. These estimates measure the flow of new investment, not the stock of existing investment. This is a good

⁷⁴These firms also operated three reverberatory furnaces.

proxy for capital spending, because Mexico produced no mining equipment domestically.

[TABLE 9 HERE]

We report both the absolute values (in real 1929 dollars) and index numbers (base year 1910=100). Prior to 1922 the U.S. Department of Commerce did not disaggregate petroleum machines from mining machines. We have estimated the 1907-21 mining machinery imports from the United States under the assumption that the proportion of mining machinery imports in total mining and petroleum equipment imports was the same from 1907 to 1921 as it was from 1922 to 1929 (45%). Our results are not be sensitive to the ratio chosen. Even if we assume that 100% of Mexico's pre-1922 mining and petroleum machinery imports went to mining, Mexico's average imports of mining machinery from 1922 to 1929 would still have been higher than average imports in 1907-1911, or 1907-1921.

From 1913 to 1915 rates of new investment fall, so much so that in 1915 there is virtually no new machinery being imported into Mexico. By 1918, however, companies were once again making significant investments in new equipment. The rate of new investment then increased rapidly. By 1920 the index reached 209. Average imports in 1920-29 were 70 percent higher than 1907-10.

These estimates are consistent with data on pumps and pumping equipment. Without a means to pump out groundwater, mines are unworkable. Most pumping

equipment imported into Mexico would have been used by mining companies.⁷⁵

Mexico produced no pumping equipment of its own. As Table 10 shows, U.S. exports of pumping equipment declined in 1913-1916. Pumping exports to Mexico then rose. In 1919 they were an order of magnitude higher than 1901-1910.

One might argue that the jump represented the replacement of pumping equipment that had been destroyed in the civil war. This is not consistent with the evidence. First, in 1918-20, the combined value of pump exports from the U.S. to Mexico exceeded the combined value of all pumps exported to Mexico in 1900-18. Even had all of Mexico's pumps been destroyed by the end of 1917, exports from the U.S. in 1918-20 would have replaced them, and still left a very wide margin (21 percent!) for new investment. Second, even if we make the assumption that all U.S. exports for 1918-20 were replacements of destroyed or damaged equipment, U.S. exports for the period 1921-29 averaged more than twice the levels for 1901-10.

[TABLE 10 HERE]

These estimates are consistent with the observations of contemporaries. In 1923, the *EMJ* noted that “more mining machinery is going into Mexico at this time than for ten years. The machinery is going chiefly to supply mines in the states of

⁷⁵ Petroleum companies and agriculturists also employed pumping equipment, but the single biggest user of pumps were mining companies, which used them to drain mines. Mexico's oil fields did not have to pump the oil out of the ground: it came out under pressure. Pumping equipment would therefore have been necessary only to move the oil through pipelines. Agriculturists would have used pumps to bring groundwater to the surface for irrigation. Most agriculture in Mexico was, however, rain-fed and did not rely on the pumping of groundwater.

Chihuahua, Sinaloa, Sonora, and Durango. Considerable new equipment for ore-reduction mills is also being imported from the United States.”⁷⁶ Later that same year, the EMJ noted that “Not in many years has there been so heavy a demand for mining machinery, and some of the border forwarding agencies are employing night shifts of men, in order to load cars and dispatch promptly freight consigned to the various mining districts of Mexico.”⁷⁷ The journal noted that in 1925 “much energy was devoted to the development and equipment of mines that recently have been idle or have been worked on only a comparatively small scale. About fifteen important construction projects were either financed during the year or were well advanced toward completion; and a number of others have been started.”⁷⁸

The evidence on the flow of new machinery and the observations of contemporaries are consistent with what we know about new investment by two of Mexico’s largest mining and smelting companies. In 1924, ASARCO committed 10 million dollars to upgrade and expand its existing plants, and build new smelters, including a zinc smelter, a coal-mining operation, a byproduct coke plant, a new copper smelter, an arsenic plant, and a flotation plant.⁷⁹ The Compañía Minera de Peñoles (which controlled one-third of Mexico’s lead output and one-fourth of its silver output) also undertook major new investments in the early 1920’s including the

⁷⁶ Engineering and Mining Journal, 4/28/1923, p. 770.

⁷⁷ Engineering and Mining Journal, 11/3/1923, p. 784.

⁷⁸ Engineering and Mining Journal, 1/16/1926, p. 122.

⁷⁹ Engineering and Mining Journal, 11/15/1924, pp. 786-87.

installation of electric generators, the expansion of its mining operations, the construction of a lead refining plant, the renovation of its copper and lead smelting operations in Torreón, and the purchase of additional mining properties.⁸⁰

These observations are consistent with what we know about the introduction of new refining technologies into Mexico in the 1920's—particularly the rapid construction of flotation plants for the treatment of silver-lead-zinc ores.⁸¹ In 1926, 2.1 million tons of ore was treated in Mexico by flotation. This grew to 3.6 million tons by 1927, and 4.1 million tons by 1928. In that year, there were 33 flotation plants in operation, treating 32 percent of the ores mined.⁸²

Evidence on the number of hectares under exploitation also indicates that there was new investment in the 1920's. (See Table 11.) In 1922, the first year for which we have good data, there were 961 mining sites working 37,529 hectares.⁸³ The number of sites and the number of hectares doubled in the next five years, reaching 2,337 sites and 74,359 hectares in 1927. The number of hectares exploited then declined. This post-1927 decline, however, was due to low metals prices. (See Table 3.) The EMJ noted in early 1929, “the low metal prices which have prevailed for the last two years for lead and zinc are principally blamed for the situation, but it

⁸⁰ The Compañía Minera de Peñoles was, by the mid-1920's, a subsidiary of the American Metals Company. *Engineering and Mining Journal*, 1/31/1925, pp. 217-220.

⁸¹ *Engineering and Mining Journal*, 2/13/1926, p. 278.

⁸² *Engineering and Mining Journal*, 10/19/1929, p. 577.

⁸³ The Mexican government did not begin to record the number of hectares actually worked, rather than the number of hectares taxed, until 1922.

is believed that a radical reduction in taxation and more favorable transportation prices might ameliorate the situation.”⁸⁴

[TABLE 11 HERE]

This rise in claims during the 1920s is consistent with the consumption of dynamite—crucial mining input. In 1918, total dynamite consumed was only 286 thousand metric tons. Within a year, that figure had doubled, and then continued climbing. In 1925, dynamite consumption was 4.5 times what it had been in 1918. By 1929, dynamite consumption had grown by a further order of magnitude.

[TABLE 12 HERE]

The data on investment all points the same way: One would be hard put to argue that political instability and institutional change caused producers to cease making new investments.

Output

The output of mineral products displays the same pattern as do the data on investment. In Table 7.1 we present estimates of the production of Mexico’s major mineral products: silver, lead, copper, gold, and zinc. Output declined during 1913-17 and then recovered. By the early 1920’s (the exact year depending on the product) output of most minerals regained their Porfirian levels. In fact, the average volume of output for 1911-20 was not much lower than for 1900-10. In 1921-30,

⁸⁴ Engineering and Mining Journal, 1/26/1929, p. 175.

the only product that did not exceed its average Porfirian level was gold. The output of silver during 1921-30 was 47 percent higher. Lead was 88 percent higher than its pre-revolutionary average. Zinc reached 12 times its 1900-10 average. (See Table 2.)

A skeptical reader might argue that even though the production of virtually all of Mexico's mineral products exceeded their pre-1911 levels during the 1920's, this does not indicate that institutional change did not impose a cost on the Mexican mining industry. Implicit in this view is a hypothetical Mexico in which output levels in the 1920's would have been even higher than those we observe.

Subjecting this argument to empirical verification is, in the case of mining, a fairly straightforward affair. One can posit either of two counterfactual cases. The first is the rest of the mineral producing countries of the world as a group. They faced the same world prices and technological constraints as Mexico, except that they did not endure 20 years of revolution, counter-revolution, and civil war. The second counterfactual is the U.S., whose western states were contiguous to the Mexican north. In the first counterfactual, Mexico would have lost world market share. In the second, Mexico would have lost market share to the U.S.

In Table 13 we present data on Mexico's world market share in silver, lead, and copper, its three most important mineral exports by both value and volume. We also present data on the U.S. market share. In some products, Mexico outperformed the United States. Mexico accounted for 34 percent of world silver production in 1900-10. This fell during the civil war, but then recovered. By 1920-29, Mexico

accounted for 40 percent of world output. The U.S. fell from 33 percent to 22 percent.

Mexico also outperformed in lead. Its share increased from 9% in 1906-10 to 13 percent in 1922-29. The U.S. share fell from 41% in 1922 to 36% in 1929.

In copper, Mexico's market share was lower than before 1910. Mexico produced an average of 7 percent of the world's copper in 1900-10. It then averaged 5 percent in 1911-18. Its share from 1922 to 1929 was only 4 percent. Even in copper, however, Mexico's market share rose during the 1920's. In 1922, Mexico had a 3 percent share. By 1929, it had doubled to 6 percent.

If we posit the U.S. copper industry as the appropriate counterfactual to Mexico, the evidence is against underperformance is stronger. The United States also lost market share. The United States accounted for 56 percent of world copper output in 1900-10, but 52 percent in 1922-29.

Taxes

One of the reasons Mexico maintained output and world market shares was because the government failed to raise taxes. Every government from 1913 onwards looked at Mexico's mining industry as a crucial source of revenue. They rapidly learned that raising rates did not necessarily raise revenues.

The resulting tax rates, while lower than those in effect during 1914-17, were higher than those under Díaz. Data from the Anuario de Estadística Minera allow us

to calculate the effective tax rate on mining in 1919. Total federal taxes came to 6.8 percent of output. State taxes added another two percent, for a total tax rate of 8.8 percent, roughly double the 1907 rate of 4.3 percent. (See Table 14.)

[TABLE 14 HERE]

The collapse of metals prices beginning in mid-1920, however, brought the bonanza enjoyed by the mining companies and the Mexican government to an end. By 1921 the price of copper was less than half of what it had been in 1917, and the price of lead had fallen nearly as far. (See Table 3.) The interim government of Adolfo de la Huerta (May-November, 1920) and President Obregón therefore reformed the tax code. In August 1920 de la Huerta appointed a commission of government officials and mining company representatives to write a new tax code. The new code made the tax on copper and silver a function of the metal's price in New York. Below 60 cents per ounce for silver and 15 cents per pound for copper, there were no taxes at all. They then increased at a sliding scale. Assay fees and the parcel tax remained unchanged. States could tax up to 2 percent of the value of output.⁸⁵

Effective tax rates declined monotonically throughout the 1920's. In 1920, total federal and state taxes on mining came to 10.2 percent of the value of output. By 1922 the new sliding scale yielded total federal and state taxes of 7.5 percent, and by 1926 they yielded 6.0 percent. By 1929, the combined federal and state tax rate

was only 5.2 percent, which was lower than the 7.7 percent tax rate that prevailed in 1905, and close to the 4.3 percent rate in effect in 1907.⁸⁶ (See Table 7.13).

Conclusions

This chapter has studied the impact of institutional change and government threats on Mexico's mining industry. Before 1909, mining companies enjoyed a very favorable environment. We can specify three hypotheses regarding the quantitative impact of institutional change after 1909. First, change should have brought investment and production to a grinding halt. Second, investment and production might have continued, but at a reduced level. Third, investment and production might have continued to rise, but at a slower rate than it would have. The empirical evidence we have shown does not support any of these propositions.

The reason was that the no government, or faction that aspired to be a government, wanted a confrontation with the United States when it was so cheap for the U.S. to enforce property rights by the simple expedient of closing a border. Lacking other markets, and fearing that any interruption in revenues could lead to their downfall, governments could not do much to alter the arrangements that had

⁸⁵ Cleland (1922), pp. 285-288.

⁸⁶ Taxes were lowered still further in 1930. In fact, the authority of states to levy any mining taxes at all were removed in the 1930 tax law. This move alone would have dropped the implicit tax rate, all other things being equal, to only 3.7 percent. *Engineering and Mining Journal*, 2/24/1930, p. 210.

been made under Díaz. The same trade of property rights for taxes continued, regardless of the identity of expected lifespan of the government.

Table 2: Mexico's Major Mining Products

Year	Gold	Silver	Copper	Lead	Zinc
1900	31	73	47	51	60
1901	35	74	70	76	49
1902	36	79	75	86	38
1903	39	84	96	81	55
1904	46	82	107	76	44
1905	59	78	136	81	109
1906	66	75	128	59	1231
1907	70	81	119	61	1266
1908	77	92	79	102	854
1909	83	92	119	95	164
1910	100	100	100	100	100
1911	90	104	116	94	87
1912	78	105	119	85	69
1913	62	91	109	55	52
1914	21	35	55	5	43
1915	18	51	43	16	317
1916	28	38	59	16	2043
1917	57	54	106	52	2465
1918	61	80	146	80	1129
1919	57	85	109	57	631
1920	55	86	102	66	854
1921	51	83	32	49	69
1922	56	104	56	89	335
1923	58	117	111	123	1008
1924	60	118	102	133	1345
1925	59	120	107	144	2826
1926	58	126	112	170	5749
1927	54	135	122	196	7514
1928	52	140	135	190	8824
1929	49	140	167	200	9495
1930	50	135	152	194	7796

Notes: Indices of Volume of Output (1910=100).

Absolute values for 1910 are as follows: Gold 41,420 kilos; Silver 2,417 Metric Tons; Copper, 48,160 Metric Tons; Lead, 124,292 Metric Tons; Zinc, 1,833 Metric Tons. Other absolute volumes can be recalculated by multiplying the index by the 1910 volume and dividing by 100.

Source: Bernstein (1964), pp. 128-29.

Table 3: Prices of Mexico's Major Mineral Products, 1900-1929

Year	Copper Cents/lb	Lead Cents/lb	Zinc Cents/lb	Silver Cents/oz
1900	16.2	4.4		61.3
1901	16.1	4.3		58.9
1902	11.6	4.1		52.2
1903	13.2	4.2	5.2	53.6
1904	12.8	4.3	4.9	57.2
1905	15.6	4.7	5.7	60.4
1906	19.3	5.7	6.0	66.8
1907	20.0	5.3	5.8	65.3
1908	13.2	4.2	4.6	52.9
1909	13.0	4.3	5.4	51.5
1910	12.7	4.4	5.4	53.5
1911	12.4	4.4	5.6	53.3
1912	16.3	4.5	6.8	60.8
1913	15.3	4.4	5.5	59.8
1914	13.6	3.9	5.1	54.8
1915	17.3	4.7	13.1	49.7
1916	27.2	6.9	12.6	65.7
1917	27.2	8.8	8.7	81.4
1918	24.6	7.4	7.9	96.8
1919	18.7	5.8	7.0	111.0
1920	17.5	8.0	7.7	100.9
1921	12.5	4.5	4.7	62.7
1922	13.4	5.7	5.7	67.5
1923	14.4	7.3	6.6	64.9
1924	13.0	8.1	6.3	66.8
1925	14.0	9.0	7.6	69.1
1926	13.8	8.4	7.3	62.1
1927	12.9	6.8	6.2	56.4
1928	14.6	6.3	6.0	58.2
1929	18.1	6.8	6.5	53.0

Source: México. Secretaría de Industria, Comercio y Trabajo (1932), pp. 364-65.

Table 4: The State of Mexican Mining Companies in 1922

Category by State of Conservation	Number of firms in category	Number of Mining Claims	Total Hectares	Average Size of Firms (Hectares)
Paralyzed	221	1,398	15,600	71
Working	153	2,178	58,868	385
In exploration	11	44	656	60
No information	40	49	551	14
All Firms	425	3,669	75,675	178

Source: Mexico. Secretaria de Industria, Comercio y Trabajo (1924), "pull-out pages" between pp. 132 & 133.

Table 5: The State of Mexico's Cyanide Refining Plants in 1922

Category by State of Conservation	Number of firms in category	Total Capacity (tons/day)	Average Firm Size (tons/day)
Destroyed	7	320	46
Bad	14	1,131	81
Regular	6	1,170	195
Good	70	20,823	297
In Construction	3	350	117
No information	12	435	36
All Firms	112	24,229	216

Source: Mexico. Secretaria de Industria, Comercio y Trabajo (1924), pp. 101-05.

Table 6: Lead and Copper Smelters in 1922

Category by State of Conservation	Number of firms in category	Number of Furnaces	Total Capacity (tons/day)	Average Size of Firms (tons/day)
Destroyed	3	2	50	17
Bad	4	7	760	190
Regular	16	25	1,808	113
Good	25	85	16,416	657
No information	9	6	472	52
All Firms	57	125	19,506	342

Source: Mexico. Secretaria de Industria, Comercio y Trabajo (1924), pp. 106-09.

Table 7: Mexico's Lead Smelting Companies, 1913 and 1919

Company	Location	Furnaces		Annual capacity (1000 tons)		Notes
		1913	1919	1913	1919	
ASARCO	Monterrey	10	7	475	410	
ASARCO	Aguascalientes	2	1	100	50	
ASARCO	Chihuahua	5	7	274	400	
ASARCO	Valardeña	3	3	140	150	
Cia Metalúrgica Mexicana	SLP	11	10	385	360	
Cia Metalúrgica de Torreón	Torreón	8	8	360	286	a
Cia Minera de Peñoles	Mapimi	6	6	325	310	b
Cia Fundidora y Afinadora de Monterrey	Monterrey	4	4	238	238	c
Mazapil Copper Co	Saltillo		3		105	
Cia de Minerales y Metales	Cerralvo		2		38	d
Cia de Minerales y Metales	Guadalupe		1		77	e
Total Capacity		49	52	2,297	2,424	

a. Not in operation as of February 1919

b. Subsidiary of Cia de Minerales y Metales in 1919

c. Smelter under lease to Cia de Minerales y Metales in 1919

d. Not in operation since January 23, 1919

e. Not in operation in 1919

Source: Engineering and Mining Journal, 1/10/1914, p. 67;
Engineering and Mining Journal, 1/17/1920, p. 119.

Table 8: Mexico's Copper Smelting Companies, 1913 and 1919

Company	Location	1913 Blast Furnaces	1919 Blast Furnaces	1913 Annual Blast Furnace Capacity (Thousand Tons)	1919 Annual Blast Furnace Capacity (Thousand Tons)
ASARCO (American Smelters Securities) ^a	Valardeña	3	3	228	250
ASARCO	Aguascalientes	8	6	730	480
ASARCO	Matehuala	3	4	325	400
ASARCO	Monterrey		1		80
ASARCO	Valardeña		3		250
Cananea Consolidated Copper Co	Cananea	8	8	868	1,198
Cia Metalúrgica de Torreón	Torreón	2	1	175	55
Compagne du Boleo	Santa Rosalia	8	7	650	700
Mazapil Copper Co	Saltillo	4	4	350	278
Teziutlán Copper Mining & Smelting Co	Teziutlán	2	2	350	328
Domocrata Cananea Sonora Copper Co	Cananea		3		320
El Fuerte Mining and Smelting Co 2	Choix		1		36
Cia Metalúrgica Mexicana	San Luis Potosi		1		72
Cia de Minas de Mexico SA ^b	Mina Mexico		1		17
Total		38	45	3,676	4,464

^aThe Valardeña works are listed as belonging to ASARCO in 1913 and the American Smelter's Securities Corp. in 1919. The American Smelter's Security Corp. was, however, controlled by ASARCO.

^bNot in operation in 1919.

Sources: Engineering and Mining Journal, 1/10/1914, p. 63; Engineering and Mining Journal, 1/17/1920, p. 117.

Table 9: Estimates of Mining Equipment Exported to Mexico from the United States and the United Kingdom, 1907-1929
(in Thousands of 1929 U.S. Dollars)

Year	Estimated U.S. Mining Machinery ^a	Reported U.K. Mining Machinery	Total Mining Machinery	Index 1910=100
1907	961	25	986	166
1908	693	27	720	121
1909	525	40	565	95
1910	494	101	595	100
1911	527	105	632	106
1912	411	76	487	82
1913	525	45	570	96
1914	404	21	425	71
1915	60	6	66	11
1916	83	1	84	14
1917	115	2	117	20
1918	361	7	369	62
1919	394	36	430	72
1920	1111	106	1217	205
1921	1063	83	1146	193
1922	1277	108	1386	233
1923	1267	29	1296	218
1924	1437	6	1443	242
1925	1940	0	1940	326
1926	1937	0	1937	326
1927	1419	0	1419	239
1928	1658	0	1658	279
1929	1767	3	1770	297

^aFrom 1907 to 1921, the estimated total is 45 percent of reported mining and petroleum machinery. The 45 percent ratio is derived from the ratio of reported oil line pipe and casings plus reported petroleum machinery to the total of those categories plus mining machinery from 1922 to 1929. For total mining and petroleum machinery in these years, see Table 6.4. From 1922 to 1929, the estimated total is the reported total (the source disaggregated petroleum from mining machinery).

Note: We note that the final results of these calculations are not sensitive to the ratios chosen.

Sources: United States: United States. Department of Commerce (various years). United Kingdom: United Kingdom. Customs and Excise Dept. Statistical Office, 1900-1934

Table 10: Pumps and Pumping Machinery Exported from the United States to Mexico, 1900-1929

Year	Thousands of 1929 U.S. Dollars	Index 1910=100
1900	73	23
1901	79	25
1902	123	38
1903	167	52
1904	219	68
1905	396	123
1906	654	203
1907	725	225
1908	263	82
1909	243	76
1910	322	100
1911	320	99
1912	268	83
1913	285	89
1914	221	69
1915	107	33
1916	77	24
1917	297	92
1918	715	222
1919	1,369	425
1920	3,762	1,168
1921	2,973	923
1922	641	199
1923	372	116
1924	545	169
1925	588	183
1926	481	149
1927	350	109
1928	421	131
1929	490	152

Source: United States. Department of Commerce, various years.

Table 11: Mining Properties

Year	Hectares Under Concession	Hectares Being Worked	Applications for New Concessions (Hectares)	Concessions Granted (Hectares)	Concessions Revoked (Hectares) ^a
1892	34,999				
1905	256,243				
1917				5,243	
1918			21,298	3,262	
1919	446,549		42,526	7,091	
1920	398,513		40,400	10,930	58,967
1921	284,561		25,436	7,459	21,022
1922	370,220	37,529	25,601	24,928	39,669
1923	361,098	40,738	33,727	20,534	29,656
1924	333,204	47,091	25,006	11,764	39,659
1925	276,629	44,770	39,722	29,771	86,346
1926	276,583	48,886	32,947	19,751	19,798
1927	259,141	74,359	212,257	7,772	25,213
1928	213,539	62,057	234,350	16,668	30,477
1929	218,988	48,653		15,378	9,929

^aConcessions were revoked for failure to pay taxes. Our estimate of hectares revoked adjusts for those concessions that were reinstated by the payment of back taxes.

Sources: Bernstein (1964), pp. 28-29;

México. Secretaría de Industria, Comercio y Trabajo (1924), pp. 132, 133, 145;

México. Secretaría de Industria, Comercio y Trabajo (1925), pp. 63, 116;

México. Secretaría de Industria, Comercio y Trabajo (1927), pp. 250, 257, 290, 292, 295, 296;

México. Secretaría de Industria, Comercio y Trabajo (1928), p. 83;

México. Secretaría de Industria, Comercio y Trabajo (1929), pp. 136-38, 146, 581;

México. Secretaría de Industria, Comercio y Trabajo (1930), pp. 71, 368, 441, 445, 447;

México. Secretaría de Industria, Comercio y Trabajo (1932), pp. 306, 354-56.

Table 12: Dynamite Consumption in Mexico, 1918-1929

Year	Metric Tons Consumed	Index 1918=100
1918	285,519	100
1919	585,711	205
1920	741,114	260
1921	565,004	198
1922	647,242	227
1923	633,362	222
1924	721,428	253
1925	1,202,653	421
1926	1,463,975	513
1927	3,072,732	1,076
1928	4,671,643	1,636
1929	5,620,138	1,968

Source: México. Secretaría de Industria, Comercio y Trabajo (1932), p. 358.

Table 13: Market Shares of Mexico and the United States in Silver, Lead, and Copper

Year	Silver		Lead		Copper	
	Mexico	USA	Mexico	USA	Mexico	USA
1900	32%	32%			5%	55%
1901	33%	32%			6%	52%
1902	37%	34%			7%	54%
1903	37%	31%			9%	53%
1904	35%	32%			8%	56%
1905	34%	31%			10%	57%
1906	32%	31%	6%	32%	9%	58%
1907	34%	31%	7%	33%	8%	55%
1908	34%	25%	11%	27%	5%	57%
1909	31%	24%	11%	30%	7%	58%
1910	32%	24%	11%	31%	7%	56%
1911	32%	24%	11%	32%	7%	55%
1912	32%	25%	10%	31%	7%	55%
1913	32%	30%	5%	32%	6%	55%
1914	17%	45%			4%	56%
1915	21%	40%			3%	59%
1916	18%	44%			4%	63%
1917	24%	41%			3%	61%
1918	32%	34%			5%	61%
1919	37%	31%				
1920	40%	33%				
1921	39%	33%				
1922	39%	27%	11%	41%	3%	52%
1923	39%	28%	13%	41%	3%	53%
1924	38%	27%	12%	40%	3%	54%
1925	38%	25%	12%	41%	4%	54%
1926	39%	24%	12%	39%	4%	54%
1927	41%	23%	15%	36%	4%	50%
1928	42%	22%	14%	35%	5%	49%
1929	42%	23%	14%	36%	6%	48%

Mexico. Secretaria de Industria, Comercio y Trabajo (1924), pp. 37-38;
Mexico. Secretaria de Industria, Comercio y Trabajo (1927), pp. 37, 41;
Mexico. Secretaria de Industria, Comercio y Trabajo (1932), pp. 18, 20, 22;
Engineering and Mining Journal, 5/4/1901, p. 556;
Engineering and Mining Journal, 6/20/1903, p. 935;
Engineering and Mining Journal, 1/7/1904, p. 8;
Engineering and Mining Journal, 3/20/1907, p. 627;
Engineering and Mining Journal, 6/20/1908, p. 1253;
Engineering and Mining Journal, 4/10/1909, p. 764.
Engineering and Mining Journal, 5/1/1909, p. 907;
Engineering and Mining Journal, 9/22/1917, p. 531;
Engineering and Mining Journal, 5/25/1912, p. 1044;
Engineering and Mining Journal, 1/11/1919, p. 47.

Table 14: Estimated Taxation Rates for Mexican Mining^a
(Taxes as a Percent of the Gross Value of Production)

Year	Federal Tax Rate (Percent)	State Tax Rate (Percent)	Combined Tax Rate (Percent)
1905	5.7%	2.0%	7.7%
1907	2.8%	1.5%	4.3%
1919	7.3%	2.0%	9.3%
1920	8.7%	2.0%	10.7%
1921	5.2%	2.0%	7.2%
1922	5.9%	2.0%	7.9%
1923	4.9%	2.0%	6.9%
1924	4.8%	2.0%	6.8%
1925	5.2%	2.0%	7.2%
1926	5.0%	1.3%	6.3%
1927	4.0%	1.3%	5.3%
1928	4.2%	1.4%	5.6%
1929	3.5%	1.2%	4.7%

^aIncludes state and federal production, export, assay, parcel, and surtaxes.

Sources and Notes

See footnotes 14 and 17 in Chapter 7 for sources and methods for 1905 and 1907. For 1919-29, we proceeded in several steps. We took the value of mining production for taxable mineral products and the value of federal production taxes directly from México. Secretaría de Industria, Comercio y Trabajo, 1924-1932. Federal parcel taxes and federal title taxes for 1923-29 were taken directly from México. Secretaría de Industria, Comercio y Trabajo, 1924-1932. For 1919-22, federal parcel taxes were estimated, by multiplying the number of hectares under concession (from Table 7.10) times the average parcel tax per hectare from 1923 to 1925 (7.31 pesos per hectare). We recognize that many firms did not actually pay the parcel tax. The tax rate we compute is the tax they legally owed, not the tax they actually paid. For 1919-22, we estimated title taxes by multiplying the number of new hectares under concession (from Table 7.10) by the average title tax per hectare from 1923 to 1925 (10.66 pesos per hectare). State taxes were estimated in several steps. Prior to 1926, state taxes were capped at 2 percent of the value of the value of all mineral products. We assumed that states taxed at the maximum (2 percent) rate. For 1926 to 1929, we estimated state taxes by multiplying the value of gold and silver produced by 2 percent (the maximum allowable under law). State taxes for other mineral products were fixed at 50 percent of the federal production tax on those products. We assumed that states taxed at the maximum allowable rate.

	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	Assets, average
Guadalupe los Reyes							-7%	-9%						\$ 75,500
Encino					1%									\$ 166,924
Carboncillo*								45%	83%	5%				\$ 265,849
Equidad						-1%	0%	0%	-1%	-2%	-1%			\$ 279,359
La Union**								20%						\$ 313,149
Union								20%	0%					\$ 313,878
La Providencia, San Juan de la Luz				43%	12%	14%	79%	48%	57%	28%	-31%	16%		\$ 318,514
La Roma*										-22%	-9%	-5%		\$ 376,970
Ocampo													55%	\$ 481,443
Compañía Minera de México, Ltd.			13%	25%	12%	19%	9%							\$ 499,311
Aurora*										-2%	-4%			\$ 527,020
Cinco Senores												26%		\$ 682,665
Eden										-6%	0%			\$ 740,856
Alaska-Mexican Gold Mining													0%	\$ 955,536
Los Ocotes										0%	0%	0%		\$ 970,500
La Dura												4%		\$ 1,049,767
Angustias, Dolores y Anexas												14%		\$ 1,103,071
Natividad										8%		0%		\$ 1,939,069
El Rayo												18%		\$ 2,037,772
Rio Plata												11%	9%	\$ 2,217,855
Dolores							0%			16%	18%			\$ 2,644,457
Mexico Consolidated*								13%	18%	16%				\$ 2,912,075
Esperanza							35%	98%						\$ 3,798,175
San Toy*											3%	2%		\$ 6,323,731
Ignacio Rodriguez Ramos, S.A.*											56%	4%		\$ 10,372,635
Batopilas						0%	4%		1%	1%	1%			\$ 12,680,198
Boleo											16%			\$ 26,380,530
Guggenheim												3%		\$ 37,224,588

Source: Engineering and Mining World, Economista Mexicano.

Companies that lost money as percent of sample
Sample as percent of all invested capital (Figure from Bernstein p. 75.)

12%
36%

