

When the Law Doesn't Matter:

The Rise and Decline of the Mexican Oil Industry

Stephen Haber, Noel Maurer, and Armando Razo

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Abstract

Changes in formal institutions do not always affect economic outcomes. When an industry has specific technological features that limit a government's ability to expropriate it, or when the industry is able to call on foreign governments to enforce its de facto property rights, economic agents can easily mitigate changes in formal institutions designed to reduce these property rights. We explore the Mexican oil industry from 1911 to 1929 and demonstrate that informal rather than formal institutions were key, permitting oil companies to coordinate their responses to increases in taxes or the redefinition of their de jure property rights.

In 1921 Mexico accounted for 25 percent of the world's output of petroleum, making it the second most important producer after the United States. Over the next nine years Mexican output declined continuously and precipitously. By 1930, output was only 20 percent of what it had been in 1921, and Mexico accounted for only 3 percent of world production. Mexico would not again reach its 1921 levels of output until 1974. It never regained its 1921 market share.

One can advance either of two hypotheses regarding the dramatic decline of Mexico's petroleum industry. One hypothesis is that the industry's decline was a result of institutional change resulting from the Mexican Revolution. The revolution led to a new constitution in 1917. The constitution ended a 33-year tradition of fee-simple

property rights and vested property rights with the federal government. The revolution also resulted in endemic political instability, which endured from 1911 to 1929. This meant that no commitments by Mexican governments toward the oil companies were credible: new governments, desperate for funds, had every incentive to renege on earlier agreements. Taxes on oil production, in fact, continually rose.

A second hypothesis is that Mexico simply ran out of oil deposits that could be extracted at a competitive cost, given prices, technology, and competing sources. That is, the causes of Mexico's decline were largely geological, not institutional. The decline of Mexico's oil industry in the 1920s is analogous to the history of Pennsylvania oil in the late nineteenth century. At one time, Pennsylvania was the largest producer of oil in the United States. Pennsylvania has not been a consequential producer of petroleum for decades, but no one thinks that this is the result of political instability, high taxes, or Pennsylvania's formal institutions.¹

Some historians of Mexico have favored the first hypothesis.² Others have favored the second hypothesis.³ Some have argued that both hypotheses are true.⁴

¹ Mexico had more oil, of course, and these deposits were tapped in the 1970s. The problem was that it was not possible to either discover or tap those sources with 1920s technology. In fact, most of Mexico's current oil wells are offshore and have to be accessed at depths an order of magnitude beyond the technological abilities of 1920s producers.

Regardless of the substance of their arguments, all sides in this debate have two things in common. First, they tend not to specify hypothesis in a falsifiable manner. Second, they do not bring to bear much in the way of systematically retrieved and analyzed data.⁵

² Linda Hall, for example, argues that: “The intransigence of both sides to the controversy over Article 27 [of the Constitution of 1917] would lead to the gradual and finally abrupt withdrawal of U.S. firms from Mexico.” Hall, *Oil, Banks, and Politics*, especially p. 35.

³ Lorenzo Meyer, for example, states that: “One can say that the factors mainly responsible for the situation were technical and economic rather than political.” Meyer, *Mexico and the United States*, p. 9. Curiously, the rest of his book is concerned with political, not technical or economic, factors.

⁴ Jonathan Brown, for example, takes this approach:

For eleven years, from the promulgation of the 1917 constitution to the 1928 Calles-Morrow agreement, the government sought to enforce public dominion over a resisting industry. The conflict retarded exploration and drilling programs. By the time that the companies and the government had settled the issue of public dominion sufficiently to permit new exploration in Mexico, cheaper production from Venezuela had captured world markets while prices reached a nadir.

Brown, “Foreign Oil Companies,” p. 385.

We argue, based on the retrieval and analysis of systematic data, that the weight of the evidence supports the hypothesis that Mexico's petroleum industry went into decline because Mexico ran out of oil. Increases in taxes had little impact on the oil companies investment decisions, because movements in tax rates had only a minor impact on corporate rates of return. Nor were the oil companies concerned about changes in their de jure property rights. They believed—correctly, it turns out—that they could mitigate the impact of those reforms. Every index of investment that we have developed points to the same conclusion: the oil companies continued to explore and invest well after output began to fall. They simply could not find sources of petroleum that could be extracted at a reasonable price using existing technology.

⁵ Thus, for example, historians chronicle changes in specific taxes on petroleum companies in great detail, implying that these had a significant effect on decisions by the oil companies to stay or leave Mexico, but do not calculate the effect of the taxes on revenues or profits. See, for example, Brown, *Oil and Revolution*, pp. 40, 179, 236-37; Meyer, *Mexico and the United States*, pp. 37, 62-63; Rippy, *Oil and the Mexican Revolution*, pp. 29, 46, 119-20; Davis, "Mexican Petroleum Taxes," pp. 406, 408-09, 414-16; Hall, *Oil, Banks, and Politics*, pp. 19, 67. Similarly, there are assertions in the literature that threats to property rights induced the oil companies to stop exploring or investing—but these assertions are not supported by systematic evidence about the stocks or flows of new investment. See, for example, Meyer, *Mexico and the United States*, pp. 11, 57.

The Mexican petroleum industry is, in short, a case where the specific features of a country's formal institutions (legally codified rules and regulations) had little impact on economic outcomes. What mattered was a broader set of informal institutions related to the organization of the industry and its foreign ownership. The industry was highly concentrated, foreign owned, and organized into a producer's association. These factors gave the petroleum companies two powerful weapons that they could deploy to protect their assets and revenues. First, they could make effective appeals to the U.S. government to intervene on their behalf. Military intervention always hung in the background, but the fact that Mexican governments from 1911 to 1929 were weak and unstable meant that the U.S. had other, lower cost, options, such as the threat that it would allow rival Mexican factions to purchase arms in the United States. These threats could not, however, be lodged every time the Mexican government tinkered with the tax rate. In order to blunt the threat of creeping "revenue expropriation" the oil companies had a second arrow in their quiver. The oil companies were able to coordinate their moves, which meant that they could threaten the Mexican government with production boycotts. Oil taxes were the single biggest source of government revenue, accounting at their peak for one-third of all government income. In the short run, the government lacked the know-how to find, extract, and market the oil. Even ignoring the threat of U.S. intervention, any expropriation or reallocation of property rights would have produced at least a temporary fall in tax income. Since every government from 1911 to 1929 faced the continual threat of armed factions and internal coups, even a brief interruption in oil revenues could cause a government to fall.

This article is organized as follows. The first section overviews the history of the Mexican oil industry from its beginnings around 1900 to the 1930s. It focuses on the effects of the Mexican Revolution of 1910, and the subsequent two decades institutional change and political instability. The second section presents data on output and investment by the oil companies. It shows that investment and exploration continued at high levels for several years *after* output began to decline—a result that is entirely inconsistent with a story of falling investment caused by uncertainty over property rights. The third section quantifies the magnitude and impact of petroleum taxes on the industry. While tax rates rose, the industry remained profitable. In fact, the rise in oil taxes was more than compensated for by a rise in oil prices. The fourth section compares the Mexican oil industry to a simple counterfactual—Mexico’s other extractive industries during the same time period. The silver, copper, and lead mining and refining industries faced similar institutional changes as the oil companies, but very different geological endowments. Output in mining did not decline in the 1920s. In fact, in many mineral products Mexico gained world market share.

Historical Overview

Mexico’s oil industry began as a source of domestic energy.⁶ The Porfirio Díaz dictatorship (1876-1911) had strong incentives to develop this industry because Mexico faced high energy costs.⁷ Díaz therefore reformed Mexico’s institutions to attract

⁶ Brown, *Oil and Revolution*, pp. 44-45; Meyer, *Mexico and the United States*, pp. 3-4.

investment rapidly. In 1884 he allocated the rights to subsurface petroleum to the owner of the surface land. In 1892 he refined this law, stating that the owners of surface rights could freely exploit subsoil wealth without special permission from the government. In 1901, he began to award drilling concessions on federal lands and granted tax exemptions to firms willing to invest in oil exploration. Finally, in 1909 he put an end to any remaining ambiguities in the earlier laws, declaring that the fields or deposits of mineral fuels were the “exclusive property” of the surface landowner.⁸

Around 1900, Díaz’ reforms began to bear fruit. Edward L. Doheny, a California oil man, received a ten-year exemption covering both import tariffs on the necessary machinery and taxes on the resulting output. He went on to found The Mexican Petroleum Company, which, through its numerous subsidiaries, came to control 1.5 million acres of oil lands, either through fee simple ownership or leasehold.⁹ Sir

⁷ These high costs were the product of the need to import coal and oil from the United States. The refining and distribution of this oil was monopolized by an affiliate of Standard Oil. See Meyer, *Mexico and the United States*, p. 4; Brown, *Oil and Revolution*, pp. 14-21.

⁸ For the most thorough history of the Porfirian oil laws, see Rippy, *Oil and the Mexican Revolution*, pp. 15-28. Also see, Meyer, *Mexico and the United States*, pp. 24-25; Brown, *Oil and Revolution*, p. 93.

⁹ The Mexican Petroleum Company of Delaware, Ltd., was a holding company for a network of firms that included the Mexican Petroleum Company of California, the

Weetman Pearson, one of the great civil engineers of the late nineteenth century, founded a second firm, the El Águila oil company (also known as the Mexican Eagle Oil Company). Pearson received a 50-year exemption from all taxes.¹⁰ He also received a zone of three kilometers surrounding each producing well, within which no other party would be allowed to drill. This protected his company against offset drilling.¹¹ Doheny and Pearson both received protection from external competition by a tariff of 3 centavos per kilo of imported crude oil and 8 centavos per kilo on imports of refined oil.¹² It took

Huasteca Petroleum Company, the Tuxpan Company, and the Tamihua Petroleum Company. In 1917 these firms were all brought together by Doheny under the aegis of another holding company, The Pan-American Petroleum and Transport Company.

¹⁰ Pearson built the Blackwall Tunnel under the River Thames, as well as four tunnels under New York's East River. His financial empire eventually came to include the *Financial Times*, the *Economist*, and Penguin Books. See Yergin, *The Prize*, p. 230. A detailed analysis of Pearson's history as Mexico's major public works contractor can be found in Connolly, *El contratista de don Porfirio*.

¹¹ For the details of his tax exemptions and special privileges, see Meyer, *Mexico and the United States*, pp 23-24; Brown, *Oil and Revolution*, p. 28; *Moody's Manual of Investments*, 1913, p. 1536; Lewis, "An Analysis," p. 41.

¹² Brown, *Oil and Revolution*, pp. 63-64.

nearly a decade for Doheny and Pearson to find enough oil to make their operations profitable. By 1911, however, Mexico had emerged as the world's fourth most important oil producer, and Doheny and Pearson controlled 90 percent of the output.¹³ U

Unfortunately for the oil magnates, the political system that underpinned their property rights soon collapsed. Díaz was overthrown in 1911. The revolution that overthrew Díaz was followed by a counter-revolution (1913), a counter-counter revolution (1913-14), a civil war (1914-17), a successful coup against the first constitutional president (1920), two more bouts of civil war (1923-24 and 1926-29), multiple failed coups (1920, 1921, 1922, 1927), and a presidential assassination (1928). Mexico would not regain political stability until 1929.

This period of coups, revolutions, and civil wars produced a series of institutional reforms that attempted to reduce the property rights of the oil companies. In 1917 Mexico wrote a new constitution which completely reformed the property rights system. Article 27 of the Constitution made oil and other subsoil wealth the property of the nation. Mexico's governments subsequently wrote enabling legislation to that constitutional article that severely reduced the property rights of the oil companies—even if those rights had been acquired before the Constitution was written. In addition, every single government from 1911 to 1928 tried to increase oil taxes.

¹³ *Mexican Year Book*, p. 79. Even as late as 1918, after dozens of other companies had entered the market, El Águila and the Mexican Petroleum Company still controlled 65 percent of Mexican crude production. Market shares were calculated from data in *Engineering and Mining Journal*, May 1, 1920, p. 1030.

The battle over taxes and property rights began under Mexico's first revolutionary president, Francisco Madero (1911-13), who demanded that the oil companies register their holdings with the government and tried to impose higher taxes. The oil companies refused to register their holdings, and negotiated a lower tax rate. In the process of negotiation, they formed a lobbying organization, the Association of Petroleum Producers in Mexico (APPM).¹⁴

Madero's successor (and assassin), General Victoriano Huerta (1913-14), needed funds even more desperately than his predecessor, and raised taxes accordingly.¹⁵ We estimate that the tax burden rose from one percent of the gross value of production under Díaz, to ten percent under Madero, and to 15 percent under Huerta— despite the fact that American oil companies refused to pay most of his tax increases.¹⁶ Huerta could not

¹⁴ In 1913 the Chamber of Deputies actually received a proposal to nationalize the industry. Rippey, *Oil and the Mexican Revolution*, p. 29. For a discussion of the taxation issues, see, Brown, *Oil and Revolution*, p. 179; Meyer, *Mexico and the United States*, pp. 31, 32, 37; Davis, "Mexican Petroleum Taxes," p. 406.

¹⁵ Brown, *Oil and Revolution*, pp. 181, 184; Davis, "Mexican Petroleum Taxes," p. 406.

¹⁶ Our analysis of oil tax revenues, levels, and rates is based on actual receipts, not the taxes decreed.

actually do anything about their recalcitrance because his army did not control the oil zone—his opposition did.¹⁷

Huerta's regime collapsed in 1914, but his fall from power did not bring relief to the oil companies. The oil zone was in the hands the Carrancistas (the followers of Venustiano Carranza), and the Carrancistas needed revenues to win a civil war against the armies led by Emiliano Zapata and Francisco "Pancho" Villa.¹⁸ In 1914, the Carrancistas tried to increase taxes through various means. The oil companies successfully resisted most of these initiatives by protesting to the U.S. Department of State, which in turn protested to Carranza, who in turn reversed virtually all of the actions of his government, save for a modest rise in taxes.¹⁹

Carranza was not satisfied with these small gains, but he needed to know how far he could push the oil companies if he was to extract the maximum amount of taxes from them. Therefore, in January 1915 he demanded that they turn over their financial data. He also levied an assessment for back taxes. The oil companies refused to turn over the

¹⁷ Brown, *Oil and Revolution*, pp. 182-87.

¹⁸ Meyer, *Mexico and the United States*, p. 46.

¹⁹ Davis, "Mexican Petroleum Taxes," p. 406; Brown, *Oil and Revolution*, pp. 214-15., 259; Meyer, *Mexico and the United States*, pp. 28, 47-48.

requested financial data and negotiated their way out of paying the back taxes.²⁰ In 1917 he made a second attempt to squeeze the oil companies by establishing a set of new taxes on oil exports. As in 1914, these attempts were only successful in the short run. Our analysis of the tax system indicates that the oil companies were so effective in negotiating with Carranza that they actually drove down the tax rate (total taxes divided by total company revenues) during the tenure of his administration, from 16 percent in 1914 to 14 percent in 1916, and to 11 percent in 1919.²¹

The Carranza government also reformed the institutions governing property rights. Article 27 of the Constitution of 1917 made oil and other subsoil wealth the property of the nation. No one debated the right of the Mexican government to declare that the subsoil was national patrimony.²² The real bone of contention between the oil

²⁰ Carranza agreed to credit their tax bills with past shipments of oil they had made to the government owned railroads. Meyer, *Mexico and the United States*, pp. 48-49; Brown, *Oil and Revolution*, pp. 214-15., 259.

²¹ For discussions of the changes in individual taxes, and the oil companies' responses, see Davis, "Mexican Petroleum Taxes;" Meyer, *Mexico and the United States*, pp. 62-63; Rippy, *Oil and the Mexican Revolution*, pp. 46, 119; Hall, *Oil, Banks, and Politics*, pp. 19, 67; and Brown, *Oil and Revolution*, pp. 236-37.

²² In fact, the *only* country after 1917 where the owner of the surface land was also the owner of the subsoil rights was the United States of America.

companies and Carranza's government was whether Article 27 affected the millions of acres of land already owned or leased by the oil companies, or whether it only pertained to new lands. The oil companies argued that Article 27 only affected properties acquired or leased after May 1, 1917 (the date the Constitution took effect) because Article 14 of the Constitution stated that laws could not have retroactive effects.²³ At first, Carranza took a strong position in regard to the retroactivity of Article 27. On February 19th, 1918, he demanded that the oil companies register their properties with the government. He simultaneously decreed a five percent royalty on all petroleum production and levied a tax of 10 to 50 percent on the value of royalties paid to lessors (the exact tax rate depending on the royalty rate per hectare). The decree affected all contracts and property rights, regardless of whether they had been acquired before or after 1917.²⁴

The vast majority of the oil companies refused to register their lands.²⁵ All of the companies refused to pay the royalties. Carranza responded by giving out unregistered

²³ Brown, *Oil and Revolution*, p. 227. For a discussion of these views, as well as the legal theories that underpinned them, see Rippy, *Oil and the Mexican Revolution*, pp. 33-43.

²⁴ Rippy, *Oil and the Mexican Revolution*, pp. 42-43; Meyer, *Mexico and the United States*, p. 62.

²⁵ El Águila and La Corona (a Royal Dutch/Shell subsidiary), however, agreed to register their lands. El Águila made it very difficult for the oil companies to maintain a united front against the government. In fact, in 1920 it negotiated a deal by which company was no longer free of export, capital, or production taxes. It also gave up the right to a

claims to Mexican citizens and by ordering the army to occupy the oil fields and cap recently drilled wells.²⁶ The oil companies played their trump card: the U.S. State Department intervened, declaring its support for the American companies. Carranza backed down.

When Alvaro Obregón came to power in 1920 (after leading a coup against Carranza) he evidently believed that he enjoyed a stronger negotiating position against the oil companies than had his predecessor. He therefore hiked oil taxes the following year by creating a new “export tax.”²⁷ We calculate that by 1922 the combined incidence

protected zone three kilometers around its open wells. It agreed pay a royalty of 25 percent of production in specie or cash, at the option of the government. In return it received private lands in the states of Tabasco and Veracruz. See Hall, *Oil, Banks, and Politics*, pp. 76-77.

²⁶ Meyer, *Mexico and the United States*, p. 62; Brown, *Oil and Revolution*, pp. 231-32; Rippy, *Oil and the Mexican Revolution*, pp. 43-45.

²⁷ Obregón had earlier decreed (1920) a tax on “infalsificables” (paper money printed during the Revolution). This was levied as a surcharge on taxes paid by oil and mining companies at a rate of one peso in paper infalsificables for every peso paid in gold. Davis, “Mexican Petroleum Taxes,” p. 412. It is not clear if this tax amounted to more than a small surcharge on existing petroleum taxes, because infalsificables only traded at 10 centavos to the peso in 1920. The government’s apparent purpose was to enlist the oil and

of the already existing taxes, plus the new export tax, produced a tax rate equal to 25 percent of the value of gross production.

Tax hikes of this magnitude provoked strong resistance by the oil companies. In protest against the increase, they curtailed output. Exports fell from over 14 million barrels per month to less than six million barrels per month in the summer of 1921.²⁸ In order to break the deadlock, the oil companies sent a delegation to a secret conference in Mexico City.²⁹ The agreement reached by the oil companies and Obregón was not made public, but its terms were made clear by the subsequent actions of each party. The oil companies agreed to pay Obregón's new export tax, in addition to all taxes instituted before 1920. The government, for its part, agreed that the oil companies could pay the export tax in Mexican bonds, which could be purchased for forty cents on the dollar. Shortly thereafter, the government declared that the export tax had to be paid in cash, but

mining companies as its agents in collecting the outstanding emissions of paper money and removing them from circulation.

²⁸ Rippey, *Oil and the Mexican Revolution*, p. 119; Meyer, *Mexico and the United States*, p. 82; Davis, "Mexican Petroleum Taxes," pp. 413-15.

²⁹ The delegation included Walter Teagle of Standard Oil of New Jersey, E.L. Doheny, of Mexican Petroleum Company, J.W. Van Dyke of Atlantic Refining, Harry Sinclair of Sinclair Oil, and Amos Beaty of the Texas Company. Hall, *Oil, Banks, and Politics*, pp. 28-30.

simultaneously lowered the nominal tax rate to forty percent of its former value.³⁰ In short, the oil companies managed to negotiate a 60 percent reduction in Obregón's new export tax. The overall tax rate therefore fell from 25 percent of the gross value of production in 1922, to 20 percent by 1924.³¹

Obregón also gave up ground on the retroactivity of Article 27. First, he leaned on the Mexican Supreme Court in 1922 to produce an interpretation of the constitution that was favorable to the oil companies: Article 27 could not be retroactive as long as the companies had undertaken "positive acts." He then negotiated a "gentlemen's agreement" with the United States in 1923 that defined "positive acts" in the broadest way imaginable. Leasing land before May 1st, 1917, even if the companies had not actively searched for oil, would be considered a positive act. Similarly, the purchase of land before May 1st, 1917, for a price that reflected the potential oil-bearing nature of the

³⁰ The government also dropped the infalsificables tax. Davis, "Mexican Petroleum Taxes," pp. 414-16; Rippey, *Oil and the Mexican Revolution*, p. 120. The tax rates of different products, before and after the decree, can be found in *Engineering and Mining Journal*, September 2, 1922, p. 420.

³¹ Due to the oil companies' resistance, taxes incurred in 1921 were not actually paid until 1922, after the negotiated agreement. This is why the tax rate spiked in 1922, despite the agreement.

subsoil also would be a positive act. In return, the United States agreed to recognize the Obregón government.³²

No sooner did Obregón name his protégé, Plutarco Elias Calles, to the presidency in 1924, than Calles (unsuccessfully) attempted to abrogate the agreement with the United States. Calles hand-picked a congressional committee to write enabling legislation to Article 27. The committee drafted a law that defined positive acts only as actual drilling prior to May 1st, 1917 and that required property holders to apply for confirmation of their rights. The law also imposed a 50-year limit on the confirmations, counting from the time that operations began, and reaffirmed the principal in the constitution that subsoil rights were not recognized along coasts and national borders. In December, 1925, the Mexican Congress approved the law. Predictably, the oil companies filed injunctions, citing the precedents created by the 1922 Supreme Court decision and the 1923 agreement with the United States. President Calles responded that his government was bound by neither the agreement with the U.S. government nor, astoundingly, by the decisions of the Mexican Supreme Court.³³

³² Meyer, *Mexico and the United States*, p. 102; Rippy, *Oil and the Mexican Revolution*, pp. 89-91; Hall, *Oil, Banks, and Politics*, p. 149.

³³ Meyer, *Mexico and the United States*, pp. 110-112, 115; Hall, *Oil, Banks, and Politics*, p. 173; Rippy, *Oil and the Mexican Revolution*, pp. 57-58.

Mexico's leading oil producers decided to openly defy the new law.³⁴ Calles responded by remanding the oil companies to the Attorney General, and canceling drilling permits. The oil companies drilled without permits. Calles then imposed heavy fines and capped wells that lacked permits. The companies broke the seals on the wells. The government sent in troops and capped the wells again.³⁵

Once again, the United States stepped into the breach. Calles was fighting a vicious—and stalemated—civil war against rebels angry with his attacks on the Catholic Church.³⁶ President Coolidge took advantage of this fact, and announced that the United States was going to allow the transport of arms across the border. This was of obvious concern to a government fighting a civil war. Coolidge followed this up in April, 1927,

³⁴ These firms controlled 90 percent of the oil producing lands in Mexico and 70 percent of current output. Rippy, *Oil and the Mexican Revolution*, p. 70.

³⁵ Meyer, *Mexico and the United States*, pp. 123-124; Rippy, *Oil and the Mexican Revolution*, pp. 58-59, 167-168; Sterret and Davis, *The Fiscal and Economic Condition*, pp. 205-206.

³⁶ This civil war is commonly referred to as the Cristero War of 1926-29. The rebels were never defeated militarily. Rather, facing both the Cristeros and a military revolt, Calles backed down in the face of American pressure in 1929 and agreed to cease trying to enforce the Constitution of 1917's anticlerical provisions.

by declaring that the persons and property of American citizens, even abroad, enjoyed protection from the United States.³⁷

Armed with Coolidge's threat, Ambassador Dwight Morrow brokered a deal with Calles to break the deadlock. On November 17th, 1927, the Supreme Court, on Calles's instructions, granted an injunction against the 1925 oil law. Shortly thereafter, Congress formally amended the law. On March 27th, 1928, the State Department announced that the controversy beginning in 1917 was at a practical conclusion.³⁸ The issue of the rights to the subsoil was settled. Properties acquired or leased prior to May 1st, 1917, were not affected by Article 27 of the Constitution of 1917.

Output and Investment

Given this description of historical events, one could conclude that the oil companies perceived that they were in an environment where their property rights were indefensible. They therefore did what any rational actor with lots of sunk costs would do: pump oil like mad, getting it out of the ground before the government could raise taxes even further or confiscate it outright. The implication is that we should observe a boom and then a bust in Mexican petroleum output. This is exactly what the data in Table 1

³⁷ Rippy, *Oil and the Mexican Revolution*, p. 170.

³⁸ Rippy, *Oil and the Mexican Revolution*, pp. 62-63; Meyer, *Mexico and the United States*, pp.133-134; Sterret and Davis, *The Fiscal and Economic Condition*, pp. 205-06.

shows. Oil output increased every year to 1921, and then declined to 20 percent of its 1921 level by 1929.

[TABLE 1 ABOUT HERE]

There is only one problem with this hypothesis: it does not square with evidence about new investment by the oil companies. If the oil companies really were exhausting known reserves as part of a strategy of withdrawal from Mexico, then we should not observe them undertaking new exploration or making new investments. We should, in fact, observe investment peaking well *in advance* of output.³⁹ The data we have assembled on oil exploration and investment, however, indicate exactly the opposite: investment peaked *after* output peaked. The oil companies kept searching for petroleum.⁴⁰ They simply could not find enough to maintain their 1918-21 levels of production.⁴¹

³⁹ This is the result that Monaldi obtains, for example regarding the contraction of the Venezuelan oil industry in the 1950s. Investment began to decline 13 years *before* output began to decline. See Monaldi. "The Political Economy of Expropriation."

⁴⁰ In the early 1930's they found enough in the new Poza Rica field to cause a minor rise in total output.

⁴¹ The deposits that had been tapped were not particularly large. It took only a few years for the sheets of salt water that lay beneath them to invade the petroleum. This meant that it was necessary to continually search for new deposits. See, for example, *Engineering and Mining Journal*, Dec. 11, 1920, p. 1136; *Engineering and Mining Journal*, Dec. 4,

Data on the drilling of new wells indicates that firms kept searching for new oil deposits long after production peaked, but failed to find much new oil. The data are reported in Table 2. There is a strong upward trend in the number of new wells drilled. More wells were drilled in 1921 than in the *combined* period 1917-20. In 1924, three years after production peaked, there were more than twice as many wells drilled as in 1921. By 1926, while production continued to decline, the number of wells drilled finally peaked at 2.5 times its 1921 level and *twenty* times its 1919 level.

One might argue that this intensive drilling campaign is consistent with a story about an industry that feared for its property rights, and therefore pumped oil from proven reserves as fast as possible. If that were the case, however, we would observe that nearly all new wells would be productive, as they would have been sunk in deposits that were already being exploited. Instead, we observe exactly the opposite: most new wells were dry. In 1919, 76 percent of new wells were productive. In 1921, the ratio was 64 percent. It then steadily declined to 28 percent in 1929. This indicates that firms were drilling in new areas in order to discover new reserves, but were failing to find any oil.

[TABLE 2 ABOUT HERE]

Even when the oil companies sank successful wells, the initial output per well (the capacity of the well, measured in barrels per day) continuously fell. At its peak in 1921,

1920, p. 1096; *Engineering and Mining Journal*, Nov. 13, 1920, p. 956; *Engineering and Mining Journal*, Jan. 22, 1921, p. 185; *Engineering and Mining Journal*, Nov. 11, 1922, p. 860. Also see Hall, *Oil, Banks, and Politics*, pp. 105, 109, 111; and Brown, *Oil and Revolution*, pp. 143, 164.

the average initial capacity per new well was 24,800 barrels per day. By 1924, average initial capacity had collapsed to only 3,400 barrels per day. It remained at that level throughout the 1920's. The combination of lower ratios of productive to unproductive wells and lower initial capacities was deadly. First, it meant that total new capacity was constantly declining. In 1921, the total capacity of new wells was 3.4 million barrels per day. By 1924, the total capacity of new wells had fallen to 1.0 million barrels per day, and continued declining at a precipitous pace, reaching 114,000 barrels in 1929. Thus, in the space of only eight years, gross new capacity collapsed by 97 percent. Second, the falling ratio of productive to unproductive new wells, coupled with the lower capacity of successful new wells, meant that drilling costs per unit of output were skyrocketing.⁴² By 1927, six years after output peaked, the oil companies began to cut back on drilling. By that point, it was clear that their exploration efforts were generating only new expenses, not new gushers.

The data on drilling operations are consistent with the observations of contemporaries regarding new exploration. As early as October 1920—well before the resolution of the property rights question—contemporary accounts report that firms were exploring for oil well beyond their original claims in Veracruz and Tamaulipas and were also entering into a great many new leases in numerous states.⁴³

⁴² Contemporary observers noted this explicitly. See Sterret and Davis, *The Fiscal and Economic Situation*, p. 204.

⁴³ *Engineering and Mining Journal*, October 9, 1920, pp. 725-26. Later accounts from contemporary sources discuss other exploration and wildcatting operations. See, for

The increase in land under leasehold was sizable. In 1920, according to the historian Merrill Rippy, the oil companies leased 2,012,604 hectares and owned an additional 677,553 hectares, for a total of 2,690,159 hectares. Five years later, the companies registered their claims under the 1925 petroleum law. Their total claims now covered 6,226,063 hectares, more than twice the amount claimed in 1920.⁴⁴ Data gathered by Lorenzo Meyer yields similar results. Meyer estimates that in 1917 the oil companies held rights to 2,151,025 hectares of oil lands.⁴⁵ When the government granted confirmatory titles, during the period 1928-37 (as a result of the 1925 oil law) it granted titles to 6,940,568 hectares.⁴⁶

The entry of new firms into Mexico also supports the hypothesis that the oil companies were actively searching for new sources of oil, and not just intensively

example, Nov. 27, 1920, p. 1050; *Engineering and Mining Journal*, Jan. 8, 1921, p. 69; *Engineering and Mining Journal*, Jan. 29, 1921, p. 232; *Engineering and Mining Journal*, June 16, 1923, p. 1074; *Engineering and Mining Journal*, Jan. 22, 1921, p. 185.

⁴⁴ Rippy, *Oil and the Mexican Revolution*, pp. 162, 172.

⁴⁵ Meyer, *Mexico and the United States*, p. 57.

⁴⁶ Meyer, *Mexico and the United States*, p. 135. Meyer's claim, that any new investment after 1917 was designed solely to exploit already proven reserves, is therefore not supported by his own evidence. See Meyer, *Mexico and the United States*, p. 57.

exploiting proven reserves. These new firms included many of the established international giants in the oil industry, such as Gulf Oil (which established a subsidiary in 1912), the Texas Company, Union Oil, Sinclair, and Standard Oil of California (all of which had established subsidiaries by 1917).⁴⁷ These were all new operations, rather than purchases of already established oil companies. The world's two largest petroleum companies, Royal Dutch-Shell and Standard Oil of New Jersey, also entered Mexico. Shell began production in Mexico in 1912, through a small subsidiary operation, La Corona, SA. In 1919, Royal Dutch-Shell purchased a controlling interest in Mexico's second largest oil firm, El Águila.⁴⁸ Standard Oil of New Jersey entered the market in 1917 by purchasing the Transcontinental Petroleum Company for \$2.5 million. By 1919, it had ten subsidiaries operating in Mexico.⁴⁹ In 1932, it acquired the Pan American Petroleum and Transport Corporation (the holding company that controlled Doheny's

⁴⁷ Brown, *Oil and Revolution*, p. 141; Rippy, *Oil and the Mexican Revolution*, p. 137.

⁴⁸ Rippy, *Oil and the Mexican Revolution*, p. 154.

⁴⁹ Meyer, *Mexico and the United States*, p. 4; Rippy, *Oil and the Mexican Revolution*, pp. 160-61; Brown, *Oil and Revolution*, pp. 152, 160-161.

interlocking empire of Mexican oil companies) and became the largest producer of petroleum in Mexico.⁵⁰

Data on the value of new investment by the oil companies follow the same pattern as the data on new wells, and support the hypothesis that both new entrants and existing companies continued to invest well after production peaked. We have gathered the financial statements of major Mexican oil companies from *Moody's Manual of Investments*. Our sample includes the Mexican Petroleum Company, El Águila, Pan American Petroleum and Transport, the Mexico-Panuco Oil Company, the Mexico Seaboard Oil Company, and the Penn-Mex Fuel Company.⁵¹ These firms accounted for 76 percent of total Mexican petroleum output in 1918, meaning that our sample captures that largest part of the industry.⁵² We focus on the value of each firm's fixed assets, rather than total assets, which may include cash, securities, and other liquid investments. This allows us to know whether firms are investing in productive apparatus or were diverting

⁵⁰ Pan American was first purchased by Standard Oil of Indiana in 1925, which then sold it to Standard Oil of New Jersey. Meyer, *Mexico and the United States*, p. 4; Brown, *Oil and Revolution*, p. 45.

⁵¹ This is not a random sample of Mexican oil companies, but is a sample of large, publicly traded firms that were followed by *Moody's Manual of Investments*.

⁵² Market shares were calculated from data in *Engineering and Mining Journal*, May 1, 1920, p. 1030; and *Engineering and Mining Journal*, July 1, 1922, p. 25.

profits into other activities. We convert the raw data into index numbers, so as to permit easy comparison in investment growth trends across companies, and report the results in Table 3.⁵³

[TABLE 3 ABOUT HERE]

Every company in the sample invested in new plant and equipment at a rapid rate well after output began to fall. The only variance is the year in which investment peaked. In the case of the Mexican Petroleum Company, investment levels peaked in 1924. For other firms it came later: 1925 in the case of Mexican Seaboard; 1930 in the cases of Mexico-Pánuco and Penn-Mex; and 1931 in the case of El Águila.

These results are consistent with estimates made by the Mexican government of total investment in the oil industry. We have taken these estimates and converted them to real dollars, using the U.S. wholesale price index, with the base year reconverted from 1967 to 1928. The results indicate a rapid run-up of investment from 1912 to 1924—three years after production peaked--and then a gentle decline from 1924 to 1936. In 1912, the real (1928) dollar value of oil company investments in Mexico was \$246

⁵³ Our figures are the book values of fixed assets, calculated at acquisition cost minus depreciation. Optimally, we would have converted these figures into replacement costs. This involves applying the same depreciation schedules across companies by asset type and adjusting the value of new acquisitions of productive apparatus for inflation. Unfortunately, many of our financial statements either lumped depreciation in with other expenses (making it difficult to back out) or failed to break down productive assets into sufficiently detailed sub-categories.

million.⁵⁴ Ten years later, in 1922, the real value of investments had more than doubled to \$511 million. The total stock of investment grew an additional 11 percent by 1924, to \$569 million. The data indicate a drop in investment to mid-1926, when it hit \$393 million, followed by a slight recovery to 1928 when it rose to \$425 million.⁵⁵

A final method of estimating investment in the Mexican oil industry is to look at the real value of capital goods imported into Mexico from the United States. This method allows us to measure flows rather than stocks. It is also an extremely accurate measure of gross investment, because Mexico produced no oil drilling equipment, pipes, casings, or storage tanks. *All* of this machinery and equipment had to be imported from the United States. Our estimates, in real U.S. dollars, are presented in Table 4. Prior to 1922, the U.S. Department of Commerce did not disaggregate petroleum machines from mining machines. Thus, the 1907-21 estimates are based on the reasonable assumption that the ratio of oil equipment expenditures to oil and mining equipment expenditures during 1907-21 was the same as it was from 1922 to 1929 (55 percent of total mining and petroleum spending). We note that partial data on mining and oil well equipment

⁵⁴ The nominal estimate, made by Carlos Díaz Dufoo, was 175 million. Díaz Dufoo, *La cuestión*, p. 102.

⁵⁵ The nominal amounts, estimated by the Mexican government and reported by Rippy are as follows: 1922 equals 510 million dollars, 1924 equals 575 million, 1926 equals 406 million, 1928 equals 425 million, 1936 equals 306 million. Data from Rippy, *Oil and the Mexican Revolution*, pp. 164, 166, 173, 181.

imports into Mexico in 1919 are roughly consistent with this ratio.⁵⁶ We also note that the results are not sensitive to the ratio chosen—even had 100 percent of mining and petroleum equipment imports during the 1907-21 period been destined for the oil industry, it would not affect our results.

[TABLE 4 ABOUT HERE]

The data are consistent with the hypothesis that investment was not affected by expectations about future institutional change. New investment dropped dramatically in 1914 and 1915, years when revolutionary violence reached extreme levels, but then recovered rapidly. In 1920, gross investment in machinery was more than twice what it had been in 1910. The data also indicate that gross investment in the petroleum industry continued its high rates until 1924, when the flow of new machinery to Mexico was 56 percent higher than it had been just three years before. New investment flows only began to decline in 1925, four years after output peaked.⁵⁷ Even in the late 1920s,

⁵⁶ In the month of August, 1919, oil equipment accounted for 67 percent of total oil and mining equipment. *Engineering and Mining Journal*, Oct. 11, 1919, p. 623.

⁵⁷ This is not the same thing as saying that the stock of investment declined. As long as new investment flows exceeded the depreciation of old equipment and the re-export of used equipment from Mexico to third countries, the stock of investment would have increased. Without estimates of re-exports of petroleum equipment and the rate at which equipment depreciated, it is not possible to estimate the stock of investment from these data. It is unlikely, however, that re-exports and depreciation would have exceeded the stock of new flows, at least through the late 1920s.

however, flows of new investment were, on average, higher than they had been during the period 1907-21.

Taken as a group, the various measures we have put together of exploration and investment indicate that the oil companies continued to invest even after output had begun to decline. Output peaked in 1921, but investment did not peak until sometime between 1924 and 1928, depending on how it is measured. The implication is that firms were not dissuaded from investing by changes in institutions, increases in taxes, or political instability. The data suggest, instead, that the oil companies believed that they could mitigate threats to their property rights and the returns from those property rights. They left Mexico when they could no longer find sources of petroleum that could be extracted at a reasonable price using existing technology.

Taxes and Profits

If our interpretation is correct, then what are we to make of the fact that the petroleum companies endlessly haggled over tax rates? Historians have noted, quite correctly, that the oil companies fought the Mexican government's attempts to introduce new taxes or raise existing ones, and have surmised from this that the tax rate was a vital determinant of whether the oil companies continued to operate in Mexico. The problem with this interpretation is that all companies at all times in all places complain about taxes. Whether they complained and whether taxes really were a determinant of their level of operations are separate issues. What was germane to the oil companies was how badly taxes cut into profits.

In Table 5 we present estimates of Mexican government revenues, oil tax revenues, per barrel taxes, total oil industry revenues, and the tax rate (total taxes divided by total revenues). Our estimates of per barrel taxes indicate a steady increase from three centavos (gold pesos) per barrel in 1912 to 47 centavos per barrel in 1922. The tax then oscillated without trend through the rest of the 1920's.⁵⁸ In 1912 oil tax receipts made up less than one percent of total government revenue. This ratio climbed rapidly, reaching five percent by 1917, 20 percent by 1920, and 31 percent by 1922. It declined after 1922, but as late as 1926 oil taxes still accounted for 13 percent of government revenue. In short, the basic fact of the matter was that petroleum taxes were a crucial component of government revenues.

[TABLE 5 ABOUT HERE]

How high were Mexican taxes from the point of view of the oil companies? That is, did increases in taxes lower the net revenues per barrel to the point that the oil companies could have more profitably deployed their capital elsewhere? We answer this question in two ways.

The first method we employ is to calculate the after-tax price for a barrel of Mexican crude oil received by the oil companies. The calculation from the data in Table 6 is straightforward. We simply subtracted the per barrel tax payments made by the companies from the average pre-tax price of a barrel of Mexican oil in that year. We

⁵⁸ The variation was driven by annual differences in the percentage of oil exported versus domestically consumed. The tax rate was considerably higher on exported oil.

calculated the average pre-tax price of a barrel of oil by dividing the industry's total revenues by the total amount of production.

[TABLE 6 AND FIGURE 1 ABOUT HERE]

The result, presented in Table 6 (and presented graphically in Figure 1), is clear. The run-up in oil prices during and after the First World War was so pronounced that the after-tax price per barrel received by the Mexican oil companies increased fourfold, despite the increase in petroleum taxes. The data support the argument that any decline in the companies' profits, therefore, was not induced by increases in Mexican oil taxes. Since the Mexican oil prices are imputed values, we performed the same exercise using the average U.S. price for crude oil.⁵⁹ We then subtracted the average total tax per barrel paid by the Mexican oil producers. Since the average American price was consistently higher than our imputed Mexican price—most Mexican crude was of rather low quality—the results are even more dramatic. Tax payments did not substantially reduce the revenues per barrel received by the oil companies.

A second way to determine the impact of Mexican taxes is to conduct a counterfactual exercise on rates of return. We first construct estimates of rates of return for six major Mexican oil companies using balance sheets and profit and loss statements

⁵⁹ We also make the reasonable assumption that Mexican oil prices did not determine world oil prices. Hence, U.S. oil prices are a good proxy for domestic oil prices in Mexico during that period.

in *Moody's Manual of Investments*.⁶⁰ We retrieved data on El Águila, the Mexican Petroleum Company, the Mexican Seaboard Oil Company, the Mexico Panuco Oil Company, the Mexican Investment Company, and the Penn-Mex Fuel Company.⁶¹ These firms accounted for 74 percent of total Mexican petroleum output in 1918, and 40 percent

⁶⁰ Returns on assets are calculated by dividing total profits (gross revenues minus expenditures) by the total value of all assets (both fixed and liquid) of the company. Interest payments made by the company to bondholders and other creditors are added back to profits, because the value of the debts are included in the value of total assets. In short, they are the value of profits divided by the value of the investment that produced those profits. An alternative measure is the rate of return on owner's equity, which divides profits by the value of paid in capital, reserve accounts, and retained earnings. In this measure, the value of interest payments is subtracted from profits and the value of the debts is subtracted from assets. As a practical matter, the Mexican companies in our sample did not carry significant amounts of debt on their balance sheets. Thus, there would have been little difference in the rate of return on assets and the rate of return on owner's equity.

⁶¹ These six companies were not chosen at random. Rather, we selected them because it was possible to retrieve their balance sheets and profit and loss statements from *Moody's Manual of Investments*.

in 1922.⁶² We then estimated a second set of rate of return estimates under the assumption that the tax rate was zero.⁶³ We backed out the value of Mexican taxes by first estimating the value of those taxes, using the tax rate estimates in Table 5 and information in the firms' balance sheets about the value of gross revenues. Because we could not separate out income from Mexican oil sales from income from other sources, we assumed that all income was generated in Mexico and was therefore subject to Mexican taxes. This maximized the impact of the tax rate on rates of return. We note that we were able to measure taxes directly for the Mexican Petroleum Company during the

⁶² Market shares were calculated from data in *Engineering and Mining Journal*, May 1, 1920, p. 1030; and July 1, 1922, p. 25.

⁶³ We took the estimated tax rate from our calculations in Table 5. We then estimated the absolute value of taxes for each year by multiplying the tax rate by the value of each firm's gross revenues. We then subtracted these estimated taxes from the value of expenditures, to calculate zero-tax profits. We then divided these zero-tax profits by the value of assets. This is essentially an exercise in comparative statics. The calculations assume that short term output is entirely inelastic, holding fixed investment constant. Short term inelasticity is a reasonable assumption given the high sunk costs in the petroleum industry. Once a well is drilled and a pipeline built, it is almost impossible to redeploy them to other uses. As long as firms are covering their variable costs, they will continue to produce as much as their fixed investment will allow.

period 1912-1917.⁶⁴ The results indicate that the method we employed in our counterfactual exercise overstates Mexican taxes by a factor of two. We further note that all of the companies in our sample had income earning assets outside of Mexico. In short, our assumptions create upper bound estimates for the impact of the tax on rates of return and bias our results against the hypothesis that taxes did not substantially affect profitability.

Our estimates of returns on assets are presented in Tables 7 and 8. There is some variance across companies, but the general pattern is for very strong rates of return in the period roughly 1916 to 1922 with some fall-off thereafter, but the decline experienced after 1922 is highly variable. For some companies, such as El Águila, Penn-Mex, Mexico-Pánuco, and the Mexican Investment Company, the drop is quite pronounced. For others, such as the Mexican Seaboard Oil Company and the Mexican Petroleum Company, rates of return remained in the double digits until 1926 for the former and 1929 for the latter.

[TABLES 7 AND 8 ABOUT HERE]

Did Mexican taxes drive this fall in rates of return? Our analysis in Table 8 suggests it did not. Two features of the data are obvious. First, even with a zero tax rate, rates of return still decline in the mid-1920's. Second, for most companies, a zero tax rate only pushed up rates of return by a few percentage points. Thus, for example, El

⁶⁴ The Mexican Petroleum Company paid taxes from 1912 to 1917 under protest. It therefore carried the value of the taxes on its balance sheets as an asset. We can therefore back out the yearly additions to this account, thereby imputing the actual amount of tax paid.

Águila's rates of return moved from two percent in 1923-27 (with positive taxes) to an average of three percent (with a zero tax rate). We obtain roughly similar results for the Mexican Investment Company, Penn-Mex, and Mexico-Pánuco. For the Mexican Petroleum Company and the Mexican Seaboard Oil Company, the impact of zero taxes would have been significant in the early 1920s, when these firms already had double-digit rates of return. Once income began to fall for these firms in the late 1920s, however, cutting taxes to zero would have raised rates of return by only four percentage points in any given year. Even had taxes been zero, other expenses—those associated with discovering reserves and developing wells--would have continued rising. The end result would not have been dramatically different. The bottom line was that Mexican petroleum pools were becoming more difficult to find and more expensive (per barrel) to develop.

Other Extractive Industries

Oil was not the only mineral commodity Mexico produced. In fact, before the revolution, Mexico was one of the world's leading producers of silver, copper, and lead. By 1911, Mexico accounted for 32 percent of world silver production, 11 percent of world lead, and 7 percent of world copper production. In all three categories, it was the second or third most important producer in the world behind the United States.⁶⁵

From the perspective of Mexico's governments and revolutionary factions, Mexico's mining industry looked a lot like petroleum. They were immobile investments with high

⁶⁵ *Anuario de Estadística Minera*, 1925, p. 37; *Anuario de Estadística Minera*, 1929-30, pp. 18 and 20.

sunk costs—in other words, like the oil wells, they were perfect revenue sources. Thus, like the oil industry, the mining industry also saw an attempt to redefine its property rights and attempts by every government to increase the tax rate.⁶⁶ In 1920, total federal

⁶⁶ Under Porfirian legislation, miners did not have fee-simple title to the subsoil, as did the oil companies. The government remained the residual claimant on mineral wealth so that miners could expropriate landowners who wished to hold up mining operations. The fact that mineral wealth was national patrimony meant that landowners had to allow prospecting, exploration, and mine development on their properties. They also had to cede all rights of way. They were allowed to charge for access, but the value of the rent had to reflect only the value of the surface land, not the subsoil wealth. In the event of dispute between mining companies and landowners, a federal mining agent would simply set the rental rate. As of 1892, mining companies could maintain their rights to a parcel solely by paying a parcel tax, which was set at a nominal level (roughly 3 dollars per hectare). The Constitution of 1917 severely reduced the property rights of miners in three crucial respects. First, it stated that miners had to work their claims in order to maintain their property rights. Most companies only worked a small portion of their total claims, and had done so since Porfirian times. The Constitution therefore implied that they could be expropriated. Second, the Constitution stated that only Mexican citizens and Mexican companies had the right to acquire concessions to develop mines. It went on to say that the government might grant this right to foreigners, provided that 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 made by former governments since 1876 that resulted in the monopoly of

and state taxes on mining came to 10.2 percent of the gross value of output, more than twice the 1910 rate.⁶⁷ In short, if institutional change and increases in tax rates caused a decline in Mexican oil output, then they should also have produced a decline in Mexican mineral production.

Mexico's mining output *rose* and remained high throughout the 1920s in every major mineral product. In Table 9 we present estimates of the production, by volume, of Mexico's major mineral products: silver, lead, copper, and zinc. Mexican mining production began to increase rapidly in 1917, and exceeded its Porfirian levels by the early 1920s, the exact year depending on the product. Mexico's silver output in 1929

lands, waters, and natural resources of the nation were subject to revision. The president was authorized to declare such contracts and concessions null and void. Bernstein, *The Mexican Mining Industry*, Appendix 1, p. 288; *Engineering and Mining Journal*, March 3, 1923, pp. 401-403.

⁶⁷ Calculated from data on prices, output, and tax rates in *Anuario de Estadística Minera*, various years. Taxes fell after 1922, but remained above their 1910 level. In 1922, total federal and state taxes had fallen to 7.5 percent. By 1926 they were down to 6.0 percent. By 1929, the combined federal and state tax rate was 5.2 percent, which was close to the combined Porfirian rate of 4.3 percent. It should be noted that these tax rates were substantial. Typical margins in the Mexican mining industry were in the range of 20 to 25 percent of gross revenues. See *Engineering and Mining Journal*, March 14, 1903, p. 398.

was 40 percent higher than in 1910. Copper output in 1929 was 67 percent above Porfirian levels. Lead production doubled. Zinc went through the roof, reaching a level 95 times that of 1910, and almost eight times its 1907 peak.⁶⁸

[TABLE 9 ABOUT HERE]

The Mexican mining industry did not just grow relative to its pre-revolutionary levels, it grew relative to the rest of the world. In most products Mexico maintained or gained world market share during the 1920s. It even outperformed the United States. In Table 10 we present data on Mexico's market share in silver, lead, and copper, its three most important mineral products by both value and volume. For example, Mexico's share of world silver production increased from an average of 34 percent in 1900-10 to 40 percent in the decade 1920-29. During the same two periods, the market share of the United States declined from 30 percent to 27 percent. Mexico's share of world lead production increased from an average of 9 percent in 1906-10 to 13 percent in 1922-29. It did at least as well, therefore, as the United States, whose average market share increased from 31 percent to 39 percent. In only one case, copper, was Mexico's average market share lower in the 1920s than before 1910. It produced 8 percent of the world's copper from 1905 to 1910, but only 4 percent of the world's copper from 1922 to 1929. Even in the case of copper, however, Mexico's market share was rising in the 1920s. That is, the market share it had lost during the production shut-downs of the civil war years of 1913-17 (when its share of world production was only 3 percent) was steadily regained in the 1920s. By 1929 it had 6 percent of world production. During the same

⁶⁸ The imposition of an American tariff almost destroyed the Mexican zinc mining industry in 1907.

period, the United States *lost* market share, falling from 52 percent in 1922 to 48 percent in 1929. Only in oil did Mexico underperform the rest of the world in the 1920s, rapidly losing market share.

[TABLE 10 ABOUT HERE]

A skeptical reader might argue that Mexican mineral output climbed in the 1920s precisely because the government was reducing the property rights of miners. The argument would be very similar to that one would make about the impact of institutional change on petroleum production: in a high sunk cost industry, the rational response of economic agents to an increase in taxes or a reduction in property rights is to extract as much income as possible in as short a time as possible from proven reserves, before the government has a chance to reduce property rights or raise taxes even further.

As we did with petroleum, we can subject this argument to a simple empirical test: if this hypothesis holds, we should not observe mining and smelting companies making substantial new investments in plant and equipment. We therefore gathered data on investment by mining companies. It strongly indicates that mining companies were making massive new investments in the late 1910s and the 1920s.

In Table 11 we present estimates of the real value of mining equipment and machinery imported into Mexico from the United States and Great Britain. We note that these estimates measure the flow of new investment, not the stock of existing investment. We also note that this is an excellent proxy for capital spending by mining companies, because Mexico produced no mining equipment domestically. All machinery had to be imported from abroad.

[TABLE 11 ABOUT HERE]

We report both the absolute values (in real 1929 dollars) and index numbers (base year 1910=100) to assess change over time. We note that 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 reasonable 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 percent). We also note that our results would not be sensitive to the ratio chosen. Even if we make the completely unrealistic assumption that 100 percent 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 from 1907 to 1911, or 1907 to 1921.

The investment data are unambiguous. First, from 1913 to 1915 rates of new investment fell in a dramatic fashion, so much so that by 1915 there was virtually no new machinery being imported into Mexico. Given the fact that the rolling stock had been commandeered for military uses, and that roadbeds had been destroyed, this stands to reason. It was extremely difficult, if not impossible to get coal and ore to smelters, or metals to the U.S. border.⁶⁹ By 1918, once the most violent phase of the revolution was at an end, rail lines started to be put back into service. Mining companies now began to make dramatic investments in new plant and equipment. By 1920 Mexico was investing record amounts in new mining equipment. Mexico's mining companies then continued

⁶⁹ *Engineering and Mining Journal*, July 26, 1913, p. 171; *Engineering and Mining Journal*, Jan. 8, 1916, p. 94.

to import new mining equipment at record levels all through the 1920s. In fact, our estimates indicate that, on average, new expenditures during the period 1920-29 were 70 percent higher than they had been in the years 1907-10.

These estimates are consistent with data we have retrieved on another major input into mining production, pumps and pumping equipment. Pumping equipment is a good proxy for mining investment for three reasons. First, pumping equipment was a vital input: without a means to pump out groundwater, mines are unworkable. Second, most pumping equipment imported into Mexico would have been used by mining companies, not other users.⁷⁰ Third, Mexico produced no pumping equipment of its own; all of this equipment was imported. Thus, using U.S. Department of Commerce records, we have constructed a data set on pumps and pumping equipment exported from the United States to Mexico. As is the case with the data on mining machines, the pumping equipment data are flows, not stocks.

As Table 12 demonstrates, U.S. exports of pumping equipment declined during 1913-1916. This should hardly be surprising, because many of Mexico's mines were idled during these years by the lack of rail service. Pumping equipment exports to

⁷⁰ Petroleum companies and agriculturalists also employed pumping equipment, but the single biggest user of pumps were mining companies, which used them to unwater 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. Agriculturalists 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.

Mexico then rose in a dramatic fashion beginning in 1918. In 1919 they were an order of magnitude higher than their 1901-1910 average. During 1920-29 they averaged more than three times their level for 1901-1910.

One might argue that this jump was the product of the replacement of pumping equipment that had been destroyed during the years of civil war. Such an interpretation is not consistent with the evidence. First, in the three years 1918, 1919, and 1920, the combined value of pump exports from the U.S. to Mexico exceeded the combined value of all pumps exported to Mexico from 1900 to 1918. Even had all of Mexico's pumps been destroyed as of the end of 1917, exports from the U.S. in 1918-20 would have replaced them, and still left a very wide margin (on the order of 21 percent!) for new investment. Second, even if we make the unreasonable assumption that all U.S. exports for 1918-20 were replacements of destroyed or damaged equipment, the level of U.S. exports for the period 1921-29 were, on average, more than twice the levels for 1901-10. The clear implication is that mining companies were investing well beyond their pre-1911 productive capacity in order to expand production.

[TABLE 12 ABOUT HERE]

Our estimates of investment spending are consistent with the observations of contemporaries. In 1923, the *Engineering and Mining Journal* noted that “more mining machinery is going into Mexico at this time than for ten years.... Considerable new equipment for ore-reduction mills is also being imported from the United States.”⁷¹ Later that same year, the *Engineering and Mining Journal* noted that “Not in many years has

⁷¹ *Engineering and Mining Journal*, April 28, 1923, p. 770.

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.”⁷² The *Engineering and Mining Journal* further noted that during 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.”⁷³

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, for example, the American Smelting and Mining Company (the largest mining and smelting enterprise in Mexico) committed 10 million dollars to the upgrading and expansion of its existing plants, as well as the construction of new smelters. This included a new zinc smelter, a coal-mining operation, a byproduct coke plant, a copper smelter, an arsenic plant, and a flotation plant.⁷⁴ 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

⁷² *Engineering and Mining Journal*, Nov. 3, 1923, p. 784.

⁷³ *Engineering and Mining Journal*, Jan. 16, 1926, p. 122.

⁷⁴ *Engineering and Mining Journal*, Nov. 15, 1924, pp. 786-87.

investments in the early 1920s. This included the installation of electric generators to supply power to its mines and smelting plants, 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.⁷⁵

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.⁷⁶ In 1926, 2.1 million tons of ore were treated in Mexico by flotation. This grew to 3.6 million tons by 1927, and to 4.1 million tons by 1928. In that year, there were 33 flotation plants in operation, treating 32 percent of the ores mined.⁷⁷

In sum, the data on investment all points the same way: there was considerable new investment in Mexican mining, smelting, and chemical refining plants in the years after 1918. One would be hard put to argue that changes in formal institutions caused producers to cease making new investments. Like the oil companies, the mining companies continued to invest even though the government was trying to reduce their

⁷⁵ The Compañía Minera de Peñoles was, by the mid-1920's, a subsidiary of the American Metals Company. See *Engineering and Mining Journal*, January 31, 1925, pp. 217-220.

⁷⁶ *Engineering and Mining Journal*, Feb. 13, 1926, p. 278.

⁷⁷ *Engineering and Mining Journal*, Oct. 19, 1929, p. 577.

property rights and increase taxes. Like the oil companies, they also believed that they could mitigate these changes. Indeed, they had precisely the same set of weapons in their arsenal as did the oil companies: the threat of U.S. intervention and their ability to credibly threaten a production shutdown because of the technology intensive nature of the industry. What was different between the two the industries was the geologic endowment: mining output rose, but the oil companies ran out of petroleum that could be tapped using existing technology.

Conclusion

This article pursues an area of New Institutional Economics that has not been addressed in the literature to date: the conditions under which formal institutions are not determinative of economic outcomes. In order to operationalize an argument about the specific features of industries and the ability to defend de facto property rights by employing a foreign power, we analyze the Mexican oil industry. The data we have presented here—the drilling of new wells, the extent of landholdings, the value of petroleum investments, the value of capital goods imports, the entrance of new firms, the impact of taxes on profits, and the performance of the country's other extractive industries—all point to the same conclusion. The oil companies perceived that they could weather any threat to their property rights. American saber rattling, often taken by historians as evidence that the oil companies were genuinely threatened, should instead be understood as a signal by the U.S. government that it would enforce American property rights. During the 1920s, this could be done at low cost. The United States simply could have supported (or been complicit with) any number of factions that

challenged the Mexican government. Saber rattling made it clear to the Mexican government that any attempt to expropriate—or levy confiscatory taxes—would be off-the-equilibrium path behavior. The oil companies realized this, and invested regardless of the government’s rhetoric or formal institutional changes.

Uncle Sam was not the oil companies’ only recourse. The oil companies were able to parry most of the minor thrusts made by various Mexican governments by virtue of the fact that they could lodge a credible threat to shut down production. The very fact that Mexican governments faced multiple violent threats to their existence gave the oil companies a very powerful weapon. They could withhold output and deny the Mexican government crucial tax revenues. The oil companies and the government both understood that an empty treasury and politically ambitious generals was (quite literally) a deadly combination.

Institutions therefore mattered, and mattered a great deal, in Mexico in the 1920s. The institutions that mattered were not, however, the formal, legally codified rules and regulations on which property rights analysis so often focuses. The institutions that mattered were of a variety we do not often think about: the institutions that allowed producers to coordinate their actions; the institutions that allowed them to influence the behavior of their home government; and the institutions that prevented Mexico from having the technological ability to independently run the industry without foreign managers and engineers.

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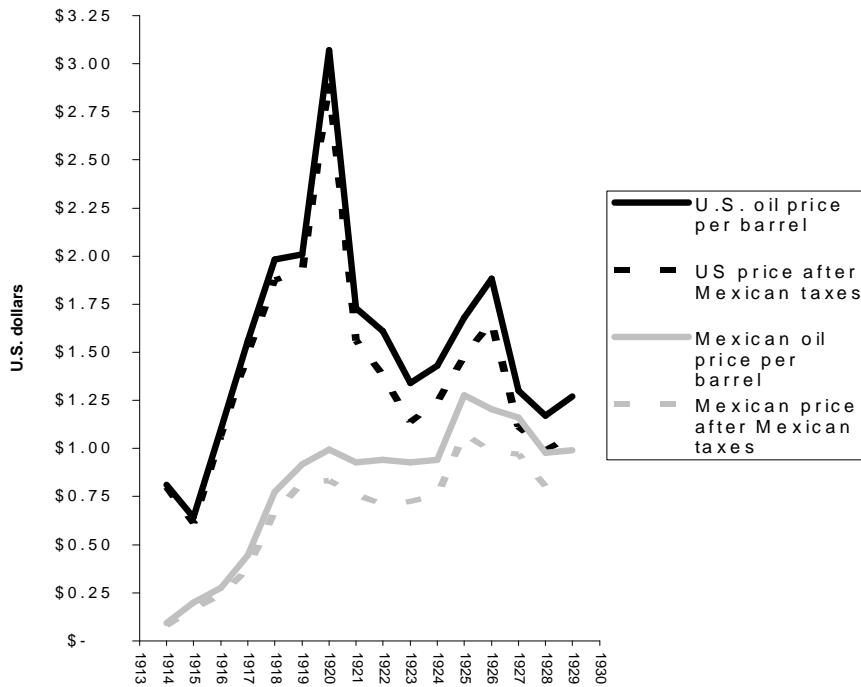
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Figure 1: Pre-Tax and After-Tax Prices for Crude Oil faced by Mexican Producers



Source: Mexican crude oil prices and the (actually paid) Mexican taxes per barrel, Table

1. U.S. average crude oil prices from Potter and Christy, *Trends in Natural Resource*

Commodities, pp. 318-19.

Table 1

Estimates of Mexican Petroleum Output and Exports

Year	Crude production (thousands bbls)	Export of crude and derivatives (thousands bbls)
1901	10	
1902	40	
1903	75	
1904	126	
1905	251	
1906	503	
1907	1005	
1908	3933	
1908	2714	
1910	3634	
1911	12,553	902
1912	16,558	7,729
1913	25,696	21,331
1914	26,235	23,366
1915	32,893	24,769
1916	40,545	27,269
1917	55,293	46,024
1918	63,828	51,767
1919	87,073	75,550
1920	156,539	145,509
1921	194,756	172,268
1922	185,057	180,866
1923	149,341	135,607
1924	139,105	129,700
1925	115,588	96,516
1926	90,610	80,719
1927	64,121	48,344
1928	50,151	10,532
1929	44,688	
1930	39,530	
1931	33,039	9,912
1932	32,805	12,302
1933	31,101	
1934	38,172	
1935	40,241	
1936	41,026	
1937	46,803	18,253
1938	38,482	

Sources: Meyer, *Mexico and the United States*, p. 16; INEGI, *Estadísticas históricas*, p. 559; Mexico, Dirección General de Estadística, *Anuario Estadístico*, 1930, pp. 395, 517-21; Sterrett and Davis, *Fiscal and Economic Condition*, p. 197.

Table 2

Wells Drilled and Capacity

Year	Total number wells drilled ^a	Productive wells	Percent productive	Initial daily capacity per well (thousands bbls)	Total initial daily capacity (thousands bbls) ^b
1901-16	279	174	62%	3.7	644
1917	79	43	54%	6.3	271
1918	43	28	65%	19.8	554
1919	41	31	76%	15	465
1920	97	62	64%	24.8	1,538
1921	317	203	64%	16.7	3,390
1922	265	158	60%	9.1	1,438
1923	467	259	55%	3.4	881
1924	699	296	42%	3.4	1,006
1925	801	298	37%	3	894
1926	808	318	39%	3.7	1,177
1927	570	204	36%	1.9	388
1928	237	96	41%		
1929	114	32	28%	3.6	115

^a1901-16 is the total number of wells in that 16 year period.

^bDaily capacity per new productive well, times the number of new productive wells.

Sources: Mexico, Dirección General de Estadística, *Anuario Estadístico*, 1923-24, p. 141; Mexico, Departamento de la Estadística Nacional, *Estadística Nacional, Revista Mensual*, February, 1930, p. 49; Mexico, Departamento de la Estadística Nacional, *Estadística Nacional, Revista Mensual*, March, 1930, p. 91; Sterrett and Davis, *Fiscal and Economic Condition*, pp. 203-04; Brown, "Foreign Oil Companies," pp. 381-82.

Table 3

Fixed Assets of Major Mexican Oil Companies
(1921=100)

Year	El Águila	Mexican Petroleum	Mexican Seaboard	Mexico Pánuco	Penn-Mex Fuel
1911	55	66			
1912					
1913	112	71			
1914	129	80			
1915	126	87			
1916	113	86			
1917	103	89			
1918	97	106			
1919	94	92			82
1920	94	100			92
1921	100	100	100	100	100
1922	163	127	121	101	100
1923	178	130	126	97	99
1924	159	137	137	97	101
1925	142	129	172	150	
1926	126	106	152	171	
1927	104	98	132	273	
1928	93	95	120	272	
1929	89	89	127	350	

Notes: Assets are valued at acquisition cost minus depreciation (book value).

Full company names are: Mexican Eagle Oil Co. (El Águila);

Mexican Petroleum Company of Delaware, Ltd;

Mexico-Pánuco Oil Company; The Mexico Seaboard Oil Company;

the Penn-Mex Fuel Company.

Source: Estimated from balance sheets in *Moody's Manual of Investments*, various years.

Table 4

Estimates of Petroleum Equipment Exported to Mexico from the United States,
1907-1929
(thousands of 1929 U.S. dollars)

Year	Reported mining and petroleum machinery	Oil line pipe and Casings	Petroleum machinery	Estimated petroleum machinery plus pipes ^a	Index of petroleum pipes and machines (1921=100)
1907	2136			1175	90
1908	1,539			847	65
1909	1,166			641	49
1910	1,099			604	47
1911	1,172			644	50
1912	914			503	39
1913	1,166			641	49
1914	898			494	38
1915	133			73	6
1916	184			101	8
1917	255			141	11
1918	803			442	34
1919	875			481	37
1920	2,469			1,358	105
1921	2,362			1,299	100
1922		881	944	1,825	140
1923		1,751	864	2,616	201
1924		1,943	897	2,841	219
1925		1,451	1,141	2,592	200
1926		1,069	584	1,654	127
1927		749	628	1,377	106
1928		681	952	1,632	126
1929		683	606	1,289	99

^a1907-21 values for imports of petroleum machinery and pipes are estimated at 55 percent of all oil and mining imports.

Source: Calculated from U.S. Department of Commerce,
Foreign Commerce, various years.

Table 5

Estimates of Mexican Petroleum Taxes and Prices

Year	Price per bbl (gold pesos)	Value of crude produced (gold pesos)	Total petroleum taxes ^a (thousands of gold pesos)	Tax per bbl (gold pesos)	Tax rate (percent)	Total tax revenues (millions of pesos)	Petroleum taxes as % of total revenues
1911	0.2	2,512	14	0	1%	111	0%
1912	0.25	4,142	494	0.03	12%	126	0%
1913	0.3	7,713	767	0.03	10%	121	1%
1914	0.3	7,874	1,234	0.05	16%		
1915	0.4	13,164	1,943	0.06	15%		
1916	0.55	22,300	3,088	0.08	14%		
1917	0.85	46,999	7,553	0.14	16%	154	5%
1918	1.4	89,656	12,008	0.19	13%	157	8%
1919	1.83	159,036	17,332	0.2	11%	188	9%
1920	2	313,076	51,314	0.33	16%	260	20%
1921	1.89	368,441	67,695	0.35	18%	293	23%
1922	1.93	357,034	87,779	0.47	25%	280	31%
1923	1.91	285,452	62,394	0.42	22%	287	22%
1924	1.95	270,966	54,467	0.39	20%	284	19%
1925	2.59	299,459	46,798	0.4	16%	322	15%
1926	2.49	225,892	41,438	0.46	18%	309	13%
1927	2.46	157,543	25,538	0.4	16%	307	8%
1928	2.03	101,946	18,349	0.37	18%	311	6%
1929	2.06	92,167	19,390	0.43	21%	322	6%

^aIncludes production, export, bar, excise, infalsificable, and income taxes.

Sources: Sterrett and Davis, *Fiscal and Economic Condition*, p. 197;

Meyer, *Mexico and the United States*, p. 16;

Davis, "Mexican Petroleum Taxes," p.419;

Mexico, Dirección General de Estadística, *Anuario Estadístico*, 1930, pp. 517-21.

Table 6

Estimates of Mexican Petroleum Pre- and Post-tax Prices
(U.S. dollars)

Year	Price of U.S. oil (U.S. \$ per bbl)	U.S. oil price net of Mexican taxes	Price of Mexican oil U.S. \$ per bbl	Mexican oil price net of Mexican taxes
1914	0.81	0.80	0.09	0.08
1915	0.64	0.61	0.20	0.17
1916	1.10	1.06	0.28	0.24
1917	1.56	1.49	0.45	0.37
1918	1.98	1.88	0.78	0.67
1919	2.01	1.91	0.92	0.82
1920	3.07	2.91	1.00	0.83
1921	1.73	1.56	0.93	0.76
1922	1.61	1.38	0.94	0.71
1923	1.34	1.14	0.93	0.73
1924	1.43	1.24	0.94	0.75
1925	1.68	1.48	1.28	1.08
1926	1.88	1.66	1.20	0.98
1927	1.30	1.11	1.16	0.97
1928	1.17	0.99	0.98	0.80
1929	1.27	1.06	0.99	0.78

Sources: Mexican data from:

Sterrett and Davis, *Fiscal and Economic Condition*, p. 197;

Meyer, *Mexico and the United States*, p. 16;

Mexico, Dirección General de Estadística, *Anuario Estadístico*, 1930, pp. 517-21, 741;

Davis, "Mexican Petroleum Taxes," p. 419;

INEGI, *Estadísticas históricas*, p. 559.

U.S. data from Potter and Christy, *Trends in Natural Resource Commodities*, pp. 318-319.

Table 7

Estimated Rate of Return on Assets, Mexican Petroleum Companies^a

Year	El Águila	Mexican Petroleum	Mexican Seaboard	Mexico Panuco	Mexican Investment	Penn-Mex
1911	3%	6%				
1912	6%	6%				
1913	10%	10%				
1914	8%	5%				
1915	9%	4%				
1916	11%	10%				
1917	14%	7%				
1918	15%	9%				
1919	27%	8%			12%	18%
1920	33%	9%			40%	34%
1921	9%	12%	34%	2%		2%
1922	8%	21%	53%	0%	-2%	-7%
1923	2%	10%	5%	1%	1%	6%
1924	2%	3%	33%	1%	-2%	5%
1925	2%	22%	22%	1%	2%	
1926	2%	34%	16%	-1%	0%	
1927	2%	15%	4%	-1%		
1928	0%	14%	0%	-1%		
1929	7%	11%	2%	-1%		
1930	3%	4%	7%	0%		4%
1931	-1%	2%	1%			0%
1932	3%		5%			

^aReturns on assets are calculated by adding back interest payments to net profits and dividing these by the value of total assets. Interest payments are added back because the value of debts of the firm are included in assets. This allows the analysis of corporate profitability normalizing for differences in debt-equity ratios.

Note: Full company names are: Mexican Eagle Oil Company (El Águila), Mexican Petroleum Company, Mexican Seaboard Oil Company, Mexico-Panuco Oil Company, Mexican Investment Company, Penn-Mex Fuel Company.

Source: Estimated from balance sheets and profit and loss statements in *Moody's Manual of Investments*, various years.

Table 8

Counterfactual (No Tax) Analysis of Oil Company Rates of Return^a

Year	El Águila	Mexican Petroleum	Mexican Seaboard	Mexican Investment	Mexico-Panuco	Penn-Mex
1911	3%	6%				
1912	7%	7%				
1913	11%	11%				
1914	10%	6%				
1915	12%	6%				
1916	14%	11%				
1917	18%	10%				
1918	19%	14%				
1919	31%	10%		14%		
1920	39%	11%		47%		
1921	11%	15%	45%		2%	
1922	10%	29%	82%	-1%	1%	
1923	4%	13%	11%	2%	1%	8%
1924	3%	5%	44%	-1%	2%	7%
1925	3%	28%	28%	3%		
1926	3%	43%	23%	0%		
1927	2%	19%	8%			
1928	1%	18%	2%			
1929	10%	15%	7%			

^aReturns on assets are calculated as in Table 7 (see note ^a).

Note: For full company names see Table 7.

Source: Estimated from balance sheets and profit and loss statements in *Moody's Manual of Investments*, various years.

Table 9

Mexico's Major Mining Products, Indices of Volume of Output
(1910=100)

Year	Index of gold	Index of silver	Index of copper	Index of lead	Index of 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
Ave. 1900-10	58	83	98	79	361
Ave. 1911-20	53	73	96	53	769
Ave. 1921-30	55	122	110	149	4496

Note: 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, *Mexican Mining Industry*, pp. 128-29.

Table 10

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

Year	Mexico's share of world silver	U.S. share of world silver	Mexico's share of world lead	U.S. share of world lead	Mexico's share of world copper	U.S. share of world copper
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%

Sources:

Anuario de Estadística Minera, 1922, pp. 37-38;

Anuario de Estadística Minera, 1925, pp.37, 41;

Anuario de Estadística Minera, 1929-30, pp. 18, 20,22;

Engineering and Mining Journal, May 4, 1901, p. 556; June 20, 1903, p. 935;

Jan. 7, 1904, p. 8; March 20, 1907, p. 627; June 20, 1908, p. 1253;

April 10, 1909; May 1, 1909, p. 907; Sept. 22, 1917, p. 531;

May 25, 1912, p. 1044; Jan. 11, 1919, p. 47.

Table 11

Estimates of Mining Equipment Exported to Mexico from
the U.S. and the U.K., 1907-1929
(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 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. From 1922 to 1929 the estimated total is the reported total (the source disaggregated petroleum from mining machinery). We note that the final results of these calculations are not sensitive to the ratios chosen.

Sources: U.S. Department of Commerce, *Foreign Commerce*, various years; United Kingdom, Customs and Excise Department, Statistical Office, *Annual Statement*, 1900-34.

Table 12

Pumps and Pumping Machinery Exported from the U.S. 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: U.S. Department of Commerce, *Foreign Commerce*, various years.