Supplemental Information
Fiscal Legibility and State Development: Theory and Evidence from Colonial Mexico

Following text to be published online.

Contents

A. Descriptives

A.1 Description of Variables and Descriptive Statistics

Table A.1: Description of Variables

	Variable	Source	Notes
Main outcome	Direct rule	Gerhard (1993a;b)	We aggregate lists of *encomiendas* from 1521 to 1650 in central and north-central Mexico (New Spain and Nueva Galicia) at the level of the 1786 administrative region to the district level and calculate the proportion of holdings in each district that had transitioned to direct rule (i.e., *corregimiento*) by the end of each decade. For the small number of *encomiendas* that alternate between private and Crown control, we code the status of that holding as of the end of the decade. When we are unable to verify the status of a particular holding at a given time point, we code its status as missing.
Treated districts	Mining Districts	Gerhard (1993a;b); Hillerkuss (2013)	
Time-invariant covariates	Latitude	Mexico's National Institute for Statistics and Geography (INEGI)	
	Longitude		
	Surface area (log)		
	Avg. elevation		
	Malarial zone		Elevation of < 1000 meters
	Avg. maize potential productivity	Food and Agriculture Organization's Global AgroEcological Zones	Potential yield of rain-fed, low-input maize.
	Avg. least-cost walking hours to Mexico City	INEGI; Goldewijk (2010); Weiss et al. (2018)	See Appendix Section A.2 for details.
	Approximate year of European contact	Gerhard (1993a;b)	
Time-varying covariates	Space-weighted avg. of PSDI	Cook and Krusic (2004)	Source reports year-by-year estimates of soil moisture/drought conditions across space calculated using tree-ring chronologies. These data are reported at the level of 2.5 degree grid cells in terms of the Palmer Drought Severity Index (PDSI), a measure of soil moisture that is standardized to local conditions. We rasterize these data and extract the space-weighted average, minimum, and standard deviation of PDSI by district and by decade.
	Space-weighted minimum of PSDI		
	Space-weighted std. deviation of PDSI		
	Epidemic climactic conditions		Severe drought followed by rainfall, as used by Garfias and Sellars (2021).

Figure A.1: Mining Districts (New Spain/Nueva Galicia)

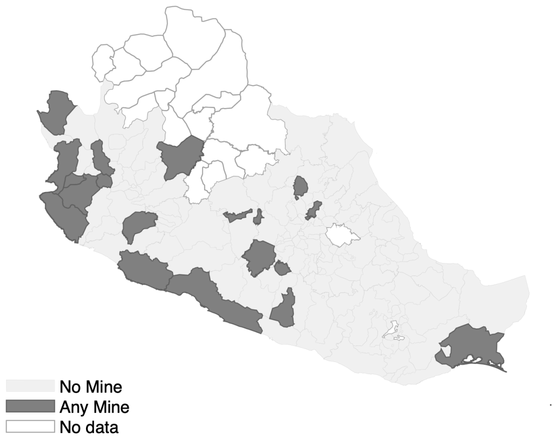


Table A.2: Descriptive Statistics

Panel A: Direct Rule Sample (New Spain & Nueva Galicia): 1520–1650

	N	Mean	Std. Dev.	Min.	Median	Max.
Direct Rule (%)	2016	0.52	0.36	0.00	0.50	1.00
Any Mine	2016	0.15	0.35	0.00	0.00	1.00
Any Early Mine	2016	0.12	0.32	0.00	0.00	1.00
Year of European Contact	2016	1522.40	6.27	1518.00	1521.00	1580.00
Malarial Zone	2016	0.64	0.48	0.00	1.00	1.00
Mean maize potential yield	2016	3644.82	1695.23	0.00	3422.03	8114.00
Avg. Altitude	2016	1560.03	736.02	25.79	1661.97	2904.21
Surface Area (log)	2016	7.64	1.19	4.68	7.80	10.03
Least-Cost Walking Time to Mexico City (log)	2016	8.73	0.94	5.16	8.93	9.97
Std. Dev. PDSI	1960	1.74	0.44	0.65	1.72	3.96
Avg. PDSI	1960	0.52	0.97	-3.10	0.39	3.38
Min. PDSI	1960	-2.16	1.24	-5.67	-2.12	1.28
Drought-Rain Around Known Outbreaks	1960	0.03	0.17	0.00	0.00	1.00
Cochineal Production Site	2016	0.19	0.40	0.00	0.00	1.00

Panel B: Royal Treasuries Sample (New Spain & Nueva Galicia): 1520–1750

	N	Mean	Std. Dev.	Min.	Median	Max.
Least-Cost Walking Time to Nearest Treasury (log)	3588	7.40	1.79	0.00	7.84	9.88
Any Mine × Post-Patio Process	3588	0.13	0.34	0.00	0.00	1.00
Year of European Contact	3588	1522.98	7.13	1518.00	1521.00	1580.00
Malarial Zone	3588	0.63	0.48	0.00	1.00	1.00
Mean maize potential yield	3588	3642.40	1674.47	0.00	3432.09	8114.00
Avg. Altitude	3588	1573.96	726.56	25.79	1676.23	2904.21
Surface Area (log)	3588	7.68	1.19	4.68	7.83	10.08
Least-Cost Walking Time to Mexico City (log)	3588	8.75	0.93	5.16	8.95	9.97
Std. Dev. PDSI	3492	1.78	0.43	0.65	1.75	3.96
Avg. PDSI	3492	0.48	0.89	-3.10	0.36	3.38
Min. PDSI	3492	-2.32	1.38	-6.62	-2.14	1.28
Drought-Rain Around Known Outbreaks	3492	0.02	0.14	0.00	0.00	1.00

Table A.3: Baseline Differences Between Mining and Non-Mining Districts

	New Spain & Nueva Galicia		New Spain	
	Any Mine	Early Mine	Any Mine	Early Mine
	(1)	(2)	(3)	(4)
Year of European Contact	-0.0045 (0.0084) {0.0044}	-0.0046 (0.0036) {0.0016}	0.021 (0.022) {0.0081}	0.00070 (0.012) {0.0050}
Mean maize potential yield	0.0000056 (0.000018) {0.000017}	0.000022 (0.000017) {0.0000090}	0.000027 (0.000019) {0.000012}	0.000029 (0.000019) {0.000013}
Cochineal Production Site	0.0066 (0.080) {0.058}	-0.0066 (0.082) {0.057}	-0.056 (0.079) {0.065}	-0.050 (0.079) {0.065}
Malarial Zone	0.17 (0.10) {0.082}	0.12 (0.095) {0.063}	0.23^{*} (0.11) {0.086}	$0.19^{\dagger}$ (0.11) {0.075}
Avg. Altitude	0.0000052 (0.000062) {0.000066}	0.000018 (0.000055) {0.000046}	0.000060 (0.000061) {0.000057}	0.000052 (0.000061) {0.000052}
Least-Cost Walking Time to Mexico City (log)	-0.027 (0.047) {0.041}	-0.024 (0.043) {0.036}	-0.0011 (0.059) {0.033}	0.017 (0.056) {0.031}
Surface Area (log)	0.017 (0.029) {0.023}	0.035 (0.026) {0.024}	-0.015 (0.032) {0.021}	-0.0021 (0.029) {0.016}
Latitude	-0.019 (0.028) {0.014}	-0.041 (0.025) {0.017}	-0.020 (0.026) {0.018}	-0.028 (0.025) {0.016}
Longitude	-0.054^{*} (0.021) {0.017}	-0.043^{*} (0.020) {0.012}	-0.028 (0.025) {0.015}	-0.037 (0.024) {0.015}
Mean of DV	0.15	0.15	0.12	0.12
SD of DV	0.35	0.35	0.32	0.32
R sq.	0.14	0.11	0.14	0.12
Observations	144	144	120	120

OLS estimations. Unit of analysis is the district. Robust standard errors in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$. Standard errors that allow for spatial correlation between districts within 500 km of each other are in curly brackets.

A.2 Distance Measure Construction

We calculate distance to Mexico City, the nearest post office, and the nearest royal treasury in several ways. The simplest measure is the (minimum and space-weighted average) Euclidean distance (by decade for the treasuries). This measure ignores any barriers to travel, such as mountains or ocean, which is a potential concern given Mexico's terrain. We therefore construct an alternative measure that incorporates terrain ruggedness, drawing on Least-Cost Analysis (LCA) methods from archaeology and using a 90-m digital elevation model (DEM) from INEGI and the procedure described in (White 2015). From this friction surface, we calculate the cumulative cost distance to the nearest treasury and extract the minimum and space-weighted average cumulative travel cost to the nearest treasury (in hours) by decade. (To ease comparability, we divide the Euclidean distance measure in km for our analysis by the maximum Tobler walking speed of 5 km/hr.)

We also construct a cost-distance measure that also incorporates land cover and elevation using the approach of Weiss et al. (2018), who estimate the typical walking speed (km/hr) across different terrain types according to IGBP land cover classifications. The elevation and slope measures are calculated from the same 90-meter DEM. For the land cover analysis, we use the Goldewijk (2010) ISLSCP II Historical Land Cover and Land Use data, which provides an estimate of global land cover from 1700 to 1990 at a resolution of 0.5 degrees. Using the 1700 data, we convert the land cover measures to IGBP equivalents to use the walking speed multipliers in Weiss et al. (2018) (Table A.4). We verified these conversions using contemporary remote sensing data from NASA's MODIS.[1]

Table A.4: Land Cover Walking Speed Multipliers

ISLSCP II Land Cover Category	IGBP Equivalent	Weiss et al. (2018) Multiplier	Description
Ocean	See text	1.00/4.82	See text for description of alternate measures
Cultivated Land	Croplands	2.50	Seasonal croplands with a bare soil period
Pasture	Grasslands	4.86	Herbaceous cover; less than 10% tree and shrub cover
Warm Mixed Forest	Mixed Forest	3.24	Over 60% mixed tree cover, with height exceeding 2m.
Grassland	Grasslands	4.86	Herbaceous cover; less than 10% tree and shrub cover
Hot Desert	Barren	3.00	Exposed soil, sand, & rocks, no more than 10% vegetated
Scrubland	Open Shrublands	4.20	Short (<2 m), woody vegetation, with 10-60% canopy cover
Savanna	Savannas	4.86	Herbaceous cover, 10-30% forest canopy cover
Tropical Woodland	Evergreen Broadleaf Forest	1.62	At least 60% broadleaf forest cover, height exceeding 2m. Year-round green vegetation.
Tropical Forest	Evergreen Broadleaf Forest	1.62	At least 60% broadleaf forest cover, height exceeding 2m. Year-round green vegetation.

Notes: See Weiss et al. (2018) for description of methodology. IGBP land cover category descriptions from the University of Oklahoma Earth Observation and Modeling Facility (EOMF).

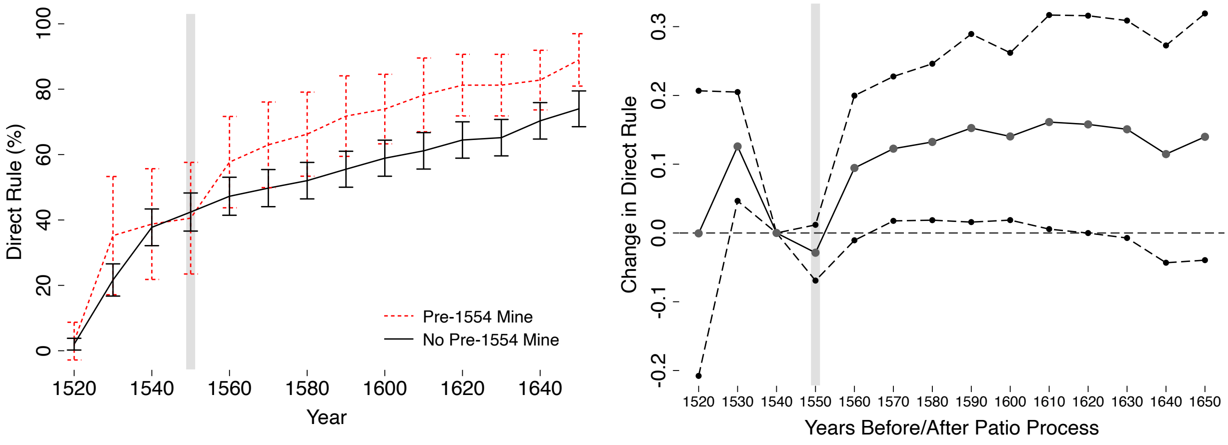
---

[1] Due to the ISLSCP II's coarser resolution, some coastal/lakefront land is coded as ocean/open water, including a couple of coastal treasuries. We use the Weiss et al. (2018) speed multiplier for open water (1.00) as a conservative estimate of the speed needed to traverse these areas. We alternatively use a multiplier of 4.86, corresponding with grassland, pasture, or savanna. Almost all land areas in overlapping ocean cells border one of these three land categories (which make up over 42% of Mexico's land area). We believe that the faster speed more accurately reflects the cost of traversing coastal zones, which are at sea level and generally flat. There is little difference between these measures in practice.

B. Additional Evidence: Main Results

B.1 Main Results with Pre-1554 Mines

Figure B.1: Patio Process and Direct Rule; Early Mines



(a) Trends over time (b) Dynamic Panel Estimates

The figure on the **left** plots the average proportion of holdings under direct rule with 95% confidence intervals for mining and non-mining districts in each decade. The figure on the **right** displays the point estimates and 95% confidence intervals of decade-by-mining district interactions from a panel regression that includes district and decade fixed effects.

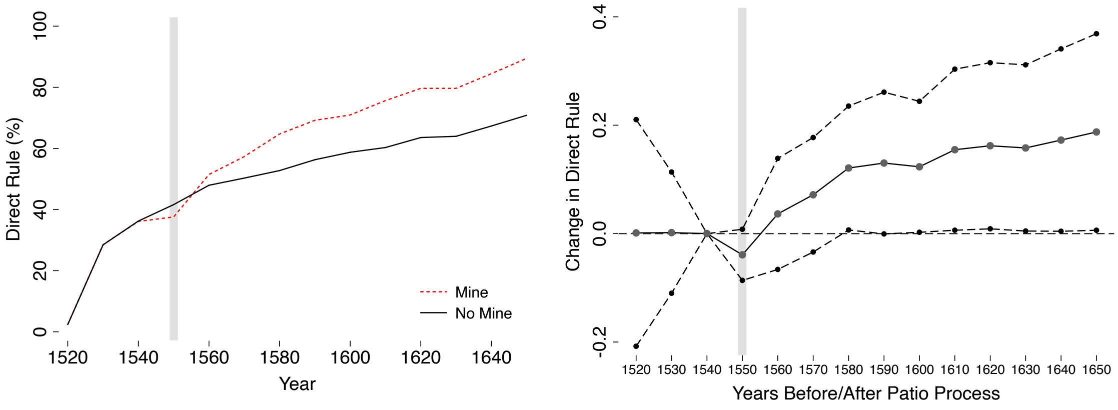
Table B.1: Patio Process and Direct Rule: Difference-in-Differences; Early Mines

	Direct Rule (% of District)			
	New Spain & Nueva Galicia		New Spain	
	(1)	(2)	(3)	(4)
Any Early Mine × Post-Patio Process	0.11^{*} (0.046) {0.046}	0.12^{**} (0.041) {0.042}	0.074^{*} (0.033) {0.039}	0.12^{**} (0.040) {0.042}
Climate Controls	No	Yes	No	Yes
Controls × Year FE	No	Yes	No	Yes
Year of European Contact × Year FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Within Non-Mining District Mean of DV	0.50	0.50	0.49	0.49
Within Non-Mining District SD of DV	0.24	0.24	0.22	0.22
R sq.	0.78	0.82	0.80	0.83
Observations	2016	1960	1680	1624
Number of districts	144	140	120	116

OLS estimations. Unit of analysis is the district-decade. Standard errors clustered at the district level in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$; errors that allow for serial correlation within districts and spatial correlation between districts within 500 km of each other in curly brackets.

B.2 Main Results with Entropy Balancing

Figure B.2: Patio Process and Direct Rule; Entropy Balancing



(a) Trends over time

(b) Dynamic Panel Estimates

The figure on the **left** plots the weighted average proportion of holdings under direct rule. The figure on the **right** displays the point estimates and 95% confidence intervals of decade-by-mining district interactions from a weighted panel regression that includes district and decade fixed effects. Weights for non-mining districts are estimated to match the means of direct rule in the pre-patio process period (1520, 1530, and 1540) (Hainmueller 2012).

Table B.2: Patio Process and Direct Rule: Difference-in-Differences; Entropy Balancing

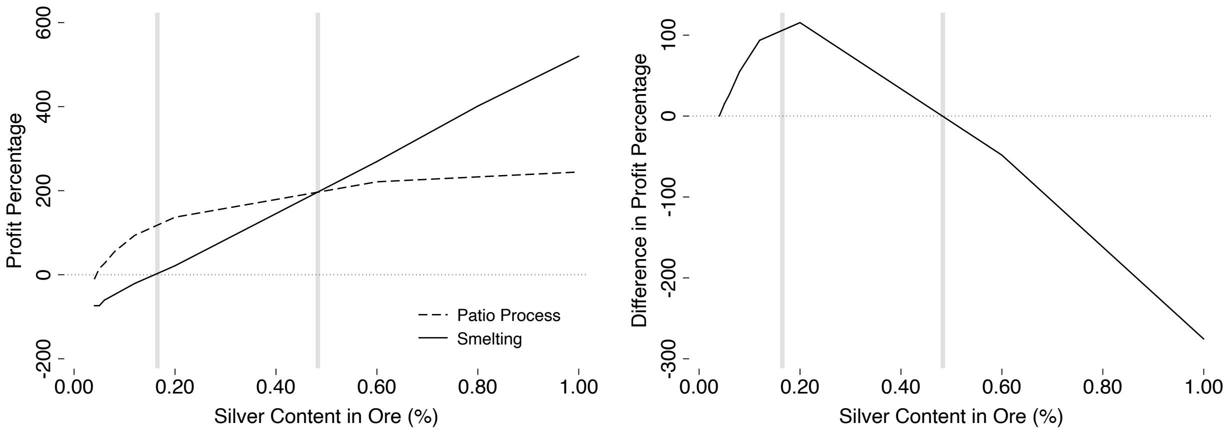
	Direct Rule (% of District)			
	New Spain & Nueva Galicia		New Spain	
	(1)	(2)	(3)	(4)
Any Mine × Post-Patio Process	0.14^{**} (0.044)	0.13^{**} (0.036)	0.098^{**} (0.030)	0.13^{**} (0.029)
Climate Controls	No	Yes	No	Yes
Controls × Year FE	No	Yes	No	Yes
Year of European Contact × Year FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Within Non-Mining District Mean of DV	0.50	0.50	0.49	0.50
Within Non-Mining District SD of DV	0.24	0.24	0.22	0.22
R sq.	0.79	0.85	0.83	0.89
Observations	2016	1960	1680	1624
Number of districts	144	140	120	116

OLS with entropy weights (Hainmueller 2012). Unit of analysis is the district-decade. Standard errors clustered at the district level in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$. Weights for non-mining districts are estimated to match the means of direct rule of mining districts in the pre-patio process period (1520, 1530, and 1540).

C. Revenue Potential as an Alternative Mechanism

The discovery of the patio process led to an exogenous increase in the Crown's legibility of silver production due to its control over the supply of mercury, an essential input in this refining technique. At the same time, however, the new technology increased the profitability of extracting certain silver deposits. In particular, mercury amalgamation enabled the profitable mining of ores with lower silver concentrations. It is therefore possible that increased profitability, and not fiscal legibility, explains the results presented in Table **??**. The Crown, for example, might have wanted to centralize power to reap the long-term benefits of a wealthier tribute tax base, to better control the supply of labor to profitable mines, to undermine a newly enriched local elite, or to protect emerging mining operations from foreign rivals. To assess these alternate mechanisms, we first take a closer look at the production impact of the patio process.

Figure C.1: Profitability Percentages for the Patio Process and Smelting



(a) Profit Percentages

(b) Difference in Profit Percentages

The figure on the **left** plots the estimated profit percentage $(net\ profit/cost)$ for processing silver using smelting (solid line) and the patio process (dashed line) at different levels of ore silver content. The figure on the **right** plots the difference in the profit percentages between the patio process and smelting. Values above zero indicate that the patio process is more profitable than smelting for a given silver content in ore. The vertical grey lines mark the ore silver content above of which extraction is profitable using smelting (left line) and in which smelting becomes more profitable than the patio process (right line). Cost estimates and effectiveness of silver extraction by method are from Guerrero (2017).

In the left panel of Figure C.1, we present estimates of the return on investment for processing silver using the patio process and the traditional method of smelting, based on detailed production information from the Hacienda Santa María de Regla in the 19th century and input prices for the second half of the 17th century, as computed by Guerrero (2017). These estimates suggest that the introduction of the patio process affected production in two main ways. First, it enabled the profitable processing of ores of very low silver content—between around 0.04% and 0.16%—which were not economically viable using smelting. Above this threshold, and for ores of a silver concentration of up to around 0.48%, amalgamation also offered a higher return on investment than smelting. For deposits with higher silver concentrations, smelting remains more profitable. This was the case because, while smelting processing costs remain fixed, the patio process requires additional mercury to effectively extract silver from even richer ores.[2]

Without detailed information about the silver-extraction processes in each district or changes in profits following the introduction of the patio process, we are unable to directly examine whether changes in profitability explain our findings. Though we cannot rule out this class of alternative mechanisms directly, we rely on a series of indirect approaches.

We first examine additional observable implications suggested by our legibility-based theory that would not necessarily by generated by a profitability-based alternative argument. We focus on two heterogeneous effects implied by our theory: the effect of the legibility shock should be higher where pre-shock legibility was lower (because the informational benefits of the shock should be greater) and lower where the cost of transition to direct rule was higher (because this should increase the barriers to political centralization). Consistent with our theory, we show that the increase in direct rule adoption was larger outside the pre-colonial Triple Alliance tribute network and farther from Mexico City, where the colonial state particularly lacked information, and in districts with a lower potential for rebellion, where the cost of transition was plausibly lower.

Second, we focus on the impact of a notable price shock to cochineal dye—one of the most important commodities produced in colonial Mexico at the time—on the adoption of direct rule in cochineal-producing districts. The cochineal price shock arguably induced a much larger increase in profitability than the introduction of the patio process. Depending on the time window and price series, the profit increase associated with this shock ranged from 180 to 420% (see Figure **??** in the paper). Given the artisanal production process, it is unlikely that production costs changed drastically over the period. We find strong evidence that this price shock did not lead to a differential increase in direct rule as a profitability-based argument might suggest.

Third, we focus on the availability of fuel, the most costly input for smelting operations but a minor one for the patio process, to assess whether the areas in which mines stood the most to gain from the patio process drive the estimated effect on direct rule. We measure the proximity of forests in each district, which provided the

---

[2] Moreover, while amalgamation is effective for silver sulphide deposits, the most common in the Americas, smelting remained the only feasible method of extracting from argentiferous lead deposits.

firewood and charcoal needed to heat up the smelting furnaces. We then estimate the heterogeneous effects of the patio process by access to nearby forests, and find that even districts that have the easiest access to firewood—those where the introduction of the patio process would have had the lowest impact on profitability—still experience a large and positive average increase in the adoption of direct rule.

Finally, we present vignettes from two important mining sites, Taxco and Pachuca, which experienced well-documented mining boom and bust cycles over our period of analysis. We show that the trajectory of centralization in these areas does not match these cycles, undermining a profitability-based mechanism in these districts.

C.1 Heterogeneity by Transition Costs to Direct Rule

We first assess whether the discovery of the patio process had an especially large effect in regions with a low initial level of legibility. We use two measures to capture this. First, as described in Section **??**, we compute walking distance from each district to Mexico City as a measure of initial legibility (see Section A.2 for details about the construction of this measure). Mexico City was the center of colonial administration in the Americas, and the Crown's ability to directly observe and monitor nearby districts would have been higher even before the discovery of the patio process. An additional increase in the observability of economic conditions should therefore not have had a lower impact on the transition to direct rule as compared to more remote and less legible areas.

We also record whether a district paid tribute to the Triple Alliance (Aztec Empire) prior to the Conquest. Upon the fall of the Aztec capital of Mexico-Tenochtitlan, the Spanish adapted the pre-existing tribute system of the Triple Alliance and expanded it to newly conquered territories. Through usurping Aztec institutions and records, the Crown gained access to information that would have been costly to acquire, most notably earlier tribute records. The Crown therefore had a better sense of local conditions in mining areas that paid tribute to the Triple Alliance, even before the introduction of silver amalgamation. Using these measures, we estimate models similar to equation (**??**), now interacting $Mine_{it} \times Post\ Patio\ Process_t$ with each measure of pre-patio process legibility.

We estimate the heterogeneous effect of the introduction of the patio process by walking hours to Mexico City and by a district's pre-colonial tributary status in columns 1–4 of Table C.1. Consistent with the theory, we find that the patio process increased direct rule by only only a fraction in districts that were part of the tribute network of the Triple Alliance. However, this difference is only significant in the specification without covariates (column 1), and its magnitude varies substantially. We also find supportive evidence in the heterogeneous effect of the shock to legibility by walking distance to Mexico City (columns 3 and 4). Figure **??** shows the heterogeneous effect of the legibility shock by distance to the capital. Estimates from column 3 indicates that the discovery of the patio process has a small effect in districts in close proximity to Mexico City relative to more distant regions where there would have been less prior information on local economic and political conditions. As with the Triple Alliance results, the heterogeneous effect by walking distance to Mexico City is smaller and not statistically significant with the full set of covariates (column 4).

Table C.1: Heterogeneous Effect of the Patio Process on Direct Rule: Difference-in-Differences

	Direct Rule (% of District)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Any Mine × Post-Patio Process	0.18**	0.13*	-0.87**	0.029	0.17*	0.16**	-0.023	0.045
	(0.046)	(0.054)	(0.32)	(0.37)	(0.068)	(0.062)	(0.061)	(0.070)
	{0.042}	{0.047}	{0.32}	{0.32}	{0.064}	{0.058}	{0.055}	{0.060}
Any Mine × Post-Patio	-0.17**	-0.018						
× Former Triple Alliance	(0.049)	(0.055)						
	{0.046}	{0.047}						
Any Mine × Post-Patio			0.11**	0.0088				
× (log) Hours to Mexico City			(0.036)	(0.043)				
			{0.035}	{0.037}				
Any Mine × Post-Patio					-0.056	-0.066		
× Resistance during Conquest					(0.076)	(0.060)		
					{0.071}	{0.057}		
Any Mine × Post-Patio							0.017*	0.0084
× Number of Towns							(0.0068)	(0.0068)
							{0.0062}	{0.0055}
Any Mine × Post-Patio +	0.016	0.11**						
Any Mine × Post-Patio	(0.03)	(0.04)						
× Former Triple Alliance	{0.04}	{0.04}						
Any Mine × Post-Patio +					0.11**	0.10**		
Any Mine × Post-Patio					(0.04)	(0.04)		
× Resistance					{0.04}	{0.04}		
Climate Controls	No	Yes	No	Yes	No	Yes	No	Yes
Controls × Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Year of European Contact × Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Within Non-Mining District Mean of DV	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Within Non-Mining District SD of DV	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
R sq.	0.78	0.82	0.78	0.81	0.78	0.82	0.78	0.82
Observations	2016	1960	2016	1960	2016	1960	2016	1960
Number of districts	144	140	144	140	144	140	144	140

OLS estimations. Unit-of-analysis is the district-decade. Standard errors clustered at the district level in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$. Standard errors allowing for serial correlation within districts and spatial correlation between districts within 500 km are in curly brackets.

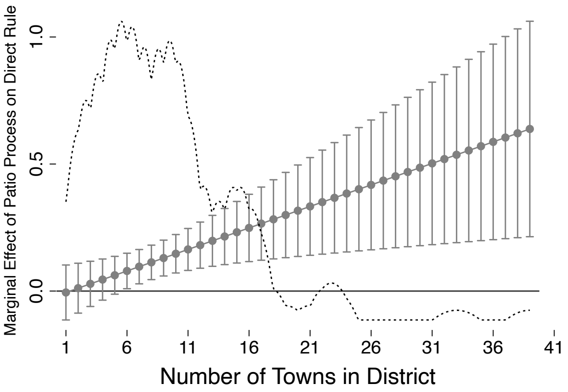
We also assess a second observable implication suggested by the theory: that increased fiscal legibility provided by the discovery of the patio process should have had a higher impact on direct rule adoption in areas where the cost of centralizing power would have been lower. From the perspective of the Crown, an important advantage of the *encomienda* was that local intermediaries had a vested interest in maintaining local political order (because they expected to remain in their position over their lifetime) and extensive local knowledge that could enable them to keep the peace more effectively. In areas prone to rebellion, the transition to more direct forms of rule was therefore costly, forcing the Crown to lose the benefits of the *encomienda* for political order (Garfias and Sellars 2021). As our theory illustrates, increasing the cost of transition should make direct rule adoption less likely following the increase in legibility.

We rely on two measures to examine this prediction. First, we construct an indicator for whether the district mounted a violent resistance to the conquest at first contact, which captures both the extent to which areas may have been able to overcome collective action problems in the past and the possibility of greater opposition to Spanish rule. Second, we use the number of towns in a district as of approximately 1786 as a measure of the difficulty of coordinating a large-scale rebellion against royal authority. We would expect collective action to be more difficult when populations are spread out among many small settlements rather than concentrated in larger towns.

Columns 5 and 6 show that fiscal legibility leads to an increase in direct rule across districts, but the effect is muted in places that mounted a resistance to the Conquest. Coefficient estimates imply that the effect of the patio process was only around two-thirds as large in districts with organized resistance during the Conquest, though these differences are not statistically significant. Columns 7 and 8 present estimates of the heterogeneous effects of the legibility shock by the number of towns in a district. As the number of towns in a district increases—and coordination between towns to organize large-scale resistance becomes more difficult—so does the effect of fiscal legibility. This effect is illustrated in Figure C.2, which plots the effect of legibility on direct rule at different number of towns per district. Taking the estimates from column 7, at the 25th percentile of this variable, when the district is split into 5 towns, the legibility shock is estimated to increase direct rule adoption by 6 percentage points, and is not significant. At the 75th percentile (11 towns), the discovery of the patio process significantly increases direct rule adoption by 16 percentage points. (These estimates are 8 and 14 percentage points when using estimates from column 8.)

These results suggest that in districts where the cost of transition from indirect to direct rule would have been higher, the increase in fiscal legibility had a more limited impact on centralization. While these measures are not perfect (e.g., the number of towns in a district is captured at a later date and could induce post-treatment bias), the results provide additional suggestive evidence in support of the theory.

Figure C.2: Silver Mining, Patio Process, and Direct Rule Heterogeneous Effects, by Number of Towns



The figure plots estimates and 95% confidence intervals of the differential change in direct rule following the introduction of the patio process for different number of towns (by 1786) per district. A kernel densitiy of this variable is overlayed.

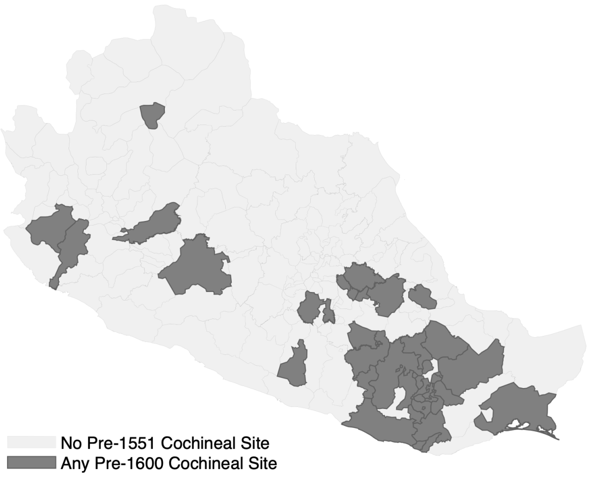
C.2 Evidence from a Cochineal Price Boom

Cochineal dye, produced from the cochineal insect, became a prized luxury good in European markets following the conquest. By the end of the 16th century, it was the third most important export commodity from colonial Mexico after silver an gold, accounting for almost 9% of the value of silver exports (Lee 1951). In Europe, the dye was considered of superior quality, due to its long-lasting deep red color, a color associated with the nobility and higher positions in the church (Marichal 2014). Following its introduction to European markets in 1526, imports primarily served the Spanish textile industry, but eventually found their way into the rest of the continent, including important textile centers in England, France, the Low Countries, and Italy, and later even into Asian markets (Lee 1951). This expansion fueled a demand-driven cochineal boom, which accelerated in the last decade of the 16th century.

To quantify this shock to cochineal external demand, we rely on a number of price series collected in different European markets, compiled and normalized to silver pesos per *arroba* ($\sim$ 25lb) by Serrano (2016). For each price series, we average prices per decade, ignoring missing years. This allows to sidestep year-to-year price fluctuations that are likely driven by short-term supply, as well as to match this data to our decadal panel on direct rule. We focus on three series: first, data from Chaunu and Chaunu (1956), who present the most complete series around the onset of the price hike based on official import registries in Seville; second, an average of prices in Spain, composed of the Chaunu and Chaunu series, as well as spottier data from Sanz (1979) and Morineau (1969), which was also mostly based on official records; and an average of all available series, including the Spanish sources, scattered transaction prices at Antwerp and Florence, collected by Sanz (1979), as well as market prices at Amsterdam, compiled by Posthumus (1946), which become more complete beginning in the second decade of the 17th century.

The resulting series are presented in the right panel of Figure **??** in the paper. Across series, there is a notable increase in the price of cochineal dye at the close of the 16th century, with an especially steep hike beginning in the 1590s. This timing may be related to the rise of Amsterdam as a new market for the dye, which in time facilitated its reach beyond western European markets, as well as to scarcity associated with the ongoing Spanish-English and Spanish-Dutch wars. The boom continued after these conflicts came to a halt—in 1604 and 1609, respectively—and lasted until at least the first few decades of the 17th century.

Figure C.3: Map of Pre-1551 Cochineal-Producing Districts



To examine whether this steep increase in the value of cochineal—with did not affect local fiscal legibility—led to a differential transition to direct rule, we compare centralization between cochineal- and non cochineal-producing districts around the years of the price hike. Since pre-Hispanic times, cochineal production had been concentrated in certain regions due in large part to the specific environmental conditions that allow for its cultivation (see Figure C.3). To identify these cochineal-producing areas, we georeference a list of production sites compiled by Donkin (1977), based on primary sources that include the Triple Alliance's *Matrícula de Tributos* for the pre-Hispanic period, and the *Suma de Visitas*, and the *Relaciones Geográficas* for the 16th century. We then assign these sites to the districts used in the main analysis. Because cochineal production seems to respond endogenously to prices, as noted by Diaz-Cayeros and Jha (2016), we focus on pre-1554 sites.

Table C.2: Cochineal-Producing Sites, Cochineal Price Shock, and Direct Rule: Difference-in-Differences

	Direct Rule (% of District)					
	(1)	(2)	(3)	(4)	(5)	(6)
Cochineal Site × Seville Price (Chaunu & Chaunu)	0.00048 (0.00033) {0.00029}	0.00052 (0.00040) {0.00033}				
Cochineal Site × Seville Price (Avg. Spain)			0.00046 (0.00034) {0.00030}	0.00049 (0.00041) {0.00034}		
Cochineal Site × Price (Avg. Seville/Florence/Antwerp/Amsterdam)					0.00024 (0.00024) {0.00022}	0.00029 (0.00027) {0.00024}
Climate Controls	No	Yes	No	Yes	No	Yes
Controls × Year FE	No	Yes	No	Yes	No	Yes
Year of European Contact × Year FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Within Non-Cochineal District Mean of DV	0.56	0.56	0.56	0.56	0.60	0.60
Within Non-Cochineal District SD of DV	0.11	0.10	0.11	0.10	0.13	0.13
R sq.	0.86	0.88	0.86	0.88	0.84	0.86
Observations	1152	1120	1152	1120	1584	1540
Number of districts	144	140	144	140	144	140

OLS estimations. Unit of analysis is the district-decade. Standard errors clustered at the district level in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$; errors that allow for serial correlation within districts and spatial correlation between districts within 500 km of each other in curly brackets. All prices are in silver pesos per arroba of cochineal, as converted by Serrano (2016). Models 1 and 2 use the price series from Chaunu and Chaunu (1956); models 3 and 4 use an average of available Spanish series, from Chaunu and Chaunu (1956), Sanz (1979), and Morineau (1969); models 5 and 6 average across all available series, including the Spanish series, prices from Antwerp and Florence (Sanz 1979), and from Amsterdam (Posthumus 1946). Pre-1551 cochineal-producing sites from Donkin (1977).

Using these data, we estimate a modified version of equation **??**:

$$Direct\ Rule_{it} = \beta_1 Cochineal\ District_i \times Cochineal\ Price_t + \Theta_t X_i + \Pi U_{i,t} + \lambda_t + \gamma_i + \varepsilon_{it}, \qquad \text{(A1)}$$

where $Cochineal\ District_i$ indicates whether a district contains pre-1554 cochineal-producing sites and $Cochineal\ Price_t$ is one of the cochineal price series described above. We present the estimates for specifications with and without climate $U_{i,t}$ and time-interacted geographic controls X_i for the three price series in Table C.2. In all cases, the estimates are very small. A one standard deviation increase in price is estimated to increase direct rule by around 2 percentage points. At an extreme, using the largest point estimate (from model 2), an increase in price from the pre-hike 1580 decade to the highest value in the Chaunu and Chaunu series—from 59.2 to 173 silver pesos per arroba of cochineal—is associated with just a 6 percentage point increase in direct rule. The rest of the coefficients suggest even smaller associations, including in models 5 and 6, which use a price series that reaches a global high of almost 240 silver pesos per arroba of cochineal in 1630. In no case are estimated coefficients statistically different from zero.

In short, when examining a different commodity—one of great importance in the colonial economy and central to economic life in producing districts—we find no evidence that a sharp increase in its revenue potential led to differential changes in direct rule. This is an appropriate testing ground for an elite- or tax base-driven profitability mechanism, given that gains from the cochineal trade were shared between merchant elites and local producers (Baskes 2000; Diaz-Cayeros and Jha 2016). Without a shift in fiscal legibility similar to the patio process for silver mining, on-site taxation of cochineal remained out of reach to the Crown, and cochineal districts did not experience the same transition to direct rule.[3]

C.3 Evidence from the Availability of Fuel for Smelting

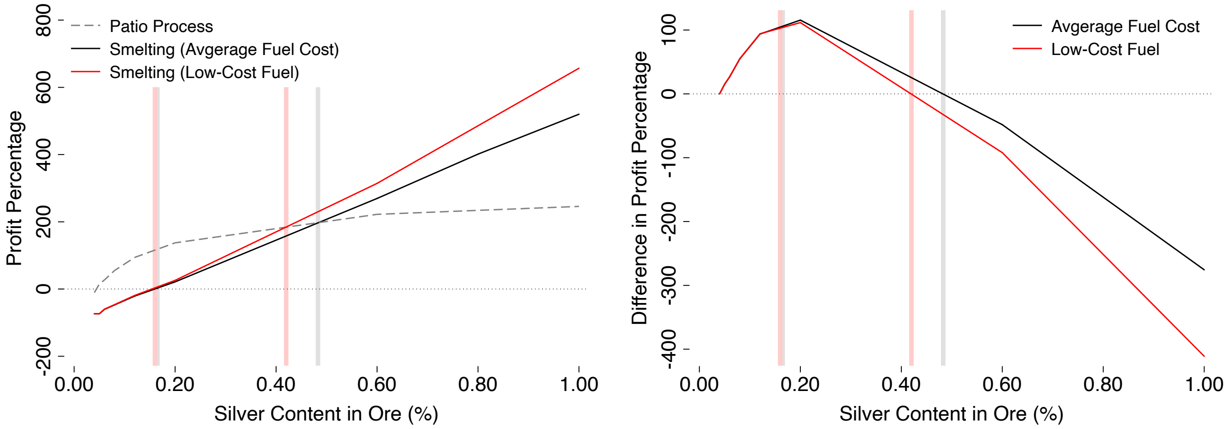
As another way to assess whether profitability might be driving the effect of the patio process on centralization, we turn back to the economics of silver extraction. To examine this mechanism, we would ideally first measure how the patio process changed each mine's profitability, and then assess whether centralization occurred primarily in districts with high average estimated profitability. A rough way to measure changes in mine profitability attributable to the patio process would be to know the silver content in ore in each mine (see Figure C.1), but unfortunately it is not possible to measure, even imperfectly, the silver content in ore that was present around the time of the discovery of the patio process. This is because silver content in ore may change over time in ways that are endogenous. As miners seek to extract silver from high-concentration areas, this changes the composition of remaining deposits. Moreover, natural geological processes, such as erosion and weathering, may have altered the composition of the remaining ore. The ore that remains today may have significantly different silver content, making it challenging to accurately determine the original silver concentrations.

We instead focus on another determinant of the profitability of the patio process, the availability of fuel wood for silver processing. Guerrero (2017), based on detailed data from an important silver-processing *hacienda*, finds that fuel was the single most important input for smelting, whereas it was a negligible input for

---

[3] The Crown in fact floated different plans to appropriate part of the increasing value of cochineal, including monopolizing its trade by forcing all imports into the king's account. Instead, what was enacted around 1608 was a hefty Spanish export tax—of approximately 14 silver pesos per arroba—on top of preexisting taxation, which included a tithe, sales taxes, export tariffs, and other levies. As Lee (1951) documents, this plan backfired: as the export tax was rolled out for all dye leaving Spain, cochineal-related revenue collapsed, and, as was recognized by the members of the council of *hacienda*, the black market for the dye exploded.

Figure C.4: Profitability Percentages for the Patio Process and Smelting



(a) Profit Percentages (b) Difference in Profit Percentages

The figure on the **left** plots the estimated profit percentage (*net profit/cost*) for processing silver using smelting (black and red solid lines) and the patio process (gray dashed line) at different levels of ore silver content and for average and low-cost fuel scenarios. The figure on the **right** plots the difference in the profit percentages between the patio process and smelting for average and low-cost fuel scenarios. Values above zero indicate that the patio process is more profitable than smelting for a given silver content in ore. The vertical lines mark the ore silver content above of which extraction is profitable using smelting (left line) and in which smelting becomes more profitable than the patio process (right line) for low-cost (red) and average-cost fuel (gray). Cost estimates and effectiveness of silver extraction by method from Guerrero (2017). Low-cost fuel is assumed to be 50% as costly as the average reported by Guerrero (2017).

the patio process. This is because traditional smelting requires furnaces to remain at high temperatures for an extended period of time in order to melt the silver out of the ore, while for the patio process all that is needed is to heat up the amalgam of ore, mercury, and other supplemental compounds once to vaporize the mercury, leaving the silver. This made smelting relatively more profitable in areas where fuel was cheap, which would have muted the profitability gains of the patio process.

To illustrate fuel's importance to the increase in profitability of the patio process relative to smelting, we create a new scenario based on Guerrero's return-on-investment estimates. In Figure C.4, we compare the difference in the return on investment between smelting and the patio process at various levels of silver content in ore for the average cost of fuel (black solid lines) and a scenario of low-cost fuel (red solid lines). Access to low-cost fuel increases the profitability of smelting for any given level of silver content in ore, which reduces the profitability gains from the introduction of the patio process. The decline in the profitability gains of the patio process becomes increasingly noticeable as the silver content in ore rises, resulting in a shift in the silver-concentration threshold under which smelting again becomes the preferred method.

In short, if profitability is the main mechanism that explains the effect of the patio process on centralization, it should be the case that this effect was driven primarily by districts with high-cost fuel. By contrast, areas with access to low-cost fuel—where the patio process was not as profitable—should not experience a transition to direct rule.

We examine this idea using two measures for the availability of nearby wood in a district. The main sources of fuel at the time were charcoal (usually created from firewood) and firewood directly, both of which were produced by silver-processing haciendas or by Indigenous groups in the proximity of mines, according to historical case studies (e.g., Studnicki-Gizbert and Schecter 2010; Fournier Garcia 2018). Our first measure is an indicator for any overlap between a district and forest land cover (warm mixed forest, tropical woodland, or tropical forest) by 1700 according to the Historical Land Cover and Land Use data set (Goldewijk 2010). These data are created from a model of potential natural vegetation based on environmental constraints, human settlement, and historic climate data. Unfortunately, these data have a relatively low resolution—0.5 degrees or roughly 50km pixels—and are estimated for a later period than would be ideal.

We therefore complement this variable with a higher-resolution measure of *potential forest* based on present-day forest cover. The basic idea behind this measure is to estimate if an area is suitable for forest cover based on present-day topographic and climactic characteristics and then exclude areas that are directly impacted by human activities. With these estimates, we can then extrapolate into what today are urban and agricultural areas. To create this measure, we first identify forest cover from high-resolution (300m) satellite imagery (ESA 2017). We use 1992, the earliest available year, and remove cropland and urban areas. We then create an indicator for forest cover following the Intergovernmental Panel on Climate Change's (IPCC) classification.[4] Using this measure as the dependent variable, we estimate a linear model that includes topographic and climactic covariates. Subject to data availability, we follow Crowther (2015) and include latitude, longitude, average slope, indicators for each vigintile of elevation, annual mean precipitation, annual mean temperature, and indicators for the month of minimum precipitation, rainy season, and for each of the 157 types of sub-climate. These covariates are from Mexico's National Institute of Statistics and Geography (INEGI). Using the estimated model, we predict forest cover into the full sample that includes present-day cropland and urban areas and compute the district average.

Using these measures, we estimate the heterogeneous effect of the patio process on centralization by access to a nearby forest, and therefore to low-cost fuel for smelting. The estimates are presented in Table C.3.

---

[4] Given our objective is to predict potential forest, we only depart from the IPCC's criteria to include "mosaic cropland and natural vegetation" as forested.

Table C.3: Heterogeneous Effect of the Patio Process on Direct Rule, by Access to Sources of Fuel: Difference-in-Differences

	Direct Rule (% of District)					
	(1)	(2)	(3)	(4)	(5)	(6)
Any Mine × Post-Patio Process	0.14**	0.11*	0.061	0.22†	0.19†	0.23**
	(0.048)	(0.048)	(0.16)	(0.12)	(0.097)	(0.066)
	{0.043}	{0.040}	{0.15}	{0.11}	{0.093}	{0.063}
Any Mine × Post-Patio × Woodland	-0.072	0.033				
	(0.046)	(0.053)				
	{0.038}	{0.040}				
Any Mine × Post-Patio × Potential Forest			0.095	-0.16		
			(0.20)	(0.17)		
			{0.19}	{0.15}		
Any Mine × Post-Patio × High Potential Forest					-0.073	-0.15*
					(0.10)	(0.074)
					{0.099}	{0.072}
Any Mine × Post-Patio + Any Mine × Post-Patio × Woodland	0.07**	0.14**				
	(0.03)	(0.04)				
	{0.03}	{0.05}				
Any Mine × Post-Patio + Any Mine × Post-Patio × High Potential Forest					0.11**	0.08*
					(0.04)	(0.04)
					{0.04}	{0.04}
Climate Controls	No	Yes	No	Yes	No	Yes
Controls × Year FE	No	Yes	No	Yes	No	Yes
Year of European Contact × Year FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Within Non-Mining District Mean of DV	0.50	0.50	0.50	0.50	0.50	0.50
Within Non-Mining District SD of DV	0.24	0.24	0.24	0.24	0.24	0.24
R sq.	0.78	0.82	0.78	0.82	0.78	0.82
Observations	2016	1960	2016	1960	2016	1960
Number of districts	144	140	144	140	144	140

OLS estimations. Unit of analysis is the district-decade. Std. errors clustered at the district level in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$; errors that allow for serial correlation within districts and spatial correlation between districts within 500 km of each other in curly brackets. Woodland is an indicator of overlap of a district with warm mixed forest, tropical woodland, or tropical forest land cover by 1700, as reported by the ISLSCP II Historical Land Cover and Land Use (Goldewijk 2010). Potential forest is the predicted probability of forest cover, using data from ESA (2017). High potential forest is an indicator for higher-than-average potential forest among mining districts.

Columns 1 and 2 show estimates from the ISLSCP woodland indicator, and the rest of the columns from the higher-resolution potential forest measure. Columns 3 and 4 use the district average potential forest variable, and columns 5 and 6 an indicator for higher-than-average potential forest among mining districts. The results are ambiguous. In some of the models (columns 2 and 3), the estimated heterogeneous effect is in the opposite direction of what one would expect from a profitability mechanism, and with one exception (column 6), the interactions are not statistically significant. Even in specifications where the point estimates support the idea that the patio process had a larger effect on centralization in districts where it led to greater profitability (for example in column 6), the effect remains large, positive, and significant in districts with nearby access to fuel.

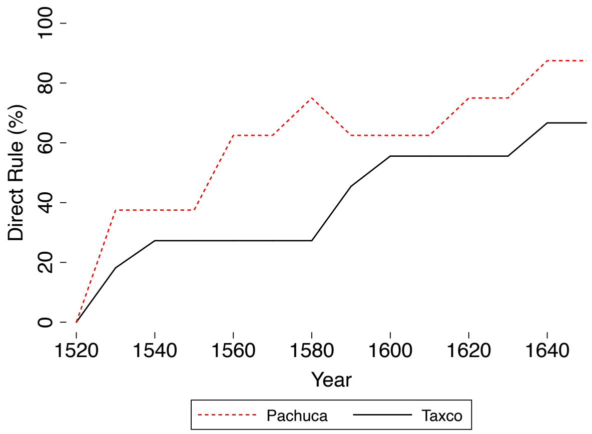
In short, one observable implication from a profitability-based argument—that the effect of the patio process should be driven by districts with little or no access to fuel—is not well supported by this evidence. Even districts that have the easiest access to firewood, where the patio process had the lowest profitability impact, still experience a large and positive average increase in the adoption of direct rule.

C.4 Qualitative Evidence from Mining Boom and Bust Cycles

To further investigate the alternative profitability channel, we examine disaggregated trends in political centralization alongside economic booms and busts in two notable silver mining centers in New Spain: Taxco and Pachuca. Silver mining was a variable economic activity, with decades-long boom and bust cycles driven by the discovery and depletion of new veins of silver deposits (e.g., Brading and Cross 1972; Bakewell 1984; Guerrero 2017). For geologic reasons, the most valuable silver deposits in Mexico are typically found about 400–600 feet below ground at the water-table level and thus often not discovered until years or decades after extraction had begun (e.g., Brading and Cross 1972, p. 548). The discovery of an especially rich vein could power a broader economic boom in the surrounding areas, while its depletion could lead to a broader contraction. Importantly, these booms and busts in profitability should not have any direct impact on fiscal legibility so long as mining activity using the patio process continued (see Section **??** for an analysis based on the depletion of mines).

To assess how these boom and bust cycles influenced the trajectory of political centralization, we examine in greater detail the transition from *encomienda* to *corregimiento* in the area around the mining centers of Taxco and Pachuca. We choose these centers for two reasons. First, while we lack detailed data on 16th-century mining production and profitability, these were important enough mining centers that there are qualitative accounts on silver booms and busts from the *relaciones geográficas* and other contemporaneous sources. Second, as these centers were located in areas of relatively dense pre-colonial settlement, there are a sufficient number of *encomiendas* nearby to examine trends in centralization over time (for Taxco, 11 in the district and 31 in adjacent districts; for Pachuca, 8 within the district and 45 in adjacent districts). We plot district trends in direct-rule adoption in Figure C.5 and provide a brief narrative on the boom and bust cycles in each center below to aid in interpretation of this evidence.

Figure C.5: The Transition to Direct Rule in Taxco and Pachuca



The figure plots the proportion of *encomiendas* that had transitioned to direct rule in Taxco (solid black) and Pachuca (dashed red) over the period of analysis.

Taxco: This had been a center of gold and tin extraction before silver mining began in the 1530s. By 1552, Taxco's silver mines were operating at close to full production, and a significant number of immigrants had arrived in the area for employment (Gerhard 1993a, p. 254). However, shortly after a major epidemic in the 1570s, mining production in Taxco began a prolonged period of decline. Production did not fully recover until the mid-18th century, almost 200 years later (Gerhard 1993a, p. 254). The graph in Figure C.5 plots the transition to direct rule in Taxco during the time period of analysis (black line). Though there was a slight trend toward direct-rule adoption in the first decades after the Conquest in Taxco, as in most of the colony, there is no evident acceleration in the transition to *corregimiento* during the period of the mining boom (between roughly 1530 and 1560 or 1570). If anything, a more notable move toward centralization seems to occur in the late 16th century as the profitability of Taxco's mines declined (though after the introduction of the patio process).

Pachuca: Silver deposits were discovered in Pachuca in 1552 shortly before the patio process was introduced (Gerhard 1993a, p. 210–1). This area was also severely impacted by the 1570s epidemic, though mining production and immigration rebounded afterwards. As of 1597, Pachuca had become the largest mining center in New Spain in terms of labor force, though its importance was arguably waning relative to the booming mines of Zacatecas and Guanajuato (e.g., Mendizabal 1941, p. 283–4). As Figure C.5 illustrates (dashed red line), there was a marked acceleration in direct-rule adoption during the first mining boom, which in Pachuca corresponded exactly with the introduction of the patio process. However, no such trend is evident during the post-epidemic recovery. In fact, there was a slight reversion to indirect rule during this second boom period as the encomienda of Tezontepec was reassigned to a private holder. This is not consistent with profitability accounts, particularly one that highlights the drive of the Crown to protect important mining sites like Pachuca from foreign rivals through more direct rule.[5]

While this evidence is only suggestive, it provides two pieces of information relevant to the interpretation of the results in the main text. First, the case-study evidence is not consistent with a purely profit-related argument in that there is no clear correspondence between political centralization and mining boom and bust cycles in nearby mines. Second, the evidence illustrates that even in some of the most important mining areas of the country, Pachuca being the largest as of 1597, some amount of indirect rule persisted. This suggests that, however important silver may have been to the imperial economy, silver mining itself did not preclude the continuation of the *encomienda* for tribute extraction.

D. Additional Evidence: Long-Term Outcomes

D.1 Differences in Perceived Extractive Value: Mining vs. Non-Mining Districts

In Section **??**, we present a cross-sectional analysis comparing a measure of long-term state investment in legibility (access to a postal office) between mining and non-mining districts. To address the concern that mining districts may vary substantially from non-mining areas in unobservable ways, we identify districts with early mines that later exhausted and compare these areas to non-mining districts. This allows us to rule out ongoing mining as a factor to explain long-term divergence, but this research design has important limitations, and it does not allow us to credibly estimate a causal effect of the patio process on long-term legibility investment.

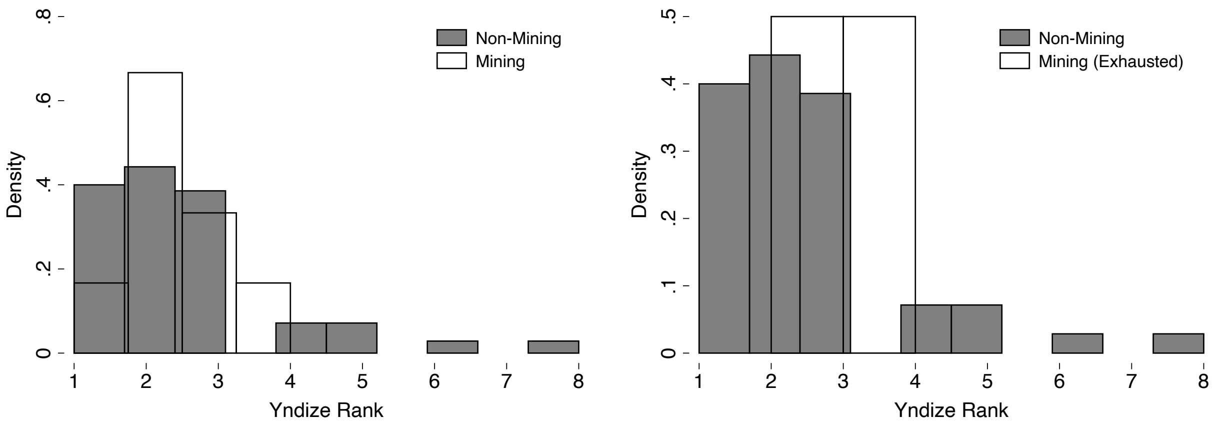
Here, we evaluate a possible alternative explanation for the result that mining areas affected by the patio process in the 1550s had more access to postal services by the second half of the 18th century. Instead of our proposed mechanism (that there was a self-reinforcing process of endogenous investment in legibility set off by the exogenous shock to legibility via the discovery of the patio process), it could be that areas with early

---

[5] This is not to say that the Crown was not concerned about foreign incursions into its colonial possessions due to their mining wealth. Indeed, when discussing a notably detailed early map from north-central Mexico, Hillerkuss (2013) suggests that mining sites were deliberately misplaced precisely due to these types of concerns. However, there is little evidence that the Crown sought a faster transition to direct rule d to mitigate these concerns and indeed some evidence in other work that indirect rule was more common where the threat of foreign incursion was highest (Pastore 1998).

mining had more potential for economic extraction, which might lead the colonial state to invest more in legibility in these areas over the longer term.

Figure D.1: Rank of Perceived Value of District; Mining and Non-Mining Districts



(a) Full Sample

(b) Excluding Ongoing Mining

To assess this mechanism, we use data from the *Yndize comprensibo de todos los Goviernos, Corregimentos y Alcadias mayores...* a secret document published in 1777 in wide circulation among those who sought to bid for colonial offices in auction. The document includes brief descriptions of each district and then ranks them from the most (rank 1) to the least (rank 8) valuable in terms of perceived extractive potential. Most districts match exactly in our sample, but in the few cases for which there is more than one entry in the Yndize, we compute the average rank.

In Figure D.1, we compare the distribution of ranks across mining and non-mining districts (left panel) and then reproduce this comparison excluding districts with ongoing mining (right panel). The non-mining group is spread out across ranks, and includes some of lowest-ranked districts as well as many of the most coveted ones. Mining districts, by contrast, are more tightly distributed around ranks 2 and 3 (or around ranks 2 and 4 for defunct mines). From the figure, it does not appear to be the case that mining districts are clearly perceived as having a higher extraction potential.

We directly compare average ranks between these groups in Table D.1. Across the full sample and the subsample that excludes districts with ongoing mining by the 1740s, there is no consistent difference in average rank. If anything, districts with early mines that were later exhausted were ranked as less desirable in the Yndize (i.e., the rank has a higher value). These results are inconsistent with the idea that these areas had more extractive potential and were therefore more attractive for state investment.

Table D.1: Differences in Rank of Perceived Value of District Between Mining and Non-Mining Districts

	District Rank by 1770s			
	All districts		Excl. Districts with Ongoing Mining by 1740	
	(1)	(2)	(3)	(4)
16th Century Mine	-0.076	0.20	0.70	1.27**
	(0.27)	(0.35)	(0.61)	(0.48)
	{0.25}	{0.27}	{0.45}	{0.35}
Controls	No	Yes	No	Yes
Mean of DV in Non-Mining Districts	2.42	2.42	2.42	2.42
SD of DV in Non-Mining Districts	1.43	1.43	1.43	1.43
R sq.	0.00038	0.28	0.0092	0.32
Observations	116	116	104	104

OLS estimations. Unit-of-analysis is the district-decade. Standard errors clustered at the district level in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$; errors that allow for serial correlation within districts and spatial correlation between districts within 500 km of each other in curly brackets.

D.2 Spatial and Temporal Investment in Fiscal Legibility Using Royal Treasuries

In addition to examining the long-term divergence in fiscal legibility between areas affected and unaffected by the patio process, we also analyze a separate measure of state investment in local fiscal legibility: the construction of *Cajas Reales* or royal treasuries.[6] The royal treasuries were a network of fiscal institutions designed to oversee and administer the collection of taxes across the territory. These institutions had broad fiscal authority over their jurisdictions and remarkable autonomy from each other (TePaske and Klein 1986). Within their catchment areas, royal treasuries coordinated tax collection and provided funds for local expenditures, including officials' salaries as well as other administrative and military expenses. Each treasury was led by an accountant, who registered and certified transactions, and a royal treasurer, who collected taxes both directly from taxpaying individuals or institutions and indirectly from other specialized officials like *corregidores* (Sánchez Bella 1968; Yuste 2002).[7]

The establishment of a new treasury brought the fiscal bureaucracy closer to the surrounding districts. This

---

[6] Chiovelli (2016) also uses the presence of treasuries as a measure of state capacity and link their location to existing levels of state development.

[7] Other positions included the *factor*, who conducted the treasury's business with other branches of the bureaucracy, the *veedor*, who assayed gold and silver and monitored its production, and a variable number of deputies. The Crown used a number of strategies to minimize agency problems with treasury bureaucrats, including regular inspections and on-site audits, reliance on independent auditing bodies to check accounts, and internal safeguards on fraud (Sánchez Bella 1968; TePaske and Klein 1986; Jáuregui 1999).

increased the ability of the Crown to monitor local conditions. In addition to facilitating tax compliance, the establishment of a treasury allowed the Crown to assess nearby economic production more reliably and thus to better evaluate the effort of local agents—*corregidores* and *encomenderos*—tasked with the collection of tribute. The creation of a treasury in a remote area, even a relatively unproductive one, was thus sometimes warranted to enable the Crown to obtain more information and control over outlying regions (Sánchez Bella 1968). Given the economic and political costs of establishing royal treasuries, the Crown had to prioritize when and where to make this investment. The placement of the treasuries followed a clear territorial logic early on, with the establishment of treasuries in Mexico City, the capital; Veracruz, Mexico's main port in the Atlantic; and Merida, a main trading center in the Yucatan. Given the importance of silver to the royal economy, it is perhaps not surprising that treasuries were sometimes established near mines following the discovery of productive deposits. This seems to have motivated the creation of early treasuries in Compostela, Durango, and Zacatecas, for example (Parry 1968; Bakewell 1971; Lacueva 2011).[8] Treasuries were eventually created to facilitate tax collection in the interior, but this investment was not made in all regions (Sánchez Bella 1968; Jáuregui 1999; Bertrand 2013).

We investigate how the early shock to fiscal legibility shaped Crown investment in treasury construction across space and time by examining how the least-cost walking hours from each district to the nearest treasury evolved from the 16th century until the late colonial period. Specifically, we construct a decadal panel of minimum walking times (in hours) from each district to the nearest royal treasury using the same least-cost analysis methodology as described in Section A.2 and information on the successive construction of new treasuries. We geolocate each treasury constructed over the colonial period and code its date of construction (Table D.2). We then construct a time-varying measure of the minimum and space-weighted average distance to the nearest caja at the district (1786 administrative region) level by decade.

Our interest is in whether districts affected by the legibility shock in the 1550s saw a differential increase in investment toward improving the Crown's ability to observe and monitor local production through the construction of nearby treasuries. In Table D.3 we present difference-in-differences estimates from an equation similar to (**??**), now using minimum distance to royal treasury as the outcome. We extend the analysis from the Conquest period until the 1750s, when a major set of fiscal reforms shifted the pattern of treasury placement. We present estimates with and without time-varying and time-interacted controls for the same two sub-samples

---

[8] Relatedly, the Crown also established treasuries along the coast to monitor contraband; the Carmen treasury is one example (TePaske and Klein 1986).

Table D.2: *Cajas Reales*/Royal Treasuries in Colonial Mexico, 1520–1810

Location	Region	Years	Source
Mexico City	New Spain	1521	TePaske and Klein (1986)
Veracruz	New Spain	1531	TePaske and Klein (1986)
Merida	Yucatan/SE	1540	TePaske and Klein (1986)
Compostela	Nueva Galicia	1543–1559	Bakewell (1971); Parry (1968)
Guadalajara	Nueva Galicia	1560	Bakewell (1971); Parry (1968)
Acapulco	New Spain	1562	Maniau y Torquemada (1794)
Durango	Nueva Vizcaya	1563	Lacueva (2011)
Zacatecas	Nueva Galicia	1571	Bakewell (1971); Parry (1968)
Chiametla	Nueva Galicia	1575–1601	Lacueva (2011)
San Luis Potosi	New Spain	1628	TePaske and Klein (1986)
Guanajuato	New Spain	1665	TePaske and Klein (1986)
Pachuca	New Spain	1667	TePaske and Klein (1986)
Sombrerete	Nueva Galicia	1681	Maniau y Torquemada (1794)
Campeche	Yucatan/SE	1716	TePaske and Klein (1986)
Zimapan	New Spain	1721	Maniau y Torquemada (1794)
Tabasco	Yucatan/SE	1728	TePaske and Klein (1986)
Bolaños	Nueva Galicia	1753	TePaske and Klein (1986)
Alamos	Sinaloa & Sonora	1770–1782	TePaske and Klein (1986)
Presidio del Carmen	Yucatan/SE	1774	TePaske and Klein (1986)
Rosario	Sinaloa & Sonora	1783–1806	TePaske and Klein (1986)
Chihuahua	Nueva Vizcaya	1785	TePaske and Klein (1986)
Michoacan/Valladolid	New Spain	1788	TePaske and Klein (1986)
Puebla	New Spain	1789	TePaske and Klein (1986)
Oaxaca/Antequera	New Spain	1790	TePaske and Klein (1986)
Arizpe	Sinaloa & Sonora	1791	TePaske and Klein (1986)
Saltillo	Coahuila	1794	TePaske and Klein (1986)
Cosala	Sinaloa & Sonora	1807	TePaske and Klein (1986)

Notes: Where no end date is noted, the treasury remains until the end of the colonial period. Because TePaske and Klein (1986) generally assign the dates establishment to the first year with available records—which might erroneously identify a treasury as being created years after its real establishment—we reviewed the secondary historical literature to verify the dates of treasury establishment. We keep the date from the most reliable source. We follow the formal criteria used during the period to identify a royal treasury: having an appointed treasurer and accountant. This sets main treasuries apart from smaller dependent offices that were staffed by these officials' deputies. The only exceptions to this coding rule are the treasuries of Veracruz and Acapulco, both of which, while technically dependent on the Mexico City treasury, were among the most important treasuries throughout the colonial period. TePaske and Klein (1986) speculate that the Tabasco treasury may have existed for a very brief period in the early 17th century (1605–1612) and then disappeared, but it is not clear whether it was merely a dependent office during those early years. Chiametla stopped operating briefly between 1587 and 1590; we consider it to be operative in the 1580 decade when we aggregate to the decadal level.

as in Table **??**: the full sample of districts in New Spain and Nueva Galicia where institutions of indirect or direct rule were employed in a consistent way (columns 1 and 2) and the core region of New Spain (columns 3 and 4).[9]

The results in Table D.3 provide mixed evidence that the introduction of the patio process encouraged endogenous investment in fiscal legibility. In New Spain, the introduction of the patio process led to a

---

[9] We use the same vector of covariates as the estimations in Section **??**: the time-varying climate measures and the time-invariant district characteristics (malarial zone, maize suitability, elevation, log surface area, log walking hours to Mexico City, year of Spanish contact, latitude, and longitude) interacted with each year indicator.

Table D.3: Patio Process and Walking Time to Nearest Royal Treasury (log): Difference-in-Differences

	Walking Hours to Treasury (log)			
	New Spain & Nueva Galicia		New Spain	
	(1)	(2)	(3)	(4)
Any Mine × Post-Patio Process	-0.12	0.076	-0.73*	-0.63
	(0.34)	(0.41)	(0.36)	(0.43)
	{0.39}	{0.40}	{0.34}	{0.40}
Climate Controls	No	Yes	No	Yes
Controls × Year FE	No	Yes	No	Yes
Year of European Contact × Year FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Within Non-Mining District Mean of DV	7.43	7.39	7.54	7.50
Within Non-Mining District SD of DV	0.40	0.41	0.27	0.27
R sq.	0.80	0.83	0.83	0.86
Observations	3588	3492	3012	2916
Number of districts	150	146	126	122

OLS estimations. The unit of analysis is the district-decade for districts with direct/indirect rule institutions. Standard errors clustered at the district level are in parentheses, with $^{\dagger}p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$. Standard errors that allow for serial correlation within districts and spatial correlation between districts within 500 km of each other are in curly brackets. Time-varying climate data is not available in four districts, which are not included in the estimations with covariates.

differential decrease in the minimum walking time to the nearest treasury in mining relative to non-mining districts of around 60 and 70 percent up to the 1750s, though this difference is not significant in the specification with covariates. When including Nueva Galicia, the decrease is smaller, not statistically different from zero, and flips signs when including covariates. We therefore cannot reject a null effect across all samples and specifications. That said and while imprecisely estimated, the coefficient estimates are substantively large for the New Spain sample, equivalent to almost two within-district standard deviations of walking time.

E. Supporting Information References

Bakewell, Peter. 1971. *Silver Mining and Society in Colonial Mexico. Zacatecas 1546–1700*. Cambridge University Press.

—-. 1984. Mining in Colonial Spanish America. In *Cambridge history of latin america, vol. 2*, ed. Leslie Bethell. Cambridge University Press.

Baskes, Jeremy. 2000. *Indians, Merchants, and Markets: A Reinterpretation of the Repartimiento and Spanish-Indian Economic Relations in Colonial Oaxaca, 1750–1821*. Stanford University Press.

Bertrand, Michel. 2013. *Grandeza y miseria del oficio: los oficiales de la Real Hacienda de la Nueva España, siglos XVII y XVIII*. Fondo de Cultura Económica.

Brading, David, and Henry E. Cross. 1972. Colonial Silver Mining: Mexico and Peru. *The Hispanic American Historical Review* 52(4):545–579.

Chaunu, Huguette, and Pierre Chaunu. 1956. *Séville et l'Atlantique 1504-1650*, vol. VI–VIII. Centre de Recherches Historiques.

Chiovelli, Giorgio. 2016. Pre-Colonial Centralization, Colonial Activities and Development in Latin America. Working Paper.

Cook, Edward R., and Paul J. Krusic. 2004. *The North American Drought Atlas*. New York, NY: Lamont-Doherty Earth Observatory and NSF.

Crowther, et al., Thomas W. 2015. Mapping Tree Density at a Global Scale. *Nature* 525(7568):201–205.

Diaz-Cayeros, Alberto, and Saumitra Jha. 2016. Conquered but Not Vanquished: Complementarities and Indigenous Entrepreneurs in the Shadow of Violence. *Working Paper*.

Donkin, Robin Arthur. 1977. Spanish Red: An Ethnogeographical Study of Cochineal and the Opuntia Cactus. *Transactions of the American Philosophical Society* 67(5):1–84.

ESA. 2017. Land Cover CCI Product User Guide Version 2. Tech. Rep., ESA.

Fournier Garcia, Patricia. 2018. Indigenous Charcoal Production and Spanish Metal Mining Enterprises: Historical Archaeology of Extractive Activities and Ecological Degradation in Central and Northern Mexico. In *Historical archaeology and environment*, ed. Marcos André Torres de Souza and Diogo Menezes Costa, 87–108. Springer.

Garfias, Francisco, and Emily A. Sellars. 2021. From Conquest to Centralization: Domestic Conflict and the Transition to Direct Rule. *Journal of Politics* 83(3):992–1009.

Gerhard, Peter. 1993a. *A guide to the Historical Geography of New Spain*. University of Oklahoma Press.

—-. 1993b. *The North Frontier of New Spain*. Norman, OK: University of Oklahoma Press.

Goldewijk, Kees Klein. 2010. ISLSCP II Historical Land Cover and Land Use, 1700-1990.

Guerrero, Saúl. 2017. *Silver by Fire, Silver by Mercury: A Chemical History of Silver Refining in New Spain and Mexico, 16th to 19th Centuries*. Brill.

Hainmueller, Jens. 2012. Entropy Balancing for Causal Effects: A Multivariate Reweighting Method to Produce Balanced Samples in Observational Studies. *Political Analysis* 20(1):25–46.

Hillerkuss, Thomas. 2013. Las minas de la Nueva España en los mapas del Siglo XVI. ¿Un secreto del Estado? *Apuntes* 26(1):10–25.

Jáuregui, Luis. 1999. *La Real Hacienda de Nueva España: su administración en la época de los intendentes, 1786-1821*. UNAM.

Lacueva, Jaime J. 2011. Marginalidad y marginación de la minería de Nueva Vizcaya (1563-1631). *Historias* 78: 39–72.

Lee, Raymond L. 1951. American Cochineal in European Commerce, 1526–1625. *The Journal of Modern History* 23(3):205–224.

Marichal, Carlos. 2014. Mexican Cochineal and European Demand for a Luxury Dye, 1550–1850. In *Global goods and the spanish empire, 1492–1824*, ed. Bethany Aram and Bartolomé Yun-Casalilla. Palgrave Macmillan.

Mendizabal, Miguel O. de. 1941. Los minerales de Pachuca y Real del Monte en la época colonial. *El Trimestre Económico* 8(30):253–309.

Morineau, Michel. 1969. Gazettes Hollandaises et trésors Américain. *Anuario de Historia Económica Y Social* 3(3):139–210.

Parry, John H. 1968. *The Audiencia of New Galicia in the Sixteenth Century*. Cambridge University Press.

Pastore, Mario. 1998. Government, Taxation, Coercion, and Ideology: A Comment on Yeager. *The Journal of Economic History* 58(2):511–520.

Posthumus, Nicolaas Wilhelmus. 1946. *Inquiry into the History of Prices in Holland*. E.J. Brill.

Sánchez Bella, Ismael. 1968. *La organización financiera de las Indias, Siglo XVI*. Escuela de Estudios Hispano-Americanos.

Sanz, Eufemio Lorenzo. 1979. *Comercio de España con América en la Época de Felipe II - tomo I: Los Mercaderes y el Tráfico Indiano*. Institucion Cultural Simancas.

Serrano, Ana Filipa Albano. 2016. The Red Road of the Iberian Expansion: Cochineal and the Global Dye Trade. Ph.D. thesis, Universidade Nova de Lisboa.

Studnicki-Gizbert, Daviken, and David Schecter. 2010. The Environmental Dynamics of a Colonial Fuel-Rush: Silver Mining and Deforestation in New Spain, 1522 to 1810. *Environmental History* (15):94–119.

TePaske, John, and Herbert S. Klein. 1986. *Ingresos y egresos de la Real Hacienda de Nueva España*. INAH.

Maniau y Torquemada, Joaquín. 1794. *Compendio de la Historia de Real Hacienda de Nueva España*.

Weiss, D. J., A. Nelson, H. S. Gibson, W. Temperley, S. Peedell, A. Lieber, M. Hancher, E. Poyart, S. Belchior, N. Fullman, B. Mappin, U. Dalrymple, J. Rozier, T. C. D. Lucas, R. E. Howes, L. S. Tusting, S. Y. Kang, E. Cameron, D. Bisanzio, K. E. Battle, S. Bhatt, and P. W. Gething. 2018. A global map of travel time to cities to assess inequalities in accessibility in 2015. *Nature* 553(7688):333–336.

White, Devin Alan. 2015. The Basics of Least-Cost Analysis for Archaeological Applications. *Advances in Archaeological Practice* 3(4):407–414.

Yuste, Carmen. 2002. Las autoridades locales como agentes del fisco en la Nueva España. In *El gobierno provincial en la nueva españa, 1570-1787*, ed. Woodrow Borah. UNAM.