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Public investment and economic activity in Mexico, 1925–1981

Felipe de Jesús Fonseca, Manuel Gómez-Zaldívar, and Daniel Ventosa-Santaulària

Abstract
Mexican economic historiography recognizes the key role that public investment played in the country's economic performance from the post-revolutionary period until the beginning of the economic liberalization that began in the mid-1980s. However, there is no concrete empirical evidence that this was the case. In this study, the authors construct a historical database of public investment—both total and broken down into its main components—for the period from 1925 to 1981, in order to measure the impact it had on economic activity. Given the possible presence of crowding-out effects between public investment and private investment, in their analysis the authors control for the latter. The results suggest that public investment had a significant impact on output one which varies depending on the category of public investment considered.

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Keywords Economic activity; federal public investment; cointegration

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I. Introduction

The economic literature recognizes the positive role that providing infrastructure services, such as ports, irrigation systems, and transport and communication routes in general plays in the long-term economic growth of any economy (Aschauer, 1989). There are two main ways in which this occurs: on the one hand, there are the spillover effects that this type of investment generates once these projects are complete (Barro, 1990), while on the other, there is the complementary effect public investment has on private investment, since positive externalities are generated that make the latter more efficient (Munnell, 1992).

According to Mexico's National Institute of Statistics and Geography (INEGI), between 1925 and 1981 (i.e., prior to the exhaustion of the import-substitution model), the Mexican economy grew at an average annual rate of 5.0 percent in real terms. Economic historiography recognizes and attributes a central role to public investment in the attainment of the high growth rates observed from the post-revolutionary period until the early 1980s, just before the period of economic liberalization.[1]

The aim of this study is to provide empirical evidence of the importance of public investment during these years and thus be able to confirm whether this assertion is justified. To do this, we construct a database of public investment for the period 1925–1981. To the best of our knowledge, this study constitutes the first attempt to measure the impact of public investment on economic activity which focuses solely on the period prior to the process of economic openness experienced by the Mexican economy.

Previous studies that have analyzed the impact of public investment on economic activity in Mexico have used data from 1950 onwards and included the period following the opening-up of trade, such as Ramírez (1994), who looks at the period from 1950 to 1991; Nazmi and Ramírez (1997), the period 1950–1990; Lächler and Aschauer (1998), the period 1970–1996, and Noriega and Fontenla (2007), the period 1950–2003. Unlike these studies, ours focuses exclusively on the period prior to the opening-up of trade and extends backwards to include the maximum amount of available data.[2]

[1] See Solís (1999) and Cárdenas (1994, 2015), among others.

[2] INEGI's compilation of historical statistics, *Estadísticas Históricas de México* (or EHM), provides data going back as far as the late nineteenth and early twentieth centuries. However, there are gaps in this information due to the revolutionary period.

Another contribution of our approach is that our database breaks down total public investment into five components, unlike the studies mentioned previously, which only consider public investment as a whole.[3] Therefore, we not only estimate the impact on Gross Domestic Product (GDP) of *total* public investment but also classify its various components according to their importance, i.e., those that have the greatest impact on economic growth.

Furthermore, and from a methodological point of view, the econometric tool we use enables us to perform a more thorough analysis by incorporating the presence of structural breaks and cointegration methods by means of maximum likelihood, which corrects bias in small samples. This is relevant, since previous studies looking at Mexico have used relatively simple techniques, such as regressions in first differences, or the Engle-Granger cointegration test.

The main results are as follows: i) there is evidence to affirm that there is a long-term relationship between GDP and total public investment, and also each of its components; (ii) total public investment has a positive and significant impact on economic activity, as do each of its components; iii) of all the components considered, those which have the greatest impact on GDP are investment in industrial development [primarily the state-owned oil company Petróleos Mexicanos (PEMEX) and Federal Electricity Commission (CFE)] and investment in transport and communications; (iv) the results suggest that total public investment has a *complementary* rather than a *crowding-out* effect on private investment, as do each of its components; (v) investment in social development (mainly schools and hospitals) and in transport and communications are estimated to have the greatest effect on private investment.

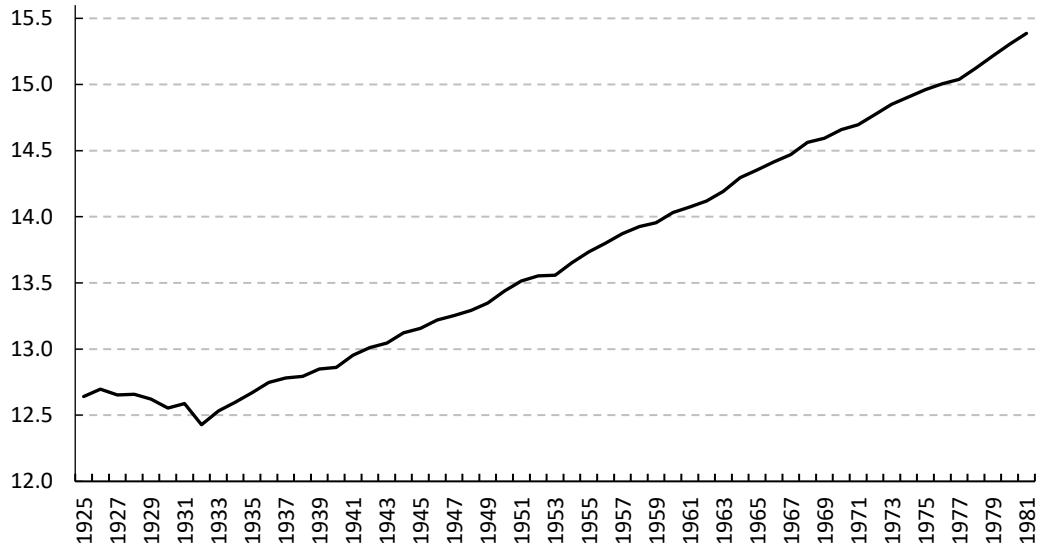
The remainder of this article is organized as follows. Section II presents the database. Section III includes the estimates and results. Finally, Section IV contains the final remarks.

[3] Of the authors mentioned above, Noriega and Fontenla (2007) are the only ones to consider the impact of different physical infrastructure components, namely industrial (kilowatts of electricity) and communications (roads and telephone lines).

II. Sources and Data

The series used in this study are: GDP, total federal public investment (and its components), and private investment, all for the period 1925–1981. The GDP series was obtained from the historical GDP series (from 1900 to 1995) in 1980 prices.[4] Graph (1) shows the evolution of the GDP series converted into 2003 prices.[5]

Graph 1. Gross Domestic Product, millions of pesos 2003
(in logarithms)



Source: Own estimates with information from INEGI.

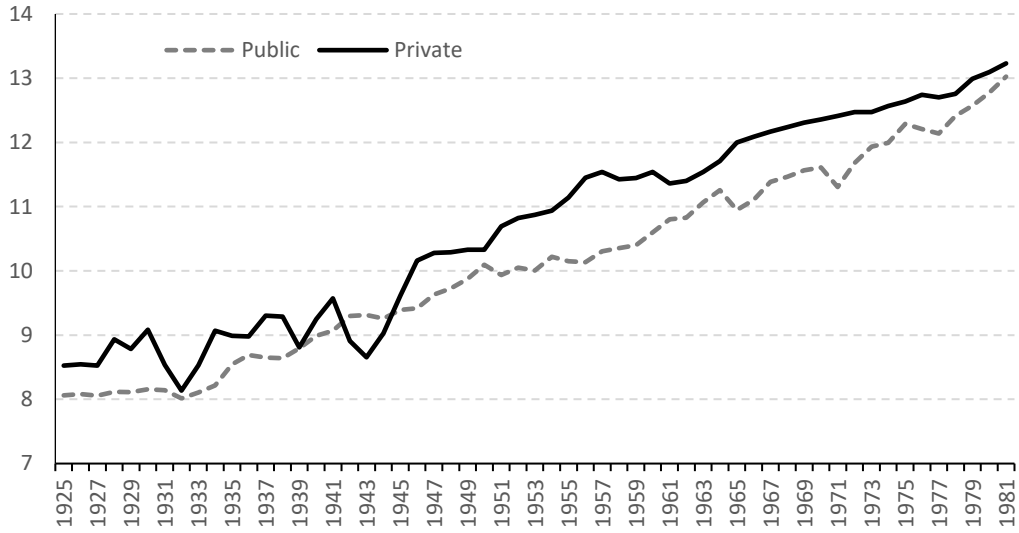
The total public investment series and its components were constructed using INEGI's compilation of historical statistics, *Estadísticas Históricas de México* (EHM). The total public investment series has five components. Most of the series are available from 1925 until 1996 and all of them were converted into 2003 prices.[6]

The private investment series was constructed using information on gross fixed capital formation (GFCF) by type of buyer (private). The data was taken from Cárdenas (1996, Tables III.6, II.2, and I.3) and Cárdenas (1994, Table A.28), which show private GFCF

[4] This series is available in the Economic Information Bank (*Banco de Información Económica*, or BIE) section of INEGI's website.
[5] The conversion of the original GDP series into 2003 prices was achieved by simple chaining with the current GDP series, in 2003 prices (also available at the INEGI website).
[6] To convert these series into 2003 prices, we constructed a GDP deflator by joining together the GDP deflator (in 2003 prices) for the period 1980–2010, taken from the National Accounts System (*Sistema de Cuentas Nacionales*, or SCN) and the series of wholesale prices in Mexico City (base 1978) contained in the EHM for the period from 1925 to 1979. This is essentially the same deflator series used in Ventosa-Santaulària *et al.* (2015).

in millions of current pesos, converted into 2003 prices with the aforementioned deflator series. Graph (2) shows the evolution of these two variables. The private investment series has a greater volatility than the public investment series, particularly in the period from the early 1930s until the end of the Second World War.

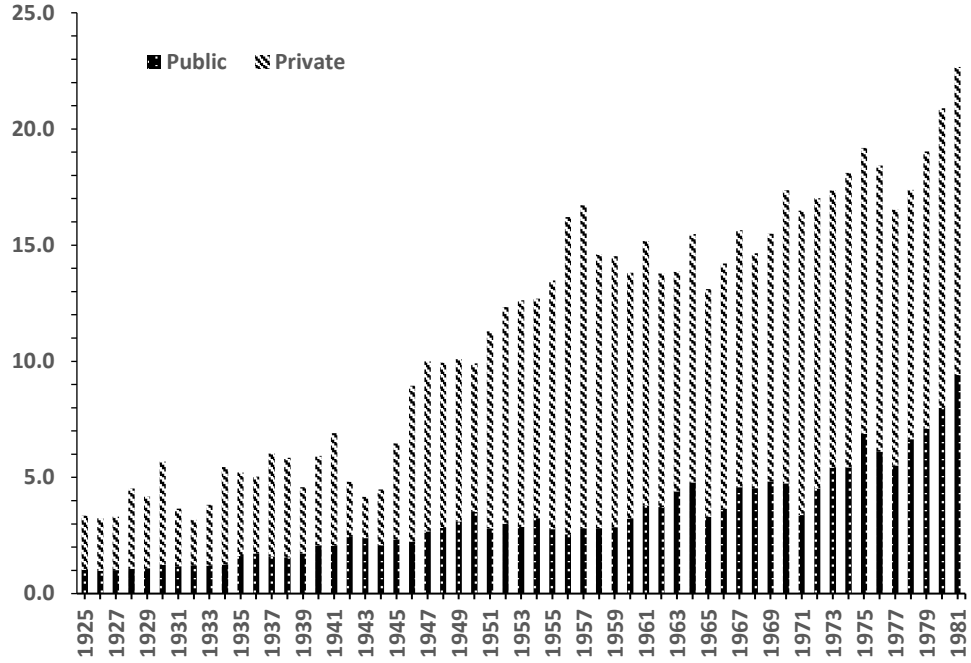
Graph 2. Public and private investment, millions of pesos 2003
(in logarithms)



Source: Own estimates with information from INEGI.

Graph (3) shows the investment series (both public and private) as a percentage of GDP. From the beginning of the sample up to 1945, public investment never exceeded 5 percent of GDP. It then began to rise, eventually reaching 10 percent of GDP in 1955, where it remained, more or less, for several years. During the subsequent period of Mexico's "economic populism" (Bazdresch and Levy, 1991), there was a sustained increase in public investment (in terms of share of GDP), driven mainly by investment in the energy sector following the discovery of oil fields. As a result, at the end of the sample (and prior to the 1982 crisis), total public investment represented 20 percent of GDP.

Graph 3. Public and private investment as percentage of GDP



Source: Own estimates with information from INEGI and Cárdenas (1994, 1996).

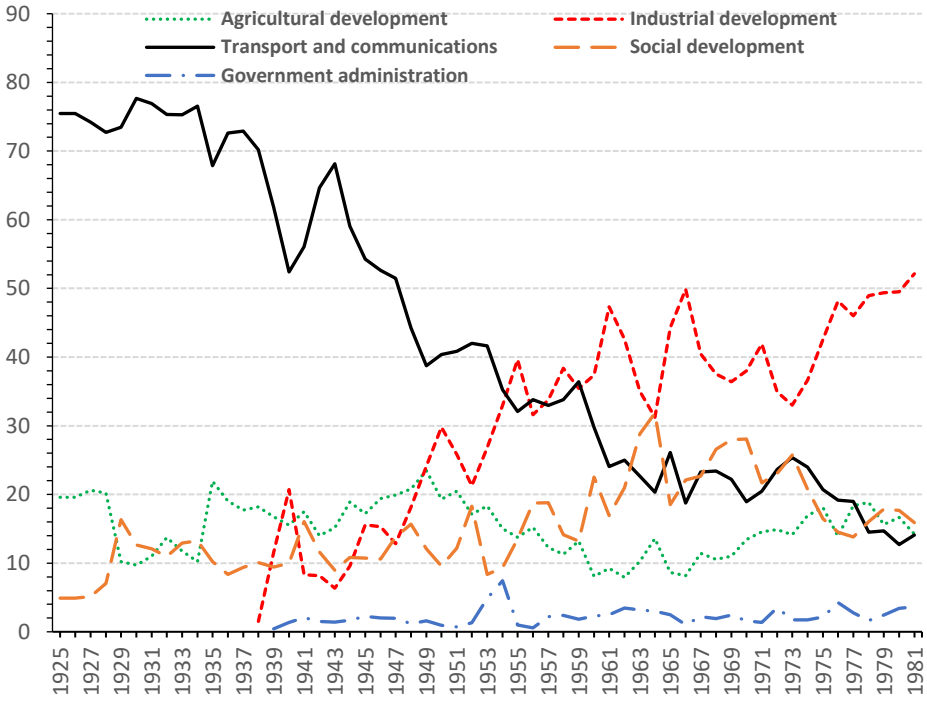
Total federal public investment can be broken down into the following components: *agricultural development*, which includes investment in agriculture, irrigation, and livestock (traces); *industrial development*. e.g., investment in state-owned enterprises (SOEs), which includes investment in the energy sector (electricity, oil, and gas), mining, and related industries; *transport and communications*, i.e., investment in roads, railways, airports, ports, and communication routes in general; *social development*, which primarily includes investment in education and health, and finally; *government administration*, which considers investment in justice, security, defense, and other government administration functions. Due to differences in the availability of information, the start years for the data on investment in industrial development and government administration are, respectively, 1938 and 1939, while that for all other concepts is 1925.

Graph (4) shows the share each component represents of total public investment during the period studied. The first thing to notice is the marked fall in the relative share of transport and communications, which initially constituted the most important component of total public investment (i.e., 75 percent in 1925), a position it maintained until the early 1950s. Its importance then began to decline, and continued to do so throughout the remaining years of the sample, eventually falling to just 15 percent.

While the relative share of transport and communications in total investment decreased, that of social development increased, reaching a peak in the 1960s of around 30 percent. However, the component that shows the most significant increase in terms of its relative importance was investment in industrial development, whose share increased from 1938 (the first year for which data is available) to 1960. During the period 1960–1973, its share fluctuated around 40 percent, then began to rise. This spurt of growth continued thanks to the boom in the oil industry and by the end of the period investment in SOEs accounted for just over half of all federal public investment.

The two other components, investment in agricultural development and investment in government administration were, on average, the lowest and most constant components in terms of their share of total public investment, i.e., 15 and 3 percent, respectively.

Graph 4. Evolution of the components of public investment in relation to the total
(in percentages)



Source: Own estimates with information from INEGI.

III. Empirical analysis and results

We begin by analyzing the statistical properties of the series. We then define their order of integration and test for the presence of structural breaks. The results show that the variables cointegrate, i.e., there is a long-run relationship between them. We therefore estimate the impact public investment (both total and by individual component) had on the country's GDP in the period 1925–1981. These cointegrated relationships are estimated by controlling for private investment. Given that the variables are in logarithms, the estimated parameters should be interpreted as elasticities. Furthermore, disaggregating total public investment into its various components allows us to determine which of these had the greatest impact on GDP growth during this period.

Statistical Properties of the Series

Table 1 (columns 1 to 4) shows the results of standard unit-root tests, i.e., the Augmented Dickey-Fuller (ADF), Dickey-Fuller-GLS (DF-GLS), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and Phillips-Perron (PP) tests, respectively. All these tests show that there is not enough evidence to reject the null hypothesis of unit root,[7] i.e., the series cannot be considered as stationary processes.[8,9] Columns 5 and 6 of Table 1 present the statistics associated with two procedures [Exact Local Whittle (Shimotsu and Phillips, 2005) and GPH (Geweke, Porter and Hudak, 1983)] that estimate the degree of fractional integration. For all series, both procedures yield estimates that are statistically different from zero, which is consistent with the results from the first standard unit-root tests. Finally, column 7 shows the test statistics of Ventosa-Santaulària and Gómez (2010). This last test allows us to distinguish between the null hypothesis of a driftless unit-root process and the alternative hypothesis of a unit-root process with drift. The results indicate that all of the series except for government administration have not only a stochastic trend (the unit-root process) but also a deterministic trend.

Using the Bai and Perron testing procedure (1998, 2003), we also test for possible structural breaks in the (differenced) series. Had we found evidence of such structural

[7] It is worth remembering that, in contrast to all the other tests, the null hypothesis of the KPSS test is stationarity. For the variables of this study, this hypothesis was rejected.
[8] Investment in industrial development is the only series for which the outcome is different: the PP test indicates that it is indeed possible to reject the null of unit root; however, this occurs with a high significance level.
[9] The results of these tests, applied to the series in first differences, indicate that they can be considered I(0) processes.

breaks, we would have had to model these in the cointegration analysis. However, the results yielded evidence of a level break for GDP only.

Table 1. Unit-root and persistence tests

Variable	*ADF*	*DF-GLS*	*KPSS*	*PP*	*Whittle*	*GPH*	*GVS*
GDP (Y_t)	1.690	-0.340	1.505***	2.598	1.019***	1.046***	0.997***
Private investment (I_t)	-0.118	0.090	1.504***	-0.103	0.880***	0.913*	0.965***
Total public investment (G_t)	1.709	-0.001	1.513***	1.511	0.916***	0.955***	0.990***
Social development (SD_t)	-0.003	0.819	1.527***	-0.526	0.773***	0.794***	0.975***
Industrial development (ID_t)	-1.355	0.836	1.194***	2.614*	0.931***	0.963***	0.962***
Transport and communications (TC_t)	0.767	-0.204	1.483***	0.611	0.867***	0.949***	0.972***
Agricultural development (AD_t)	0.797	0.315	1.425***	0.587	1.017***	1.045***	0.951**
Government Administration (GA_t)	0.449	0.987	1.170***	-1.614	0.625***	0.777***	0.867

§ The specification of the auxiliary regression includes a constant. The maximum number of lags was determined by $\lceil 12(T/100)^{1/2} \rceil$.
The symbols ***, ** and * denote rejection of the null at the 1, 5 y 10 percent, respectively.

Cointegration Analysis

Having found evidence that all the variables behave as I(1) processes, we then perform a Johansen test (see Johansen, 1988, and Johansen and Juselius, 1990) to identify whether GDP, private investment, and public investment are cointegrated. First, we estimate the impact of total public investment on GDP growth. We then estimate the impact of each of each investment component separately. This allows us to identify: i) which type of public investment had the greatest impact on GDP, and; ii) the relationship between public and private investment during the period under study; we are thus able to establish whether the two types of investment are complementary or if there is a crowding-out effect between them.

The second column of Table 2 shows the order of the VEC, i.e., the number of lags selected for each of the series. Columns 3, 4, and 5 report the results of the Johansen tests: trace, *lmax*, and also trace test results when we use critical values suited to the sample sizes employed (Small Sample, or SS). In all cases, it is possible to reject the null of no cointegration between GDP, private investment, and total public investment, as well as for each individual component of the latter. There is therefore evidence of a constant (positive) long-run equilibrium relationship between GDP, public investment

(total and each of its components), and private investment.[10]

For total public investment, social development, transport and communications, and government administration, we found evidence of two cointegrating relationships, whereas for investment in both industrial and agricultural development we found evidence of only one cointegrating vector. The estimated parameters of these relationships are reported in column 6 (VECM).

For those cases where there are two cointegrating vectors, we obtain the elasticity of GDP with respect to each type of public investment by substituting the second cointegrating vector in the first, thereby eliminating private investment, I_t. The last column of Table 2 shows the elasticity of GDP with respect to each different type of public investment. We are thus able to classify the components of public investment by their impact on Y_t. To the best of our knowledge, this result cannot be found in any of the previous applied studies relating to Mexico, since none of these disaggregate the various components of public investment.

Our estimates suggest that the component with the greatest impact on Y_t (i.e., that which produces the highest elasticity) is investment in industrial development, with an estimated elasticity of 1.47. This result is consistent with the fact that the country's output during the period was highly dependent on SOEs. This particular investment boosted demand for energy, (i.e., oil and electricity), not only through its direct impact on GDP but also indirectly, through the resulting positive externalities for other Mexican industries, which were provided with the energy they needed to produce, possibly at lower prices. Cárdenas (2015), for example, notes that during the oil boom, public investment in this sector enabled the growth of related sectors through Hirschman-type linkages, due to the fact that oil requires inputs for its expansion, which allowed the expansion of other sectors through the availability of foreign currency and generated fiscal resources to be used in other sectors (Cárdenas, op. cit., p. 632).

[10] In Appendix 2, we show the results of the autocorrelation, heteroscedasticity, and normality tests performed on the residuals of the short-run equations. In all cases, the residuals are found to comply with the standard assumptions (independence, homoscedasticity, and normality).

Table 2. Results of the cointegration test and estimated cointegrated vectors

Variable	*Selected Lags*	*Johansen test*			VECM	Substiting VECM (2) into VECM (1)
		Trace	*Lmax*	*Trace SS*		
Total public investment (G_t)	7	43.34***	22.61**	43.34**	(1) $Y_t = 7.1 + 0.56 \cdot I_t + u_t$	$Y_t = 7.14 + 0.69 \cdot G_t$
		20.73**	13.76	20.73**		
		6.96	6.96	6.96	(2) $I_t = 0.06 + 1.24 \cdot G_t + v_t$	
Social development (SD_t)	4	43.78***	21.57*	43.78***	(1) $Y_t = 7.6 + 0.13 \cdot I_t + u_t$	$Y_t = 8.62 + 0.33 \cdot SD_t$
		22.21**	15.86**	22.21**		
		6.34	6.34	6.34	(2) $I_t = 7.9 + 2.52 \cdot SD_t + v_t$	
Industrial development (ID_t)	3	41.66***	28.52***	41.66**	$Y_t = 25.7 + 0.55 \cdot I_t + 1.47 \cdot ID_t + u_t$	$Y_t = 25.7 + 0.55 \cdot I_t + 1.47 \cdot ID_t$
		13.14	9.535	13.14		
		3.60	3.60	3.60		
Transport and communications (TC_t)	5	47.85***	25.84**	47.85***	(1) $Y_t = 6.4 + 0.57 \cdot I_t + u_t$	$Y_t = 4.37 + 1.23 \cdot TC_t$
		22.01**	17.92**	22.01**		
		4.09	4.09	4.09	(2) $I_t = -3.7 + 2.15 \cdot TC_t + v_t$	
Agricultural development (AD_t)	7	51.49***	32.39***	51.49***	$Y_t = 7.4 + 0.4 \cdot I_t + 0.16 \cdot AD_t + u_t$	$Y_t = 7.4 + 0.4 \cdot I_t + 0.16 \cdot AD_t$
		19.09	14.07	19.09		
		5.02	5.02	5.02		
Government administration (GA_t)	7	52.24***	30.31***	52.24***	(1) $Y_t = 408.8 + 1.32 \cdot I_t + u_t$	$Y_t = 994.8 + 0.47 \cdot GA_t$
		21.93**	16.13**	21.93**		
		5.79	5.79	5.79	(2) $I_t = 443.9 + 0.36 \cdot GA_t + v_t$	

The number of lags was determine using the Akaike Information Criteria for VARs. Trace SS employs small samples critical values.
The symbols *** and ** denote rejection of the null at the 1 and 5 percent, respectively.

The second highest GDP sensitivity is that with respect to investment in transport and communications, for which the elasticity is estimated at 1.23.[11]

In nineteenth-century Mexico, the general lack of an effective system of transport and communications represented a major obstacle to the growth of both production and trade. During the Porfiriato period (1876–1910), the government invested heavily in the country's rail network. Between 1880 and 1910, this network grew from 1,074 km to 19,280 km, providing rail links between the country's capital and its other major cities, as well as connections to the country's export regions.[12] Given that our period of study begins almost immediately after the end of the Mexican Revolution (an event during which many important channels of communication were destroyed), the high elasticity of GDP with respect to investment in transport and communications is logical, since the latter stimulated production and trade, which had stagnated during the revolutionary period. Guajardo, Salas, and Velázquez (2010) point out that rail infrastructure and services suffered a severe physical deterioration due to the Revolution. They further state that from the 1930s onwards, roads and motor transport began to assume—in a slow and rudimentary way—the function previously performed by the railroads (Guajardo, Salas, and Velázquez, op. cit., p. 701).

The elasticity of GDP with respect to the remaining three components—agricultural investment, government administration, and social development—is lower and inelastic: 0.40, 0.47, and 0.33, respectively. Meanwhile, the elasticity with respect to *total* public investment is 0.69, which is approximately the average of the elasticity of its components.

Our results indicate that private and public investment are positively related and that both have a positive and significant impact on GDP. This finding contrasts with those of Nazmi and Ramírez (1997) and Lächler and Aschauer (1998), who suggest that the positive impact of public investment on growth was at the expense of private investment. In our case, our results indicate that public investment not only increases the aggregate demand for goods and services but also generates positive benefits for the various factors of production and for the marginal productivity of private investment.

[11] This is in line with other international studies in which investment in transport and communications has been identified as one of the most important determinants of GDP growth; see, for example, Easterly and Rebelo (1993) and Canning and Fay (1993).

[12] The impact of railroads on growth in nineteenth-century Mexico and the Porfiriato period in particular has been studied by Coastworth (1979).

IV. Concluding Remarks

Public investment is generally acknowledged as one of the main growth engines of the Mexican economy in the period from the end of the revolutionary war (1910–1920) until the late 1970s–early 1980s. Nevertheless, previous literature provides no adequate evidence to support this assertion. By constructing a historical dataset just large enough to allow reasonable empirical analysis, we provide support for the argument that public investment was an important source of growth during this period.

Furthermore, our results indicate that both public and private investment have a positive impact on economic activity during the period studied, and that production is more sensitive to specific components of total public investment, i.e., investment in industrial development and investment in transport and communications. We also find that public investment has a complementary effect on private investment during this period, in some cases with elasticities above unity.

This impact of public investment can be seen in the context of Ilzetzki, Mendoza and Végh (2013), in the sense that fiscal multipliers are higher in economies with low indices of trade liberalization and fixed exchange rates, the precise characteristics of the Mexican economy during the period analyzed.

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Appendix 1. Detection of Structural Breaks

The results in Table A1 contain three test statistics associated with the Bai and Perron (1998, 2003) procedure applied to the first difference of the series (this procedure can only be applied to stationary data). These tests show conclusive evidence of a structural break for GDP only, for which all three test statistics concur not only in finding a break but also on the date when this occurs, i.e., 1934. Evidence of structural change is weaker for the total public investment and agricultural expenditure series, since we ultimately use the sequential test (as recommended by Bai and Perron, 2003, themselves) to infer results. In neither of these two series does the sequential test provide any evidence of a structural break.

Table A1. Results of the Bai and Perron test.

Variable	Sequential test			UD MAX (Date)	WD MAX (Date)
	Test statistic		Date		
GDP	0 vs 1 1 vs 2	42.575*** 3.585	1943	42.575*** (1934)	42.575*** (1934)
Private investment	0 vs 1	1.470	—	1.473 —	2.035 —
Total public investment	0 vs 1	4.089	—	8.951** (1934, 1972)	13.755** (1934, 1943, 1956, 1956, 1972)
Social development	0 vs 1	0.744	—	1.707 —	2.215 —
Industrial development	0 vs 1	2.740	—	3.124 —	4.961 —
Transport and communications	0 vs 1	1.509	—	1.751 —	4.383 —
Agricultural development	0 vs 1	3.847	—	7.491* (1935, 1950, 1961)	14.752*** (1935, 1950, 1958, 1966, 1974)
Government administration	0 vs 1	1.156	—	1.283 —	2.049 —

§ The maximum number of lags was determined by $\left[12(T/100)^{1/2}\right]$. The distribution of errors may vary between subsamples.
The symbols ***, ** and * denote rejection of the null at the 1, 5 y 10 percent, respectively.

The only case where the Bai and Perron test shows convincing evidence of a structural break is the GDP series (in 1943). In no other case does the sequential test yield sufficient evidence to reject the null hypothesis of no break. Therefore, we believe that a better strategy is to proceed with a standard cointegration analysis, making sure that the short-run equations satisfy the assumptions of independence, homoscedasticity, and normality.

Appendix 2. Normality, autocorrelation and Homoscedasticity.

Table A2. Normalidad (Doornik Hansen), Autocorrelación (Ljung-Box Q, 4-lags), Homocesaticidad (ARCH, 4-lags)

	Normality	**Autocorrelation (4 lags)**			**Heteroskedasticity (4 lags)**			**ECM in VEC**		
	DH[1]	Eq. 1	Eq. 2	Eq. 3	Eq. 1	Eq. 2	Eq. 3	Eq. 1	Eq. 2	Eq. 3
Total public investment	3.783	8.746*	2.057	0.750	3.482	10.369**	4.434	-0.174*	-0.097	0.507
								0.101**	0.138	-0.126
Social development	10.153	5.690	1.998	0.131	7.111	6.168	5.205	-0.062*	-0.136	0.855***
								0.047**	0.101	-0.548***
Industrial development	2.376	2.931	1.147	4.004	4.473	3.441	1.230	-0.002***	0.001	-0.014***
Transport and communications	8.991	4.803	1.803	1.645	5.452	6.790	1.670	-0.114**	0.728*	0.467*
								0.073**	-0.338*	-0.184
Agricultural development	8.303	2.784	1.523	1.853	7.326	6.714	8.274*	0.048***	0.169	0.451***
Administración gubernamental	11.790*	5.084	3.924	0.900	3.464	1.790	0.077	-0.227**	0.156	1.376
								0.077**	-0.053	-0.463

The symbols ***, ** and * denote rejection of the null at the 1, 5 y 10 percent, respectively.
[1] Doornick-Hansen test statistic.

From Table A2, we infer the following: i) setting a confidence level at 5%, all short-run equations satisfy the normality, independence, and homoscedasticity assumptions (except in the case of total public investment, for which equation 2 shows no evidence of heteroscedasticity); ii) in all cases, there is at least one significant error correction mechanism, which implies additional evidence of cointegration, and; iii) only for private investment is there any systematic evidence that it can be considered weakly exogenous. GDP, meanwhile, is always affected by disequilibrium and therefore cannot be considered weakly exogenous. Public investment in social development, agricultural development, and industrial development is not weakly exogenous, whereas total public investment and public investment in transport and communications and government administration are.