Railroads and the Colombian Economy

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Abstract

Recently in Colombia has emerged a new interest in explaining some facts in economic history within the context of cliometrics. However, the analysis of transportation infrastructure and its impact on the Colombian's economic development has not received enough attention. The objective of this paper is to close this gap, after all transportation developments is a central topic in the study of country's economic history. In particular, this paper wants to answer, in a quantitative way, three main questions. First, what was the impact of the reduction of transportation costs on the Colombian economy? To this end, we use social savings estimations. Second, was the construction of railroads a main determinant in boosting coffee exports? The hypothesis is that improvements in transportation have been trigged by, and subsequently have contributed to, the expansion of coffee exports during the first half of the twenty century. To test this hypothesis we use Vector Auto-regression (VAR) estimations. Third, could declines in transportation costs, due to expansion in transportation infrastructure, explain reductions in the divergence among agricultural prices across Colombian cities? Finally, this paper provides a new database that contribute to the study of transportation developments in Colombia. The main contribution is to demonstrate, contrary to the popular believes, that railroads did not play an overwhelming role in Colombia's economy during the first half of the twentieth century.

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1. Introduction

Latin-America's economic history literature has few studies that analyze the impact of railroads development on the economic growth within the framework of the new economic history.[1] In Colombia, recently, has emerged a new interest in explaining some facts in economic history following the cliometrics' approach. However, the analysis of transportation infrastructure and its impact on the Colombian's economic development has not received enough attention. The objective of this paper is to close this gap, after all transportation developments is a central topic in the study of a country's economic history. In particular, this paper wants to answer, in a quantitative way, three main questions. First, what was the impact of the reduction of transportation costs on the Colombian economy? To this end, we use social savings estimations. Second, was the construction of railroads a main determinant in boosting coffee exports? The hypothesis is that improvements in transportation have been trigged by, and subsequently have contributed to, the expansion of coffee exports during the first half of the twenty-century. To test this hypothesis we use Vector Auto-regression (VAR) estimations. Third, could declines in transportation costs, due to expansion in transportation infrastructure, explain reductions in the divergence among agricultural prices across Colombian cities? Finally, the paper provides a new database that contributes to the study of transportation developments in Colombia.[2] The main contribution is to demonstrate, contrary to the popular believes, that railroads did not play an overwhelming role in Colombia's economy during the first half of the twentieth century.

2 Social Savings and railroads' price elasticity of demand for freight and passenger transport services estimations

The geographical and topographical conditions of Colombia made the construction of transportation infrastructure very costly. The lack of economic resources and an underdeveloped capital market also slowed the pace of infrastructure developments. Before the rail era, which started in the latter years of the nineteenth century, mules were the typical mode of freight transportation, and transportation infrastructure consisted of primitive roads, which were in poor conditions, and few navigable rivers, which were not interconnected. The lack of adequate means

[1] The exceptions are J. Coastworth (1981), G. Gujardo (1998), W. McGreevey (1975), and W. Summerhill (1996).

[2] The database is available upon request.

of communication caused high transportation costs, the isolation of regions and market fragmentation within the country.

To estimate the responsiveness of the economy to changes in transportation costs we need to estimate price elasticity of demand for railroads' freight and passenger services. This enables us to calculate the social savings on railroad freight.

In Colombia railroad' freight rates and passenger fares were steadily reduced as a consequence of subsidies from the government. Because revenues came mainly from freight and passenger fares, railroads net operating revenues were often insufficient to cover all the spending. In fact, net revenues were always negative after 1947. The hypothesis is that railroad rate reductions were the primary cause for net losses of railroad revenues. To support this hypothesis it is necessary to estimate price elasticity of demand for transportation service to see how the demand responded to fare reductions. In particular, if the demand for transport services is elastic then it would not be clear that reductions in the rates led to operating losses in the railroad companies. We also want to estimate if railway transportation services were sensible to additions in railroad tracks length, opening of new lines. Lastly, social savings are estimated to infer how much the economy saved due to reductions in transportation cost.

2.1 Data

We assembled railroad data on total freight service per ton-km, passenger service per km, freight rates, passenger fares, and railroad track length for fifteen railway companies for the period 1914-1980. Our main sources of information are the official statistical yearbooks, the railroads national council review, and the yearly memoirs of the ministry of public works. The study sample goes up to 1980, since desegregated information by railroad companies is only available until that year. Data for ton-km and passenger-km were only published since 1931. However, data for tons of freight and number of passengers are available for early years. Then using this information and information on average km we constructed these variables for the period 1914-1930. On the other hand, data on variables that capturing network quality[3] by railroad companies such as number of stations, locomotives, freight cars, freight yards, doubly tracking, signaling equipment, among others, are too sporadic to be used. As we will see below, to capture network externalities we add to the regressions the total length of nationwide railroads and the population of the department in

[3] D. Puffert (1992) emphasized the role of spatial dimensionality of network externalities in the railroad system.

which the railroad companies had tracks. The latter is a proxy to control for the population of the regions connected by each railroad.

2.2 Econometric set up

The elasticity of demand for freight and passenger transport service is estimated for several specifications, using annual data from fifteen companies for the period 1914-1980. The exercise starts by defining a constant price demand elasticity specification for each given company i, $i = 1, \ldots, N$, in year t, $t = 1, \ldots, T$. In log form, we specify:

$$\ln Q_{it} = a_0 + e\ln P_{it} + b\ln K_{it} + g\ln Z_{it} + a_i + e_{it}, \qquad (1)$$

where:

Q_{it} is total freight service in terms of ton-km.

P_{it} is the unit price: real freight rate per ton-km.

K_i is kilometers of railroad track in operation.

Z_i is the set of control variables for other determinants of demand.

a_i is a company effect.

ε is the price elasticity of demand for freight, i.e., $\frac{\partial \ln Q}{\partial \ln P} = \varepsilon < 0.$

β is the railroad track length elasticity of transportation demand, i.e.; $\frac{\partial \ln Q}{\partial \ln K} = \beta > 0.$

e_i is the residual, and it is assumed to have mean zero $E[e_{it}] = 0$, and $Var[e_{it}] = \sigma_i^2$;

The set of control variables, Z, includes real GDP, population, and the opening date of each railroad that controls for the creation of railroads own demand for freight. The expected effect is that older companies had a larger level of ton-km or passenger-km, because they had more time to create their own demand.[4] Also we include a dummy for the companies that had tracks in the coffee regions because it is expected that they carry higher volumes of freight.[5] We

[4] The idea of introducing this dummy variable in the specification came from Summerhill, W. (1996). He estimated railroad demand function for freight in Brazil by 1887.

[5] McGreevey, W. (1975) classified the Antioquia, Cucuta, La Dorada, Girardot-Tolima, and the Pacifico railroad as the railroads of the coffee regions. This dummy is only included in the estimation of the freight demand function.

also include the length of national highways to control for inter-modal competition.[6] This variable may also capture some network externalities between railroads and highways. To capture the network externalities of the railroad system itself, we add the total length of nationwide railroads and the population of the department in which each railroad company had tracks as other control variables. Finally, equation (1) is also used for estimating the demand function for passenger transportation service, in which Q is total passenger per km, and P is the real passenger fare per km.

The estimation of (1) assumes that prices are exogenous, or they are not controlled by supply shifts, because the observed fares are regulated prices. However, in later estimations this assumption is relaxed. Two parametric approaches are used. The first uses pooled data equations, which assume that the intercept is the same across companies. The second approach uses fixed effects equations, which assume each railroad has a separate intercept. Individual effects, α_i, can be fixed or random. The random effect model is excluded because: i) there are not enough degrees of freedom to get consistent between estimator, and ii) the sample of individuals is equal to the population (the fifteen railroad companies).The presence of fixed effects is usually evaluated by means of the common slope test, which is an F test based on the restricted (pooled) and unrestricted (fixed) sum of square residuals, where the null is the common intercept hypothesis. The rejection of the null favors the model of fixed effects. In addition, all panel estimations took into account the correction for heteroscedasticity across and within panels.

An extension of (1) is to allow endogenous prices for freight and passenger transport services. Then instrumental variables are used in the estimation of both pooled and fixed effects estimations (i.e., *within* two least square estimations). Besides the exogenous variables in the model the set of instruments for rate includes the rate lagged one period, and a group of dummy variables. This group includes a dummy for railroad ownership (i.e., if the railroad is owned by the nation or by the private sector), a dummy for the period in which railroads were administrated by the *National Railroad Administrative Council*[7], and a dummy for the period in which the

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[6] A better indicator of inter modal competition could be the unit prices that trucks and buses companies charge for freight and passenger transportation service. Unfortunately, a complete information is not available.

[7] The National Railroad Administrative Council (Consejo Administrativo de los Ferrocarriles Nacionales) was created in 1931. The *Council* has the function of organizing, regulating all the issues related with railroad constructions and maintenance. It is important to mention that the *Council* decided that rates and fares should be fixed according to social public interest rather than to railroad profit maximization. Therefore, the *Council* reduced both freight and passenger fares.

railroads financed with the American indemnity for the separation of Panama[8] entered in operation.

A second functional form is based on non-constant price elasticity model. This specification assumes a quadratic term in prices. Using the same definitions as before the non-constant model is given by:

$$\ln Q_{it} = a_0 + e\ln P_{it} + b\ln K_{it} + g\ln Z_{it} + f_1\ln P_i \times \ln K_{it} + f_2\ln P_i \times \ln Z_{it} + d \times [\ln P]^2 + e_{it} \qquad (2)$$

where the price elasticity of demand for freight is given by the following parametric equation:

$$\frac{\partial \ln Q}{\partial \ln P} = e + f_1 \ln K + f_2 \ln Z + 2d \ln P$$

and the railroad track length elasticity of transportation demand is

$$\frac{\partial \ln Q}{\partial \ln K} = b + f_1 \ln P$$

This specification is employed using both exogenous and endogenous rates. Testing the functional form of the demand functions, constant price elasticity against non-constant price elasticity, is done through Wald's tests.

2.3 Results

The estimations of demand elasticities are carried out for 1914-1980 period. This sample is divided in three sub-periods, which are broken according to the main institutional changes in the development of railroads in Colombia. The first includes the years from 1914 to 1930. This period is characterized by an active and strong government support in the building of the main track lines.[9] The second phase goes from the thirties to the mid-fifties,[10] which the completion of

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[8] During the government of Pedro Nel Ospina (1922-1926), the United States paid to the Colombian Government US$25,000,000 as an indemnity for the separation of Panama (that took place in 1903). This indemnity was a windfall gain for the economy that joined with an increase in the international coffee price in 1924 and the insertion of the country in the financial world markets contributed to end the recession of the early twenties. Large percentage of the resources from the indemnity were oriented towards public works constructions, especially to transportation infrastructure.

[9] The Antioquia, Barranquilla, Caldas, Cartagena, Norte section 1 and 2, Cucuta, Cundinamarca, Girardot, La Dorada, Magdalena, Pacifico Sur, Nariño and Nordeste railroads constituted the panel units for the first period.

[10] The panel units that are included in the second period are the Antioquia, Barranquilla, Caldas, Cartagena, Norte section 1 and 2, Cucuta, Cundinamarca, Girardot, La Dorada, Magdalena, Nordeste, Nariño and Pacifico railroads.

some lines, and the changes in government transportation policy in favor of highway constructions are the main features of that period. In addition, during these years the *National Railroad Administrative Council* was created and the policy of low rates were fully implemented. The last,[11] covers from the mid-fifties up to the eighties in which railroads become a state enterprise known as *Ferrocarriles Nacionales* and all the railroads were nationalized.

The exercise starts contrasting the null hypothesis of homogeneous intercepts against the fixed effects model in which individual differences are captured by the regression intercept. In the presence of heterogeneous individuals the pooled OLS estimations may lead to serious bias.[12] Thus, the fixed effects model yields unbiased estimators because it controls by non-observable variables associated with each company characteristics. For all periods, the results from the F-test reject the hypothesis of homogenous intercepts in favor of the fixed effects. Regarding the functional form the results from the Wald's test indicate that the null hypothesis of constant price elasticity is not rejected.[13] In sum, the relevant results on the demand elasticity parameter come from the fixed effects, and the constant price elasticity specification.

Table 1 shows a summary of the results of freight and passenger demand elasticities.[14] Column (2) and (6) has the results from the fixed effect estimations based on the constant price elasticity model. In particular, the former reports the inferences when exogenous prices are assumed, while the latter shows the estimations for the case of endogenous prices.

For the entire sample, the demand for freight and passenger transportation tends to be inelastic to changes in rates. In fact, the elasticity for freight is –0.81 and –0.96, when rates are considered exogenous and endogenous respectively. Concerning passengers, that elasticity is lower [–0.58 and –0.66]. These results suggest that the government's policy of reducing rates did not attract substantial increments in the volume of freight and passengers. Rates were set below the optimal level, because public authorities set them according to social service criteria rather than monopolists' profit maximizing prices. Thus, railroads operated in the inelastic proportion of their demand curves. Regarding railroad tracks, transport service for freight is elastic to tracks' length [1.63 and 1.66], while transport service for passenger is not [0.69 to 0.72].

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[11] The panel units included in this period are the Antioquia, Centrales, Magdalena and Pacifico railroads.

[12] See, Hsiao C. (1995).

[13] We estimate the non-constant price elasticity for the entire period. Then, based on these coefficients, elasticities for each sub-period are evaluated at the means of the explanatory variables.

[14] Ramírez María Teresa (1999) presents the complete results from the constant price elasticity for the pooled and fixed effects estimations.

In addition, it is important to analyze by periods the railroad's activity. The evolution of the operating revenues is a good indicator for that purpose.[15] Graph 1 depicts that revenues had a positive trend from 1915 to 1946.[16] Thereafter, that trend is decreasing.[17] In particular, from 1915 to 1930 railroads operating revenues grew at annual rate of 7.5%, along with an increase in the operating capacity. In fact, the transported freight grew on average in ton-km in 15% per-year, and passenger movement grew 18%. Nonetheless, between 1931-1946 revenues grew only 3% per-year. During this period new railroads entered in operation. These projects were financed with the American Indemnity resources and external debt.[18] Despite this network extension, railroad revenues were less than half of those in the previous period; the growth rate fell to 8% per-year in freight and 7% for passengers (graph 2). The demand elasticity also fell for this period. The price elasticity for freight is considerably lower [–0.18 and –0.38] than those reported for 1914-1930 period [–0.44 and –0.54].[19] In contrast, the demand elasticity for passengers was slightly higher passing from –0.58 to –0.67 between both periods when prices are exogenous, and from –0.59 to –0.88 when prices are endogenous in the system. Regarding the demand elasticity for railroad tracks, this coefficient fell drastically between these periods for both freight and passengers.

The results suggest that the economy responded in large magnitude to the earlier railroad expansion, while the later additions in track length had only a moderate impact on railroad's transportation services. The average ton-km by line was almost constant between 1914 and 1942. At least two arguments could explain this outcome. First, the development of highway construction produced competitive pressure to railroads with higher quality service despite higher fares (table 2).[20] Second, the economic situation in both domestic and international markets created a sharp drop in Colombia's international trade, due to i) the economic recession of the thirties, and ii) World War II. In sum, railroad companies were not able to sustain their own demand or create a new one. The drop in the demand elasticity also reflects the relative inefficiency of Colombian railroads. After 1955, freight price elasticity and track elasticity are

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[15] See Gómez, A. (1982).

[16] The annual rate of growth was 5.4% for total railroads, and 8.2% for national railroads.

[17] The years after 1946 were characterized by the nationalization of the railway system that results in large reduction in railroad rates .

[18] For instance, four national railroads, which their construction started in the previous decade, were opened in 1931.

[19] Summerhill, W. (1996) found that the price elasticity of demand for railroad transportation in Brazil by 1887 was –0.7. Coatsworth, J. (1976) found that this elasticity was –0.558 in Mexico by 1910.

[20] See *Memorias del Ministerio de Obras Públicas y Transporte* during the 1930's.

much more elastic than in previous periods (table 1), while passenger price elasticity remained the same. This result is mainly explained by the construction of the Atlantic Railroad, which connected new strategic regions to the nation's capital.

Regarding the other control variables, it is important to mention that, in general, the total length of nationwide railroads was not significant in the estimations while population by department was significant with the expected sign in the equations of passenger demand; and the length of national highways was also significant with the expected sign in both freight and passenger demand equations.

2.4 Social Savings Estimation

According to Robert Fogel (1964) the social saving methodology consists in calculating in any year the difference between the actual cost of shipping goods in that year and the alternative cost of shipping exactly the same bundle of goods without the railroads.[21] He used this methodology to evaluate the proposition that railroads were indispensable to American economic growth during the nineteenth century. He found that railroads did not make an overwhelming contribution to American economic growth.[22] After Fogel's study, the counter-factual methodology, social savings estimations, was applied to different countries by a large number of researchers.[23] However, social savings methodology has generated large controversy because its calculation assumes a counter-factual scenario that involves very strong assumptions.[24] Despite the criticisms on this methodology,[25] we decided to calculate the social saving for 1927 because i) there is a complete information on rates for this year, and ii) social saving estimations keep in accordance

[21] See also, P. O'Brien (1977).

[22] Fogel (1964) states that " Economic growth was a consequence of knowledge acquired in the course of the scientific revolution of the seventeenth, eighteenth and nineteenth centuries. This knowledge provided the basis for a multiplicity of innovations that were applied to a broad spectrum of economic process. The effectiveness of the innovations was facilitated by political, geographic and social rearrangements. All of these developments began before of the birth of the railroad and the railroad was not needed for transformation in economic life that followed from them". (Page 235).

[23]For instances, John Coatsworth (1981) estimated the social savings of railroads in Mexico, William McGreevey (1975) calculate the social savings for Colombia's coffee railroads, Antonio Gomez Mendoza (1982) for Spain, William Summerhill (1996) for Brazil, G. R. Hawke (1970) among others.

[24] For a survey on this controversy, see Fogel, R. (1979).

[25] Calculations of social savings on backward economies received major criticisms. For instance, G. Toniolo (1983) stated that the social savings approach is not fruitful for the study of the contribution of railways to the economic growth in backward economies (page 227).

with the new line of research on railroads, and allow us to contrast the Colombian experience with other studies.

Railroads in Colombia were constructed with the purpose to connect productive regions with the Magdalena River,[26] and then with seaports. For this reason, railroads were a complementary system to fluvial transportation rather than a substitute. Indeed, railroads were mainly a substitute to the costly earlier land transportation, say mules, human porters and animal-drawn carts.

Table 2 presents the rates by mode of transportation taken from different sources. For instance, McGreevey (1975) calculated that the average rate for freight transportation by mule between 1845-1930 was $0.416 per ton-km, while the average rate for freight transportation by railroads between 1905-1929 was $0.15 per ton-km. According to the Ministry of Public Works[27] in 1927 the rates for freight by mode of transportation were by human porters $1 per ton-km, by mules $0.4 per ton-km, by animal-drawn wagons $0.2 per ton-km, by the Magdalena River $0.024 per ton-km, and by railroads $0.05 per ton-km. Thus, transportation rates by animal-drawn wagons were four times larger than railroads' rates, and mules' rates were eight times larger. It is important to note that the Magdalena River's freight rates were always lower than railroads' rates.

Social savings generated by railroads are calculated based on the above information. Table 3 presents the estimations for 1927. This year seems a good choice since the government strongly supported the construction and maintenance of railroads, and the alternative modes to railroad transportation were still mules and animal drawn carts. The results indicate that by 1927 the social savings represented 7.8% of the GDP, assuming that mules were the alternative mode of transportation to railroads, and 3.37% of the GDP, assuming that animal-drawn carts were the alternative mode. Comparing these values with the international evidence, their magnitude is very similar to those estimated for the United States for the nineteenth century (see Fogel, 1964 and Fishlow, 1965). These values are higher than those calculated by William McGreevey (1975) for the Colombian coffee railroads of 3.2% of the GDP in 1924, assuming mules as the main alternative mode of transportation to railroads. However, they are considerably lower than the estimated social savings for countries with pre-rail conditions similar to Colombia. For instance, William Summerhill (1996) estimated a social saving for the Brazilian Railroads of 5% of the

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[26] The *Magdalena* River is the main navigable river in Colombia.

[27] See *Memorias del Ministerio de Obras Públicas y Transporte,* 1927

GDP for 1887, and 22% of GDP for 1913, and John Coatsworth (1976) estimated a social saving for Mexico equal to 24% of the GDP for 1910.

Finally, one of the main criticisms to the social saving methodology is that in its calculation a price elasticity of demand is assumed equal to 0. To correct for this problem Fogel (1979) proposed to adjust the social saving as: $\frac{S_t}{S_0} = \frac{\varphi^{1-\varepsilon} - 1}{(1-\varepsilon)(\varphi - 1)}$ for $\varepsilon \neq 1$, where S_t is the true social savings, S_0 is the social saving computed on the assumption that $\varepsilon=0$, φ is the ratio between the alternative mode of transportation rate and the railroad rate. Following this suggestion, the social saving indicator for Colombia was adjusted assuming a price elasticity of demand of $|0.5|$. The new result is a social saving of 4.11% of GDP if mules were the alternative mode of transportation, and 2.25% of the GDP if animal-drawn cart is assumed as the alternative mode of transportation. Adjusted for the same price elasticity of demand the social savings on railroads freight service in Mexico by 1910 was 16.6% of the GDP, and the social savings in Brazil by 1913 was 11.2% of the GDP.[28] Again these values are considerably higher than those estimated for Colombia in 1927. This result suggests that the gains from railroads' construction in Colombia were lower than the gains in other countries with similar pre-rail transportation systems.

3 Link between railroads and the Colombian export sector: The coffee case

The economic historians have emphasized the existence of a close inter-relationship between railroad development and the rise of coffee exports in Colombia. Most of the literature has characterized that link as indispensable (Beyer, 1947, McGreevey, 1975, Urrutia, 1979, and Poveda, 1986, among others)[29]. The literature emphasizes this interrelationship based on the fact that former railroads were constructed with the purpose to move coffee to the ports. For example, the *Cucuta* railroad constructed in 1888 crossed the main coffee zones at that time. Thus, to make competitive coffee exports from other regions it was necessary to reduce the transportation cost through railroad constructions.[30]

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[28] See Summerhill, W. (1997)

[29] For instance, Urrutia, M. (1979) states that "The coffee history is closely related with the railroad history. Without coffee, railroads would not have been economically feasible, and coffee would not have been expanded without railroads."

[30] See Urrutia, M. (1979) and Poveda, G. (1986).

Historically, from the last years of the nineteenth century up to the beginning of 1990's coffee was the main exported commodity.[31] The expansion of coffee production started by the end of the 1880's and by 1898 the share of coffee in total exports was more than 50%. However, coffee production declined during the *one thousand days' war* (1899-1902), and only by the mid 1910's did coffee exports reach again the observed values of 1898. The periods of coffee expansions coincided with the impulse of railroad constructions. Beyer (1947) estimated that 71% of the total kilometers of railroads by 1898, and 80% by 1914, were utilized for coffee transportation (table 4). In addition, coffee exports represented more than 70% of total freight moved by the Antioquia railroad in 1895, 70% of the total freight moved by the Girardot railroad in 1908, and a similar percentage was observed for the Barranquilla railroad in 1891.[32] These figures have been used[33] to highlight the influence of railroads on the expansion of the coffee sector. However, railway lengths were insufficient and unconnected among regions. Consequently, these numbers have to be interpreted with caution. According to Palacios (1980), by the 1910's mules continued to be the main means of transporting coffee.[34]

Figure 3 depicts railroad freight by sectors since the mid 1920's. The graph shows that in relative terms the agricultural economy was closely related with railroads. Agricultural commodities represented 30% of the total volume of goods transported by rail in 1930's. Hereafter, its share remained constant, around 25%, until 1970. Graph 4 depicts the quantity of coffee shipped by railroads during the period 1926-1981. As we can observe, the absolute amount of total coffee freight fell throughout the period. For instance, railroads shipped 518,412 tons of coffee by 1946, while they only shipped 271,526 tons in 1966, and only 168,103 tons in 1978. By the end of 1920's the share of coffee was 16%. Thereafter, it started to decline, and by 1961 that share represented 5% of the total freight. One reason that explains such a decline was the appearance of truck competition, which covered large parts of the coffee regions. Another factor was that the *Buenaventura* port, located in the Pacific Ocean, became the main port for coffee exports. In fact, more than 60% of coffee exports were shipped by the *Pacific* railroad to the *Buenaventura* port in 1950,[35] so the other coffee railroads[36] lost their importance in transporting

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[31] From 1942 to 1962 coffee represented more than 80% of the value of total exports and, until 1985 coffee represented more than 50% of this value.

[32] See Beyer, 1947

[33] See Poveda Ramos, G. (1986).

[34] See Palacios, M. (1980)

[35] See Anuario General de Estadistica, several years.

coffee. For instance, the share of coffee in the total freight transported by the *Antioquia* railroad passed from 70% in 1895 to 20% in 1933 and to 7% in 1950. Similarly, for the *Girardot* railroad that share passed from 70% in 1908 to 7% by 1950.[37] To sum up, railroads appear to have played an important role in coffee expansions, because early lines were constructed mainly to transport coffee.[38] The purpose of this section is not to determine if there was or was not a relation between railroads and coffee expansion. Instead, the interest is in answering the questions: i) to what extent railroads affected coffee expansions? , ii) How large were those effects?, iii) There was a two way causality? Or what was the direction of the causality?

3.1 Data

Time series information are available for railroad tracks (in km) and coffee exports (in bags of 60 kilograms) from 1896 to 1990. However, the analysis is narrowed for the period 1904 to 1955, for two reasons. First, during the *one thousand days' war* (1899-1902) coffee's crops were destroyed, railroad construction was stopped, and railroad companies stopped operations. Second, because of the consolidation of the highway system by mid 1950's, railroads lost their importance in coffee transportation.

3.2 Results

This section employs time series techniques, *Granger Causality* tests and Vector Autoregresive (VAR) estimations, to answer the above questions. To avoid the problem of spurious regression, the starting point is to determine the stationarity of the series, that is, to evaluate if the series have a unit root. These tests are carried out through the Augmented Dickey-Fuller (ADF) test.[39] The result indicates that the null hypothesis of a unit root is rejected at 5% of significance for both cases. Therefore, the series are stationary, i.e., I(0).[40] Then, the *Granger Causality* test is used to determine whether railroad constructions influenced coffee exports. Table 5 summarizes the

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[36] Such as the Antioquia Railroad, The Girardot Railroad, The Caldas Railroad, The Cucuta Railroad and La Dorada Railroad.

[37] Own calculations based on data from the *Anuario General de Estadistica* (several years).

[38] As pointed out by Bayer(1947) the pattern to transport coffee during the XIX century was fairly uniform: from plantation to river by mule, from river port to coastal port by boats.

[39] The lag structure was chosen according to the Akaike Information Criteria (AIC).

[40] This result was confirmed through Phillips-Perron Tests.

results.[41] They suggest that there was a two-way relationship between these two variables, as the literature has suggested. Coffee exports helped to explain the expansion in the railroads system, and railroads helped to explain the expansion in coffee exports. This result is not surprising because railroads were built to transport coffee to the ports. In addition, coffee was the compensated freight for railroads that guaranteed their economic feasibility, at least in the first years of operation. The following relevant question is to establish the magnitude of such effects. The estimation of the following VAR system is carried out to study the dynamic interrelationship between coffee exports and railroad track length for the period 1905-1955:

$$y_t = a_1 + A_{11}(L)y_{t-1} + A_{12}(L)x_{t-1} + m_{1t} \quad (3)$$

$$x_t = a_2 + A_{21}(L)y_{t-1} + A_{22}(L)x_{t-1} + m_{2t} \quad (4)$$

where y_t is the log of coffee exports during time t, x_t is the log of railroad track length during time t, a_i is the constant, A_{ij} are the polynomials in the lag operator L, and m_{1t} , m_{2t} are the white-noise error terms. An important issue is the determination of the optimal lag length. The ACI and the SBC indicate that 2 lags are the most appropriate lags for the system.

Graphs 5 and 6 depict the results from the impulse response function. In this case, the impulse response function quantifies the effects of an initial shock of the railroad track length on coffee exports, and the effects of a shock of coffee exports on the railroad length.[42] In the VAR models the shocks are measured as a first period standard error shocks. To standardize the response of one variable to the other, the units of the impulse response function are in terms of residual’s standard deviation.[43] Graph 5 depicts the effects on railroad length of a one standard deviation shock to the error term in the coffee export equation (μ_{1t}). The vertical axis measures the response of the shock, while the horizontal axis measures the time horizon following the shock. The results indicate that increases in coffee exports affected positively railroad track length. That is, expansions in coffee exports induce new construction or expansion in the railway

[41] The AIC selects a lag length equal to two.

[42] The identification issue it is very important here. To orthogonalized the innovation we used the Choleski decomposition. The order of the variable was: log of railroad tracks, log of coffee exports. However, in our results the order of the variables had not qualitative effects since the contemporaneous correlation between the errors is very small (0.092). Therefore, in this case the order of the factorization makes little difference.

[43] We divide the response of a variable by the standard deviation of its residual variance. Then all the responses are in fractions of standard deviations. This is the method used by the statistic package RATS. See RATS user’s manual, version 4 (1996)

system. After one year of the innovation, railroads constructions began to increase, reaching their maximum response at four years; after that the effects decline. However, the magnitude of this response is low, because it represents at most one-third of the standard deviation. On the other hand, Graph 6 plots response of coffee exports due to a shock in railroad tracks length. Increases in railroad length led increases in coffee exports. After four periods these effects start to vanish. The magnitude of these effects is also low (one-fifth of the standard deviation).

Table 6 presents the variance decomposition for a forecasting horizon of 10 years. The variance decomposition of the error indicates what proportion of the movements in a series is due to its own shocks against shocks to the other variables. At the first steps, much of the variance of the error in both series is explained by their own shocks. After the third period, the series gain importance in explaining each other's innovations. For instance, the change in coffee explains 8.7% of the forecast error variance of railroad length in the fourth period. Similarly, railroad length explains 7.4% of the forecast error variance of coffee exports. These almost symmetrical results confirm the feedback relationship suggested by the results of the Granger Causality test. The results suggest that there was a feedback relationship between coffee exports and railroads' expansions, but the magnitude of the response of one variable to changes in the other was small. One reason is that the Colombian railway system had few and unconnected tracks that could not substitute completely for the traditional means of transportation for coffee by land, mules, at least during the first thirty years of the century. Then railroads were replaced by the highway transportation system, and the importance of railroads in transport coffee declined drastically. This result leads to the question of what was the interrelationship between highway developments and coffee expansions?

The same procedure is applied for the log of coffee exports and kilometers of highways. The exercise covers the period 1936-1990. The second step is to estimate the VAR system. According to the ACI the optimal lag are 2 periods. Graphs 7 and 8 plot the time path resulting from the impulse response function. In particular, Graph 7 plots the effects on coffee exports of a one standard deviation change in highways' length. Increases in highways' length lead to increases in coffee exports. The magnitude of this effect is considerably larger than that produced by increasing railroads' tracks. The coffee exports response to changes in highway's kilometers represents half of the standard deviation while the response to changes in railroad tracks' kilometers is one-fifth of the standard deviation. On the other hand, graph 8 plots the response of highway's length to increases in coffee exports. The graph indicates that increases in coffee exports affected positively the length of highway. One interpretation could be that increases in coffee's exports raised the economy's income enhancing investment highways. The results from the variance decomposition confirm the above results (table 7). At period four, highway length explains 20% of the forecast error variance of coffee exports, a larger percentage than that explained by railroad length (7.4%). In addition, the same exercise is applied for the log of coffee exports and the log of highways plus railroads kilometers.

In sum, the results from those exercises suggest that railroads did not play the overwhelming role in the expansion of coffee exports in Colombia, in contrast to the traditional hypothesis. Finally, the construction of railroads favored the export sector in other Latin America countries to a greater extent than in Colombia. In particular, larger gains took place in Mexico, where half of the social savings on railroads freight services were attributed to the export sector.[44] On the other hand, Summerhill (1995) points out that coffee growers in Brazil obtained large benefits from the decrease in transport costs made possible by railroads, but over time, similar to Colombia, the impulse to coffee production from cheap transport declined.[45]

4. Transportation's infrastructure developments and its effects on market integration: Convergence in agricultural commodity's price among regions.

Developments in the transportation infrastructure lower the cost of freight and reduce commodity prices in the market. In this way transportation's developments link distant markets and reduce the price gaps for the same commodity across regions. In other words, as a consequence of reduction in transportation costs, commodity prices among regions tend to converge resulting in an integration of the market. This is the hypothesis that this section attempts to test empirically for agricultural prices in Colombia. The primary result is that price dispersion across region declined sharply during the thirties with the development of highway infrastructure, and the expansion of the railway system, but after that no further major declines in inter-regional price dispersion took place.

4.1 Data

To examine whether declines in transportation costs, due to expansions in transportation infrastructure, can explain reductions in the divergences of agricultural prices among Colombian cities, we assembled annual price series for eight agricultural commodities for the twelve larger

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[44] See J. Coatsworth (1981)

[45] See W. Summerhill (1995), page 165.

cities in the country. The goods in the sample are potato, rice, corn, sugar, salt, *panela*,[46] plantains and red beans, which are typical components of a household consumer basket in Colombia;[47] and the cities are Bogotá, Barranquilla, Bucaramanga, Cali, Manizales, Medellín, Pasto, Cartagena, Cucuta, Naiva, Pereira and Villavicencio[48]. Our main sources of information are the *Anuario General de Estadística de Colombia*, the *Anuario Estadístico del Ministerio de Agricultura*, and the *Boletín Mensual de Estadístical del DANE*. Price data were assembled for the period 1928-1990.

4.2 Agricultural Price Convergence in Colombia: 1928-1990

This section use two different approaches to measure agricultural price convergence across main regions in Colombia. The first one is to examine the evolution of a coefficient of variation among cities for each agricultural price series.[49] We construct a coefficient of variation for eight agricultural commodity prices among the twelve larger cities[50] of Colombia from 1928 to 1990.[51] Graph 9 illustrates the evolution of price dispersion among regions. The results suggest that inter-regional price dispersion was substantial for the earlier years of the thirties. That large dispersion could be the result of the deficiency in transportation infrastructure, partly because of geographical barriers, that results in higher transportation costs[52] and isolation of the regions. The lack of an adequate transportation infrastructure explains that the production of some commodities was oriented mainly to supply local markets making the quantity of goods moved across regions very small. However, during the thirties, the coefficient of variation declined

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[46] *Panela* is a kind of brown sugar that is compacted in small blocks. *Panela* is a commodity broadly consumed in Colombia.

[47] Actually, sugar, salt and *panela* are not indeed agricultural goods. Sugar and *panela* can be classified as manufactured agricultural goods, while salt is a manufactured mineral good.

[48] As in Slaughter (1995), it is assumed that city's prices reflect the overall regional price. Of course, as he pointed out rural prices probably exceed urban price because of additional transportation costs.

[49] The coefficient of variations is defined as the standard deviation of the series divided by its mean.

[50] Under the assumption that the price of each city represents the price of its own region.

[51] W. Summerhill (1995) uses this approach to illustrate the degree of intra-regional market integration due to transportation improvements that took place during the second half of the 19th century in Brazil. He computes a coefficient of variations for local coffee prices among thirty-six counties in the province of Sao Paulo finding that intra-regional price dispersion fell from 0.27 in 1854 to 0.14 in 1906.

[52] Higher transportation cost were also the results of higher charges imposed for transferring cargo, higher terminal handling costs, and higher insurance rates. According to Currie (1950), the combination of these costs raised 20 to 25 percent the transportation costs over what might otherwise be reasonably expected (page 102).

sharply. In fact, by the end of 1930's regional price dispersion was considerably smaller than in the previous decade. For instance, the coefficients of variation of some agricultural prices in 1938 were three times smaller than those recorded in 1928. This decline might be associated with the development of highway infrastructure, and the consolidation of the railway network[53], which lowered freight fares and interconnected markets. From 1945 to 1990 coefficients of variations, in general, maintained a rough constancy. Then, no further major declines in inter-regional price dispersion took place in Colombia. In particular, graph 9 shows that *panela* and potatoes were the goods in which the reductions in inter-regional price dispersion were larger. In fact, the coefficient of variation for *panela* fell from 0.60 in 1928 to 0.17 in 1940, and for potatoes it fell from 0.41 in 1928 to 0.22 in 1940. It is important to mention that these two commodities are produced mainly in the central region of country where major developments in transportation infrastructure took place. On the other hand, the price of rice presented the smaller dispersions among cities. This result is explained by the fact that rice is produced is various regions of the country (mainly in Bolivar (north), Tolima (center) and Meta (center-south)).

The second approach to examine whether there was commodity price equalization across regions is to estimate the rate of price convergence among pairs of cities. To this end, we follow M. Slaughter (1995) who estimates the commodity price convergence that was induced by the antebellum transportation revolution in the United States. The relation between prices in region A and B can be written as $P_B = (1+c_{ad})\, P_A$, where c_{ad} is the percentage ad-valorem transportation costs, and $P_A < P_B$. P_B/P_A goes toward one when transportation costs approaches to zero. This relation is estimated in terms of the log-linear regression specification: $ln(P_B/P_A)_{it} = a_i + bt + e_{it.}$ If $b < 0$ the series converges, if $b > 0$ the series diverges. To estimate the equation, Slaughter constructs price ratios for each chosen commodity in each city.[54] The ratios should be initially greater than one so that convergence means that the ratios decline towards one. He finds a strong convergence in each commodity ratio.[55] Then, he concludes that transportation revolution

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[53] Saying that the railways system was consolidated by the end of the 1930's can be an exaggeration, since Colombia had few and disperse railroads tracks compared with other countries, even countries with the same level of development.

[54] He estimated commodity price convergence among six cities: Boston, New York, Philadelphia, Charleston, New Orleans and Cincinnati.

[55] Slaughter (1995) also assumed specific transportation costs then the relation between prices in region A and region B is given by $P_B = P_A + c_s$, where c_s is the dollar specific transportation costs and again $P_A < P_B$. Since the transportation revolution lowered c_s then $(P_B - P_A)$ approaches to zero when c_s tends to zero. He constructed price differences for each commodity in the six cities in the way that price differences should be initially greater than zero.

strongly integrated product markets because it sharply cut interregional transportation cost by building canals and railroads.[56]

We examine convergence among seven cities in Colombia. The cities represent six main regions within the country. The central region is represented with Bogotá, the west central with Medellín and Manizales, the north with Barranquilla, the east with Bucaramanga, the west pacific with Cali, and the south with Pasto. We chose these cities because besides that they represent the major regions of the country; they have the larger time series coverage for the commodity prices. The commodity price sample was reduced to *panela*, potatoes, corn, rice, sugar and salt. We drop from the sample plantains and red beans because the time series for these goods are too sporadic, i.e. these series do not have continuos coverage across cities for the study sample. In total we construct twenty-one price ratios for each commodity. As we mention above, the ratios are constructed to be initially greater than one, so convergence is met when the ratios decline towards one.[57] Tables 8 to 13 summarize the results for the convergence estimation between pairs of cities. We estimate convergence rates (β) first for the entire period 1928-1990, and then for the 1950-1990 sub-period, when major developments in highways infrastructure took place. Table 8 reports the result for the potato price series. Potato prices are lower in Bogotá and Pasto, which are located in the main regions that produce this good. For the first period, only eight price ratios converge towards one; two ratios diverges; and the coefficient of the other eleven price ratios are not statistically significant. The magnitude of the estimated convergence rate for all the eight price ratios that converge is very small. In fact, the range for the estimated convergence rates varies from -0.0075 to -0.0020. Taking for example the larger rate (Cali/Manizales), the results indicate that this price ratio converged towards one at a rate of 0.75%. This means that the price ratio in 1990 had fallen to about 63% of its 1928 value; and the half–life of convergence is about 92 years. Looking the ratios, the results suggest that in general geographical proximity explain the convergence. It is the case of ratios such as Bucaramanga/Bogotá, Cali/Bogotá, Medellín/Barranquilla, Cali/Manizales, Cali/Medellín, and Manizales/Medellín. Surprisingly, we did not find convergence between Manizales/Bogotá and Medellín/Bogotá. It is important to highlight that none of the ratios that include Pasto converge towards one. This means that there exists a segmented market for this commodity.

[56] See Matthew Slaughter (1995), page 1.

[57] See Matthew Slaughter (1995), page 11.

The results for the sub-sample 1950-1990 are quite different. First, the rates of convergence are, in general, larger than the rate for the entire period. In fact, the range for the estimated convergence rates varies from –0.0011 to –0.0032. To compare the results, we take for instance the Barranquilla/Bogota ratio. For the entire period, the rate of convergence is –0.0045. This means that the price gap between the two cities vanishes 0.45% in one year, and the half-life of convergence is about 150 years. While the results for the 1950-1990 sub-sample indicate that the gap between the prices vanishes 1.1% per year, and the half-life of convergence is about 61 years. Two more results are also important. First, all the price ratios that include Barranquilla, except for Barranquilla/Pasto, tend towards one. This result means that after the fifties the potato price of Barranquilla tended to be equal to the potato price in other cities, as a result of improvements in the transportation network. Second, the potato price of Pasto diverges from the potato price of all the cities. This result can be an evidence of market segmentation for this good.

Table 9 presents the results for the *panela* ratios. For the entire period twelve ratios converge to one; two ratios diverge; and seven are not statistically different from zero. In general, the rate of convergence for the *panela* price is faster than for the potato price. The convergence rates lie between –0.016 and –0.0021.The faster convergences are between Bogotá and Bucaramanga, and Bogotá and Cali, which are cities with good transportation networks. In those cities, price ratios converged towards one at a rate of 1.5% per year. That is a price ratio in 1990 fell to about 41% of its 1934 level; and the half-life of convergence is about 46 years. The price dispersion between Manizales and Bogotá, and the lack of price convergence between Manizales and Medellín are two surprising results given their close geographical location. Again, the price in Pasto, which is the most remote city within the sample, does not converge towards the price of the other regions. For the 1950-1990 sub-sample, price six ratios tend to diverge in spite of their closer location. It is the case of Manizales/Medellin, Bogotá/Manizales, Bogotá/Medellín.

Table 10 summarizes the results for rice ratios. Twelve ratios converge towards one. However, the rate of convergence is slower than for the *panela* prices. The magnitude of the rates is between –0.0077 and –0.0021. The results of the sub-sample differ from the results of the entire period mainly in the fact that during the 1950-1990 Bucaramanga did not converge towards the price of the others cities. Table 11 presents the results for corn. Eleven price ratios between pair of cities converge but at very slow rate. In fact, the rate values are between –0.012 and –0.002. A puzzling result is the convergence between the prices of Pasto and Barranquilla since these cities are located in the extreme part of the country. For the period 1950-1990, it is important to highlight that the price of Bogota diverges at a rate near to 1% per year from the prices in Manizales, Medellín and Pasto. Table 12 presents the results for the price of salt convergence between pairs of cities. Again the evidence for the entire sample suggests that Pasto is not integrated with the market of other regions. However, for the 1950-1990 period the price from Pasto tends to converge towards the price of Cali, Manizales and Medellín. Finally, table 13 shows the results for sugar. For the entire period, there are eleven ratios that converge to zero, but at very slow rate, even slower than the rate of convergence for the others commodities. In this case the largest rate of convergence is –0.0046. For the sub-sample the rates of convergence are slower, and there are only seven price ratios that converge. This evidence suggests that nationwide the markets for this good are not integrated.

The results from this section indicate that market integration in Colombia has been limited and is still bound by the lack of adequate transportation networks. Therefore, transportation costs have high weight in explaining price difference of the same commodity across cities. In addition, the results suggest that there exist a group of cities, in particular the three larger cities (Bogotá, Cali, and Medellín) whose commodity prices have converged in the long run. This is associated with that fact that the transportation system, in particular highways, was developed mainly to join these markets and promote economic development in these regions. However, prices converge at very slow rate, making the pace of market integration also very slow.

5 Conclusion

Railroads did not play an overwhelming role in the Colombian economy, in contrast to other Latin American countries with similar pre-rail transportation system such as Brazil and Mexico. The social savings estimation indicates that the savings spanned by the development of the railroad network were considerably larger in Brazil and in Mexico than in Colombia. In addition, we found that railroads caused expansions in coffee exports, but the magnitude of these effects were lower than those suggested in the literature. Finally, the lack of an appropriate transportation infrastructure explains the dispersion in prices across regions in the country due to high transportation costs. This suggests that even highways did not help draw the country together.

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6. Tables

Table 1: Elasticities Results from Alternative Specifications of Demand in Colombia.

A. Price Elasticities of Demand for Freight Services (ton-km) and Railroad Track Elasticities: Summary

Period	Elasticities with respect to	**Price Assumed Exogenous**				**Price Assumed Endogenous**			
		Constant Elasticity		Non Constant Elasticity		Constant Elasticity		Non Constant Elasticity	
		pooled	fixed	pooled	fixed	pooled	fixed	pooled	fixed
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1914-1980	rate (real $)	-0.7944	-0.8087	-0.7301	-0.7794	-0.9377	-0.9660	-0.6688	-0.7039
	tracks(km)	1.4128	1.5901	1.3844	1.5944	1.3473	1.6628	1.3127	1.1975
1914-1930	rate (real $)	-1.3020	-0.4434	-1.2250	-0.8479	-1.5252	-0.5337	-1.0273	-0.9097
	tracks(km)	0.7217	1.3104	1.2092	1.5807	0.4137	1.0899	1.1960	0.8614
1931-1954	rate (real $)	-0.4672	-0.1775	-0.7964	-0.4964	-0.5530	-0.3777	-0.8087	-0.5117
	tracks(km)	1.5163	0.5836	1.3865	1.6530	1.5066	0.4731	1.1985	0.7353
1955-1980	rate (real $)	-1.0272	-0.9538	-0.8039	-0.7885	-1.5360	-1.4292	-0.7592	-1.1451
	tracks(km)	2.1499	2.1677	1.6497	1.7459	1.1704	1.9971	1.5029	1.5939

B. Price Elasticities of Demand for Passenger Services (in pass.-km) and Railroad Track Elasticities: Summary

Period	Elasticities with respect to	**Price Assumed Exogenous**				**Price Assumed Endogenous**			
		Constant Elasticity		Non Constant Elasticity		Constant Elasticity		Non Constant Elasticity	
		pooled	fixed	pooled	fixed	pooled	fixed	pooled	fixed
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1914-1980	fare (real $)	-1.1963	-0.5813	-1.3293	-0.8490	-1.3182	-0.6587	-1.5295	-1.0681
	tracks(km)	1.3632	0.6886	1.3204	0.6327	1.3019	0.7221	1.3804	0.5404
1914-1930	fare (real $)	-1.0660	-0.5818	-1.3197	-0.4313	-1.0807	-0.5875	-1.3168	-0.6117
	tracks(km)	0.9106	1.2729	1.5224	0.7475	0.8119	1.1016	1.1579	0.6169
1931-1954	fare (real $)	-1.5001	-0.6711	-0.7344	-0.9121	-1.5930	-0.8814	-1.5251	-0.9380
	tracks(km)	1.5474	0.5104	1.4511	0.7197	1.5256	0.5896	1.3777	0.5537
1955-1980	fare (real $)	-0.1788	-0.4491	-0.3683	-0.1359	-0.4765	-0.8201	-0.4184	-0.5021
	tracks(km)	0.9029	1.0958	1.3834	0.6870	0.9061	1.1984	1.3605	0.6466

Source: computed.

Table 2: Transportation Rates: Chosen years by mode of transportation

Years	Mode of Transportation	Observations	Freight Rates current pesos	Passenger Fares current pesos	Sources
Average 1845-1930	Mules		0.416 ton-km		William McGreevey (1975)
Average 1905-1929	Railroad		0.15 ton-km		William McGreevey (1975)
1924	Magdalena River		0.0175 ton-km ascent 0.01 ton-km descent	0.062 passenger-km ascent express 0.041 passenger-km descent express 0.045 passenger-km ascent ordinary 0.035 passenger-km descent ordinary	Ministry of Public Works Memoirs, 1924
1927	Human Porters Mules Animal-drawn carts Railroad Magdalena River		1 ton-km 0.4 ton-km 0.2 ton-km 0.05 ton-km 0.024 ton-km ascent 0.0135 ton-km descent	 0.0806 passenger-km ascent express 0.0533 passenger-km descent express 0.0585 passenger-km ascent ordinary 0.0455 passenger-km descent ordinary	Ministry of Public Works Memoirs, 1927
1930-31	Magdalena River Railroad (1931) Highway	 Boyaca Line-Trucks Cambao Line-Trucks Pacho Line-Trucks Boyaca Line-Bus	0.026 ton-km ascent 0.012 ton-km descent 0.071 ton-km 0.15 ton-km 0.135 ton-km 0.15 ton-km	0.0823 passenger-km ascent express 0.0589 passenger-km descent express 0.0648 passenger-km ascent ordinary 0.0502 passenger-km descent ordinary 0.0111 passenger-km 0.02 passenger-km 0.02 passenger-km 0.02 passenger-km 0.03 passenger-km (average)	Alfredo Ortega, 1932 Ministry of Public Works Memoirs, 1931
1936	Highway Railroad	Bogota-Villavicencio (125Km.) 1/	0.12 ton-km 0.051 ton-km	0.016 passenger-km 0.0091 passenger-km	Ministry of Public Works Memoirs, 1936
1938	Highway Railroad	Armenia-Ibague (100 Km.)	0.0653 ton-km 0.055 ton-km	0.03 passenger-km direct trip 0.025 passenger-km turist 0.015 passenger-km 3rd class 0.0098 passenger-km	Ministry of Public Works Memoirs, 1938
1947	Highway Railroad	Cali to the Sea Cali to the Sea	0.09 ton-km 0.07 ton-km		Annuals of Engineering, 1953
1967	*Caminos de Herradura:* (animal drawn carts) Local Road Main Highway Railroads		15 ton-km 1.2 ton-km 0.38 ton-km 0.25 ton-km	 0.082 passenger-km	Annuals of Engineering, 1966-67 Anuario General de Estadistica, 1968

1/ Before 1936 (date that the highway was opening), the transportation rate in this route (Camino de Herradura) of one ton of freight was $40.

Table 3: Social Savings Estimations on Railroad Freight Service in Colombia, 1927

Alternative mode of transportation: Mules	
a) Total Freight Services in ton-km 1/	191 million ton-km
b) Railroad Rate	$0.05
c) Mules transportation rates	$0.40
d) a*b	$9.55 million
e) a*c	$76.4 million
f) Social Savings1	$66.85 million
g) GDP	$850 million
h) Social Savings1 / GDP (%)	**7.86%**
Alternative mode of transportation: Animal-drawn carts	
a) Total Freight Services in ton-km 1/	191 million ton-km
b) Railroad Rate	$0.05
c) Animal-drawn wagon rate	$0.20
d) a*b	$9.55 million
e) a*c	$38.2 million
f) Social Savings2	$28.65 million
g) GDP	$850 million
h) Social Savings2/ GDP (%)	**3.37%**
Adjusted Social Savings by price elasticity of demand equal to -0.5	
Social Savings1	$27.57 millions
Social Savings1/ GDP (%)	**4.11%**
Social Savings2	$16.42 millions
Social Savings2/ GDP (%)	**2.25%**

1/ Excludes Livestock; Source: Computed

Social Savings International comparisons:
1. Assuming: e=0
Fishlow: 4% GDP ante-bellum USA, 1859
Fogel: 8.9% GDP at the very most, USA 1890
Metzer: 4.5% GDP Tsarist Russia, 1907
Gomez Mendoza: 19.2% GDP Spain, 1912
Coatsworth: 24%-38.5% GDP Mexico, 1910
Summerhill: 4.5% GDP Brazil, 1887
Summerhill: 22% GDP Brazil, 1913
McGreevey: 3.2% GDP Colombia, 1924 (coffee railroads)

2. Assuming: e=-0.5
Coatsworth: 14.9%-16.6% GDP Mexico, 1910
Summerhill: 11.2% GDP Brazil, 1913

Table 4: Kilometers of Railroads Utilized in Moving Coffee

Years	Total Railroad Km (a)	Railroads utilized in moving coffee km (b)	(b) / (a) (%)
1898	593	423	71.33
1914	1,143	919	80.40
1922	1,571	1,382	87.97
1933	2,892	1,943	67.19
1937	3,060	1,928	63.01
1949	3,426	2,246	65.56

Source: Beyer, Robert (1947) for 1898,1914,1922
Own calculations for 1933, 1937 and 1949.

Table 5:Granger Causality Test for Coffee Exports and Railroad Tracks: 1905-1955

Null Hypothesis:	p	F-stat	P-value
Log of railroad tracks does not Granger Cause log of coffee exports	2	6.2061	0.0044
Log of coffee exports does not Granger Cause log of railroad tracks	2	4.0402	0.0251

Source: Computed

Table 5a: Granger Causality Test for Coffee Exports and Kilometers of Highways: 1936-1990

Null Hypothesis:	p	F-stat	P-value
Log of national highway length does not Granger Cause log of coffee exports	2	8.5015	0.0007
Log of coffee exports does not Granger Cause log of national highway length	2	2.5758	0.0862

Source: Computed

Table 6: Results from the Variance Decomposition-Railroads Tracks and Coffee

1. Variance decomposition of Railroads Tracks

Period	S.E.	Tracks	Coffee
1	0.04531	100.00	0.00
2	0.05734	98.30	1.70
3	0.06584	94.70	5.30
4	0.07240	91.31	8.69
5	0.07787	88.15	11.85
6	0.08250	85.51	14.49
7	0.08648	83.32	16.68
8	0.08992	81.54	18.46
9	0.09292	80.07	19.93
10	0.09555	78.87	21.13

Source: Computed

2. Variance decomposition of Coffee

Period	S.E.	Tracks	Coffee
1	0.13900	0.00	100.00
2	0.14558	2.37	97.63
3	0.15997	4.82	95.18
4	0.16629	7.36	92.64
5	0.17301	9.76	90.24
6	0.17803	11.93	88.07
7	0.18260	13.83	86.17
8	0.18651	15.46	84.54
9	0.18998	16.87	83.13
10	0.19302	18.07	81.93

Source: Computed

Table 7: Results from the Variance Decomposition-Highways and Coffee

1. Variance decomposition of Highways

Period	S.E.	Highways	Coffee
1	0.05436	100.00	0.00
2	0.06604	97.30	2.70
3	0.07780	95.27	4.73
4	0.08817	92.67	7.33
5	0.09715	90.42	9.58
6	0.10481	88.65	11.35
7	0.11132	87.30	12.70
8	0.11684	86.26	13.74
9	0.12155	85.46	14.54
10	0.12558	84.83	15.17

Source: Computed

2. Variance decomposition of Coffee

Period	S.E.	Highways	Coffee
1	0.12957	0.00	100.00
2	0.16758	12.90	87.10
3	0.18280	17.05	82.95
4	0.19081	19.79	80.21
5	0.19576	21.75	78.25
6	0.19926	23.27	76.73
7	0.20196	24.49	75.51
8	0.20416	25.50	74.50
9	0.20600	26.35	73.65
10	0.20758	27.08	72.92

Source: Computed

Table 8: Commodity price convergence across cities: Potatoes, 1928-1990

Cities' Price Ratios ln (P_B/P_A)	Convergence Rate (β)	R^2	Number Observation
Barranquilla/Bogota	-0.0045 (0.0008)***	0.3389	61
Bucaramanga/Bogota	-0.00203 (0.0008)***	0.0942	61
Cali/Bogota	-0.0067 (0.0013)***	0.3304	61
Manizales/Bogota	-0.0014 (0.0011)	0.0232	61
Medellin/Bogota	0.00053 (0.0008)	0.0066	61
Bogota/Pasto	0.00068 (0.0011)	0.0059	61
Bucaramanga/Barranquilla	0.0022 (0.0009)**	0.0812	61
Cali/Barranquilla	-0.0005 (0.0011)	0.0038	61
Manizales/Barranquilla	0.0028 (0.0012)**	0.0812	61
Medellin/Barranquilla	-0.00343 (0.0011)***	0.1376	61
Barranquilla/Pasto	-0.00166 (0.0015)	0.0224	61
Cali/Bucaramanga	-0.005 (0.0011)***	0.2917	61
Bucaramanga/Manizales	-0.0006 (0.0008)	0.0097	61
Bucaramanga/Medellin	0.0008 (0.0012)	0.0087	61
Bucaramanga/Pasto	-0.0009 (0.0015)	0.0061	61
Cali/Manizales	-0.0075 (0.0008)***	0.5931	61
Cali/Medellin	-0.00745 (0.0016)***	0.2551	61
Cali/Pasto	-0.00081 (0.0015)	0.0055	61
Manizales/Medellin	-0.00354 (0.0015)**	0.08875	61
Manizales/Pasto	-0.0007 (0.0014)	0.0041	61
Medellin/Pasto	0.0017 (0.0015)	0.01959	61

Note: Standard Deviation in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Computed

Table 9: Commodity price convergence across cities: *Panela*, 1934-1990

Cities' Price Ratios ln (P_B/P_A)	Convergence Rate (β)	R^2	Number Observation
Barranquilla/Bogota	-0.0001 (0.0016)	0.0001	56
Bogota/Bucaramanga	-0.0162 (0.0012)***	0.7654	56
Bogota/Cali	-0.0152 (0.0011)***	0.7807	56
Manizales/Bogota	0.0053 (0.0011)***	0.2812	56
Bogota/Medellin	-0.01002 (0.0011)***	0.6265	56
Bogota/Pasto	-0.00212 (0.0025)	0.0131	56
Barranquilla/Bucaramanga	-0.0097 (0.0015)***	0.4519	56
Barranquilla/Cali	-0.01015 (0.0012)***	0.5748	56
Barranquilla/Manizales	-0.0023 (0.0008)**	0.1249	56
Barranquilla/Medellin	-0.005 (0.0013)***	0.2227	56
Barranquilla/Pasto	0.0032 (0.0023)	0.0322	56
Bucaramanga/Cali	-0.0005 (0.0013)	0.0027	56
Manizales/Bucaramanga	-0.0047 (0.0016)***	0.1393	56
Medellin/Bucaramanga	-0.00455 (0.0011)***	0.2189	56
Pasto/Bucaramanga	-0.01104 (0.0019)***	0.3621	56
Manizales/Cali	-0.0061 (0.0007)***	0.5887	56
Medellin/Cali	-0.006 (0.0010)***	0.3982	56
Cali/Pasto	-0.0097 (0.0014)	0.4502	56
Manizales/Medellin	-0.0016 (0.0010)	0.0453	56
Manizales/Pasto	0.0025 (0.0017)	0.0446	56
Medellin/Pasto	0.0044 (0.0016)***	0.1263	56

Note: Standard Deviation in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Computed

Table 10: Commodity price convergence across cities: Rice, 1928-1990

Cities' Price Ratios $\ln(P_B/P_A)$	Convergence Rate (b)	R^2	Number Observation
Bogota/Barranquilla	-0.0067 (0.0011)***	0.3574	63
Bucaramanga/Bogota	-0.0011 (0.0009)	0.0229	63
Bogota/Cali	-0.0052 (0.0007)	0.4511	63
Bogota/Manizales	-0.003 (0.0008)***	0.168	63
Bogota/Medellin	-0.0021 (0.0008)***	0.1012	63
Bogota/Pasto	-0.0002 (0.0007)	0.0012	63
Bucaramanga/Barranquilla	-0.0077 (0.0012)***	0.3961	63
Cali/Barranquilla	-0.00147 (0.001)	0.0374	63
Manizales/Barranquilla	-0.0037 (0.0009)***	0.2304	63
Medellin/Barranquilla	-0.0045 (0.0008)***	0.3473	63
Pasto/Barranquilla	-0.0064 (0.0110)	0.0302	63
Bucaramanga/Cali	-0.0063 (0.0010)***	0.3741	63
Bucaramanga/Manizales	-0.0041 (0.0012)***	0.1654	63
Bucaramanga/Medellin	-0.0032 (0.0009)***	0.1607	63
Bucaramanga/Pasto	-0.0013 (0.0009)	0.0306	63
Manizales/Cali	-0.0022 (0.0004)***	0.3075	63
Medellin/Cali	-0.00307 (0.0006)***	0.3087	63
Pasto/Cali	-0.005 (0.0010)***	0.2879	63
Medellin/Manizales	-0.0008 (0.0006)	0.0273	63
Pasto/Manizales	-0.0017 (0.0012)	0.0983	63
Medellin/Pasto	0.0019 (0.0008)**	0.0741	63

Note: Standard Deviation in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Computed.

Table 11: Commodity price convergence across cities: Corn, 1928-1988

Cities' Price Ratios $\ln (P_B/P_A)$	Convergence Rate (β)	R^2	Number Observation
Bogota/Barranquilla	-0.0019 (0.0014)	0.0337	61
Bogota/Bucaramanga	0.0047 (0.0012)***	0.2212	56
Bogota/Cali	-0.00617 (0.0013)***	0.2871	61
Manizales/Bogota	-0.008 (0.0001)***	0.4205	61
Bogota/Medellin	0.0037 (0.0013)***	0.1263	61
Bogota/Pasto	0.0045 (0.0012)***	0.1944	56
Bucaramanga/Barranquilla	-0.01053 (0.0009)***	0.6922	56
Cali/Barranquilla	-0.00897 (0.0011)***	0.5069	61
Manizales/Barranquilla	-0.01038 (0.0011)***	0.6168	61
Medellin/Barranquilla	-0.01228 (0.0009)***	0.7611	61
Pasto/Barranquilla	-0.0106 (0.0012)***	0.5711	56
Bucaramanga/Cali	-0.0014 (0.0010)	0.0341	56
Bucaramanga/Manizales	-0.0015 (0.0012)	0.0272	56
Bucaramanga/Medellin	-0.0016 (0.0008)**	0.0708	56
Bucaramanga/Pasto	-0.00059 (0.0012)	0.0047	56
Manizales/Cali	-0.0014 (0.0010)	0.0265	61
Cali/Medellin	-0.00259 (0.0010)**	0.0872	61
Cali/Pasto	-0.002 (0.0015)	0.0369	56
Medellin/Manizales	-0.004 (0.0013)***	0.1422	61
Manizales/Pasto	-0.0024 (0.0015)	0.0596	56
Medellin/Pasto	-0.0024 (0.0009)***	0.0741	56

Note: Standard Deviation in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Computed.

Table 12: Commodity price convergence across cities: Salt, 1928-1988

Cities' Price Ratios $\ln(P_B/P_A)$	Convergence Rate (b)	R^2	Number Observation
Bogota/Barranquilla	-0.0061 (0.0016)***	0.1985	56
Bucaramanga/Bogota	-0.0036 (0.0014)***	0.1063	56
Bogota/Cali	-0.0024 (0.0010)**	0.0791	59
Manizales/Bogota	0.00014 (0.0011)	0.003	56
Bogota/Medellin	-0.0031 (0.0030)	0.0867	56
Bogota/Pasto	-0.0008 (0.0020)	0.0031	56
Bucaramanga/Barranquilla	-0.0097 (0.0017)***	0.3527	56
Cali/Barranquilla	-0.0086 (0.0015)***	0.3417	56
Manizales/Barranquilla	-0.0059 (0.0013)***	0.2736	56
Medellin/Barranquilla	-0.0092 (0.0014)***	0.4287	56
Pasto/Barranquilla	-0.0025 (0.0021)	0.0268	56
Bucaramanga/Cali	-0.0011 (0.0010)	0.0212	56
Bucaramanga/Manizales	-0.0037 (0.0013)***	0.1206	56
Bucaramanga/Medellin	-0.00053 (0.0011)	0.0039	56
Pasto/Bucaramanga	0.0027 (0.0017)	0.0626	56
Cali/Manizales	-0.0026 (0.0010)***	0.0921	56
Cali/Medellin	0.0006 (0.0010)	0.0062	56
Pasto/Cali	0.0016 (0.0016)	0.0168	56
Medellin/Manizales	-0.00323 (0.0009)***	0.1683	56
Pasto/Manizales	-0.001 (0.001)	0.0059	56
Pasto/Medellin	0.0022 (0.0018)	0.0231	56

Note: Standard Deviation in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Computed.

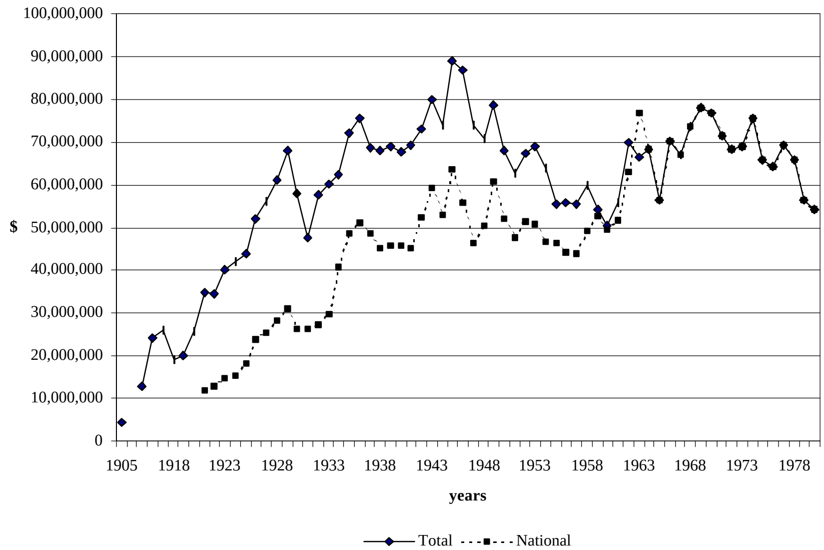
Table 13:Commodity price convergence across cities: Sugar, 1933-1990

Cities' Price Ratios $\ln (P_B/P_A)$	Convergence Rate (b)	R^2	Number Observation
Bogota/Barranquilla	-0.0026 (0.0005)***	0.374	57
Bucaramanga/Bogota	-0.0007 (0.0005)	0.0418	57
Bogota/Cali	0.0007 (0.0006)	0.0204	57
Manizales/Bogota	-0.001 (0.0006)	0.0424	57
Bogota/Medellin	-0.003 (0.0007)***	0.2523	57
Bogota/Pasto	-0.00118 (0.0008)	0.03702	57
Bucaramanga/Barranquilla	-0.00375 (0.0005)***	0.5466	57
Cali/Barranquilla	0.0009 (0.0008)	0.0314	57
Manizales/Barranquilla	0.0015 (0.0007)**	0.073	57
Medellin/Barranquilla	0.0003 (0.0006)	0.0005	57
Pasto/Barranquilla	-0.0046 (0.0010)***	0.2881	57
Bucaramanga/Cali	-0.0009 (0.0006)	0.0379	57
Bucaramanga/Manizales	-0.0019 (0.0006)***	0.1431	57
Bucaramanga/Medellin	-0.0044 (0.0007)***	0.4424	57
Pasto/Bucaramanga	-0.0008 (0.0008)	0.0187	57
Cali/Manizales	-0.0012 (0.0007)*	0.0565	57
Cali/Medellin	-0.0037 (0.0009)***	0.2221	57
Pasto/Cali	-0.0009 (0.0010)	0.0162	57
Medellin/Manizales	-0.0022 (0.0009)***	0.095	57
Manizales/Pasto	-0.00268 (0.0009)***	0.1276	57
Medellin/Pasto	-0.0042 (0.0009)***	0.2687	57

Note: Standard Deviation in parenthesis, * significant at 10%, ** significant at 5%, *** significant at 1%.
Source: Computed.

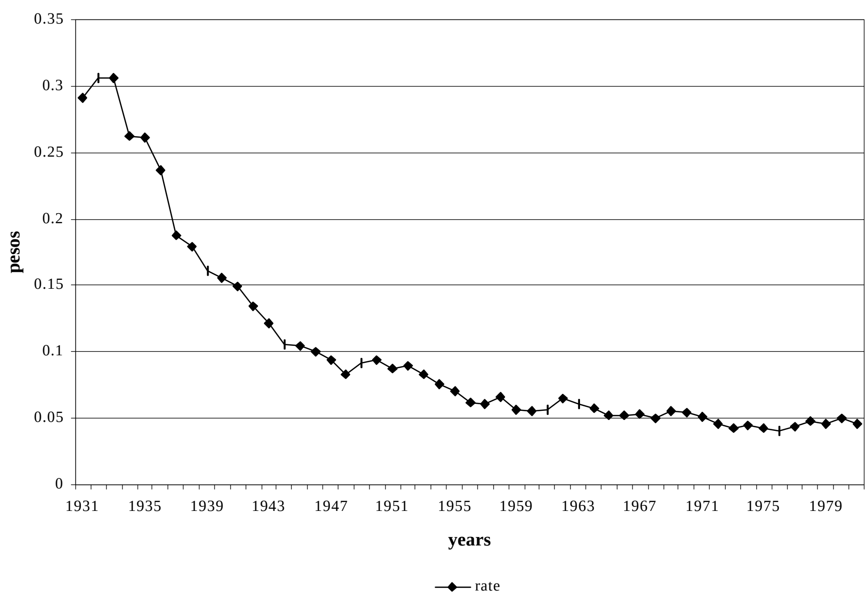
7 Graphs

Graph 1: Railroads Operating Revenues (pesos 1950)



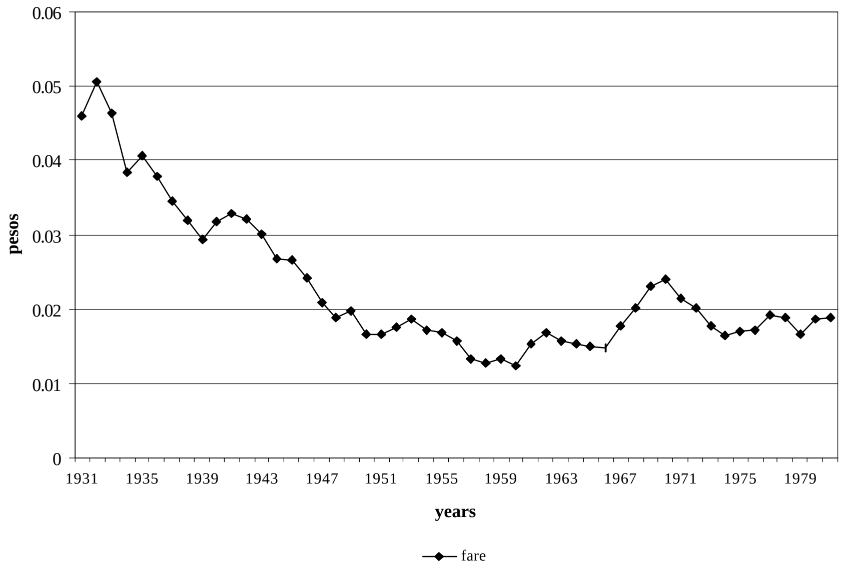
Source: Maria Teresa Ramirez, On Infrastructure and Economic Growth, UIUC dissertation, Chapter 3.

Graph 2: Railroads Rates per Ton-Km (constant pesos 1950)



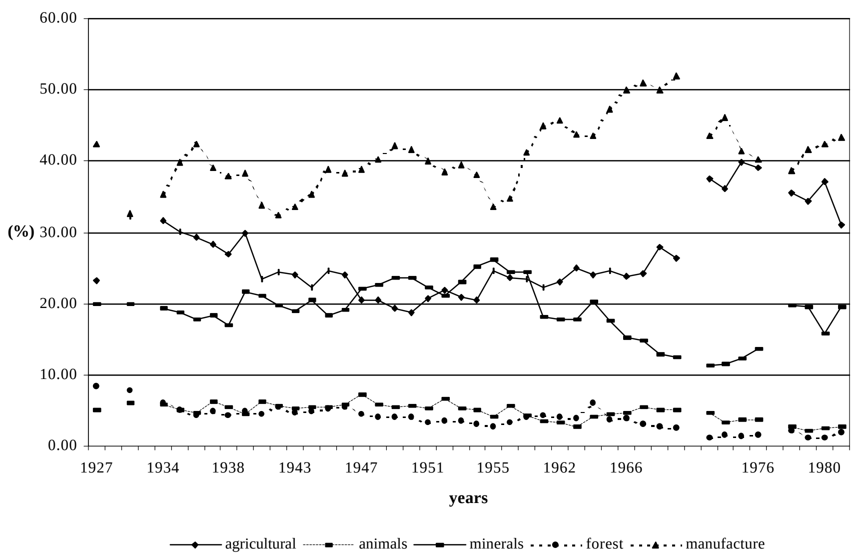
Source: Maria Teresa Ramirez, On Infrastructure and Economic Growth, UIUC dissertation, Chapter 3.

Graph 2a: Railroads Fare per Passenger-Km (constant pesos 1950)



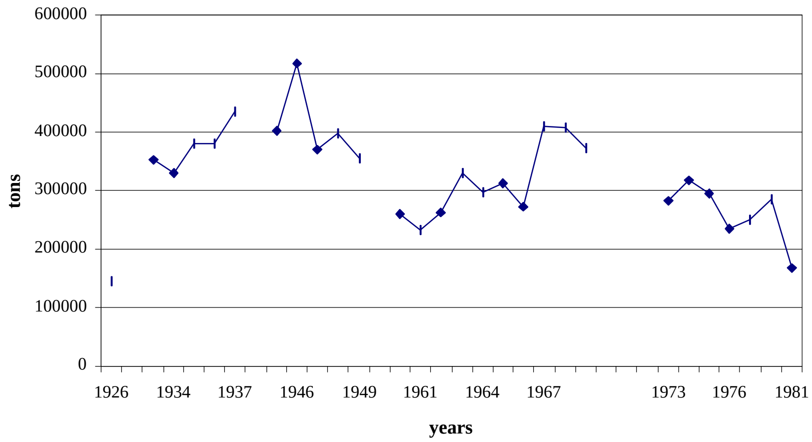
Source: Maria Teresa Ramirez, On Infrastructure and Economic Growth, UIUC dissertation, Chapter 3.

Graph 3: Railroads Type of Freight (% total freight)



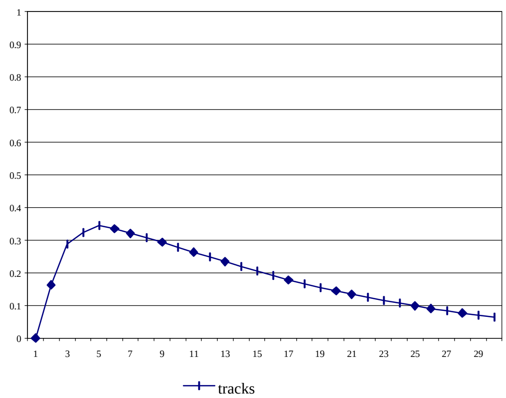
Source: Computed based on data from: Anuario General de Estadistica de Colombia, several years Memorias del Ministerio de Obras Publicas y transporte several years, Anuario de Transporte y Comunicaciones several years, Los Ferrocarriles en Cifras, several years.

Graph 4: Quantity of Coffee Shipped by Railroads

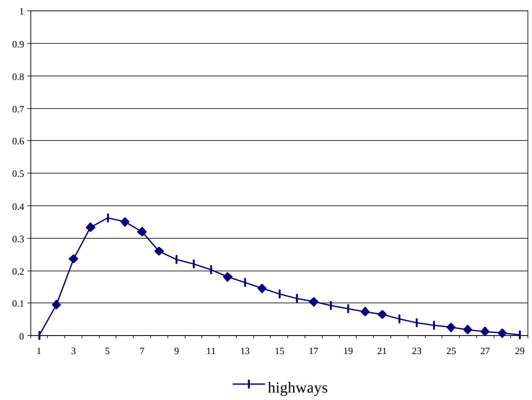


Source: Anuario General de Estadistica de Colombia, several years.

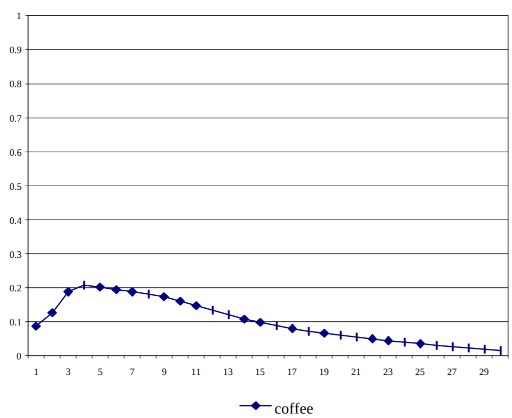
Graph 5: Response of Railroads to a shock in Coffee



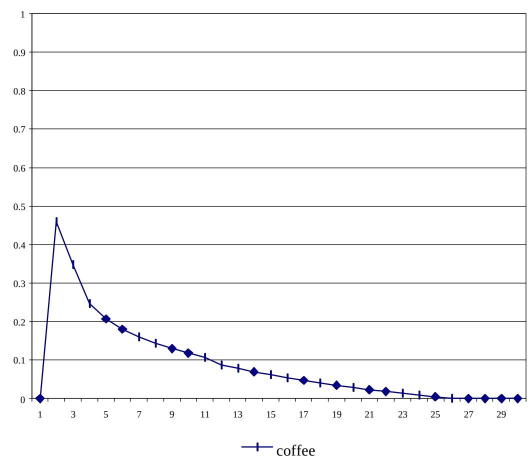
Graph 7: Response of Highways to a shock in Coffee



Graph 6: Response of Coffee to Shock in Railroads

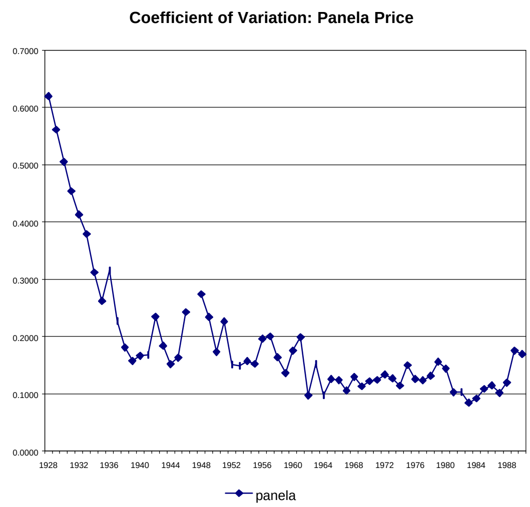


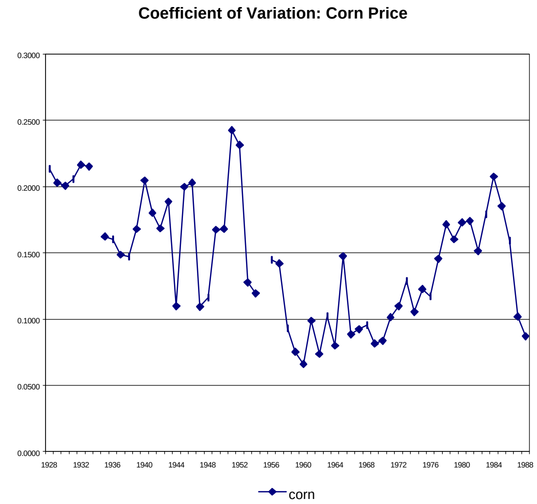
Graph 8: Response of Coffee to a shock in Highways

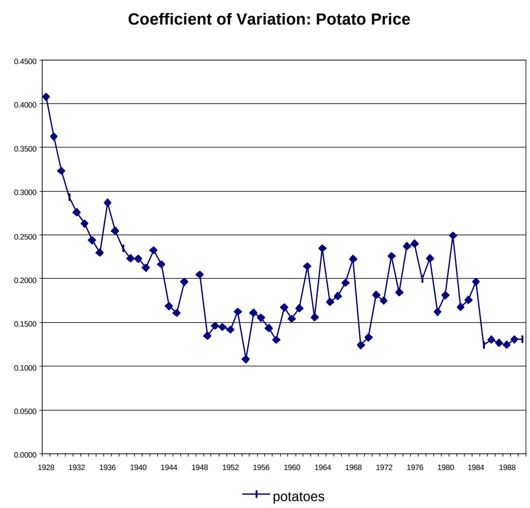


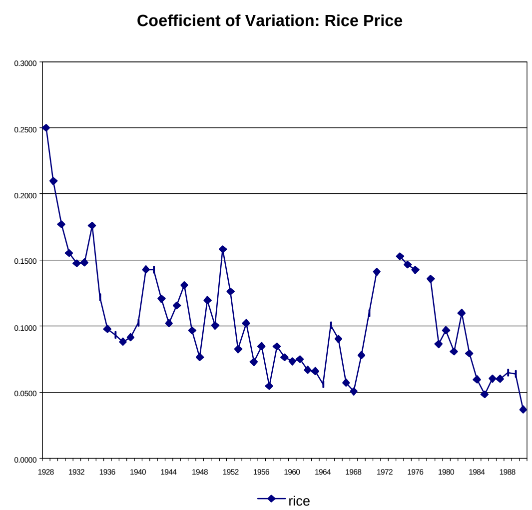
Source: Computed

Graph 9: Coefficient of Variation-Commodity Price

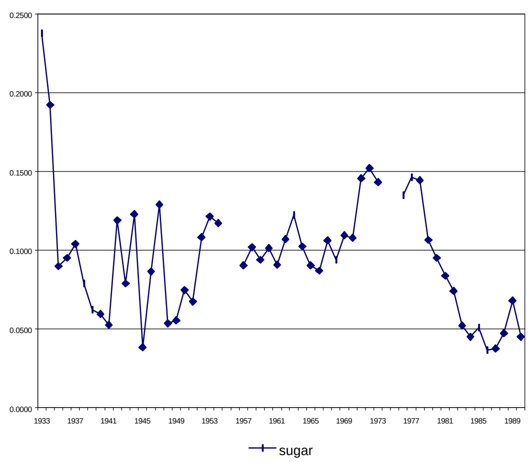




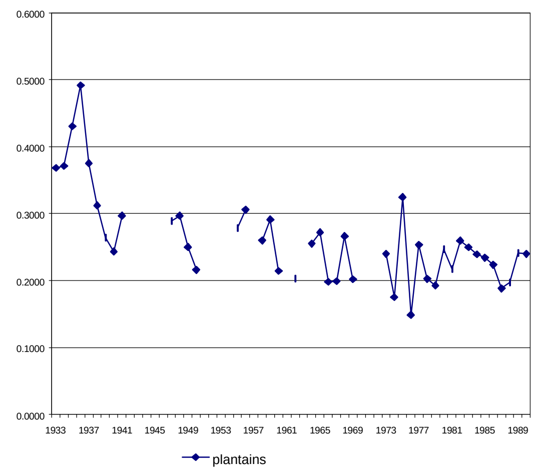




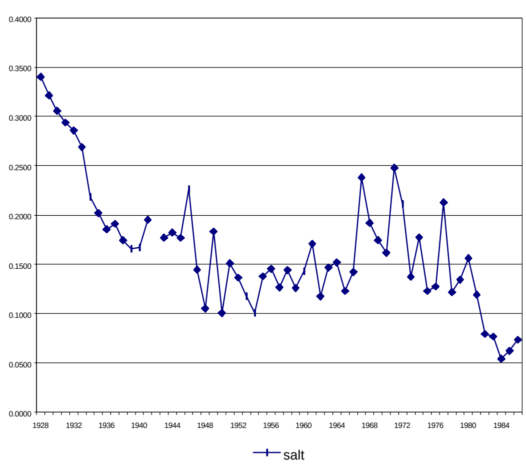
Coefficient of Variation: Sugar Price



Coefficient of Variation: Plantains Price



Coefficient of Variation: Salt Price



Coefficient of Variation: Red Beans Price