Railroad Capital Stock Changes in the Post-Deregulation Period

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This paper involves the estimation of a model of railway road and equipment capital stocks and the changes in their levels that have occurred since 1983. The model is based on balancing the level of investment and the level of degradation of the capital stocks to create a data series for roadway capital and for equipment capital. A two-stage least squares errors in variables model is applied. This is appropriate as degradation and exact constant dollar investment are not directly observable. Results obtained from the model indicate that Class I railroads have increased their absolute capital stock levels over the period examined. This holds for both roadway and equipment capital although roadway capital has increased at a somewhat faster rate.

INTRODUCTION

One of the expected benefits from deregulation of a previously regulated industry is a movement to a more rational cost and production structure in line with market conditions. As part of this transition for the railroad industry, it would be expected that with the removal of most regulation of transportation rates, railroads would be forced to undertake changes in the way their services were provided to the shippers. A large portion of this change would be expected to come in the form of modification and rationalization of the capital plant as the firms moved to a new, more efficient cost structure. This paper involves the estimation of investment and capital degradation functions for the U.S. rail industry to evaluate the changes that have occurred in these two critical areas of capital stock analysis.

Over the last three decades, a number of papers have examined the transportation industry's cost and/or production functions, both prior to and following deregulation. Most of this work has involved the use of proxy variables for the level of capital stock. The most common proxy variable is the miles-of-road operated. While use of miles-of-road has been commonly acknowledged as an inaccurate indication of the actual level and quality of the capital stock, it has been generally used as the best available measure. Unfortunately this "size" factor alone is unable to accurately reflect the nature of rail capital as a multidimensional entity. The availability of a data series on overall rail capital stocks, or, more desirably, series broken into roadway and equipment capital stocks, would greatly improve the ability to accurately estimate railroad transportation costs for both regulatory and economic analytical purposes.

Research into the nature of rail costs and production has included work by Caves, Christensen, and Swanson (1980, 1981a, 1981b, 1981c); Spady and Friedlaender (1976); Bereskin (1989, 1996); Barbera, Grimm, Phillips, and Selzer (1987); and Lee and Baumel (1987). Each of these papers has applied the translog function to a cost model to obtain estimates of the structure of railroad costs. Of primary interest in these models was the underlying response to short-run changes in output level and the effects this would have on the level of cost. Barbera, Grimm, Phillips, and Selzer (1987) and Lee and Baumel (1987), as an example, are both primarily aimed toward measuring economies of scale and density in the industry rather than in examining the dynamic question of long-run costs and changes in capital structure. These studies involve the development of a generalized cost function with the primary emphasis on developing a short-run as opposed to a long-run cost model. While both studies estimate an underlying cost structure using the translog functional form, the methodological emphasis differs between the two.

The Barbera, Grimm, Phillips, and Selzer study (1987) is primarily concerned with directly estimating the cost relation to test hypotheses concerning economies of scale and density in the industry and thus estimates only the cost function. Alternatively, Lee and Baumel (1987) deals with a simultaneous estimation of both the cost and demand function for rail services for the years 1983 and 1984, where the translog function is used as a Taylor series approximation to an unknown underlying cost function while the demand function, being a derived relationship, is modeled as a Cobb-Douglas structure. Both studies find that economies of density exist although the estimates obtained by Lee and Baumel (1987) are significantly lower than for Barbera, Grimm, Phillips, and Selzer (1987) while both agree that returns to scale appear to be insignificant. Again, however, the proxy variable used for the size of capital stock in each of these studies is miles-of-road, an approximation that may introduce a bias into the results as miles-of-road fails to address the condition and level of quality of the roadway capital. One interesting conclusion of all these works is that there appears, at least in the earlier pre-deregulation analysis, to be a fairly large amount of excess capital stock. Estimates range from capacity utilization levels at 30-35% (Friedlaender 1971) to the existence of up to 200,000 miles of excess trackage (Keeler 1974). The implication of these studies is that when given the chance, under deregulation the industry is likely to reduce the number of miles of road, reduce the level of capital stocks, or find a way to use capital more efficiently.

Friedlaender et al. (1993) have estimated a model of railroad costs where the capital structure has been specified using an inventory theoretic approach. Using a modified network approach and looking at several service categories as defining the output level, they are able to estimate the appropriate level of capital necessary to efficiently operate given the desired output level. Their findings indicate that the railroad industry is over-capitalized and should optimally be reducing the level of capital stock. There are two possible flaws with this study as it compares to the current situation in the rail industry. First, a large portion of their data on railroad investment, and as such capital, was from the pre-deregulation period when railroads were greatly restricted in their ability to rationalize their capital plant. Second, by the early 1990's, there were indications from the industry that for certain traffic types (particularly double stack and other intermodal trains) the industry was approaching some restrictions on capacity. This latter result may not be completely inconsistent with the Friedlaender results as it would be expected that, when given a chance to rationalize their plant, the railroads would attempt to develop more efficient use of their available capital by investing in plant and equipment that was more appropriate to market demands, and then later reducing the excess levels toward the more appropriate total stocks as suggested by this research.

In an effort to determine the effects of density and railroad mergers on costs, Ivaldi and McCullough (2001) estimated a translog model of short-run railroad costs using different types of car-miles as a measure of traffic. Miles-of-road is used as a proxy for fixed capital stock although this is modified by using the number of ties replaced in each year as a proxy for investment in roadway structure. Alternatively, Bitzen and Keeler (2003) have, in an effort to explain productivity growth in the deregulated industry, applied both miles-of-road and developed price indices for right-of-way capital structure and for equipment capital to explain the effects of capital within railroad costs. Neither of these studies directly develops an estimate of what the capital stock may have looked like during the studied period.

One of the primary concerns of deregulation was to create the ability on the part of the industry to operate more efficiently and gain increased traffic (as well as greater flexibility in the area of abandonment and sale of unprofitable lines). Therefore, it would be expected that during the first several years following deregulation the railroads would be in a process of both improving the quality of the capital stock and reducing the excess capacity. Excess capacity may however be reduced in two opposed manners. First, the capital may be sold off or depreciated so that an actual reduction takes place. Second, if pricing flexibility, changes in work rules, and more demand-related marketing is able to increase the total level of traffic on a given railroad, the "excess" portion of capacity will be reduced through gains in traffic. It is possible that in the post-deregulation period both of these factors were important in the railroad industry.

DEVELOPING A MODEL OF RAIL CAPITAL

The methodology applied here is an inventory model of capital accumulation based on degradation of capital through usage and replacement (and upgrading) through investment. Under this model, the level of capital available at any period is indicated as:

(1) $K_t = K_{t-1} + I_t - D_{Kt}$

where K_t is the capital stock at time t , K_{t-1} is the capital stock at time t-1, I_t is a measure of the investment occurring during the t^{th} period and D_{Kt} is some proportionality measure associated with degradation of the existing capital stock.[1]

Several problems exist with the use of the above relationship in determining the level of the capital stock. First, the rate of degradation is not constant over time and is related to the level of activity on the part of the firm because capital is a factor of production and is degraded during the production process. Second, degradation of the capital stock, as opposed to accounting depreciation is generally not directly observable. Finally, the initial level of capital at t=0 (other than at the initial start up point for the firm) may not be observable either. For most capital estimation analysis, this latter problem is finessed through the use of the assumption that if observations are available for enough of the lifetime of the firm, eventually the initial capital stock will have been completely depreciated and therefore become insignificant. Over a very long period, this assumption on the degradation of the initial physical capital stock may be realistic as the model will be expected to eventually converge to a reasonable estimate of the capital stock. In the rail industry, where some physical capital is expected to have a life of several decades, the assumption of the initial capital stock being rapidly depreciated to zero may be heroic at best. Even considering the possible shortfalls, this model has nonetheless been used in a number of capital estimation cases with varying degrees of success.

Following from equation (1), and using financial data it is possible to estimate the level of investment in a given year. This may then be adjusted by a price index to obtain an estimate of the level of real investment where P_t is a proxy measure of the purchase price of new capital goods.[2]

(2) $I_{kt} = I_t / P_t$

The level of a firm's degradation at any time t is somewhat harder to evaluate. For purposes of this analysis, the level of degradation will be proxied by the depreciation values stated at the level of 1983 dollars.

(3) $D_{kt} = D_t / P_t$

Because depreciation levels are constant once the asset is put into place, the values of depreciation always refer back to the dollar value of the capital goods in the year they were put into place. This methodology necessarily creates a problem in estimating degradation in that depreciation is an accounting measure. The depreciation rates as set therefore do not directly relate to the intensity of usage of the asset and the reduction in remaining life. However, there is no accounting way that the real degradation can be measured directly. As a result, constant dollar depreciation is used within an errors-in-variables estimation resulting in the closest approximation of the actual degradation value.

Historic levels of investment and assets, used to create the starting level of capital stock, may be obtained or estimated from the firm's financial reports. The price values are determined from price index publications. It is then necessary to obtain an estimate of the level of capital degradation which may then be related to specific activities of the firm. Values developed are then introduced into equation (1) to develop reasonable estimates of capital relative to the initial starting value at t=0. In the current model, this has been done for two classifications of rail assets: roadway and equipment.

DATA AND ESTIMATION

The long history of railroad regulation has provided an unusually valuable data source. Each railroad has been required to provide appropriate accounting information, previously to the Interstate Commerce Commission (ICC) and currently to the Surface Transportation Board (STB), on a timely basis. This information has been collected and compiled by the Association of American Railroads (AAR) and is available through their publication *Analysis of Class I Railroads*. When combined with the input price and shipper and other car data published by the AAR in *AAR Railroad Cost Indexes*, and *Railroad Facts*, and the U.S. Bureau of Labor Statistics producer price indices, a fairly complete picture of rail operations may be developed. While the price indices may not correspond exactly to individual input prices, the several index classifications do allow each index to represent an overall class of input types. Of particular interest was the price index for materials and supplies, which was used in approximating the level of real (1983 dollar) roadway investment and to restate the level of degradation to constant 1983 dollar values. The wholesale price index, as developed by the Bureau of Labor for Railway Equipment (WPU 144), was used to deflate the values of railway equipment investment and to restate the level to a constant 1983 dollar value. All variables were evaluated, when possible, in terms of their AAR classification as eastern or western railroad companies. Operating statistics were obtained from the *Analysis of Class I Railroads*, the same AAR source as for the asset, investment, and depreciation values.

The data was developed for the years 1983 to 2005, inclusive. This period was chosen as being the longest over which consistent data was available. Prior to 1978, the ICC required a different set of accounts, making data from these earlier periods inconsistent with the more recent data. Likewise, the reporting of the data was modified following 1979 causing potential inconsistencies between 1978-1979 and the following years. In addition, the accounting system was changed from retirement, replacement, betterment accounting to depreciation accounting starting with 1983. It was decided that even though the period from 1978 through 1982 may have been desirable, that the years 1983-2005 were the only period over which the accounting data was continuously consistent as the rail accounting system underwent changes in both 1978-1979 and 1983. The levels of railway assets are reported at year-end levels so that these values were used as a starting place. Investment and degradation equations were developed for the years 1984 through 2005, which could then be used with the 1983 year-end value to develop the estimates of capital stocks that would have been reported at the end of each subsequent year

The estimation period involves a time over which a number of mergers occurred. As the data used was a paneled data set, estimation involved the use of dummy variables to indicate each firm. Thus it was necessary to determine an appropriate convention both for defining the firms and adapting their data to the analytical needs. The decision was made to follow the reporting of the AAR railroad names as indicative of the management structure. One significant modification to the database was necessary with respect to the mergers. As a merger occurs, the previous data series ends and one (or more) of the old entities is folded into the new (or existing) firm. For example, when the Union Pacific, Missouri Pacific, and Western Pacific were effectively combined for reporting purposes, the Missouri Pacific and Western Pacific ceased to exist as separate entities while the Union Pacific grew substantially. Likewise when the Norfolk & Western and Southern Railway systems merged, both entities ceased to exist and the Norfolk Southern was listed as the consolidated firm. In each of these cases it was necessary to modify the data series to minimize the effects of these discontinuities wherever lagged variables were used. The convention that was used was to create a new firm dummy variable to account for the newly defined firm and to additionally sum the values of the merger partners in the year prior to the joint reporting and to consider this as the equivalent period earlier firm, as if in the merger process, capital assets had been transferred directly between the firms where lagged variable values were needed.

The data set as thus constituted consists of 22 years of observations with 28 firms before consolidation. After consolidation and removal of several firms from the list of Class I railroads due to reduction in comparative revenues, the final year (2005) consisted of data for only seven firms. Likewise, because the estimation of investment levels involved the use of lagged variables, the data set for actual estimation was reduced by one year. Additionally, several data points were eliminated due to reporting anomalies such as in the year 1999, when Conrail reported a part of the year separately and the rest of the year was combined into the CSX and Norfolk Southern data. Constructing the data in this manner gave 267 observations for a varying number of firms per year for the 22 years, a large enough sample to provide sufficient degrees of freedom for most estimation techniques associated with pooled data. The variables used in the model are detailed in Table 1.

Table 1: Definition of Variables

D_RD_83	Roadway degradation (constant 1983 dollars) (proxied by roadway depreciation / P_MS)
D_EQ_83	Equipment degradation (constant 1983 dollars) (proxied by equipment depreciation / Pcu_eqp)
I_RD_83	Investment in roadway (constant 1983 dollars) (Investment in road / P_MS)
I_EQ_83	Investment in equipment (constant 1983 dollars) (Investment in equipment / Pcu_eqpt)
GTMC	Gross ton miles of cars contents and cabooses for firm f at time t (in millions)
CM:	Car miles for firm f at time t
TM:	Train miles for firm f at time t
THP	Thousands of horsepower miles (locomotive unit miles * average horsepower)
THS	Total switching hours (road switching + yard switching)
MR:	The miles of rail operated by firm Af@ at time At@
TR	The miles of track operated by firm Af@ at time At@
P_F:	Price index for fuel (applicable only to the transportation sector)
P_WS:	Price index for wages and supplement.
P_MS:	Price index for materials and supplies.
P_O:	Price index for other operating expenses.
Pcu_eqpt	Producer price index for railroad equipment
d(firm #):	Firm dummy variable to compensate for inter-firm variation of non-merger firms
D_rr_#	Separate dummy variables representing firms where mergers have occurred Each firm is indicated by a pre-merger number and a post merger number. Mergers are assumed to have occurred when the reporting entities are changed.
D_rr_yr	Dummy variable to account for the first year of a newly merged firm This allows for restatements of capital stock values as a result of the merger.
GTM_CM	Gross ton miles per car mile (GTMC / CM)
GTM_TM	Gross ton miles per train mile (GTMC / TM)
A_RD_83	Constant dollar value of roadway assets (roadway assets / P_MS)
A_EQ_83	Constant dollar value of equipment assets (equipment assets / Pcu_eqp)
A_RD_83_L	Lagged value of constant dollar roadway assets
A_EQ_83_L	Lagged value of constant dollar equipment assets
I_RD_83_L	Lagged value of constant dollar roadway investment
I_EQ_83_L	Lagged value of constant dollar equipment investment
GTMC_l	lagged value of gross ton miles
n_op_inc	Reported railroad net operating income
n_op_Inc_L	Lagged value of railroad net operating income
Prime	Prime interest rate
Oth_cars	The number of non-Class 1 railroad owned cars
Shpr_car	The number of railroad cars owned by shippers

Estimation was accomplished using the single equation two-stage least squares procedure in the Soritec econometric software package on a PC using Windows-2000. Two-stage least squares was applied as an appropriate method for obtaining consistent estimates for an errors-in-variables model through the use of instrumental variables as suggested by Fomby, Hill and Johnson (1984, pp.478-482). This methodology is appropriate for both the degradation and investment equations. Degradation, as stated earlier, is not directly measurable and must be estimated and related to operations. Investment is more questionable, as a dollar value is reported in the railroad accounting records. However, the process of deflating to constant dollar values brings a degree of variation into the investment levels as well so that it is appropriate to use the error-in-variables method for this series as well. The regression results are listed in Tables 2a-d.

REGRESSION RESULTS

Each of the equations for degradation and investment was estimated using the two stage least squares method. Instruments included the size parameters miles of road (MR) and miles of track (TR), and the operating parameters gross ton miles (GTMC), car miles (CM), train miles(TM), thousands of horsepower-miles (THP), and thousands of switching hours (THS). Also included was the prime interest rate as a measure of the cost of capital, the price indices for fuel, materials and supplies, wages and supplements, and other railroad goods. Several additional "manufactured variables" were also included. These were gross ton miles per car mile (GTM_CM), gross ton miles per train mile (GTM-TM), and lagged gross ton miles (GTMC_L). The number of shipper (shpr_car) and non-Class I owned cars (oth_cars) were included as instruments as were current and lagged values of net operating income (n_op_inc and n_op_inc_l). Lagged values of price adjusted roadway and equipment assets (as proxies for previous capital) were also included as well as dummy variables for each of the railroads both before and following any mergers and also for the year immediately after the merger to reflect accounting changes and consolidations..

Results of stage II of the regressions are shown in Tables 2a-d. For each of the degradation equations, the initial variables used in the second stage regression included the road and track miles, the five operating statistic measures, the lagged value of either price adjusted roadway or equipment assets, the variables GTM_TM and GTM_CM., and the variables oth_cars and shpr_car. For the investment equations, additional variables representing the four railroad price indices, the number of non-Class-I owned cars and shipper-owned cars, and current year and lagged net-operating income were also included as was lagged gross ton miles and lagged constant dollar investment. One problem with the use of railroad size and operating parameters jointly in estimation of degradation and investment is that a great deal of multicollinearity exists between the variables. While multicollinearity is less of a problem for forecasting equations, it often yields large standard errors (and small t statistics) which cause the analyst to reject coefficient estimates. For this reason, following the initial regression estimate, the equations were each parsed by deleting and adding back variables until each equation consisted of only variables that made economic sense and which were statistically significant at the 0.10 level or better.

Roadway Degradation

Roadway degradation involves wearing out of the right of way. The dependent variable here was d_rd_83. The expectation was that the signs should be positive for the size, operating parameters and lagged real asset levels, and generally negative for the number-of-car variables.

Following the parsing process, the equation for roadway degradation (Table 2a) uses three variables, all of which carry the expected positive signs. These are miles of road, gross ton miles, and the lagged value of real roadway assets (A_RD_83_L). As expected, the equation indicates that degradation will increase if the railroad has a larger track structure. If gross ton miles should increase, wear on the track structure should also increase. Finally, a greater level of real roadway

Table 2: Regression Results Two-Stage Least Squares

a. Dependent Variable: D_rd_83

Variable	Coefficient	Std Err	T-stat	Significance
CONST	-1903.80	4384.24	-.434238	.664
MR	3.25027	.843092	3.85517	.000
GTMC	.147630E-03	.377838E-04	3.90722	.000
A_RD_83_L	.113298E-01	.206156E-02	5.49576	.000

Equation Summary

No. of Observations	= 267	R^2 = .8663 (adj)= .8648	
Sum of Sq. Resid.	= .505099E+12	Std. Error of Reg.= 43823.8	
Log(likelihood)	= -3230.52	Durbin-Watson = 2.07152	
Schwarz Criterion	= -3241.69	F (3, 263) = 567.961	
Akaike Criterion	= -3234.52	Significance = .000000	

b. Dependent Variable: D_EQ_83

Variable	Coefficient	Std Err	T-stat	Significance
CONST	-4895.57	5244.8	-.321131	.748
MR	-3.31296	1.09347	-3.02976	.003
TR	1.72666	.631069	2.73608	.007
GTMC	-.139352E-03	.581495E-04	-2.39644	.017
TM	.124520E-02	.411629E-03	3.02506	.003
THS	.179520E-01	.508226E-02	3.53229	.000
A_EQ_83_L	.239878E-01	.267445E-02	8.96923	.000
SHPR_CAR	-.956163E-01	.203804E-01	-4.69159	.000
GTM_CM	721.844	191.539	3.76865	.000

Equation Summary

No. of Observations = 267	R^2 = .8918 (adj)= .8885
Sum of Sq. Resid. = .151266E+12	Std. Error of Reg.= 24213.7
Log(likelihood) = -3069.56	Durbin-Watson = 1.81361
Schwarz Criterion = -3094.70	F (8, 258) = 265.922
Akaike Criterion = -3078.56	Significance = .000000

assets (a proxy for capital) would tend to lead to a higher level of degradation (weather and time as well as usage) as is expected. Fit of the equation is good with an adjusted R^2 of 0.86 and a DW statistic of 2.07.

Equipment Degradation

Like roadway degradation, equipment degradation is expected to be positively related to the operating parameters, GTMC, CM, TM, THP, and THS. The relationship to miles-of-road and

c. Dependent Variable: I_RD_83

Variable	Coefficient	Std Err	T-stat	Significance
CONST	57622.3	29250.0	1.96999	.005
CM	.175356E-01	.418481E-02	4.19029	.000
I_RD_83_L	.771935	.533591E-01	14.4668	.000
N_OP_INC	.704320E-01	.218780E-01	3.21930	.001
N_OP_INC_L	-.580408E-01	.220752E-01	-2.62923	.009
OTH_CARS	-.645415	.353463	-1.82598	.069
SHPR_CAR	.671552	.391572	1.71501	.088

Equation Summary

No. of Observations	= 267	R^2 = .9427 (adj)= .9414	
Sum of Sq. Resid.	= .915058E+12	Std. Error of Reg.= 59325.0	
Log(likelihood)	= -3309.85	Durbin-Watson = 2.44887	
Schwarz Criterion	= -3329.41	F (6, 260) = 713.203	
Akaike Criterion	= -3316.85	Significance = .000000	

d. Dependent Variable: I_EQ_83

Variable	Coefficient	Std Err	T-stat	Significance
CONST	30237.0	12155.1	2.48760	.013
TM	.281691E-02	.705368E-03	3.99353	.000
GTMC_L	-.441859E-03	.122698E-03	-3.60118	.000
P_F	-141.548	59.3870	-2.38348	.018
I_EQ_83_L	.673764	.756373E-01	8.90784	.000
N_OP_INC_L	.362118E-01	.213422E-01	1.69672	.091

Equation Summary

No. of Observations = 267	R^2 = .6943 (adj)= .6884
Sum of Sq. Resid. = .903119E+12	Std. Error of Reg.= 58823.7
Log(likelihood) = -3308.10	Durbin-Watson = 2.26213
Schwarz Criterion = -3324.86	F (5, 261) = 118.557
Akaike Criterion = -3314.10	Significance = .000000

track miles is more problematic however. Depending on how trains are run and the types of trains, a bigger railroad may cause more or less wear on the equipment. It is expected also that for both gross-ton-miles per car-mile and per train-mile the relationship should be positive. The relationship to non-Class I cars should however be negative.

After parsing the regression model, eight variables (Table 2b) were found to have statistical significance. As miles-of-road increases, there is less wear on equipment, all else being held constant. However as track-miles increase (double trackage) speeds also tend to increase and this allows the equipment to wear out faster. As GTMC increases the equation indicates that the equipment would wear out slower. At first this seems counter intuitive, however, this should relate to both the type of traffic and speeds. If the traffic is heavy-loading traffic carried in non-Class I cars, the degradation of railroad-owned equipment should decrease. This is confirmed by the negative coefficient on the shipper-car variable as well. As would be expected, equipment degradation increases with each of the following, train miles, switching hours, gross-ton-miles per car-mile (heavy wheel loading) and the lagged value of deflated equipment assets. The equation explains more than 88% of the variation with no noted problem of autocorrelation (DW = 1.81).

Roadway Investment

The expected relationships for roadway investment are a bit more complex than for degradation. Generally, the greater the number of miles of road and track, greater investment would be expected. Also, with greater traffic, investment would be expected to increase. Increases in investment should also come from an increased ability to spend the necessary money (operating income). Input prices are generally expected to be negatively related to investment. Ownership of cars may have either a positive or negative effect depending on the type of car and the type of traffic.

As shown in Table 2c, the parsed equation for real equipment investment is explained by six factors and yields an adjusted R^2 of 0.94 with a DW statistic of 2.45. As car-miles increase, the equation predicts that there will be more investment in roadway as is expected. The lagged value of investment in roadway also carries a positive sign consistent with the fact that in many cases large-scale roadway projects are a multi-year undertaking. Net operating income has a positive effect in the current year but a negative effect when lagged one period. This relates to the availability of funds. If income is down in a given year, some cutbacks will be made to roadway investment (deferred maintenance). However this may be made up in the following year if profitability increases. The variables for other-cars and shipper-cars likewise have opposite signs. Much of the increase in shipper owned cars over the last two decades has been in heavy duty cars such as utility owned coal cars. These cars are newer and generally in better condition, but also involve heavy wheel loading which leads to the need for a better track structure. Cars owned by non-Class I railroads have remained relatively stable in number and tend to be older but because they often have lower wheel loadings they do not cause as much wear on the track structure.

Equipment Investment

Equipment investment is not generally expected to be related to the number of miles-of-road or of track. However, it is normally expected to relate positively to operating parameters, negatively to input prices, and positively to previous investment and income.

As shown in (Table 2d) the regression results generally follow the expected pattern (although the regression statistics are the least robust of the four models). As train-miles increase, equipment investment is expected to increase. As prices increase, investment is expected to decrease as the available dollars go to pay for the factors of production. This is especially true for fuel prices which are far more volatile than the other price indices. As fuel becomes more expensive in any given year, the pool of funds available to pay for additional equipment is reduced. As would be expected, there are positive coefficients on lagged equipment investment (multi-year programs) and lagged net operating income. The one quirk here is the negative sign on lagged gross-ton-miles. As traffic increases it is expected that equipment investment will also increase. However, previous period traffic has a negative effect on equipment investment which is tempered by the positive relationship with lagged net operating income. If earnings are up, the firm is expected to invest more in plant and equipment in the following period. Of the four equations, the equation for investment in equipment explains the least of the variation with an adjusted R^2 of 0.69. Autocorrelation does not appear to be a problem however as the Durbin-Watson statistic is 2.26.

IMPLICATIONS OF THE MODEL

Having estimated the levels of investment in both roadway and equipment it remains to substitute the results into equation (1) to obtain estimates of the net change in roadway and equipment capital for each district and each year. This is accomplished by summing the fitted values of the regression estimates for investment and degradation to obtain a value of the net change in capital stock by class for each period. For each of the years in the sample period, the estimated values of degradation and investment taken from the regression results are evaluated at the regional level to get an estimate of capital stock on an eastern/western regional basis. These values are then summed to develop estimates for the capital stocks in the United States as a whole.

The results of this analysis are reported in Table 3 and 4 and Figures 1 and 2, which show the changes in the levels of railway capital (previous period level plus investment minus degradation) that occurred over the projected period of 1983 through 2005. Roadway capital is seen to be expanding on a fairly consistent basis for the total period in both the east and west. Equipment capital is relatively flat through the examined period, staying steady through the first 10 years, expanding through the next six and once again staying steady through the last six years. Some of the stability in railroad-owned equipment capital levels may be explained by the increase in shipper and other railroad-owned cars over the period following deregulation. As mentioned above, many of these (particularly shipper-owned) cars were heavy load cars such as covered hoppers and coal cars that required the railroads to increase their motive power but also allowed for reductions in the relative stock of railroad-owned cars. This demonstrates a factor in the growth of both types of capital as a change was occurring in the types of equipment and trackage used as firms tried to move toward a more competitive stance in the general transportation marketplace.

Figures 3 and 4 show the relative changes in the levels of capital based on the number of miles-of-roadway operated in each of the districts. On this basis, both roadway and equipment capital are seen to be increasing not only over time but also relative to the size of the railroad. This change in capital compared to size is consistent with the tendency to sell off or abandon lower density lines (reducing both miles-of-road and miles-of-track) as would be expected in the period following deregulation. If one recalls that railroad capital, especially right-of-way capital tends to be long-lived it makes sense that when placed in a position of competition, not only with other railroads but also the motor carrier industry, that the railroads would initially be concerned with maintaining and improving the level of the right-of-way (nothing moves rapidly or safely on bad track).

Figures 5 and 6 show the levels of roadway and equipment capital used by the railroads on a per gross-ton-mile basis. In the east, there is a dramatic increase in roadway capital per gross ton mile in the early years of deregulation. This then becomes fairly level for the remainder of the period. Much of this early improvement in eastern roadway capital may be a result of Conrail’s investments in right of way. In the west, the trend was generally downward after an early jump in 1986, a year where several consolidations took place. By 1997, the western railroads had essentially stabilized their roadway-per-gross-ton-mile ratio and maintained it through the end of the period.

Equipment capital per gross ton mile shows a decidedly different pattern. In the east, the ratio is highly stable over the entire period. In the west however, the trend is downward on a consistent basis. Much of this is attributable to the shippers buying many of the heavy-duty (aluminum-coal and grain) cars that were put into service over this period. The railroads had to provide motive power but not the cars. The dramatic decrease in capital stock per unit of traffic demonstrates the move toward efficiency by the railroads. This is especially true in the west as much of the increase in traffic involved heavier wheel-loading cars on primarily high-density trackage. Additionally, the equipment numbers reflect the railroads’ adoption of the new technology of the articulated double-stack car. This process is expected to continue into the future at a slower rate while other outdated equipment is further depreciated or written off. It is interesting to note that, especially in the west,

Table 3: Estimated Roadway Capital Stock

	EAST			WEST			Total U.S.
Year	Invest	Degrade	Capital Stock	Invest	Degrade	Capital Stock	Capital Stock
1983			17,130,406			19,812,932	36,943,338
1984	951,843	528,767	17,553,482	1,383,514	704,488	20,491,957	38,045,439
1985	957,029	517,760	17,992,750	1,754,522	701,374	21,545,105	39,537,855
1986	1,359,532	515,585	18,836,697	1,583,004	696,611	22,431,498	41,268,195
1987	1,274,051	510,488	19,600,259	1,404,826	699,872	23,136,452	42,736,711
1988	998,476	519,988	20,078,748	1,400,615	720,881	23,816,186	43,894,934
1989	1,257,319	507,710	20,828,357	1,262,966	721,719	24,357,433	45,185,791
1990	971,010	496,515	21,302,851	1,404,635	712,242	25,049,827	46,352,678
1991	927,696	493,725	21,736,822	1,227,022	704,008	25,572,842	47,309,664
1992	929,624	488,125	22,178,321	1,163,959	668,630	26,068,171	48,246,492
1993	936,924	490,392	22,624,853	1,198,481	649,704	26,616,948	49,241,801
1994	901,297	492,653	23,033,497	1,264,396	667,042	27,214,302	50,247,799
1995	856,533	490,471	23,399,559	1,300,587	703,472	27,811,417	51,210,976
1996	1,063,987	492,646	23,970,900	1,681,776	767,826	28,725,367	52,696,267
1997	970,375	499,310	24,441,965	1,686,409	786,322	29,625,454	54,067,419
1998	1,011,356	507,576	24,945,746	1,706,094	798,047	30,533,500	55,479,245
1999	1,230,052	521,812	25,653,985	1,935,341	829,757	31,639,084	57,293,069
2000	1,058,399	473,789	26,238,596	1,850,134	849,002	32,640,216	58,878,812
2001	1,246,558	474,750	27,010,404	1,764,080	877,089	33,527,207	60,537,611
2002	1,013,071	488,372	27,535,103	1,865,073	881,929	34,510,351	62,045,454
2003	985,012	540,902	27,979,213	2,024,680	916,243	35,618,788	63,598,000
2004	1,076,831	557,510	28,498,534	1,952,148	949,323	36,621,612	65,120,147
2005	1,125,610	655,386	28,968,758	2,070,053	951,243	37,740,422	66,709,180

Figure 1: Estimated Roadway Capital Stock

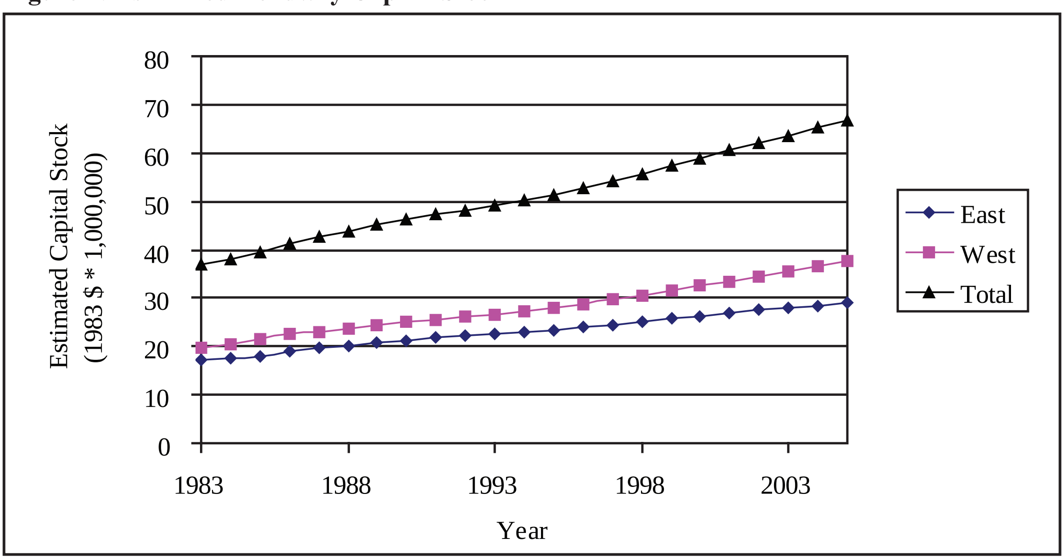


Table 4: Estimated Equipment Capital Stock

Year	EAST Invest	EAST Degrade	EAST Capital Stock	WEST Invest	WEST Degrade	WEST Capital Stock	Total U.S. Capital Stock
1983			10,543,715			12,080,666	22,624,381
1984	267,784	494,392	10,317,107	406,391	498,750	11,988,307	22,305,414
1985	424,826	481,985	10,259,948	353,317	465,890	11,875,735	22,135,682
1986	490,174	463,273	10,286,848	435,163	453,929	11,856,969	22,143,817
1987	379,411	450,913	10,215,347	343,089	451,814	11,748,244	21,963,591
1988	315,042	458,228	10,072,162	414,080	475,954	11,686,371	21,758,532
1989	377,938	346,379	10,103,721	585,425	483,816	11,787,980	21,891,702
1990	484,021	408,726	10,179,017	510,585	454,622	11,843,943	22,022,960
1991	387,848	387,671	10,179,194	463,904	432,100	11,875,747	22,054,941
1992	424,900	367,408	10,236,686	412,156	447,256	11,840,647	22,077,333
1993	394,385	371,670	10,259,401	419,393	447,876	11,812,164	22,071,566
1994	600,759	397,461	10,462,700	568,152	466,584	11,913,733	22,376,433
1995	534,635	394,555	10,602,780	809,477	478,966	12,244,244	22,847,024
1996	696,617	387,822	10,911,575	801,321	442,883	12,602,682	23,514,257
1997	722,127	387,424	11,246,278	784,477	430,702	12,956,457	24,202,735
1998	541,064	406,361	11,380,982	876,885	436,400	13,396,942	24,777,923
1999	713,406	425,822	11,668,565	830,777	455,724	13,771,994	25,440,560
2000	792,152	279,072	12,181,646	656,570	320,576	14,107,989	26,289,634
2001	606,545	417,373	12,370,818	451,762	440,363	14,119,388	26,490,206
2002	438,647	407,543	12,401,922	383,900	433,166	14,070,123	26,472,045
2003	446,459	418,391	12,429,989	414,069	427,127	14,057,065	26,487,055
2004	399,794	430,569	12,399,215	585,981	464,736	14,178,310	26,577,525
2005	567,560	449,512	12,517,262	305,641	470,856	14,013,095	26,530,357

Figure 2: Estimated Equipment Capital Stock

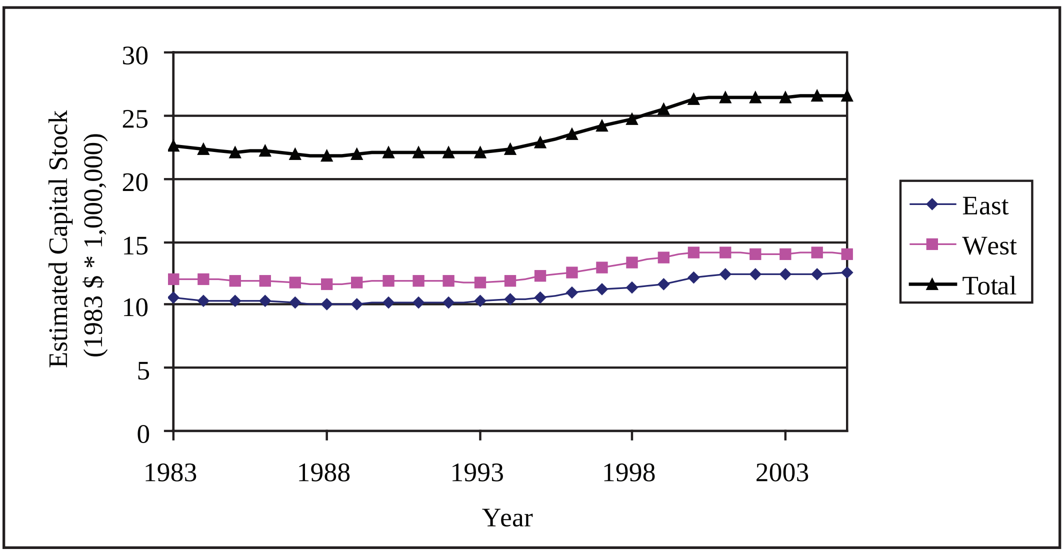


Figure 3: Estimated Roadway Capital Stock per Mile of Road

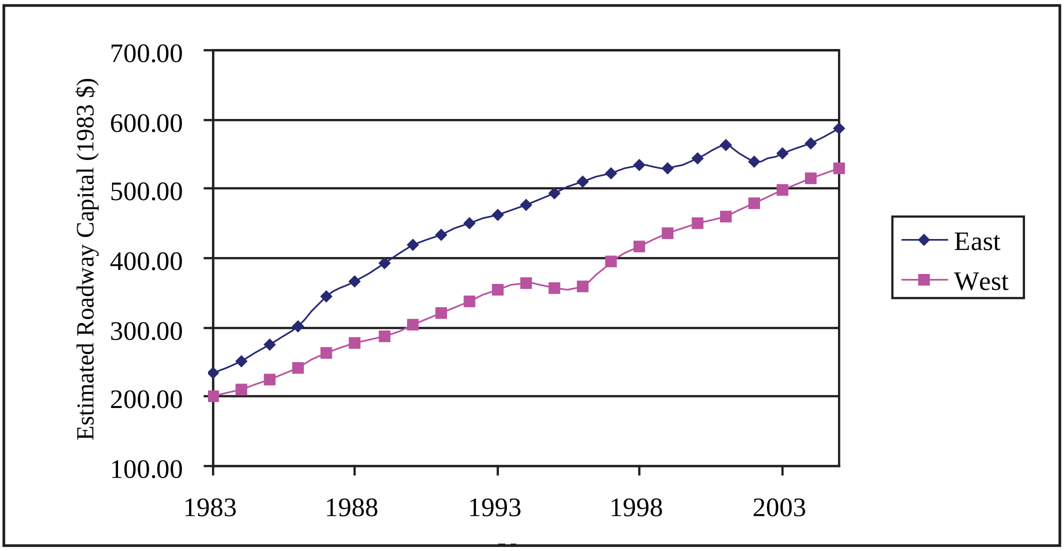
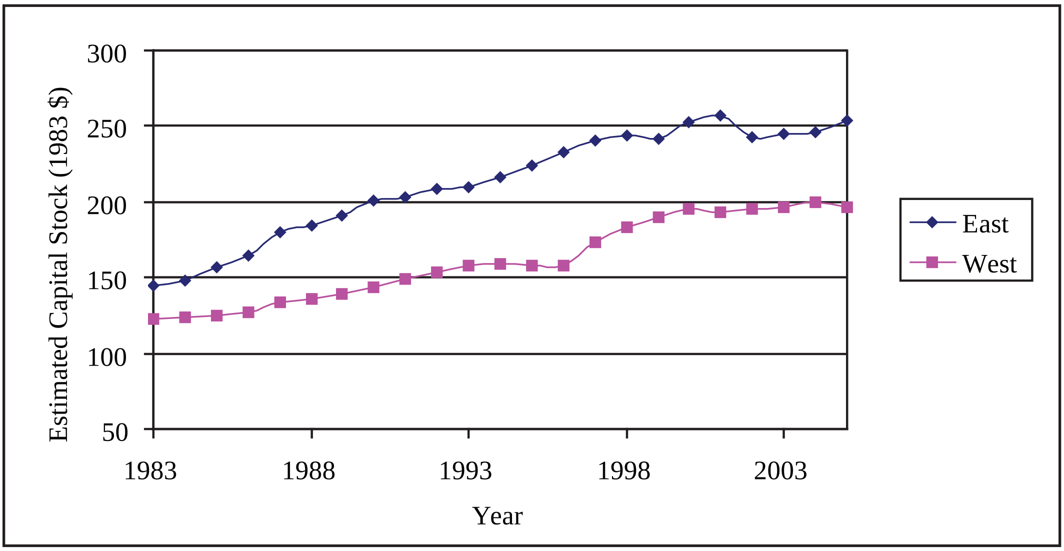


Figure 4: Estimated Equipment Capital Stock per Mile of Road



railroads seemed to be achieving a much more efficient usage of their capital stocks relative to traffic levels. This may be explained in part by both increased usage of higher-density lines and increased utilization of shipper-owned equipment.

CONCLUSION AND AREAS FOR FURTHER RESEARCH

The model presented here provides a method of obtaining reasonable estimates of railroad capital structure under some rather restrictive regression and data creation assumptions, indicating that following deregulation, the railroads tended to adjust the rate of capital accumulation in an attempt to become more economically efficient by concentrating more on roadway investment rather than on equipment.

Figure 5: Estimated Roadway Capital Stock per Gross Ton-Mile

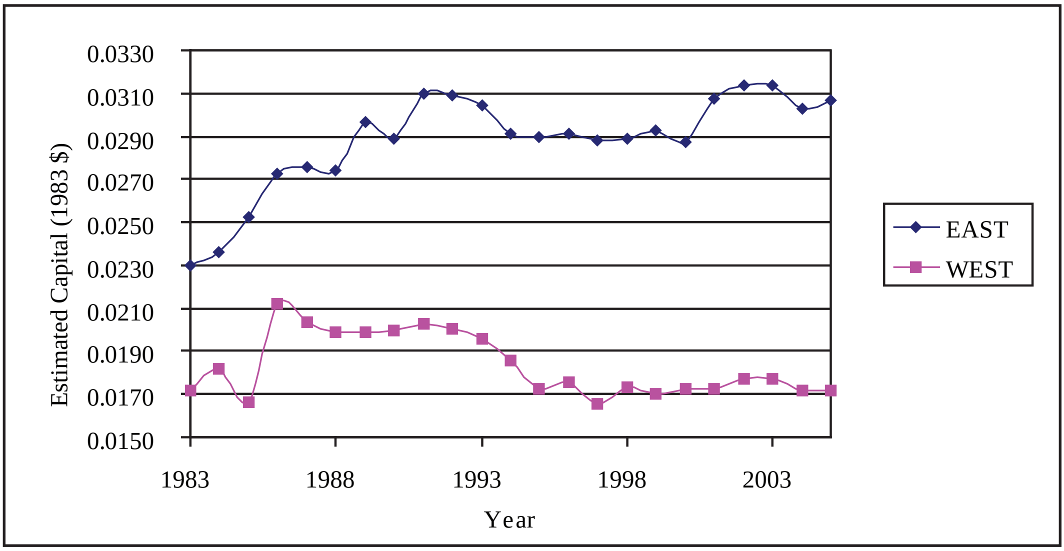
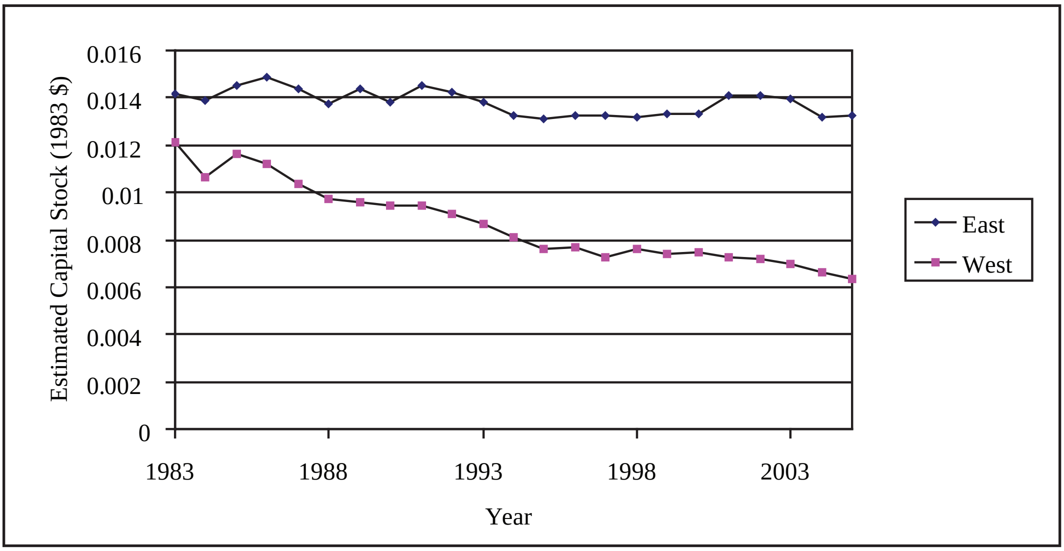


Figure 6: Estimated Equipment Capital Stock per Gross Ton-Mile



Several additional areas for further study in the area of railway capital structure are immediately suggested by the current research. First, the data may allow adjustment so that the equipment classification may be further disaggregated into locomotive, freight car, and other equipment classifications. This breakdown would allow for closer examination of exactly how the railroads were investing. Second, this study has concentrated on roadway and equipment expenditures. A third classification of capital expenditures on other items exists and inclusion of these items (such as office computers) may give valuable insights into relative changes in managerial as opposed to operational concentration.

Additionally, the analysis could be extended to a more interrelated simultaneous equation methodology along with estimates of railroad costs such as in Friedlaender (1993) rather than the two-stage least squares (instrumental variable) method used here. This would allow for possible interactions between the error terms of the capital stock degradation and investment estimates with the other cost factors in the various sectors of rail operation as well. It is expected that such research will yield significant advances in the area of analysis of the rail transportation production and costing problem.

Finally, the estimates of capital stocks can be used in the development of models of rail cost. These estimates, for example, show that capital has been, in fact, increasing over the last two decades at the same time that miles of road has been decreasing. Use of the capital stock values can therefore greatly reduce the biases introduced into costing models by the use of a single-size variable such as miles of road or number of cars.

Endnotes

1. A more general derivation of the perpetual inventory method of estimating capital stocks can be found in "Fixed Reproducible Tangible Wealth in the United States 1925-94," U.S. Department of Commerce; August 1999.

2. There is always some question in a model such as this as to whether the investment values for each year should be taken directly from the accounting data or estimated. Two arguments can be made for using estimated values. First, the deflators to put the estimates into real terms are not completely accurate as investment involves the purchase of many different items which may not be covered by the price index as accurately as desired. Second, some investment programs that are put in place involve more than one year's expenditures so that the smoothing that is accomplished by estimating investment and then using a projected value may in fact more accurately represent the real pattern of investment over time.

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