Matt Horton

10/12/11

Logistical S-Curve

The Fate of the Passenger Rail Car in the U.S.

History.

The early 1800's, brought a revolution to transportation that changed how the world fundamentally worked. Rail technology not only made commerce incredibly more efficient, it made people many times more mobile than ever before. Rail companies represent one of the first examples of corporate structure. A fundamental portion of these corporations was rooted in passenger rail service.

Beginnings.

Passenger rail technology evolved rapidly both in structure and in purpose. Cars that transported people exclusively began looking much like carriages and carts. By 1870, the passenger car fleet began to take shape and specialized to meet specific needs of the customer. In this decade, cars were predominately coach style with baggage cars being used concurrently. Sleeper cars also began to find their niche with travelers taking advantage of the quickly expanding rail network.

Development.

1880 saw the fleet of passenger cars specialize even further as it expanded. As travelers began to travel longer distances and as rail attracted a more diverse range of classes, cars were created that catered to the entertainment and daily needs of customers. This decade saw the development of both Parlor and Diner cars. Parlor cars were required to provide the male gentry a place to commune and smoke tobacco. Diner cars allowed passengers to eat in a more formal setting than the coach cars.

Guilded Age.

At the peak of passenger car era in 1930, 63,900 vehicles were in use. Rail was the dominate transportation mode of the day and the diversity and size of the passenger car fleet reflected this reality. At this point, business men could work on the train while traveling in office cars. Mail cars had also been widely deployed as a way for the Postal Service to increase efficiency while subsidizing the rail companies for providing service, especially in remote areas.

Decline.

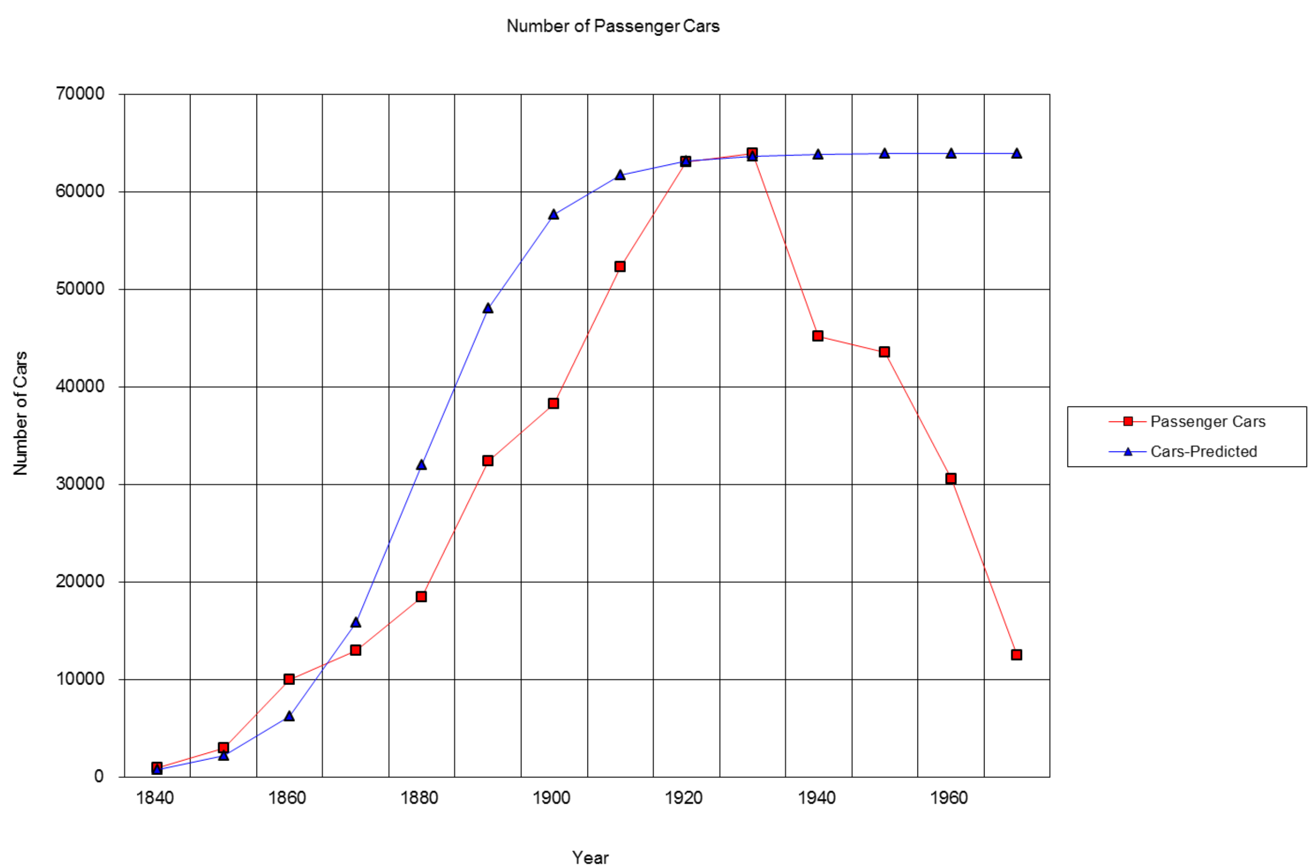
After 1930, the number of passenger cars began to decline dramatically. People in the U.S. traveled less, in general, during WWII and mode substitution became prominent in the post-war period. Automobiles and the interstate highway system eliminated demand for most short and mid-range trips. The aviation industry then eliminated the demand for long-range trips, especially from the profitable business classes.

Predicting Passengers

Year	Passenger Cars	Predicted Passengers Cars
1840	900	742
1850	3000	2201
1860	10000	6248
1870	13000	15826
1880	18400	31950
1890	32400	48074
1900	38200	57652
1910	52300	61699
1920	63100	63158
1930	63900	63654
1940	45200	63819
1950	43500	63873
1960	30600	63891
1970	12500	63897

Predicted Passengers is calculated using the formula: $S(t) = K/[1+\exp(-b(t-t_0)]$ K represents the theoretical saturation level and is 63900 in the case of passenger cars. T(0) is the theoretical year at which half of K is reached. The value is 1888 in this scenario.

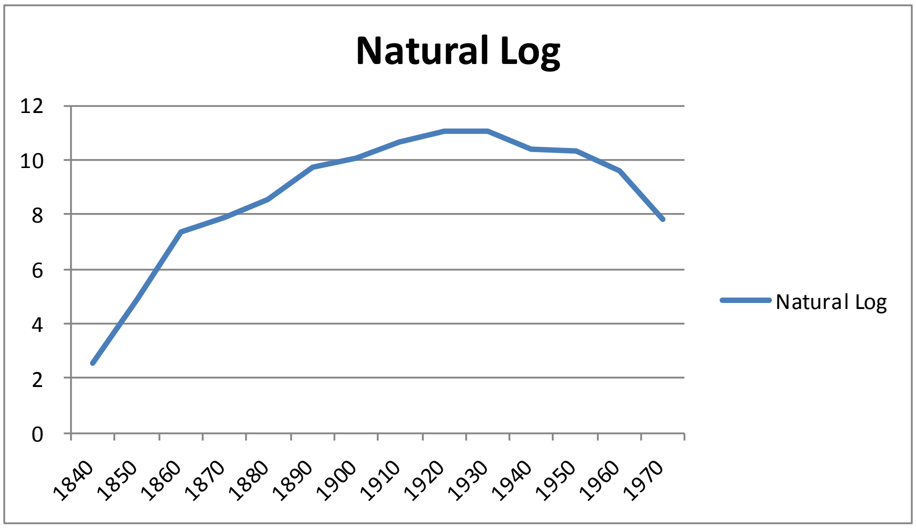
S-Curve.



This graph shows the actual historical number of passenger cars in deployment in comparison to the predicted number of cars using the formula above. The model appears to very closely predict the actual levels of deployment from the historical data. Using this model, we can generally identify the major life-cycle stages of the technology. 1840 to 1860 marks the "birth" stage of the technology as it was slowly implemented and fine-tuned. 1860 to 1900 saw the widespread adoption of the technology at a break-neck pace and can be considered the "deployment" phase. 1900 to 1930 is where the technology came of age and reached "maturity" as very few cars were produced while maintaining very high overall numbers. 1930 to 1970 witnessed a wholesale abandonment of the technology and marks the "decline" stage.

Natural Log.

	Natural Log
1840	2.539715
1850	4.94766
1860	7.355606
1870	7.880335
1880	8.575137
1890	9.706753
1900	10.03611
1910	10.66443
1920	11.03988
1930	11.06507
1940	10.37263
1950	10.29596
1960	9.592436
1970	7.801893



The natural log of actual numbers of passenger cars is necessary to run more complex regressions of the data. This shows a smoother curve of the data graphed a section before.

Regression Statistics.

Birth to Maturity (1840 – 1930)

Regression Statistics	
Multiple R	0.951667122
R Square	0.905670311
Adjusted R Square	0.892194641
Standard Error	8.991886303
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5434.021865	5434.02	67.2078	7.79471E-05
Residual	7	565.978135	80.854		
Total	8	6000			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1774.681714	14.38235888	123.393	6.1E-13	1740.672839	1808.6906	1740.67284	1808.69059
2.539714886	12.77042047	1.557741223	8.19804	7.8E-05	9.0869478	16.453893	9.0869478	16.4538931

The regression add-in on Microsoft excel was used to generate evaluation statistics of the data. With an R-squared statistic above .9 and a very high t-statistic, this model shows a very close fit to the data set. This means that the deployment of rail passenger cars statistically behaved in a very predictable matter until maturity.

Maturity through Decline (1930 – 1970)

Regression Statistics	
Multiple R	0.908956425
R Square	0.826201782
Adjusted R Square	0.739302673
Standard Error	6.591627606
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	413.100891	413.101	9.5076	0.091043575
Residual	2	86.89910899	43.4496		
Total	3	500			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2048.419229	30.47582468	67.2146	0.00022	1917.292339	2179.5461	1917.292339	2179.54612
11.06507464	-9.81734841	3.183895477	-3.08344	0.09104	-23.516545	3.8818482	-23.516545	3.88184816

When the same regression is run on the decline of the technology, somewhat different results emerge. The R-squared comes in high at .82 and the t-statistic large but almost half of the opposite side of the curve. This small but noticeable difference can be attributed to the rapid mass adoption of alternative modes which caused the decline to happen at a much faster rate than the implementation of passenger cars.

Conclusions.

The number of passenger cars in the U.S. followed a typical life-cycle for a transportation technology and fits closely with regression models. It grew slowly in the beginning years as the technology as the early-adopters did fine-tuning and costumers became comfortable with what it had to offer. Passenger cars then exploded in popularity and became widely adopted as the standard for travel in the U.S. In the time around WWI, its adoption continued to grow but at a slowing rate as the mature technology reached its natural limitations. After 1930, other modes emerged in direct competition with passenger rail cars. Automobiles and passenger planes emerged as more attractive technologies and a mass substitution took place causing the number of passenger rail cars to decline rapidly.

It will be interesting if this technology re-emerges as a viable mode. Deployment of roads has been in the “mature” phase for a few years and the market appears to be searching for a substitution. High speed rail has been all the rage among transportation planners as a high-capacity alternative to highways. Only time will tell if HSR catches in the U.S. and the passenger rail cars see a new age of glory.

Bibliography.

Moody’s. “Transportation Manual.” 1992. New York: Moody’s Investor Service, 1 – 1214.

Railroad Facts. “1989 Edition.” 1989. Washington: Association of American Railroads, 1-61.

Solomon, Brian. “Great Passenger Trains: The Milwaukee Road’s Hiawathas.” 2006. St. Paul: MBI Publishing Company, 1 – 159.

White, John H. “The American Railroad Passenger Car.” 1978. Baltimore: Johns Hopkins University Press, 1 – 693.

Yenne, Bill. “Great Passenger Trains: Great Northern Empire Builder.” 2005. St. Paul: MBI Publishing Company, 1 – 160.