The Effect of branch line abandonment on local highways : a site specific study
by Thomas Randall Fortenbery

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Applied Economics
Montana State University

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The methods were then applied to a study site, the Newlon Junction to Richey branch line, and the estimated highway costs associated with the abandonment of this line were computed. The estimated highway costs were then used to show that exclusion of these costs in a benefit-cost analysis of branch line abandonment will affect results. From this it is proposed that any analysis which excludes highway impact is incomplete, and as such the results do not suggest an optimal level of rail activity.

The conclusion drawn from a review of the literature is that previous studies of branch line abandonment have not been complete. They have not explicitly considered highway impact in the analysis. As such, they have not accurately estimated the impact of branch line abandonment on local communities.

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APPROVAL

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Thomas Randall Fortenbery

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citation, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

6/14/84 — Date

Gail L. Cramer — Chairperson, Graduate Committee

Approved for the Major Department

6/14/84 — Date

Bruce R. Beattie — Head, Major Department

Approved for the College of Graduate Studies

6-25-84 — Date

M. Malone — Graduate Dean

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ABSTRACT

A method to estimate physical highway impacts resulting from branch line abandonment was developed. Next, incremental cost curves were derived which show the incremental costs associated with increased truck traffic.

The methods were then applied to a study site, the Newlon Junction to Richey branch line, and the estimated highway costs associated with the abandonment of this line were computed. The estimated highway costs were then used to show that exclusion of these costs in a benefit-cost analysis of branch line abandonment will affect results. From this it is proposed that any analysis which excludes highway impact is incomplete, and as such the results do not suggest an optimal level of rail activity.

The conclusion drawn from a review of the literature is that previous studies of branch line abandonment have not been complete. They have not explicitly considered highway impact in the analysis. As such, they have not accurately estimated the impact of branch line abandonment on local communities.

CHAPTER I

INTRODUCTION

A recent occurrence in Montana has been a shift from rail transportation services to trucking services in the short haul transport of grain from rural areas to assembly centers. One cause has been the abandonment of railroad branch lines which the railroad companies assert are not economically viable without subsidization from other revenue sources.

The passage of the Staggers Rail Act of 1980 and Interstate Commerce Commission (ICC) Decision Ex Parte 347 (sub. no. 1) are institutional changes which will affect the behavior of railroads in terms of branch line abandonment. It has been suggested that the result of these actions will be an environment in which branch line abandonment may be less costly and time consuming for railroads (Seaver, 1983). It has also been suggested by the Montana Governor's Transportation Advisory Council that the combination of the Staggers Act and Burlington Northern's (BN) increased usage of high volume unit trains and large grain subterminals may result in an accelerated level of branch line abandonment in Montana. One result could be an increased number of Montana grain producers being isolated from local rail service (Governor's Transportation Advisory Council).

The transition from rail to truck for short haul services has not been accomplished without protest from some affected communities. There is concern that much of the adverse economic impact of railroad abandonment accrues to rural communities; elevators lose business, farmers face longer truck hauls from the farm, local tax bases decrease, and the rate of road deterioration increases.

Railroads have argued that the utilization of unit trains and subterminal facilities will result in reduced rail rates for farmers. It has been countered, however, that the lower freight rates may not be sufficient to offset the increase in trucking costs from farms to mainline facilities. Wheat farmers argue that loss of local rail service will jeopardize their ability to profitably market their produce. In addition, rural communities fear that loss of local rail service could adversely affect local businesses. If farmers must travel to mainline communities to acquire rail service, they may also rely on mainline communities for other services previously purchased locally.

The controversy surrounding branch line abandonment to date has been lacking in analytical inputs. The result has been confusion by shippers, carriers, and governments concerning the local effects of branch line abandonment. The few analytical studies which have been done have not explicitly considered highway impact in the analysis. Highway impact has either been assumed minimal or has not been discussed. Therefore, this study will discuss a method to calculate highway impact resulting from branch line abandonment, and thus provide the basis for a more comprehensive understanding of the community impacts of branch line abandonment.

The Montana Rail System

In 1983 there were 5,126 miles of rail track operating in the State of Montana (Montana Rail Plan, 1982). The BN operated 93 percent (4,769 miles) of this total, and the Union Pacific, Soo Line, and Butte, Anaconda, Pacific Railroad operated the remaining 7 percent (Montana Rail Plan, 1982). The BN also operated 18 branch lines in Montana in 1983. Thirteen of these, totaling 319 miles, were in some category of proposed abandonment (Lewis).

There are three categories identified by the State of Montana in the abandonment process. Category one contains those lines the railroad anticipates filing for abandonment within three years (Montana Rail Plan, 1980). There were ten Montana branch lines in category one in 1983. They totaled 160.5 miles of track (Lewis). Category two refers to those lines which the carrier is studying for possible abandonment because of an expectation that either operating costs or rehabilitation costs will be excessive compared to potential revenues (Montana Rail Plan, 1980). In 1983 there were no Montana lines classified in category two (Lewis). Category three refers to those lines for which an application for abandonment has been filed with the ICC (Montana Rail Plan, 1980). There were three branch lines statewide totaling 158.5 miles included in category three in 1983 (Lewis).

Statement of the Problem

The Newlon Junction to Richey branch line extends 45.4 miles through Richland and Dawson Counties in Eastern Montana. There are three active stations along the line (Lambert, Enid, and Richey) which primarily handle farm products (93 percent of all traffic and 100 percent of outbound traffic in 1980). Seventy-three percent of the traffic was accounted for by three shippers/receivers in Richey, while five additional customers accounted for the remaining 27 percent (Montana Rail Plan, 1982). Traffic volume on the line fluctuated considerably in the late 1970s and by 1980 was down measurably from the previous years (Table 1). The line averaged 7.5 carloads per week in 1980, and generated a total revenue for BN of about $1.3 million (Table 1), with an estimated net profit of $172,000 (Montana Rail Plan, 1982). As noted in Table 2, the total avoidable costs incurred by BN from providing branch line service was a little over $1 million. In addition, the opportunity cost foregone based on a 12.1 percent rate of return on the line amounted to $48,957 (Montana Rail Plan, 1982).

In 1983 the Newlon Junction to Richey line was in category one of abandonment. The 1982 Montana Rail Plan identified the line as being in poor condition with service sometimes interrupted in wet weather due to the poor condition of the road bed. The Rail

Table 1. Railroad Use Statistics for the Newlon Junction to Richey Branch Line in 1980.

Station	Carloads Number	Carloads Percent	Tons Number	Tons Percent	Commodity
			Originating		
Lambert	74	19.0	6,377	19.1	Farm Products
Enid	21	5.4	1,810	5.4	Farm Products
Richey	267	68.6	23,008	68.8	Farm Products
			Terminating		
Lambert	10	2.3	885	2.6	Chemicals
Richey	13	3.4	1,151	3.4	Chemicals
	3	1.0	150	0.5	Lumber & Wood Products
	1	0.3	50	0.2	Other
Total Traffic	389	100.0	33,431	100.0	

1980 Statistical Summary

Length: 45.4 miles
Million Gross Ton-Miles Per Mile: 0.086
Carloads Per Week: 7.5
Carloads Per Mile: 8.6
Revenue: $1,301,126

Traffic Volume History

1976	801
1977	450
1978	649
1979	865
1980	389

Source: 1982 Montana Rail Plan, Montana Department of Commerce.

Plan also identified the estimated rehabilitation cost of the line to be at $5.1 million. Without rehabilitation the line will be incapable of handling fully-loaded (100 ton) covered hopper cars in the future (Montana Rail Plan, 1982).

Freight traffic on the Newlon Junction to Richey line currently faces competition from truck services and unit train facilities in Sidney, Circle, and Wolf Point (see Figure 1). The branch line is paralleled from Sidney to Richey by Federal Aid Primary 51 (State Highway 200) which also continues west to Circle. Federal Aid Secondary 254 connects Richey with Federal Aid Primary 25 allowing travel northwest to Wolf Point, and Glendive

Table 2. Estimated Revenues and Costs for the Newlon Junction to Richey Branch Line in 1980.

Revenues Attributable	Revenues/Costs
1. Freight Originated and/or Terminated on Branch	$1,301,126
Avoidable Costs	
2. On-Branch Costs (Lines 2a through 2c)	$ 468,928
a. Maintenance of Way and Structure (Normalized)	362,701
b. Transportation	77,134
c. Freight Car Costs	29,093
3. Off-Branch Costs	612,000
4. Total Avoidable Costs (Line 2 plus Line 3)	$1,080,928
5. Avoidable Loss from Operations (Line 1 minus Line 4)	($ 220,198)*
6. Net Liquidation (Line 6a plus Line 6b)	$ 404,600
a. Materials	211,600
b. Land	193,000
7. Rate of Return	12.1%
8. Opportunity Cost Foregone (Line 6 times Line 7)	48,957
9. Total Avoidable Loss (Line 5 plus Line 8)	($ 172,241)*

*Parenthesis indicates gain.
Source: 1982 Montana Rail Plan, Montana Department of Commerce.

to the southeast. Figure 2 shows the Newlon Junction line and local roadways, including the Montana Highway Department's estimates of highway traffic density in 1981.

An expected result of abandonment of this line is an increase in grain traffic over the local highway system in order to market locally produced grain. This, in turn, may adversely affect the quality of the road system in the Richey area. The problem, then, is to determine if abandonment of the Newlon Junction to Richey branch line would adversely affect the existing road system, and then identify the costs associated with any highway impact.

Need for the Project

There has been little research quantifying the various impacts of branch line abandonment on individual communities. Such work may be desirable, however. For example, the importance of quantifying the economic impact of rail line abandonment is evident in the

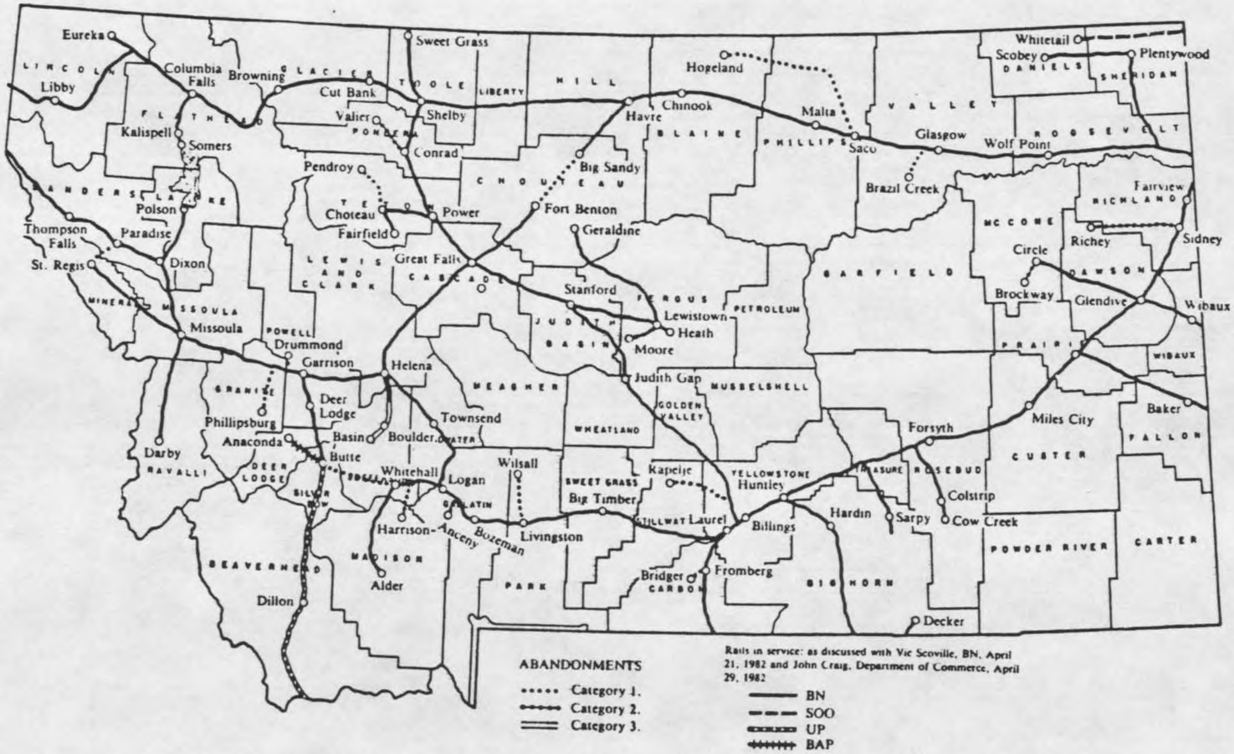

Figure 1. The Montana Railroad System, 1982.

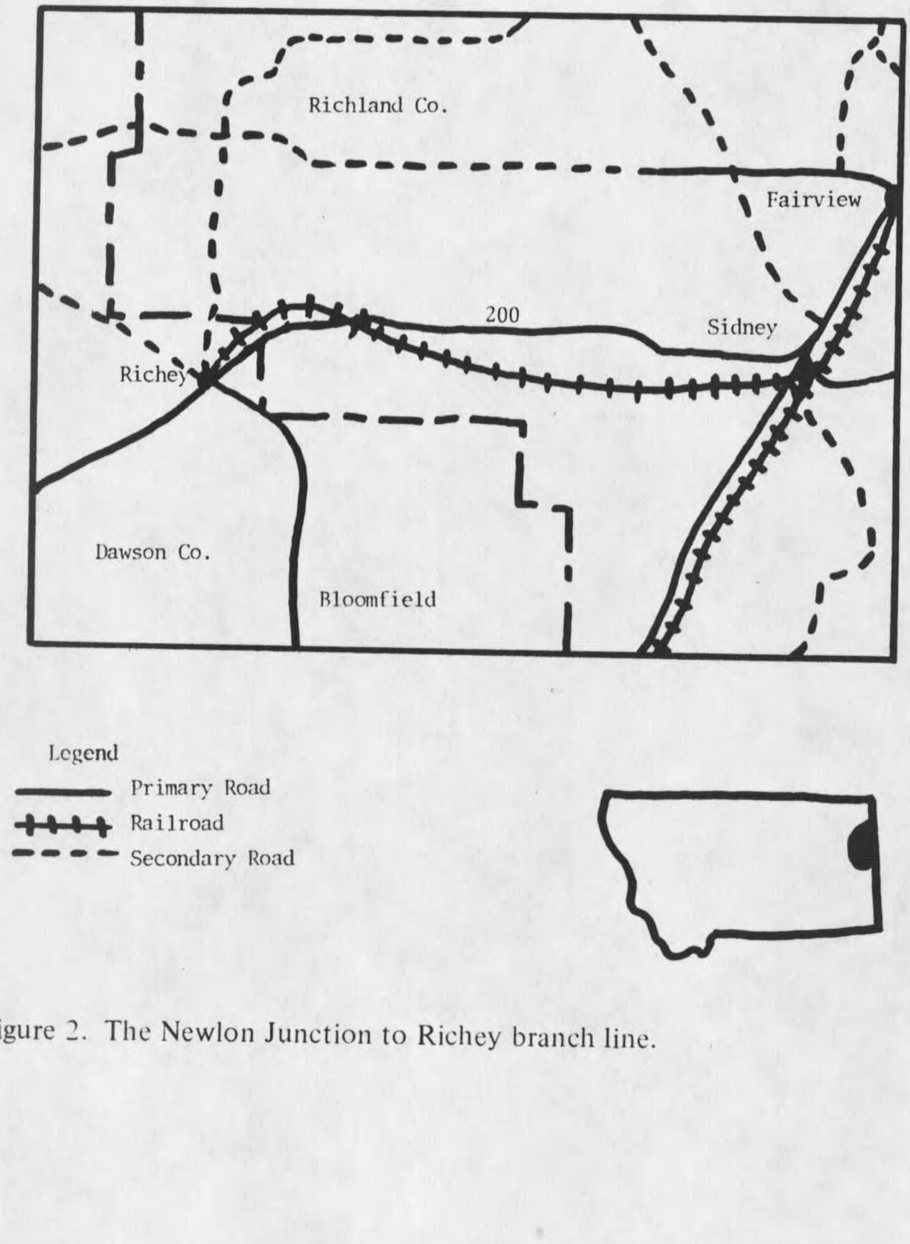

Figure 2. The Newlon Junction to Richey branch line.

lack of consensus among affected parties as to the magnitude of various impacts. Conceivably, improved information could reduce conflicts and possibly prevent litigation in some cases.

Of specific interest is the impact on local road systems. This is because Montana's road systems provide the only alternative to rail systems in grain marketing. Unfortunately, however, there is no consensus as to the effect a branch line abandonment will have on a local road system. Purnell (1976) contends that an abandonment will usually adversely affect local road systems, while Zimmer (personal communication) states that there has been little work or agreement (in the engineering profession) in identifying the best way of measuring the impact.

The Newlon Junction to Richey branch line was chosen to study potential highway impacts in Montana for five reasons. First, the line seems to be typical of lines being considered for abandonment in Montana. It is currently classified in category one of abandonment, as are the majority of branch lines in Montana. This implies that there has not been a decision made regarding abandonment of the line. Second, the line predominantly serves the agricultural industry, again typical of Montana lines considered for abandonment. Third, there is potential competition from both trucks and truck/unit train combinations for branch line freight. Fourth, there are few alternate truck routes to substitute for branch line service. Fifth, data exist that reflect the traffic patterns on the single primary road serving the area. This will allow estimates of the amount and distribution of freight traffic diverted from the branch line to the highway, and subsequently the impact of such a diversion.

Objectives

This study has two main objectives. The first is to present a method for quantifying the highway impacts resulting from branch line abandonment. This method will then be applied to the Newlon Junction to Richey study site. This will provide an estimate of the physical and corresponding economic impact on Montana Highway 200 which would result from rail abandonment.

The second objective is to discuss why calculation of highway impact is important in considering the overall effect of an abandonment on a community. If highway impacts are not explicitly identified, then it is possible that the costs to a community resulting from branch line abandonment will be underestimated. The result in such a situation would be a less than comprehensive understanding of the social costs resulting from branch line abandonment.

Procedure

The first step requires that data reflecting the total amount of grain and other freight shipped over the Newlon Junction to Richey branch line on an annual basis be generated. This is important in that it will provide a basis from which to estimate the expected increase in highway freight traffic resulting from abandonment. The annual rail traffic will be estimated using rail traffic data from 1976 to 1982. It is useful to consider rail traffic over several years because of annual fluctuations in traffic (Table 1).

The estimated increase in highway freight traffic will then be divided into equivalent axle loads (EAL).[1] The estimated increase in EAL's will be compared to the current traffic density estimates for Highway 200 from the Montana Department of Highway's "Rural Traffic Flow Map." From this comparison an estimate of the expected range of percentage increases in EAL's resulting from abandonment can be calculated. The percentage increase in EAL's can then be used to estimate highway damage by use of a damage function.

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[1] Equivalent axle load is a standardized measure of the total traffic moving across a road surface in some given time period. It involves expressing the gross weights of all vehicles in terms of eighteen thousand pound axle loads.

A damage function expresses the increased pavement thickness required to maintain road serviceability at pre-abandonment levels. The damage function corresponding to the Richey area will be derived by plotting points associated with pavement increases for every 10 percent increase in traffic loads. The equations used to derive these specific points have been presented by Purnell (1976), and are discussed in Chapter 3.

Once a damage function has been specified, an incremental cost curve can be derived which will show the expected highway damage cost associated with any given level of highway traffic increase. From the cost curve the increased costs of highway maintenance resulting from the diversion of branch line traffic can be quantified. These costs can then be viewed in the larger context of the general implications of branch line abandonment.

CHAPTER II

LITERATURE REVIEW

In dealing with branch line abandonment a society has two basic alternatives: first, provide a subsidy sufficient to provide an incentive to the railroad to maintain service, or second, incur the costs associated with abandonment. The burden on society, then, is to determine which alternative will maximize (minimize) net social benefits (costs) and then take the appropriate action.

Branch Line Subsidization

In discussing the first alternative, Wilson, Tyrchniewiez, and Mason (1981) have noted there are instances in which cooperative efforts between a railroad and community can maintain branch line service. They suggest that a possible solution in these instances would be to revise the current rate structure to include a specific rate, in addition to the through rate, for branch line service. Currently there are no differences between rates on branch line points of origin and mainline points of origin (Wilson et al., 1981). By instituting a surcharge for branch line service, shippers would face the opportunity cost of maintaining the line.

A surcharge for branch line service may present another problem, however, in that the price charged may be inefficient. This is because a large portion of the total cost of providing branch line service is independent of output (Wilson et al., 1981). The implication is that average costs are falling through the observed range of output, with marginal costs below average costs (Figure 3).

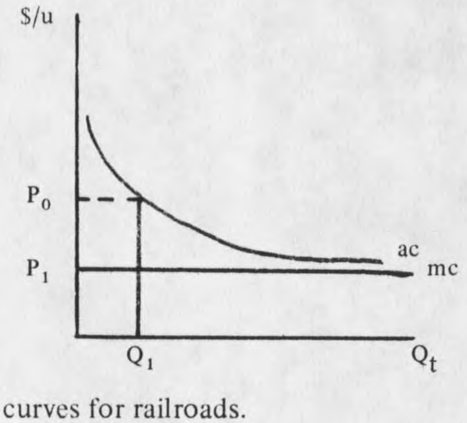

Figure 3. Cost curves for railroads.

Seneca endorses a similar cost structure when she states that the rail industry is exemplified by large, sunk physical investments in long term facilities. These investments are not transferable to other uses without large monetary losses. The result is that a long-term view of incremental costs is not appropriate; a large proportion of fixed costs remain fixed over any contemplated planning horizon. From this Seneca asserts that average costs are decreasing over the observed range of output, implying that marginal costs must lie below average costs.[1]

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[1] Wilson, Tyrchiewiez, and Mason and Seneca assert that average and marginal costs are falling through the observed range of output. This may be a more restrictive conclusion than necessary, however, in that a high level of fixed costs only implies that average costs are falling, which in turn only implies that marginal costs must lie below average costs, and not that marginal costs must also be falling.

The functional form implied by Figure 3 is TC=F+VQ where TC is total costs, F is fixed costs, V is variable costs, and Q is output. This implies constant marginal costs (MC) equal to V:

$$MC = \frac{\partial TC}{\partial Q} = V$$

It further implies average costs (AC) which approach, but never reach, a minimum:

$$AC = \frac{TC}{Q} = \frac{F}{Q} + V$$

This functional form satisfies the argument that average costs are falling through the observed range of output, with marginal costs below average costs, but does not impose the restriction that marginal costs be declining.

The implication of such a cost structure is that the efficient price, i.e., price set equal to marginal cost (P_1 in Figure 3), will not recover total costs. The result of such a price structure could be a lack of incentive for railroads to provide branch line service over the long run. If, on the other hand, price is set at P_0, then any consumers willing to pay the marginal cost of service, but not average cost, would be eliminated from the market. This price would thus be inefficient because it deviates from the marginal cost of production (Wilson et al., 1981).

Baumol and Bradford (1970) (as well as Seneca) have asserted that in such a situation the traditional Pareto optimum price, where price is set equal to marginal cost, may not maximize social welfare. The contention is that in the case where pricing at marginal cost will not recover total costs, a second best, or Pareto quasi-optimal, pricing structure may be used to maximize social welfare (Baumol and Bradford, 1970). Baumol and Bradford have stated that the objective of such a pricing structure (subsidy) is one of the following:

1. the subsidy results in maximizing the sum of producers and consumers' surpluses.
2. the subsidy results in a price structure from which it is not possible to change with gainers compensating losers, or
3. the subsidy results in maximizing an individual's utility, given the utility level of every other individual.

All three of these alternatives basically maintain that a subsidy is warranted if it maximizes net social welfare.

The result of such a pricing technique is that a second best solution is achieved. While the price is not economically efficient (i.e., not set equal to marginal cost), market conditions may be such that this is the most efficient solution which can be achieved. Baumol and Bradford make this clear by referring to the problem as "maximization in the presence of an added constraint. Resource allocation is to be optimal under the constraint that government revenues suffice to make up for the deficits . . . of individual firms that constitute the economy" (p. 265). This "second best" pricing technique is referred to as the Ramsey Pricing Principle, and is applicable when marginal cost pricing will not recover total costs (Baumol and Bradford, 1970).

In studying two rail lines in Canada, it was found that pricing at marginal cost would recapture 20-35 percent of the cost of providing rail service (Wilson et al., 1981). Wilson, Tyrchiewiez, and Mason concurred with Baumol and Bradford that subsidizing the resulting deficit, thus applying the Ramsey Pricing Principle, is justified if it can be shown that marginal benefits are equal to or greater than marginal costs.

Branch Line Abandonment

Probably the most comprehensive work computing the benefits and costs of branch line abandonment was by Baumel, Miller, and Drinka in 1976. They analyzed seventy-one branch lines in Iowa. The purpose was to determine the benefits and costs of rehabilitating each line and discuss the impacts of abandonment on communities and individual businesses (Baumel, Miller, and Drinka, 1976).

The 1976 study defined the benefits resulting from rehabilitation as:

> the total annual transportation and handling cost savings to grain shippers, fertilizer receivers, and shippers and receivers of other products if the line is upgraded rather than abandoned (p. 5).

The costs of upgrading were defined as:

> the total annualized cost of upgrading the line to 263,000-pound carrying capacity and to Federal Railroad Administration Class II Standards . . . plus the fixed cost of maintaining the line at that level of upgrading (p. 5).

The conclusion was that fifty-six percent of the seventy-one Iowa lines yielded a benefit-cost ratio of less than 0.25. Only eight of the lines produced a benefit-cost ratio greater than one (Baumel , Miller, and Drinka, 1977). This was attributed to the fact that there were so many lines in Iowa that the additional distance to another line was relatively short, therefore the incremental costs of moving products to another line were small compared to the costs of line rehabilitation (Baumel et al., 1976). The Baumel et al. study did not fully account for highway impacts resulting from abandonment, however. The authors did recognize that such an impact exists (1976, p. 156), and even discussed a method to estimate such an impact (1976, p. 437), but did not apply the method to all seventy-one branch lines.[2]

The impact method was applied to three of the study lines, and the benefit-cost ratios of these lines were recomputed with the inclusion of the highway impact. The authors found that one line actually provided a net highway benefit from abandonment (or a cost to rehabilitation), but the other two lines did present a net highway cost from abandonment. On one of the two lines, the identified highway cost was $51,291 (Baumel et al., 1976). When the authors considered upgrading this line with new 115 pound rail, inclusion of highway impact changed the benefit-cost ratio from 0.08 to 0.13. When used 90 pound rail was used to upgrade the railroad, the benefit-cost ratio changed from 0.12 to 0.19 (Baumel et al., 1976). Similar changes were computed on the other line yielding a net highway impact; with new 115 pound rail the ratio changed from 0.17 to 0.22, and with used 90 pound rail the ratio changed from 0.29 to 0.34 (Baumel et al., 1976). From the analyses of these three lines, it was concluded that highway impact changed benefit-cost ratios only slightly, and therefore highway impact was not included in the analyses of the other sixty-eight lines (Baumel et al., 1976, p. 182).

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[2] The method used by Baumel, Miller and Drinka for computing highway impact basically consisted of collecting data on the estimated construction and maintenance costs resulting from one vehicle pass over one mile of road. This procedure assumed that optimal truck routings would take vehicles to a hard surface road as soon as possible. They then combined these routings and an estimate of the optimal number of pre- and post-abandonment trips with the estimated cost per vehicle pass. The difference between the pre- and post-abandonment costs became the incremental highway cost of branch line abandonment. This cost was then compared with the estimated increase in fuel and registration tax revenues caused by the increased truck traffic. The difference between highway costs and increased tax revenues was identified as net highway impact (Baumel et al., 1976).

The conclusion that highway impact is unimportant is questionable. Calculated benefit-cost ratios on five of the other sixty-eight lines were less than one, but would have exceeded one if the ratios were affected by the same magnitude from inclusion of highway impact as those on the two lines that were considered (Table 3). The implication that can be derived from these benefit-cost ratios is that highway impact, if explicitly considered in the calculation of benefits resulting from rehabilitation (or abandonment) may affect the suggested decision. There is no argument presented as to why highway impact was computed on lines with such low benefit-cost ratios initially, nor why one would not expect similar changes in benefit-cost ratios when considering highway impacts on lines with an initial ratio close to one.

Table 3. Benefit-Cost Ratios for Selected Branch Lines in Iowa.

Line Name	Benefit-Cost Ratios: Single-Car Rate	Benefit-Cost Ratios: Multiple-Car Rate
Burt to Ledyard to Halfa		
New 115 pound rail	.59	.28
Used 90 pound rail	.94	.44
Estherville to Rake		
New 115 pound rail	.64	.77
Used 90 pound rail	.98	1.19
Mason City to Kesley		
New 115 pound rail	.64	.46
Used 90 pound rail	.81	.58
Moorland to Carroll		
New 115 pound rail	1.12	.71
Used 90 pound rail	1.41	.89
Carroll to Harlan		
New 115 pound rail	.99	.78
Used 90 pound rail	1.23	.97

Source: Baumel, Miller, and Drinka, 1976.

In 1982, the Montana Department of Commerce conducted a benefit-cost analysis on the rehabilitation of the Newlon Junction to Richey branch line (Montana Rail Plan, 1982). Benefits in this study were defined as "those economic impacts which could occur after abandonment but which could be prevented by the continuation of rail service" (p. 4-8). Costs were defined as "the amount necessary to stabilize a line so that normal annual maintenance can then be made to keep the line at an appropriate standard . . . any economic disbenefits of [rehabilitation] were also counted as costs" (p. 4-8).

In discussing abandonment costs, the State of Montana study does recognize that an abandonment may adversely affect local roads. For the Newlon Junction to Richey line, however, highway costs were not considered in the benefit-cost calculations. The Department of Commerce estimated the increase in truck traffic to be about five vehicles per day. Based on this it was determined there would be no measurable incremental damage to highways from abandonment (Montana Rail Plan, 1982). The benefit-cost ratio calculated for the Newlon Junction to Richey line was 0.38. This was based on rehabilitation benefits of $3,416,100 and rehabilitation costs of $8,949,100 (Montana Rail Plan, 1982).

While consideration of highway impacts resulting from abandonment have been lacking in the economics literature, there has been some research by engineers. Purnell (pp. 23-24) suggests the following basic premise:

> any increase in the number or weight of motor carriers using a highway facility arising from rail service discontinuance will create a need for additional asphaltic concrete overlays on the highway forced to assumed additional truck passes.

Purnell goes on to suggest that any need for resurfacing affected highways to facilitate increased truck traffic is a cost which will have to be borne by state and/or local governments. Furthermore, if these costs are avoided initially by deferring the necessary maintenance and re-paving, the service life of the road will be reduced, resulting in a decline in pavement rideability and serviceability.

If the increase in truck traffic resulting from an abandonment can be estimated, it is possible to determine the level of highway impact which would be expected to result from the abandonment (Purnell, 1976). By identifying the expected level of highway impact, one can estimate the economic impact on society, i.e., the increased costs of highway maintenance and/or use resulting from an abandonment.

In discussing highway maintenance expenditures as a function of vehicle traffic, the Organisation for Economic Cooperation and Development (OECD) makes a distinction between two types of maintenance; surface and structural. Surface maintenance, which refers to the restoration of road surface characteristics such as evenness, skid resistance, and impermeability, does not change as a function of heavy freight traffic or traffic increases (OECD, 1982). One would therefore not expect increases in surface maintenance costs from abandonment.

Structural maintenance refers to adapting a road so as to accommodate changes in traffic load, thus prolonging a road's useful life and compensating for accumulated fatique (OECD, 1982). Such maintenance usually encompasses pavement overlays. Structural maintenance is a function of both vehicle weight and traffic density; therefore a railroad abandonment may affect structural maintenance costs (OECD, 1982). In calculating the economic impact on highway structures resulting from branch line abandonment, therefore, it must be determined whether or not a sufficient amount of traffic is diverted to the highway to change the structural maintenance needs.

CHAPTER III

METHODOLOGY, BENEFIT-COST ANALYSIS, AND DATA REQUIREMENTS

Methodology

In analyzing objective one, estimation of highway impacts from abandonment, it is necessary to first specify a damage function. Such a function is a relationship between required pavement overlay and traffic density, measured in equivalent axle loads.

Purnell specified such a function (referred to as an impact graph) as:

$$f(\Delta t, \%\ EAL)$$

where Δt refers to required overlay thickness, and % EAL is the percentage increase in equivalent axle loads. Purnell's specification of this function is shown in Equation 1:

$$\Delta t = \frac{SN_A - SN_{NA}}{a_1} \qquad (1)$$

where Δt is the required overlay thickness in inches, SN_A is the exact design structural number following increases in equivalent axle loads following abandonment, SN_{NA} is the design structural number with pre-abandonment traffic density, and a_1 is the surface layer coefficient related to the material being used for the surface layer of the pavement structure. A structural number (SN) is defined as:

> an index number derived from an analysis of traffic roadbed soil conditions, and regional factor thay may be converted to thicknesses of various flexible pavement layers through the use of suitable layer coefficients (a_1 in Equation 1) related to the type of material being used in each layer of the pavement structure (Van Til, 1972, p. 5).

Van Til defined the regional factor as "a numerical factor used to adjust the structural number of a flexible pavement structure for climatic and environmental conditions" (p. 5).