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AN INCREMENTAL APPROACH TO RAILWAY CONTRIBUTION ANALYSIS

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ABSTRACT: *One of the most significant weaknesses of railway management information is the lack of understanding of the relationships of various traffic segments making up the system, and their value to the organisation. Recent use has been made of avoidable cost analysis in attempt to expand the available information for management. However these do not seem to have adequately met these needs if management response is any guide.*

The most significant shortcoming of the avoidable analyses undertaken to date is the way they have treated traffic groups, which are subjectively determined in the first instance, as independent entities within the system. They make no allowance for the interaction in terms of resource use between traffic groups and therefore provide no information in regard to the importance of groups of traffics to the system.

In this paper an alternative method of analysis of railway cost/revenue relationships is proposed, which could provide an improved management information flow. This method basically relies on (conceptually) building up the railway system from a zero base, and in so doing taking specific account of the joint and common resources which provide the interactive link between activities.

Historical Perspective

Australian Railways have developed over 120 years or so on parochial lines, each being centred around its home state capital. Gauge differences, political barriers, and the existence until relatively recent times of comprehensive coastal shipping services mitigated against any significant shift from the historical colonial development pattern. Unlike the situation in the U.K. and U.S.A., where parallel routes and common markets led to highly competitive railways, the Australian systems tended to radiate from state capitals, with each having a similar range of services; suburban and country passenger services over the major routes, mixed trains and rail motors for lesser country passenger services and goods trains over virtually all the non metropolitan system.

Within the systems there was some recognition of different categories of service (e.g. suburban passenger; interstate freight) but these were usually on the basis of different operating characteristics rather than as market oriented definitions.

However, reporting of each of the systems was on the basis of aggregate financial performance, in line with the prevailing view that each system was a single entity and should be managed and reported as such.

This was certainly not discouraged by the Treasury masters who required the railways to basically report and control on a cash basis, but who otherwise showed little interest in encouraging the railways to behave or report in any recognisably business-oriented manner.

It is only in relatively recent times that there has been recognition by the railways that the business is, in fact, many businesses, and that each requires specific management information and reporting. Evidence of this can be seen in the reporting in recent years by VicRail and the State Rail Authority (S.R.A.) of N.S.W. of results by categories of service. These rely on allocation of all recorded costs between categories of service. (VicRail Board (1978), (1979), (1980), (1981)).

In Victoria, the allocation of costs to category of service is left to the individuals in charge of the 700 or so cost responsibility centres. Naturally there are rather different interpretations of individual costs by individual managers, largely due to their different background, experience and perceptions. The track foreman in the Mallee will see his position from a quite different perspective than would an accounting officer in Head Office. Because of the allocation process the resulting information can have little relevance to management of the business and none at all to management of individual sectors.(1)

1. Many of the allocated costs will in fact be specific to particular business segments and to that extent the allocation process is providing useful information. It is the arbitrary allocation of non specific costs which causes the "category of service" reporting to lose its usefulness for business management.

Matters such as pricing initiatives, development of business priorities, investment analysis, operations planning etc. are not assisted in any way by the existing "category of service" information.

Avoidable Cost Approach

An alternative and undoubtedly more constructive approach is that of looking at the avoidable costs of the system by major traffic groups. In Victoria, there have been no less than three studies of this nature undertaken in recent times; one by VicRail on selected major freight traffics (for the 1980 Transport Inquiry), and one each by Transmark (for the Ministry of Transport (1981) and ARRDO (1981) which analysed all traffics. These studies all related to the need to obtain some idea of the relative contribution generated by each traffic group.

Earlier attempts internally to develop a contribution analysis methodology within VicRail provided limited information but lacked the corporate view taken by the recent avoidable cost analyses. These early attempts at contribution analysis were essentially an extension of the traffic costing system used mainly for pricing which has been developed over the last 8 years or so.

The avoidable cost studies provided a more meaningful "snapshot" of VicRail than had previously been available in that they attempted to come to grips with the problem of cost causation instead of arbitrary cost allocation. However, each of the recent studies was undertaken for different purposes and, perhaps a not surprising result has been that similar traffic groups have been reported with quite different results. The degree of disaggregation of traffic (freight in particular) has had some influence on this; the greater the disaggregation, and therefore the smaller the traffic groups, the lower are the relative proportion of costs which have been regarded as avoidable.

One difficult aspect of these avoidable cost studies was that traffic groups which were large (e.g. grain) tended to produce relatively poor results for traffics which are considered to be fundamental to the system. This arose particularly because of the relatively high proportion of route infrastructure costs (tracks, stations, etc.) which could be associated with these traffics and therefore could be considered as avoidable. Smaller traffic groups by contrast, tended to have all their avoidable costs associated with rolling stock and train operation being too small to support any significant infrastructure. The effect was to place some of the more significant traffics, such as grain well down the ranking order although the infrastructure considered avoidable with grain was obviously essential to other less significant traffics (e.g. many of the grain "routes" are also associated with fertiliser and livestock traffics.)

The problem with the use of these study results was one of reconciliation between the information provided by the studies and intuitive understanding of the nature and importance of various traffics to the total railway. The acceptance of the study results at face value, seemed to point to management decisions which could lead to structural changes which intuition suggested might make long term survival rather questionable.

However, there would seem to have been a more fundamental problem in the determination of a rational and consistent basis to determine which are really avoidable and which are "joint" with other traffics. If an assumption is made that some readjustment of the system will follow "avoidance" of a particular traffic, a quite different end result can be obtained as compared to a strict "ceterus paribus" approach to the remaining traffics.

This serves to highlight the most serious shortcoming of the avoidable approach to corporate contribution analysis; that of having the "joint" costs mixed up with the "non-avoidable" part of the system and these costs therefore being left out of any specific analysis.

By the very nature of avoidable analysis the information derived always relates to a subtraction of revenues and associated costs from the pre-existing total railway. In effect the information will only relate to the immediate avoidability of the traffic in question and will not provide any adequate information in regard to the "remaining" traffic group revenues and costs. As a result the mass of revenue/cost relationships cannot be explored except on a one at a time basis, and therefore the real problems of the relationship of traffics to one another cannot be explored. The situation is illustrated diagramatically in Diagram (1) which shows the nature of a series of "one off" withdrawals of traffics from the total system.

The summing of the avoidable costs and revenues cannot be undertaken with any certainty of reliability since the cost avoidability becomes greater as the traffic group (or sum of traffic groups) increases in size. Ultimately all costs are avoidable at the total traffic level.

However although it is not strictly legitimate to sum the avoidable revenue and costs, this has been done in the case of one study to provide information in regard to the residual fixed costs of the system defined as whose which exist but have no identifiable avoidability with any particular group tested. This was identified in the appropriate report as the joint cost of the system. Since there is no simple way to quantify this fixed component, other than by regarding it as the residual left when all traffic group costs have been taken away, there is no real check on the validity or consistency of the avoidable cost analysis. Mathematically this fixed cost can be anywhere between 0% and 100% of total costs. It is because of this open-ended approach to defining "fixed cost" that there is no adequate control on avoidable cost analysis.

Value of Contribution Analysis

Io be of real management value, contribution analysis must provide adequate management information. It must relate to the total system, be interactive across all traffics and be dynamic in that adjustments to the system can be incorporated or tested with relative simplicity. On each of these grounds the avoidable costing exercises have some deficiencies which are not likely to be resolved by pursuing and refining the existing methodology.

It has been suggested that there is a much greater need for rail to improve its capacity to manage rather than rely on technological achievement (Neuschel 1976). If the ability to manage is to be improved then the level and usefulness of management information will have to be matched to that need. To the extent that contribution analysis is necessary to provide basic business-oriented, performance data, it has to be an integral part of the management information system.

The uses of a contribution analysis system include :-

(i) provide a total view of the various business elements of the system

(ii) provide a more effective framework for cost control; based on cost-revenue relationships and overall significance of business groups to the railway as a whole.

(iii) provide a means of traffic ranking for development of marketing, operational and technical priorities.

(iv) provide a means of identifying opportunity costs of resources, particularly those like rolling stock and locomotives which have multiple, readily interchangeable uses.

(v) provide a means of identifying subsidy requirements for activities maintained at the direction of third parties.

(vi) provide information in regard to the optimum system size and activities for the best financial results.

(vi) provide a tool for basic assessment of operating and investment alternatives prior to detailed evaluation.

A new Approach

Io develop a concept that will meet the above needs, it is necessary to go back to basics in regard to the railway. In the avoidable costing exercises, mentioned earlier, it was suggested that residual fixed costs remained if all the

DIAGRAM 1.
AVOIDABLE ANALYSIS
ILLUSTRATION OF INDIVIDUAL SUBTRACTIVE NATURE OF AVOIDABLE TRAFFICS

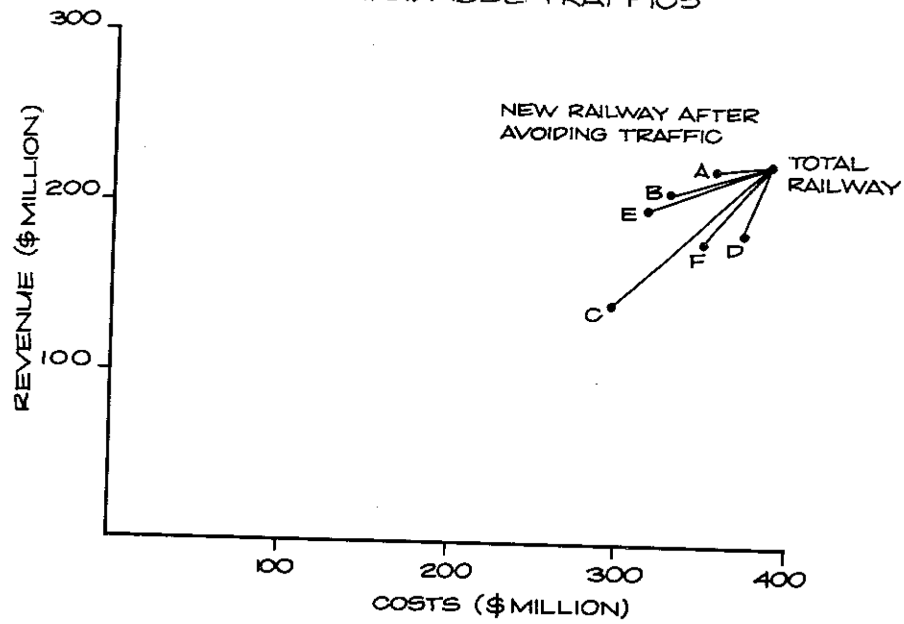
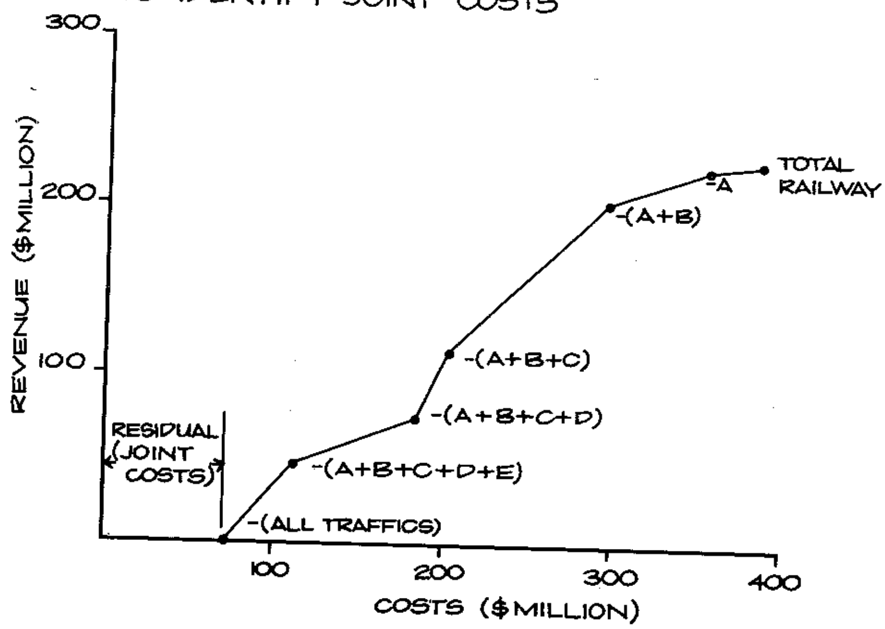


DIAGRAM 2.
AGGREGATION OF AVOIDABLE TRAFFICS TO IDENTIFY 'JOINT' COSTS



avoidable costs were summed; in other words, the railway with no traffic would have an unavoidable residual cost as shown in Diagram (2). In reality it would be possible for the railway to shed all its costs if it ceased handling all its traffic.(1)

The avoidable cost concept relies on withdrawal of one traffic group at a time from the existing whole railway. Since the process is conceptual, it is possible to change the process in any way that will contribute to a better understanding of the system. Therefore, it is quite realistic to develop the "mirror image" of the avoidable costing concept; perhaps best described as an incremental approach.

If it is assumed (conceptualising again) that there is no railway and therefore zero revenue and zero costs as a base case, it is then possible to develop costs and revenues for a range of traffic groups in turn; essentially developing a range of one-traffic railways which all occupy the same geographic area and within the same total route structure. Thus, in Victoria, it is possible to develop route networks for individual traffic groups complete with resources which will also, in the total railway, be shared in some way with other traffic groups.

This is shown in diagrams 3A - 3D, where the system network (route trackage) required for a number of different traffic groups has been identified. In a one-traffic railway, the route-trackage required can be identified using this network concept as well as the appropriate terminal facilities. The network concept is fundamental to the specific inclusion of the joint costs in the analysis, and it is at this stage that the analysis follows a quite different path as compared to avoidable analysis.

There are three levels of cost which can be identified in the railway context; these being specific costs, common costs and joint costs. Professor Kolsen (1968 and 1979) defines joint costs as those which are associated with two or more outputs in fixed proportions for which the costs are indivisible, while common costs are those associated with an element of choice as to the relative level of outputs produced.

This could perhaps be paraphrased in terms of "and" or "or" costs. Joint ("and") costs involve provision for "x" and "y" indivisably while common ("or") costs relate to "x" or "y" situations.

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1. There may be some residual financial costs (i.e. interest) but in an economic sense the cessation of all activities would result in a zero resource requirement. In the longer term the financial costs could also be reduced to zero by redemption of the capital debt

DIAGRAM 3A
GRAIN NETWORK

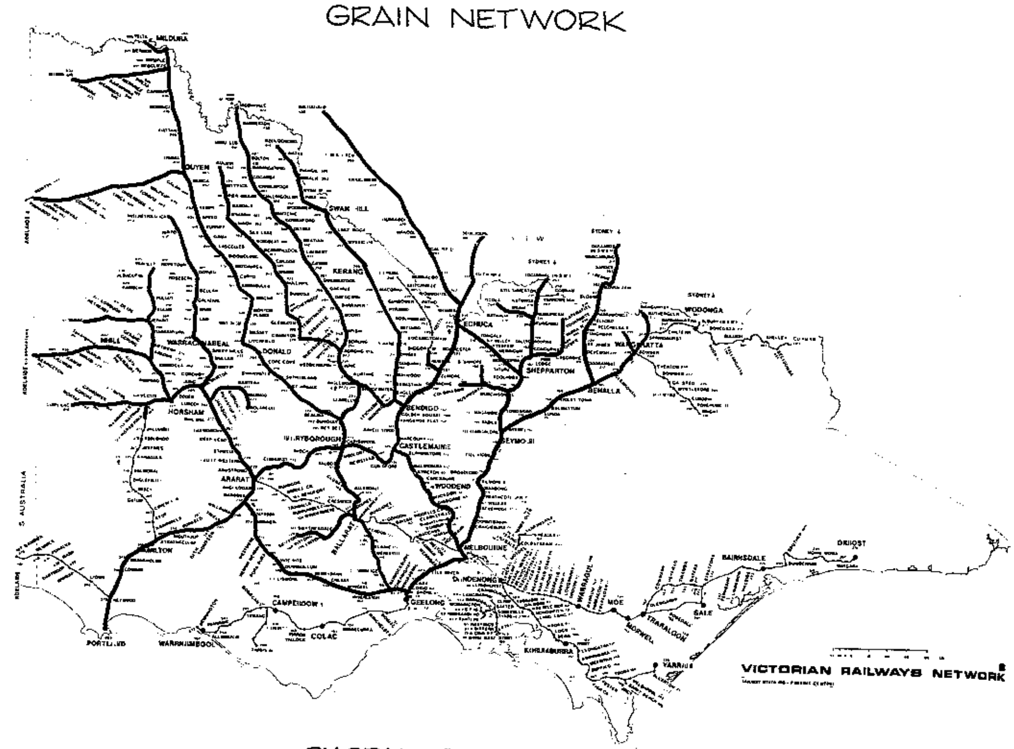


DIAGRAM 3B.
INTERSYSTEM NETWORK

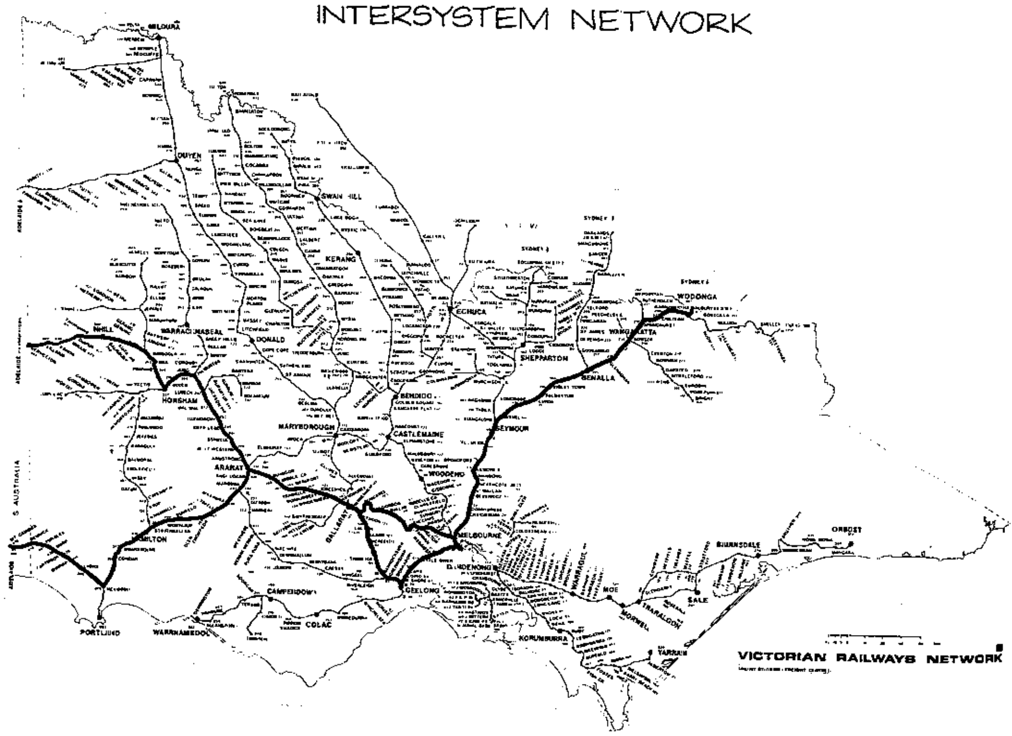


DIAGRAM 3C
TIMBER NETWORK

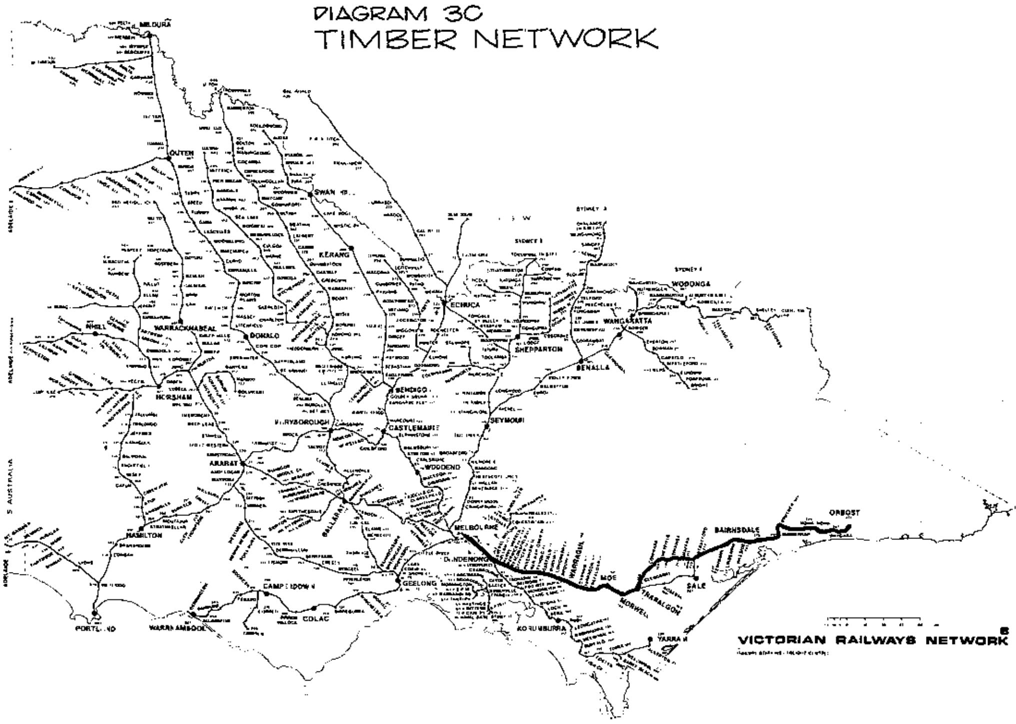
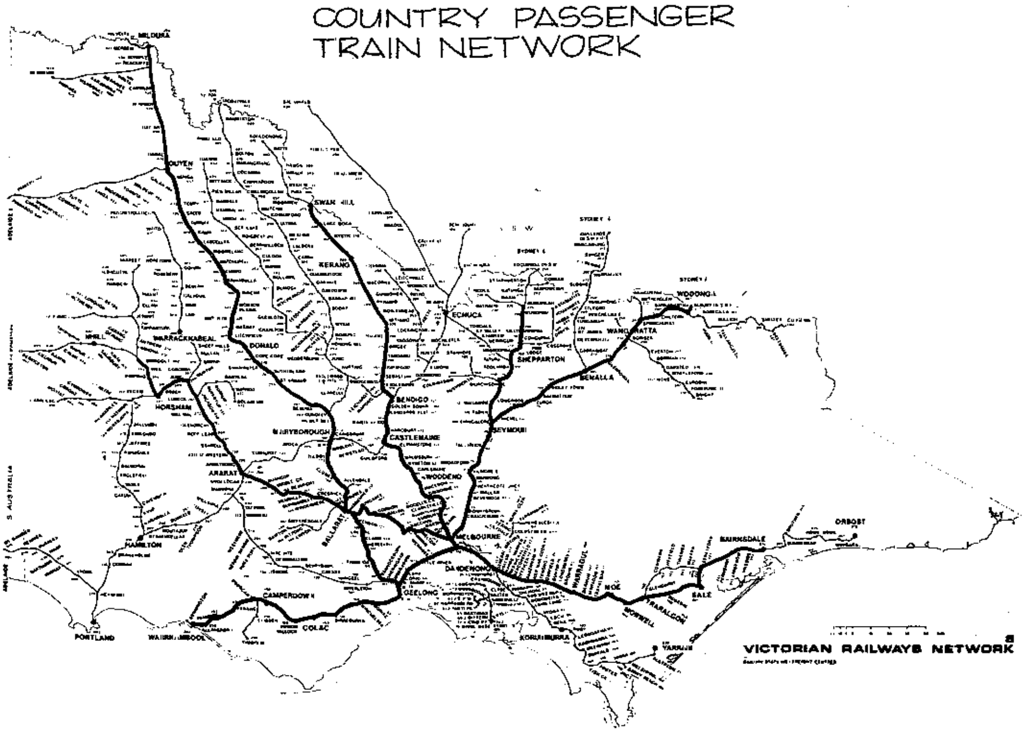


DIAGRAM 3D
COUNTRY PASSENGER TRAIN NETWORK



Using the above definition, it is clear that a large proportion of conventionally-labelled joint costs of a railway are, in fact, common costs. For instance, locomotives have physical constraints as to their route availability, loads etc., but within these limits they can be utilised for any combinations of traffic (i.e. for traffics "x" or "y" or ...) For the purposes of incremental traffic group analysis, where the grouping is relatively coarse, the majority of costs associated with the physical plant and operation can be considered as common while most of the infrastructure and administrative costs can be considered as joint.(1)

In the avoidable cost analysis joint costs were always included in the non-avoidable category, while common costs were usually included by relating the costs to physical measures of activity such as gross tonne kilometres. This latter process has the disadvantage of missing the essential relationships between traffics since, effectively, the common costs were proportioned (allocated) by physical measures. In a way, this treated them as a form of specific cost.

To actually undertake the incremental analysis of individual traffic groups from a zero base it is necessary to distinguish each of the above cost categories.

Identification of Costs

Specific costs by definition can be associated with particular traffic groups and are therefore fairly easily dealt with (e.g. livestock wagons and stockyards are specific to livestock traffic). Joint costs, by definition are inseparable costs and therefore need to be included in for each relevant traffic group. This is done by reference to the "network" associated with each particular traffic group. The routes, terminals, signalling etc. resources (and by derivation costs) required for each traffic are attached to that group even though the same costs may be attached to any number of other groups. As long as the analysis deals only with one-traffic railways, the means of including the joint costs will present no problems.

At the point when it is desired to aggregate two or more traffic groups, the above treatment of joint costs will lead to double-counting unless specific care is taken to include each element of the network only once. This is the second key requirement for the inclusion of the joint costs; that each element of the costs be included in an aggregation of traffics with the first group to be associated with the cost, and subsequent traffic groups then make joint use of the resources. Diagram (4) provides a simple illustration of a two traffic aggregation, where only joint costs and specific costs for two traffic groups (A and B) are present.

1. It is arguable that true joint costs are not a significant factor in railway costs at all; the conventionally categorised joint costs are in fact usually common costs. However for the generalised nature of incremental cost analysis it is convenient to tag the costs as shown; perhaps with a request to the purists for a degree of tolerance.

The inclusion of the common costs presents the most difficult problems in regard to data collection and analysis. By definition these costs are "or" costs; they have a number of alternative uses to which they can be related and this makes their inclusion or exclusion with any traffic group subject to an element of choice.

As already indicated most common costs (for the purpose of this analysis) will be associated with physical plant and operations (e.g. locomotives, rolling stock). However, not all physical plant and operation costs will be found to be common; to the extent that there is a minimum year-round activity level associated with a particular traffic, the basic level of resources required to maintain that level of activity be specific to the traffic concerned. Where there is any seasonality in the traffic, the physical resources required to cater for the traffic will be the resources required at the time of maximum activity; providing during the non peak times a group of "available" resources for alternative traffic needs. This then provides a framework for identification of the common costs; minimum (off peak) traffic needs will identify the specific resources required while maximum resources can be identified at the peak traffic period. Providing the resources are of multiple use, the common costs can be identified by reference to the difference in resource requirements for peak and off peak activity levels.

The most conspicuous resources that will fall into the common cost category are locomotives, train crews, and general purpose wagons. To adequately identify the common resources it is necessary to relate them to individual traffics in terms of the physical quantum by the time (or season) of requirement. For instance, if traffic group "A" requires a peak resource level in January while traffic group "B" requires a peak resource level in April, the total level of resources will be quite different to a situation where both peak at the same time. As an illustration of the effect of seasonality the monthly wagon requirement for three traffics which use a common group of wagons are shown in diagram (5). The aggregate wagon requirement to handle these three traffics year round is clearly less than the aggregate requirement for each individual traffic. The difference arises because of the common usage of a proportion of the wagon fleet.

The aggregation process for common resources is similar to that for joint resources, except that the former is complicated by the need to have a time reference. To control the aggregation of common resource costs it is necessary to refer to the level of those resources available from traffics already included in the aggregation process (in order to identify the additional requirement, if any) and the known total availability of those resources to avoid over exhaustion.

The process already described is in effect one of flagging the resources required for each traffic group on the basis that would be the only traffic handled by the railway.

DIAGRAM 4
AGGREGATION OF TWO TRAFFIC GROUPS
(SPECIFIC AND JOINT COSTS ONLY)

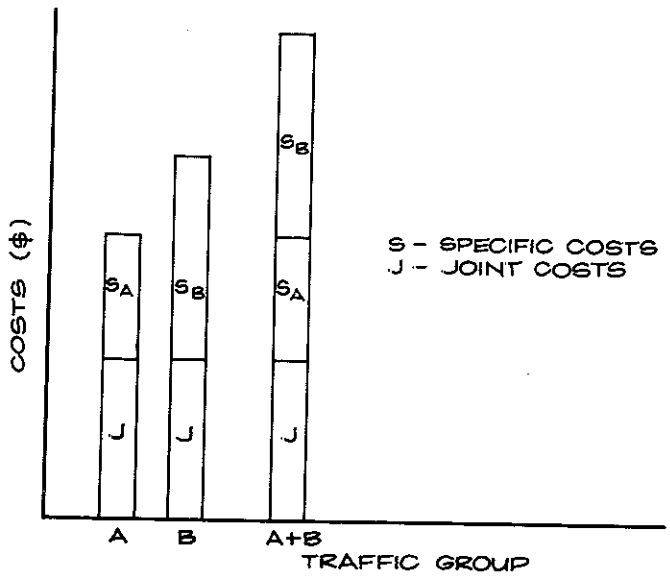
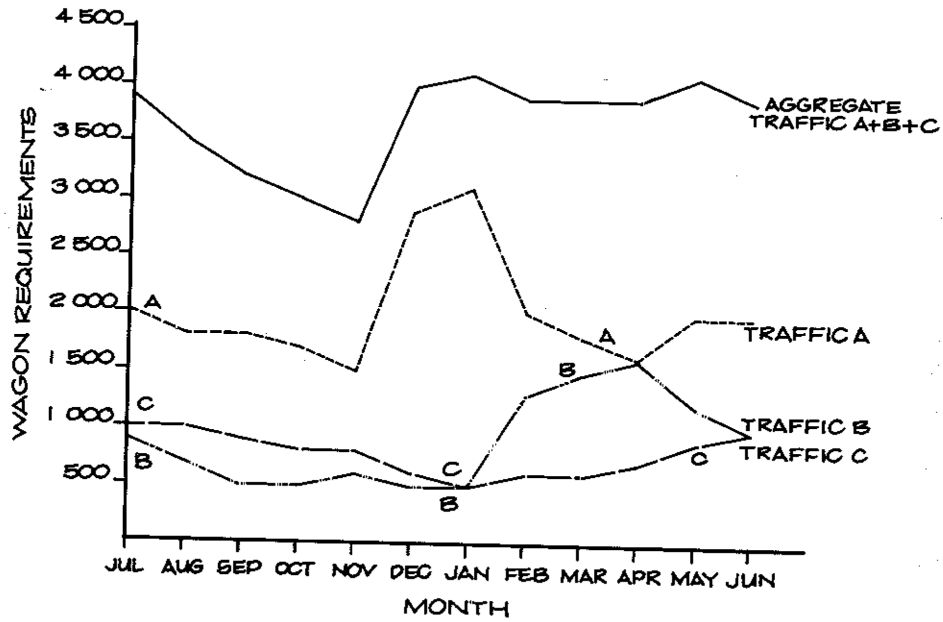


DIAGRAM 5.
WAGON REQUIREMENTS BY MONTH FOR
THREE TRAFFICS USING A COMMON
WAGON TYPE



Certain resources will have a single (specific) flag while others will have multiple (joint or common) "flags." It is these latter flags which provide the link between various traffic activities of the railway. The flags would be related to the physical resources of the system (e.g. wagons, labour units, route infrastructure) rather than to costs for ease of data collection and simplicity when "adjusting" the system. Unit costs can be relatively simply developed and applied to the resource units at an appropriate stage of the analysis. These unit costs can be adjusted externally to the bulk of the analysis to reflect changing cost levels or productivity changes.

Once the flagging has been completed each traffic group will have resources labelled to it which represents the peak resource requirement for that traffic. Some resources will be uniquely associated with that traffic, but a proportion will also be labelled to other traffics as shown diagramatically in Diagram (6). The aggregate of the costs flagged to each traffic group is obviously in excess of the recorded total costs, since all common and joint resources would then be counted at least twice.

At this stage of the analysis the information will be of no more value to management than that generated by avoidable analysis. It could only provide a "snapshot" of each traffic group in turn, and this would be confused to the extent that non-specific costs would be included with each traffic. To obtain useful management information from the analysis it is necessary to build on the interactive relationship between sectors of the railway so that the sum of all traffic group costs will aggregate back to the recorded system total costs.

The joint and common costs, which are the key to this interaction, need to be included in the aggregation the first time they are met, but the same resources will, by definition, then relate to additional traffics which have those same resources flagged. In these latter cases, where the aggregated system has already been "loaded" with a joint or common cost, all subsequent flags relating to that cost are able to be ignored. In effect, once these resources have been introduced to the system in conjunction with any traffic group, any subsequent traffic group introduced to the system can make use of them.

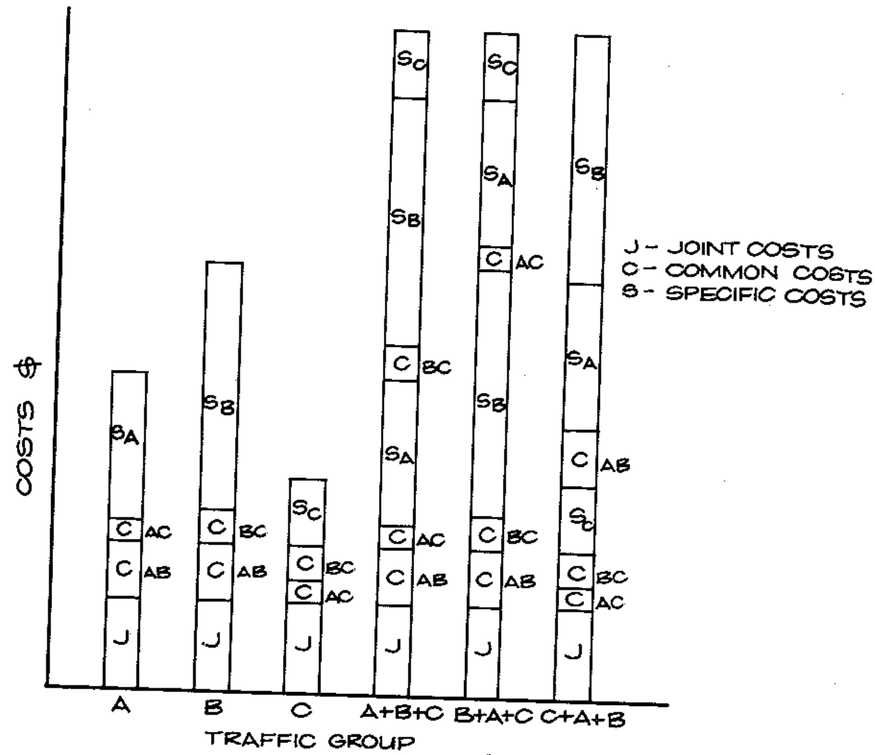
The aggregation process can be undertaken in any sequence at all providing the resources have been correctly flagged.

The Problem of Ranking

If random selection of traffics is undertaken, the system will provide no information in regard to the ranking order of traffics. From a management viewpoint it is obviously useful to have information in regard to which traffics are more important to the system (in economic terms) and in which

DIAGRAM 6.

AGGREGATION OF THREE TRAFFIC GROUPS (SHOWING EFFECT OF SEQUENCE VARIATIONS)



relative order these traffics occur. It can enable management to give priorities to various system activities such as investment choices, operational decisions, and marketing activities. It can also lead to identification of opportunity costs of various resources (information which is singularly lacking at the present time) and provide a basis for identification of subsidy requirements.

In order to undertake the aggregation of traffics in a ranking sequence it is necessary to relate the costs and revenues for each traffic group as the aggregation process takes place. The costs and revenues must therefore be aggregated simultaneously.

Compared to the problems of cost identification revenue presents few difficulties. In the main, revenue generation can be closely related to traffic groupings down to a relatively micro level. Apart from certain non-traffic activities (e.g. station cafeterias, land leasing, billboards), most revenue can be directly related to specific traffic activities either in gross terms, or in unit revenue terms (e.g. cents revenue per tonne km). These revenues can be fairly easily associated with the traffic groupings used for cost analysis.

Since the costs for each traffic are comprised of three categories, two of which inter relate to other groups, it will be immediately obvious that a data handling problem of some magnitude exists at this point; a problem which can be readily handled by computer, provided the criteria for ranking is adequately defined.

One of the basic objectives of this analysis is to identify the corporate "worth" of the various activities which are undertaken. Because of the inclusion of joint and common resources with each traffic group, it is rather unlikely that any single traffic will individually produce an optimum financial result (i.e. the best total dollar return). It is much more likely that a number of traffic groups will aggregate to provide an optimum result on the basis that the joint and common costs will be less significant over a group of traffics than for any single one.

The objective therefore is one of identification of the group of traffics which will produce the optimum result, and, since the inputs are costs and revenues, this result will be in terms of the best possible financial result. This optimal result can be reached by an iterative process in regard to the costs and revenues of each traffic group in turn; the traffic groups being loaded in varying sequences until the optimum system is located. The sequential order that the traffics are "loaded" would in fact be their ranking order of importance to the railway. The ranking process would not stop at the optimum situation but would continue through until the total system had been recreated and thus provide a total view of the system as it now exists.

Diagram (7) illustrates the concept graphically. In effect the expectation is that there will be a group of traffics whose incremental revenues will exceed their incremental costs and together will provide the optimal result for the railway system. There will also be traffics whose incremental revenues will be lower than their incremental costs; these traffics will be those that fall between the "optimum result" and the "total railway" points on the graph

Problems of Implementation

There are several significant problems that need to be considered when implementing incremental cost analysis.

Foremost amongst these is the collection, analysis and flagging of resource and cost data.

Selection of coarse traffic groups will make the data problem easier, but at the same time, coarse groupings will limit the advantages in terms of management information. The development of reasonably disaggregated traffic groups will depend both on the need for appropriate information and the ability to provide it. To that extent, the development of an incremental model is seen as a continuing and dynamic process with continual review and redefinition of the data inputs and information needs. As time passes the level of detail can be extended to an appropriate level. The model is not seen as the appropriate tool for detailed analysis of particular situations, but rather one capable of providing general guidance and direction which can be pursued with detailed separate analysis where needed.

As suggested earlier the separate identification of physical resources and appropriate unit costs will simplify the data problem. Separate expertise can be called on to identify the physical system and its relationships, and concurrently to analyse the cost information and develop cost causation relationships.

The identification of the physical resources needs to be undertaken such that all relevant resources, including spares and backup are identified, but that extraneous and redundant resources are excluded. This may involve an iterative development procedure using the incremental model, since redundant resources that are readily identified should (presumably) have been disposed of already. The identification of the redundant resources is seen as being important if the model is to be properly responsive to cost and/or revenue changes to the system.

While the resources are mainly of a physical nature and therefore reasonably easy to conceptualise and analyse, the costs are rather more difficult. For a start the conventional accounting records maintained by most Australian railways do not provide a particularly detailed analysis of costs suitable for behavioural analysis. If anything, the records tend to be maintained on organisational lines so

DIAGRAM 7A
CORPORATE CONTRIBUTION ANALYSIS

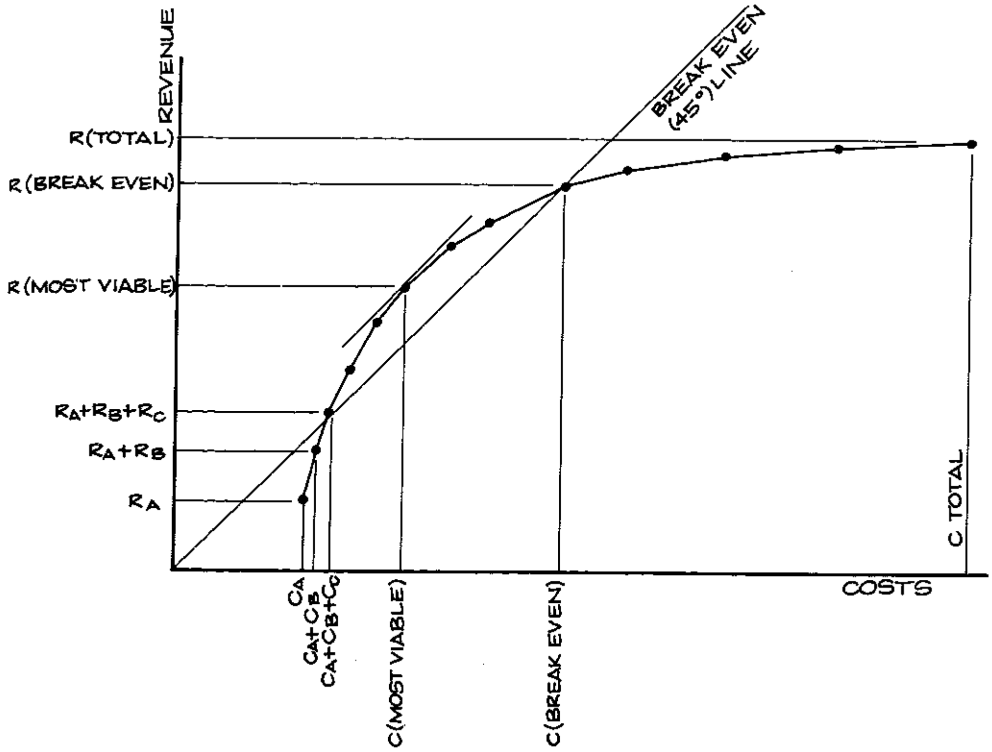
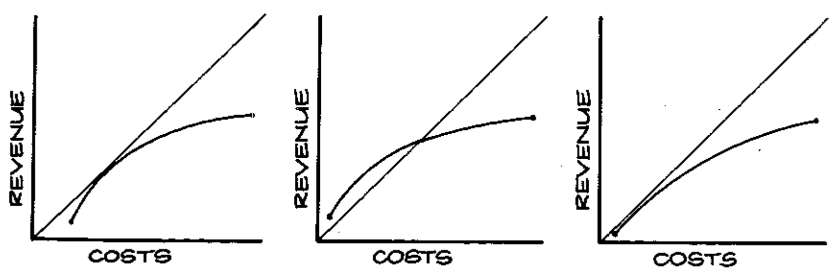


DIAGRAM 7B
ALTERNATIVE POSSIBILITIES



that functional costs are foremost and business group cost records are hard to identify. Recent developments in most systems are tending to improve the situation with some "activity" identification of costs. There is little doubt that reorientation of the cost recording systems would simplify the development and maintenance of an incremental model.

Another problem associated with cost records is that the accounting cycle period in a number of cases does not match the cost cycles of various resources. For instance with railway track, the sleepers, rails, fastenings and even the line and level of track all have a renewal cycle in excess of one year. Similarly, wagons are maintained on a cyclic basis of up to five years.(1) The understanding of long term cost behaviour is an essential feature of the incremental model and therefore the cost information will need to be derived from more than just accounting records. In reality, considerable input will be required from technical experts and it may be necessary to develop simulation models to represent certain cost relationships

The costs themselves will be of limited direct use. Their analysis needs to be directed to cost causation such that a reasonable understanding of cost behaviour is available. In the short term, this may have to be done by making some crude but demonstrably robust cost-causal estimations.

The problem of revenue identification should normally be relatively simple since the revenue records have been traditionally based on a "commodity" concept. A certain amount of analysis will be required in some particular cases such as separation of L.C.L. and wagon load freight or metropolitan and country passenger revenue. Generally, this separation will be fairly straight forward and providing the method follows that used for cost separation, should provide compatible revenue and cost groupings.

One aspect of the cost analysis which has not been covered is that associated with the capital cost of the assets used by the system. Most railways in Australia treat capital costs (interest, depreciation etc.) in quite different ways, in their accounting records and this is now further complicated by the rapid emergence of direct loan raising and leverage leasing as means of funding new assets.(2)

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1. In reality many of these long term cyclic costs will be "smoothed" in the accounting records by virtue of large system aggregates; there will always be some rerailing and resleepering, and some wagon "lifting" going on which will tend to remain a constant proportion of costs over a number of years.

2. Leverage leasing relates to funding and ownership assets by a third party who leases them to the operator (railway) to provide a service for a customer or group of customers.

For the purposes of incremental analysis, it is considered that the appropriate way to handle the capital costs is to use current replacement value, annualised by referral to an appropriate economic life and discount rate. This measure then provides an indication of the life of the traffic group in question. Where a traffic group is located in a negative part of the aggregation curve (i.e. above the point where the curve passes from the positive to negative side of the break even line) with capital costs included, it, prima facie, should be considered as a short term traffic which may continue only as long as the existing assets remain. Conversely where a traffic group is located in the positive part of the aggregation curve (i.e below the point where the curve passes from the positive to negative side of the break even line) with capital costs included it can be regarded as a long term traffic capable of supporting asset renewal at the appropriate time. Clearly, the treatment of capital costs could occupy a complete paper of its own. However the incremental model is designed to provide management information and not to analyse individual investment decisions in detail, so that a fairly simple but reliable treatment is all that is required.

Conclusion

The incremental model described above has not been tried in practice so that its real worth vis a vis the effort in constructing and maintaining the model are unknown. However, in the light of inadequate management information at the present time, it would seem that worthwhile benefits could accrue from the use of such a model.

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