Transportation: The Employment and Land Use Implications

ECONOMIC IMPACTS OF TRANSPORTATION: NORMATIVE CONSIDERATIONS

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Ideally, transportation planning and operating policy is carried out by considering a number of alternatives, estimating what difference it made whether we chose one alternative or another, and then attempting to place values on the differences so as to select the most satisfactory alternative. In practice, we do a poor job of separating the second of these (estimating the impacts) from the third (evaluation). Because transportation has economic and development impacts, it is (implicitly) thought to be good; more transportation would be better, except by those who believe that more transportation is always bad.

Laying out the consequences of alternatives is a descriptive task; how to evaluate those consequences is a normative task. These two topics can be differentiated as "economic impacts" (the positive questions) and "benefit-cost analysis" (the normative question).[1] These terms are set forth as preliminary definitions of the dichotomy emphasized in this paper.

If transportation were costless -- consumed no resources, such as concrete and clean air -- then more transportation would always be better than less. If there is a cost, this means that something else has to be given up in order to get more transportation. If something has to be given up, it is possible that the least valuable thing given up is still more valuable than the transportation services produced by giving it up. Therefore, it is just as possible to have too much transportation as too little, having too much is just as bad as having too little, and having transportation that is too cheap (to the user) is no better than having transportation that is too expensive. Too much transportation means that the resources used to produce the last increment of transportation would have produced more value had they been used for something else.

Example One: Transportation and Land Use

Understanding of the transportation and land use relationship has progressed from debating the issue of whether transportation causes land use or the other way around, to the representation of transportation and land use as an equilibrium system. Each affects the other, and adjusts so as to reach a balance. Travellers and shippers select modes and destinations

[1] A very succinct and readable explanation of this distinction is Storey (1987).

depending upon what they might gain from the movement and how much it costs. Providers expand or shrink capacity depending upon where the travel is and how much the capacity costs.

Basic Equilibrium. These concepts can be demonstrated graphically in very simple ways, so long as we are willing to abstract the essential characteristics from the noisy background of the real world. Using the rent theory model attributed to von Thunen and adding a few generic elements, a portion of the transportation and land use equilibrium can be illustrated. The words used to create an intuitive impression of the relationships are almost arbitrary, so not too much should be read into them.

In this simplified model, "employment" all occurs at a single point, which is at the center of the "city." Workers live in residences that take up some amount of land, in a fixed ratio of housing to land and workers to housing, i.e., workers per square meter of land.[2] Thus land is needed to produce workers, who travel to the center to work. The greater is the demand for workers in the city, the farther out will be the extent of the city.

The "cost" of producing a worker is the transportation to and from the center (nothing else varies with location, so other costs are irrelevant). For a given demand (schedule), the higher is the cost of transportation, the smaller will be the extent of the city, and the fewer the number of workers employed. For a given transportation rate (constant per unit of distance), the "supply" of workers is the area of a circle whose radius is the price paid to the worker, divided by the transport rate (the maximum commuting distance). The graph of the value of land that is located more favorably than the maximum distance is the familiar rent gradient, consisting entirely of location rent.

Figure 1 shows a picture of the market for workers, in the city center, and a cross section through the rent gradient. The price of a delivered worker is p^*, the quantity of workers employed is Q^*, and the outer edge of the developed area is x^* from the city center. The supply curve is the formula for the area of a circle, whose radius is x.

Comparative Statics of Transport Rates. Suppose the transport rate were to change, but everything else were the same. Then an adjustment process occurs, resulting in a new equilibrium. If the transport rate goes down, then the gradient flattens, the city spreads out, rent near the center is reduced, more housing is constructed, and more employment occurs. What could be better?

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2 The purpose of simplifying assumptions is analytic: to focus on exclusively those characteristics that make a difference. Numerous assumptions could be constructed in a more realistic form, but they would not make the model realistic and they would add complications that would obscure the essential relationships rather than illuminate them.

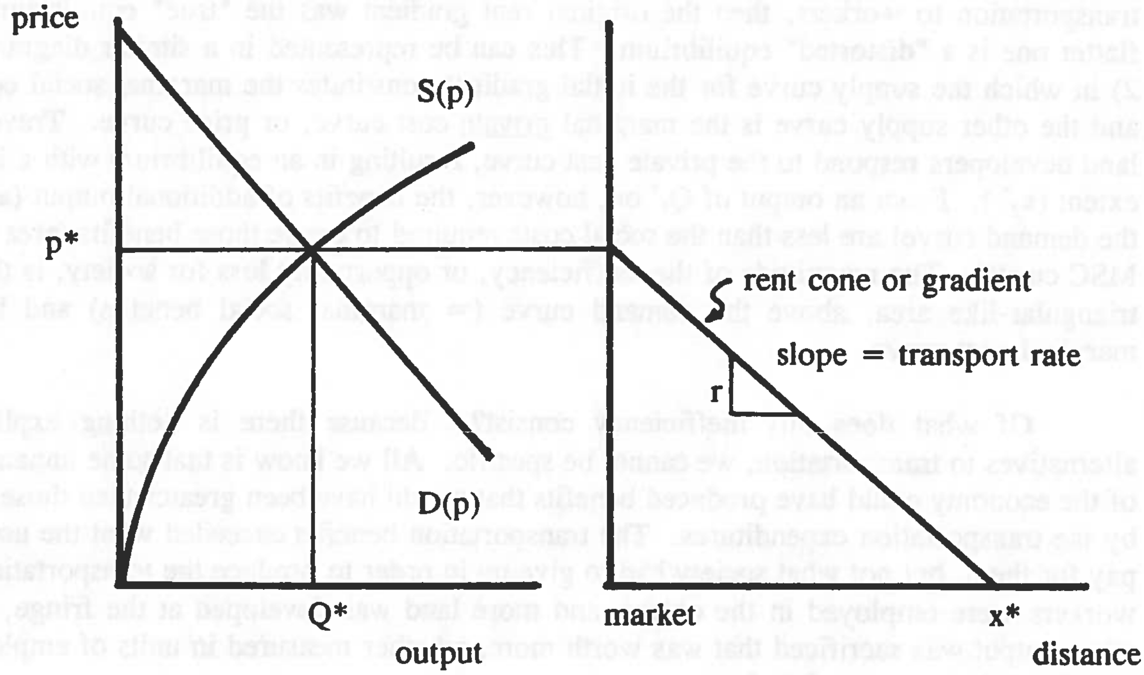


Figure 1. Equilibrium for single market and single land use.

Determining that this is unambiguously better requires a number of assumptions, not yet made explicit. These assumptions can be stated in a variety forms, but we will do so in terms of market behavior. Travellers are assumed to pay the costs of transportation, and all other markets (e.g., employment and land) are assumed to function efficiently. No economic sectors are taxed to provide services to any other sector, such as transportation. Under these circumstances, the reduction in the cost of transport is a pure technological phenomenon: a Pareto improvement that reduces total costs to society as a whole and makes no person worse off (except the rentier landlords earning monopoly profits from close-in land). This comes close to being manna from heaven.

Transportation Efficiency. If, alternatively, we assume that the lower cost of transportation is achieved by taxing employers or landowners and providing subsidized transportation to workers, then the original rent gradient was the "true" equilibrium and the flatter one is a "distorted" equilibrium. This can be represented in a similar diagram (Figure 2) in which the supply curve for the initial gradient constitutes the marginal social cost curve, and the other supply curve is the marginal private cost curve, or price curve. Travellers and land developers respond to the private cost curve, resulting in an equilibrium with a larger city extent (x_2^*). From an output of Q_1^* on, however, the benefits of additional output (area under the demand curve) are less than the social costs required to create those benefits (area under the MSC curve). The magnitude of the inefficiency, or opportunity loss for society, is the shaded triangular-like area, above the demand curve (= marginal social benefits) and below the marginal cost curve.

Of what does this inefficiency consist? Because there is nothing explicit about alternatives to transportation, we cannot be specific. All we know is that some unnamed sector of the economy could have produced benefits that would have been greater than those produced by the transportation expenditures. The transportation benefits exceeded what the users had to pay for them, but not what society had to give up in order to produce the transportation. More workers were employed in the center, and more land was developed at the fringe, but some other output was sacrificed that was worth more, whether measured in units of employment or in dollars or in some other form.

Example Two: Economic and Development Impacts

A great deal of discussion in the public sector centers on using transportation to spur economic growth or land development. By and large, such efforts will not be successful unless the transportation expenditures are justified on purely transportation grounds.

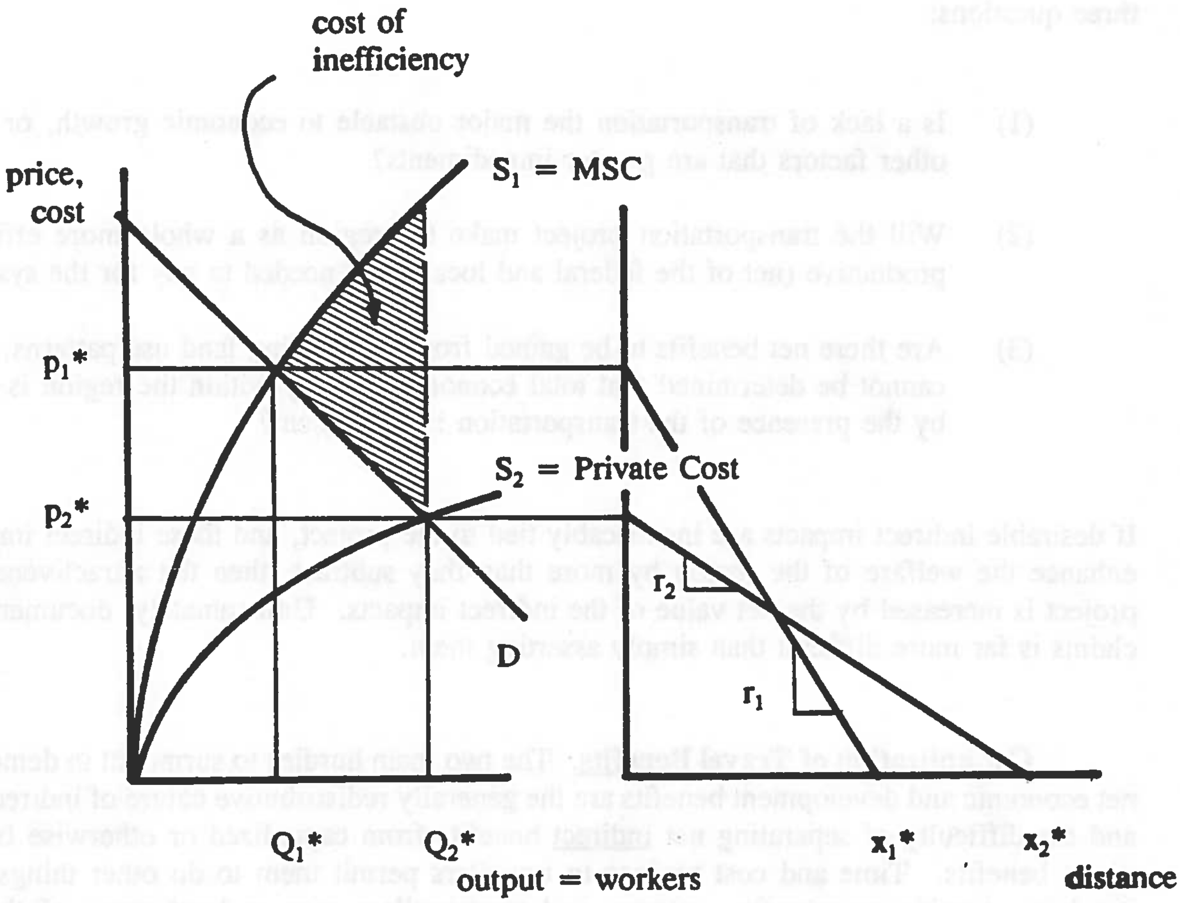


Figure 2. Impacts of a reduction in the transport rate.

Framing the Right Questions. Much analysis of economic and development impacts has been done without thinking carefully about the right questions to ask. Predicting that an expenditure of $2 billion will create more jobs than an expenditure of $20 million, all other things being equal, does not require any analysis at all. Attention instead should be given to determining whether the expenditure will create more jobs, more total income, or a better distribution of income than another equal expenditure. These kinds of questions are more difficult to address but more worthwhile to understand.

A rough idea of the kinds of normative issues to be addressed may be gained from these three questions:

(1) Is a lack of transportation the major obstacle to economic growth, or are there other factors that are greater impediments?

(2) Will the transportation project make the region as a whole more efficient and productive (net of the federal and local taxes needed to pay for the system)?

(3) Are there net benefits to be gained from rearranging land use patterns, even if it cannot be determined that total economic activity within the region is increased by the presence of the transportation improvement?

If desirable indirect impacts are inextricably tied to the project, and these indirect impacts will enhance the welfare of the region by more than they subtract, then the attractiveness of the project is increased by the net value of the indirect impacts. Unfortunately, documenting such claims is far more difficult than simply asserting them.

Capitalization of Travel Benefits. The two main hurdles to surmount in demonstrating net economic and development benefits are the generally redistributive nature of indirect impacts and the difficulty of separating net indirect benefits from capitalized or otherwise transferred direct benefits. Time and cost savings to travellers permit them to do other things, perhaps involving earning or spending money, and nontravellers reap at least some of these gains indirectly. If travellers are willing to pay a premium to live near a transit station, then part of the worth of land and residential buildings consists of traveller benefits capitalized into real estate values. The benefits are real, and the transfers from traveller to landowner may be of substantive interest, but adding the real estate appreciation to the travel benefits is double counting. Retail sales volumes and office space rentals are similarly affected.

Conceptually, it is necessary to construct a neutral reference alternative against which to compare the project. For example, the cost of providing housing and transportation for the elderly under the base alternative could be compared to the costs of providing the same level and quality as part of a mixed-use development in the vicinity of a transit station.

A Simplified Regional Economy. Any schematic representation of an economy is an invented abstraction, and displays only a minuscule share of the structure that could be described. The representation in Figure 3 is one way to illustrate the flows into, through, and out of a local economy. Only money flows are shown (resources flow in the opposite direction). Dollars from outside flow into the region as project expenditures, in combination with tax dollars levied on activities within the region. Some project expenditures immediately flow back out of the region, as purchases of imports (e.g., rail cars). Money expended on imports is referred to as a "leakage". Purchases of local labor and other inputs generates income to those factors, and this income is then used to purchase other goods and services (food, buildings), some of which is also imported. This recycling of money is called the "multiplier effect", meaning that a dose of external funds generates income in an amount greater than the dose itself.

The lines with arrows can be thought of as pipes, in which money flows between the blocks. Imagine, for a moment, that the pipes are transparent and the money is a clear liquid. The money can be seen sloshing through the pipes, in a more or less stable pattern we will refer to as the initial equilibrium. Now a dose of money, which is dyed red, is introduced through the "higher government" pipe. It becomes slightly diluted as it mixes with local revenues (matching shares) in the project expenditure pool, and turns pink as it moves into the local economy and also out the imports pipe. Some of the pink moves back out as tax revenues to state and federal treasuries. As the red injection circulates round and round through the local economy, its color becomes fainter until eventually it fades away completely.

Decades ago, the outside injection was called "pump priming." The idea was that a shot of expenditures was needed to get the economy working, after which it would sustain itself. The priming worked because there were idle resources sitting around not knowing what to do, and a little stimulus served to start them up. Whether or not the pump priming analogy was ever an applicable metaphor, it is mistaken to think there are stagnant local economies that simply need a little external injection to get them going, after which they will throw off surpluses like weeds. In general, pumping up one locality means siphoning off of another, and whether the result is a gain, a loss, or a wash depends upon the specifics.

If the action of interest is the red-dyed injection, then the impacts are the pink coloring, until the flows run clear again. Because the injection has augmented the flows, the differences between the volumes with the injection included, and the volumes as they would have been without the injection, constitute the impacts. The ratio of the gradually diminishing pink flows that cycle through the local economy to the initial injection is called the multiplier, and is always greater than one.

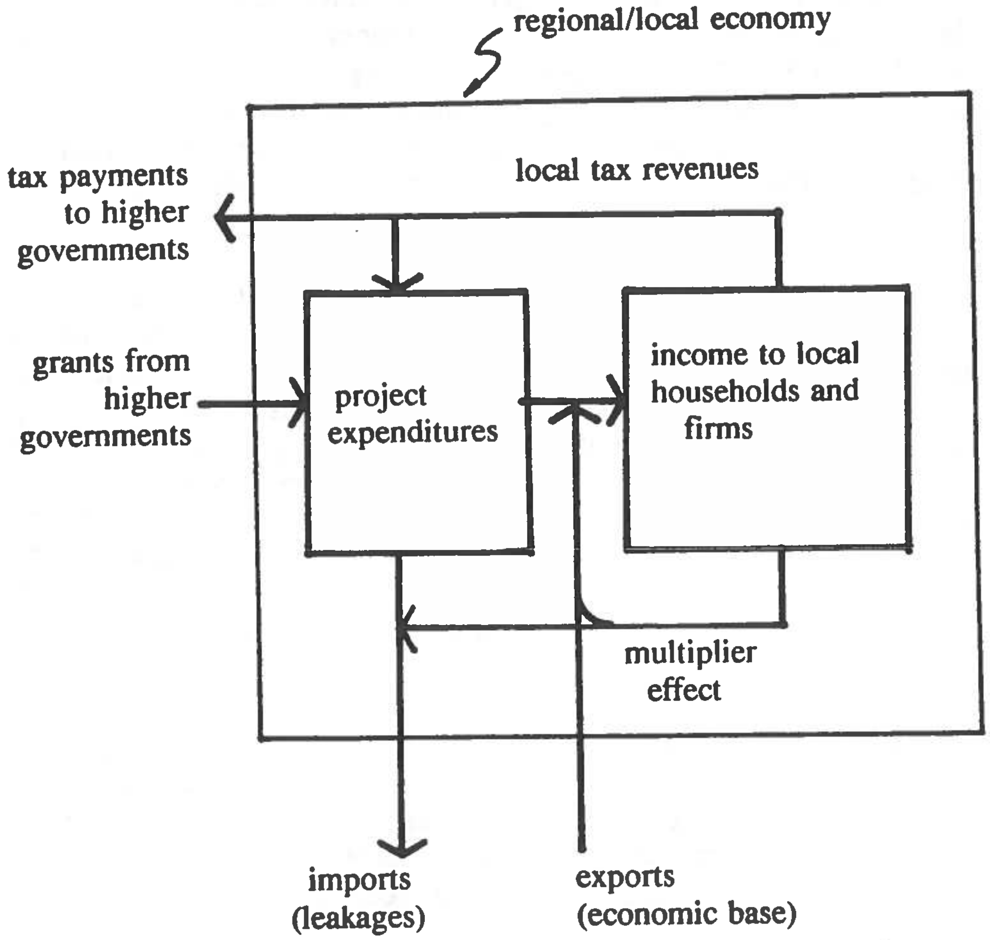


Figure 3. Simplified description of a local economy.

This model is purely descriptive, in that it provides no clue as to what would be a "good" inflow of external dollars, or a desirable level of leakages, or the ideal multiplier. The greater is the multiplier, the better off are suppliers within the region versus those outside. To the degree that the residents of a region are happy to receive federal dollars, non-residents are unhappy to have to supply the dollars. The normative side is addressed within the benefit-cost framework.

Benefit-Cost Evaluation. A highly simplified schematic of the project evaluation framework is shown in Figure 4. Costs are restricted to project capital costs, while the benefit side includes user benefits (time, running cost, and accident savings), environmental externalities, and facility operating costs.

In quantifying and summarizing costs and benefits, it is assumed that all costs and benefits are stated in constant base-year dollars, that all future costs and benefits are discounted to the base year, and that all costs and benefits are measured as changes relative to the base alternative, or (ideally) relative to the next best substitute alternative. The alternative generating the greatest net benefits is preferred, and the accumulation of worthwhile complementary projects constitutes the program, or investment "needs."

When evaluating related projects, the outputs of one become the input assumptions for the next. Thus the order in which projects are evaluated is important because, in principle, they are all increments to each other. If, alternatively, the projects are unrelated, then the same base alternative can be used in evaluating each one. In every case, costs and benefits are always impacts, measured against some base situation, but not all impacts are costs or benefits. Impacts that are neither cost nor benefit are "transfers" between individuals or groups.

Indirect Benefits. Figure 5 combines Figures 3 and 4 into a single evaluation framework. Direct travel benefits are shown to be the result of balancing supply and demand, each of which is indirectly affected by the project. The project alters real travel costs, which in turn create economic and development impacts. Demand, in particular, is affected by land use changes which may occur in part as a consequence of the project. Properly accounted for, then, travel benefits already include indirect impacts.

The space between the dashed vertical lines labeled "gray area" admits to a few exceptions to this general rule. These exceptions all constitute some form of market failure:

(1) Imposed Market Distortions. Limiting the benefits of interest to the immediate travel market assumes that other markets make whatever adjustments are needed in an efficient manner. If there are impediments that prevent correct adjustment,

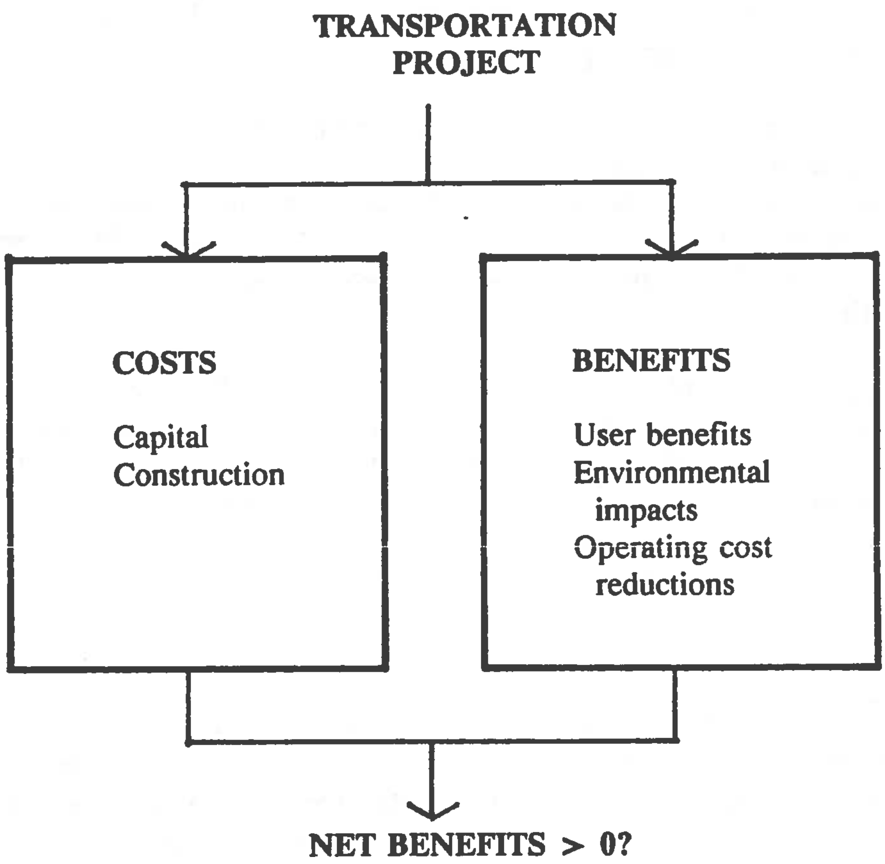


Figure 4. Outline of Benefit-Cost evaluation of project.

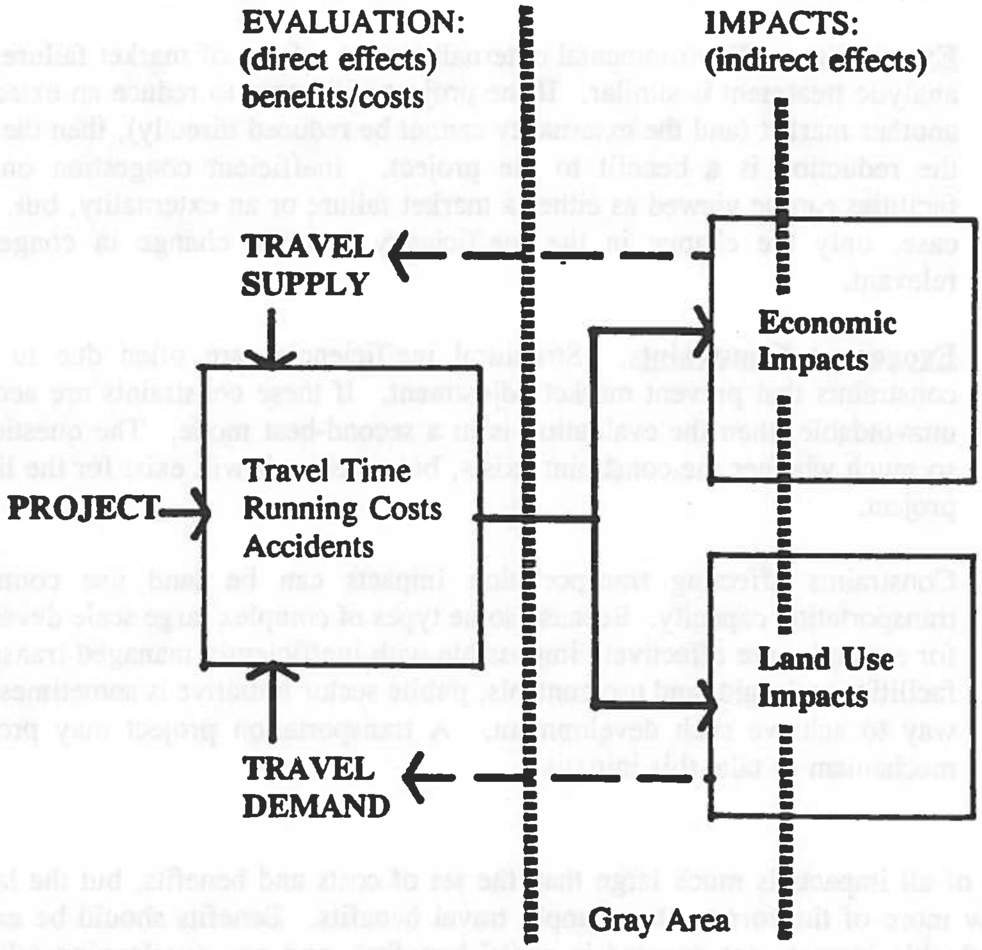


Figure 5. Integration of project evaluation and indirect impacts.

then the resulting market failure is an impact which may be taken into account in evaluating the value of the project.

The most common failure is the inefficient pricing of publicly operated transportation facilities and services, such as highways, transit, parking, airports, and waterways. Impediments in land markets are more elusive, but may include neighborhood image, public property, ownership fragmentation, and other obstacles to adjustment. The effect on project evaluation depends upon whether the project will make the inefficiencies better or worse.

(2) Externalities. Environmental externalities are a form of market failure, and the analytic treatment is similar. If the project will serve to reduce an externality in another market (and the externality cannot be reduced directly), then the value of the reduction is a benefit to the project. Inefficient congestion on parallel facilities can be viewed as either a market failure or an externality, but, in either case, only the change in the inefficiency (not the change in congestion) is relevant.

(3) Exogenous Constraints. Structural inefficiencies are often due to imposed constraints that prevent market adjustment. If these constraints are accepted as unavoidable, then the evaluation is in a second-best mode. The question is not so much whether the constraint exists, but whether it will exist for the life of the project.

Constraints affecting transportation impacts can be land use controls and transportation capacity. Because some types of complex large scale development, for example, are effectively impossible with inefficiently managed transportation facilities and rigid land use controls, public sector initiative is sometimes the only way to achieve such development. A transportation project may provide the mechanism to take this initiative.

Thus the set of all impacts is much large than the set of costs and benefits, but the latter may include a few more of the former than simply travel benefits. Benefits should be exhaustive (including valuable impacts not counted in travel benefits), and non-overlapping (eliminating most indirect impacts). Aggregation of benefits for project evaluation nets out, and hence ignores, all transfers among individuals, i.e., it does not address equity impacts.

Connections Among Impacts. A virtue of the benefit-cost framework is that it organizes the relevant pieces in an unambiguous way, whereas impact relationships have no inherent structure. An illustrative example is presented in Figure 6. The first column of items

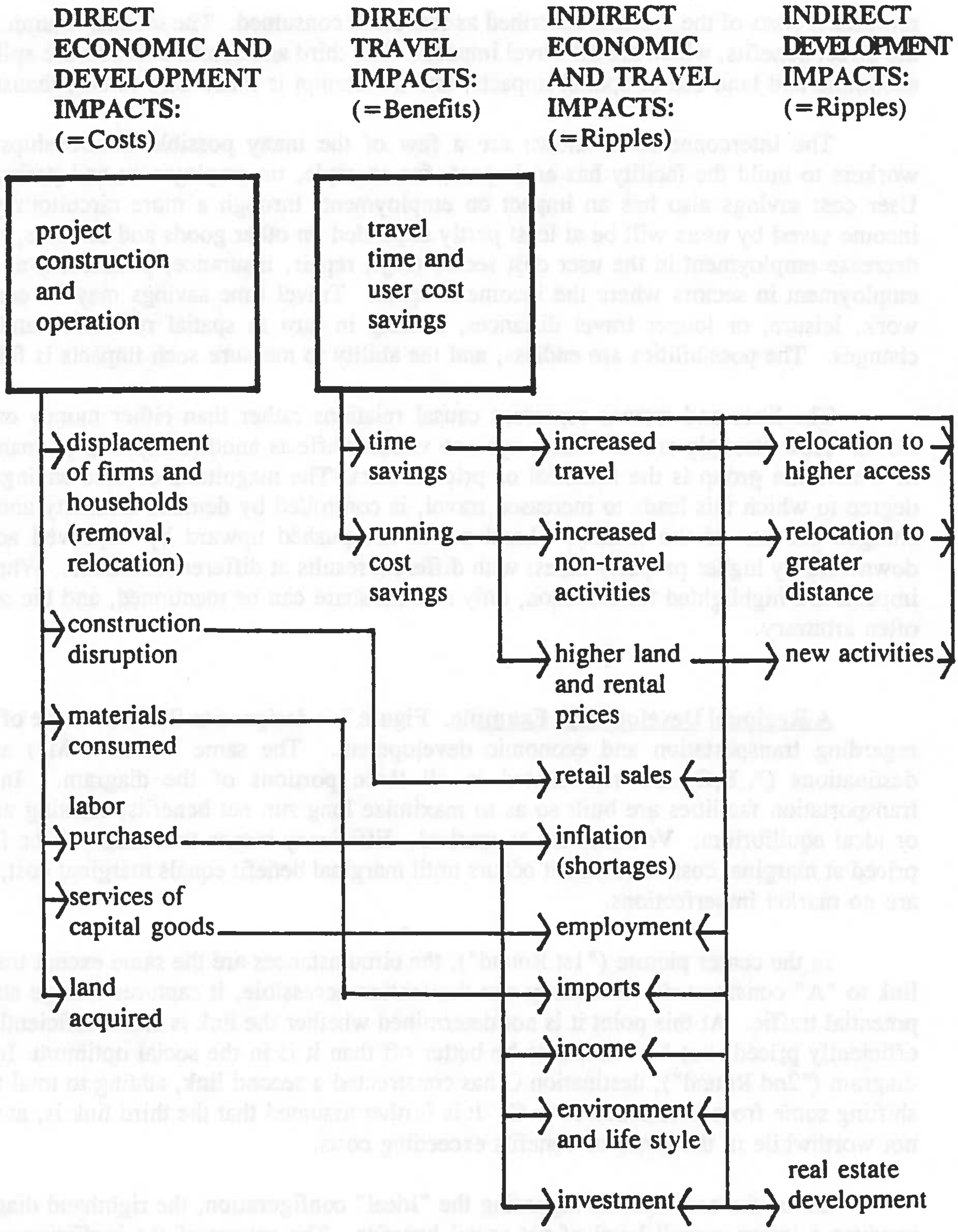


Figure 6. Examples of connections among direct and indirect impacts.

represents costs of the project, described as resources consumed. The second column represents the direct benefits, which are all travel impacts. The third and fourth columns are split between economic and land use or spatial impacts, and no attempt is made here to be exhaustive.

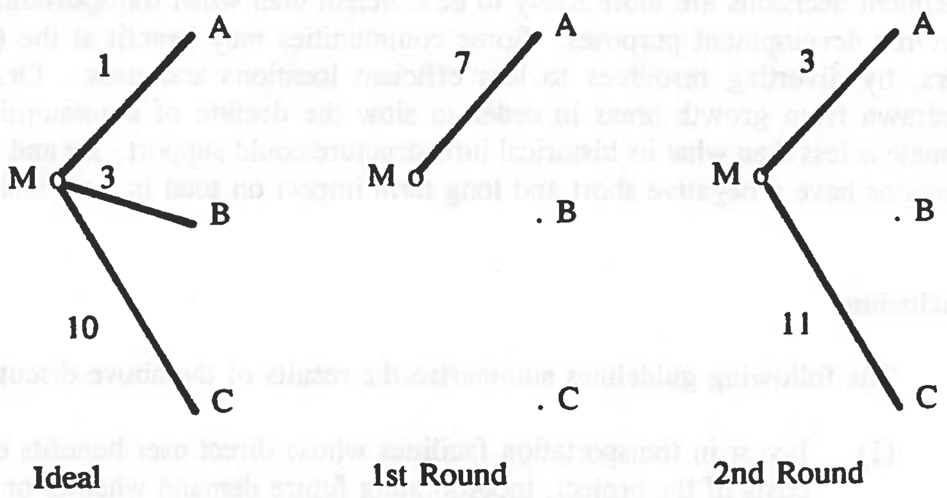
The interconnections shown are a few of the many possible relationships. Hiring workers to build the facility has an impact, for example, on employment and perhaps wages. User cost savings also has an impact on employment, through a more circuitous path: the income saved by users will be at least partly expended on other goods and services, which will decrease employment in the user cost sector (e.g., repair, insurance, petroleum) and increase employment in sectors where the income is spent. Travel time savings may be consumed in work, leisure, or longer travel distances, leading in turn to spatial relocation and land use changes. The possibilities are endless, and the ability to measure such impacts is fairly small.

The lines and arrows represent causal relations rather than either money or resource flows. How strongly and in what ways one variable affects another depends on many factors, of which one group is the financial or price factors. The magnitude of time savings, and the degree to which this leads to increased travel, is controlled by demand elasticity and the price charged for use of the facility. Land prices are pushed upward by improved access, and downward by higher property taxes, with different results at different locations. When indirect impacts are highlighted for attention, only a small share can be mentioned, and the selection is often arbitrary.

<u>A Regional Development Example</u>. Figure 7 is designed to illustrate some of the issues regarding transportation and economic development. The same market ("M") and tourist destinations (A,B,C) are represented in all three portions of the diagram. In the left, transportation facilities are built so as to maximize long run net benefits, creating an efficient or ideal equilibrium. Volumes are as marked. Efficiency means that usage of the facilities is priced at marginal cost, investment occurs until marginal benefit equals marginal cost, and there are no market imperfections.

In the center picture ("1st Round"), the circumstances are the same except that only the link to "A" constructed. With only one destination accessible, it captures a large share of the potential traffic. At this point it is not determined whether the link is either efficiently sized or efficiently priced, but "A" seems to be better off than it is in the social optimum. In the right diagram ("2nd Round"), destination C has constructed a second link, adding to total traffic and shifting some from destination A to C. It is further assumed that the third link is, at this point, not worthwhile in the sense of benefits exceeding costs.

Given the assumptions regarding the "Ideal" configuration, the righthand diagram must produce a lower overall level of net social benefits. The source of the inefficiency might be excess capacity in one or both of the two links, or underpricing on one or both. Destination B



HYPOTHETICAL EXAMPLE:

Demand at "M" for tourist destinations "A", "B", and "C"

"Ideal" maximizes net benefits.

"1st Round" starts with no transportation connections, adds one.

"2nd Round" adds another, and precludes third.

Figure 7. Hypothetical example of incremental transportation investment.

remains underutilized, and some tourist activities may shift from B to A or C. Which communities are worse off depends upon how the infrastructure was financed and is now priced; all might share in the lower (compared to the ideal) net benefits, or some might be better off at the expense of others. The difference in net benefits between the Ideal and the 2nd Round may be large or small, but the latter is necessarily lower. The loss may be due to a failure to recognize and anticipate the ideal, or it may be the result of competition between destinations to capture market share, perhaps at the expense of taxpayers.

When transportation is evaluated on transportation grounds -- benefits to users -- investment decisions are more likely to be efficient than when transportation is constructed for economic development purposes. Some communities may benefit at the (greater) expense of others, by diverting resources to less efficient locations and uses. Or, resources may be withdrawn from growth areas in order to slow the decline of communities whose economic rationale is less than what its historical infrastructure could support. By and large, such resource diversions have a negative short and long term impact on total income and product.

Conclusions

The following guidelines summarize the results of the above discussion:

(1) Invest in transportation facilities whose direct user benefits exceed the life cycle costs of the project, incorporating future demand whether or not it is affected by the presence of the project. Few transportation capital improvement plans or "needs" studies meet this standard.

(2) Operate facilities efficiently by charging users enough to cover the full costs of the facility, including land and opportunity costs. Many existing transportation facilities and some proposed ones could meet this standard if it were applied, but so far it has not.

(3) Transportation impact studies may have some supporting value for planning and policy setting, but they misleadingly fail to distinguish between impacts that are benefits versus the majority of impacts which are simply transfers from a benefit-cost point of view.

(4) Investment in or subsidy of transportation services whose user benefits do not exceed their costs is bad for the economy, no matter how much they stimulate travel or economic development. The only way to create jobs and strengthen the local economy, using transportation, is to invest in projects and policies whose direct benefits exceed their costs.

(5) **The main normative interest for economic impact analysis is in the evaluation of equity impacts (transfers), which is separate from efficiency impacts (benefits versus costs).**

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