Evaluation of Social Externalities From Investments
In Community Infrastructure by Industrial Enterprises

by

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Roads, electrical generation for facilities, hospitals, schools, housing, and recreational facilities are investments that are often made by mining enterprises in communities where they are operating. Often these enterprises argue that the services generated by this community infrastructure are external benefits created by the firm and should be added to the other output or benefits that constitute the primary purpose of the enterprise's operations.

In this paper we wish to outline a method for the evaluation of the social benefits and costs that should be appropriated to the enterprise for these facilities that are used by the community at large.

To identify what is or is not an external benefit from this infrastructure investment it is necessary to determine what proportion of the expenditures on these facilities is required in order to induce sufficient labour to work in this mining operation. It is also necessary to measure the value placed on the community services that are now available to other individuals in other parts of the country because some workers have moved from these areas to work in the mining enterprise.

To analyze this problem we will examine two alternative cases that are descriptive of many mining
operations. First, a methodology will be developed for evaluating community infrastructure in a situation where prior to the mine beginning its operations no significant level of habitation existed in the immediate area of the mine. In the second case we assume a community existed prior to the development of the mine. The mining enterprise employs a significant amount of its labour from the local population, but also attract skilled workers from other parts of the country. A substantial number of people in the community who are not directly or indirectly employed by the mine are able to use some of the community infrastructure constructed by the mine.

I. Mine Located in a Remote Region

When a mine is located in a region where no previous community existed then as a first approximation all community infrastructure costs including such things as roads which may also be used by the labourers in non-work related activities should be included as costs of the mining operations. The key questions to ask are: (a) would this infrastructure investment have been made by the community by some other government agency if the mining enterprise were not in the region, and (b) are these infrastructure investments just adequate or are more than adequate to attract the incremental labour force required by the enterprise to the region?

If these facilities would not have been built without the existence of a mine and these investments are just adequate to attract the required number and quality of labour to the area then the surplus or economic rent received by the inframarginal labour that should be included as an externality to the mine plus the value of facilities released elsewhere. The unskilled labour will likely place a relatively low evaluation on such
items as roads and electricity facilities as they do not have or can afford a smaller quantity of the capital items, e.g. automobiles and appliances, that are complementary to the consumption of the services from these community infrastructure investments. On the other hand the skilled workers will value these items highly as they already have or plan to purchase a significant quantity of the complementary capital items. These two evaluations can be illustrated by the compensated demand curves shown in figures 1A and 2B.

Figure 1
Valuation of Road between Mine Site and Urban Area

A: Unskilled Worker

Value per Vehicle mile

B: Skilled Worker

Value per Vehicle mile

\[ V_u^o \]

\[ V_s^o \]

\[ V_u' \]

\[ V_s' \]

\[ Q_u \]

\[ Q_s \]

\[ Q_u' \]

\[ Q_s' \]

\[ Q_u'' \]

\[ Q_s'' \]

\[ Q_u''' \]

\[ Q_s''' \]

\[ V_u^o \] and \[ V_s^o \] are the total value of time, gasoline, maintenance, depreciation expended per vehicle mile by skilled and unskilled workers prior to the road improvement, \[ V_u' \] and \[ V_s' \] refer to these same costs after the road has been upgraded.
The value that the unskilled (low income) workers place on the road improvement is the difference between what it would cost them to make the trip if the road were not improved $V_u^0$ and what it costs with the improved road $V'_u$ times their previous quality of trips $Q_u^0$ plus the marginal valuation of the increased use they make of the road.

If we approximate the demand for road services by a linear curve then the value that a representative unskilled worker places on this service per year can be written as follows:

Annual Benefits
(1) from road improvement
for an unskilled worker
$$= (V_u^0 - V'_u)Q_u^0 + \frac{1}{2}(V_u^0 - V'_u)(Q'_u - Q_u^0)$$

Annual Benefits
(2) from road improvement
for a skilled workers
$$= (V_s^0 - V'_s)Q_s^0 + \frac{1}{2}(V_u^0 - V'_u)(Q'_u - Q_u^0)$$

It is important to note that the value of expression (1) for the unskilled worker will generally be much less than the value of expression (2) for the skilled workers and management even though the road is available to all the people who live in the mining community. We would also expect that the total costs per vehicle mile $V'_s$ for skilled workers would be significantly larger than the cost per mile for unskilled worker $V'_u$ because of the greater value placed on the time required for travel in the case of the skilled workers. By the same reasoning it is also expected that $V'_s$ will be greater than $V'_u$. However, the ratio of $V_s^0/V'_s$ will probably be larger than the ratio of $V_u^0/V'_u$ because the overall travel costs of higher income people will fall by a greater proportion due to the road improvement because the time costs of travel are a larger
proportion of the total costs of travel for the high income individuals.

In the decision to work in a remote mining community the workers of different types will require a level of compensation that is a combination of a monetary payment, on some occasions a payment in kind, and community services that will make them at least indifferent between working at this mine site and being engaged in their next best alternative activity. The mine community services such as roads, communications and electrification will be valued higher per worker by those in the higher wage categories than for the unskilled (low wage) workers.

Figure 2

A: Market for Unskilled Workers

B: Market for Skilled Workers
In this case the money expenditures on roads or electrical services should be included in the cost of the mine but there are no direct benefits from these services that should be added to the value of the mine output. An indirect benefit may arise, however, if the movement of labour to the mining community causes a reduction in the amount of subsidy paid by the governments for the supply of these services or their substitutes in the community in which the individual previously lived. This value is shown as the shaded area ABCD in Figure 3. A more realistic case might be that the service is now being rationed in the area from which labour is migrating. In this case the indirect benefit that is added to the mining sector's output should be the value of the new consumers place on the service now that some of the previous consumers of the service have moved to the mining community. If the services are being rationed in a proportional and non optimal manner then the value of the additional released service is measured by the area of triangle EFG in Figure 4.

Figure 3

Indirect Benefits From Labour Migration
Reduction of Subsidies in Sending Region

[Diagram showing marginal social cost and private cost with shaded areas representing subsidy and demand for services before and after labour migration]
The area EFG represents the consumer surplus received by those individuals who prior to the migration of labour from the community would not have consumed the service but who are now able to obtain the service. This shaded triangle can be estimated in an approximate fashion as follows:
\[
\text{Indirect Benefit} = \frac{1}{2}
\]

This analysis has dealt primarily with investments such as roads and electric services. However, community investments are also made for such things as hospitals and schools which are made available to the inhabitants. While such services are likely to be valued more by the higher income individuals on a willingness to pay criterion, they are essentially investment expenditures rather than expenditures on consumption. For such expenditures a person's willingness to pay may be greatly constrained by his ability to pay.

If the parents were to currently value the higher future incomes of their children due to education equal to their actual discounted values then such educational expenditures should be treated as part of the wage bill of the mine. This compensation would have been included by the workers in their decision to move to the mine area. Alternatively, if the parents place the value of the educational expenditures provided to their children at zero then the benefits such as the higher future income of the workers' children that arise from these expenditures should be added entirely to the output of the mining enterprise.

In many cases the families of workers would have previously been using hospital and school services in the area they migrated from but enjoy more and better quality services after they have moved to the mining community. In addition, these services are not likely to be fully valued in the family's current income. As it is difficult to measure the present value of the benefits of education and health care we will assume that these benefits have a present value approximately equal to the

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cost of the expenditures that are made. The maximum value of the additional benefits generated by the mine from providing community services would be equal to the cost of the expenditure made, while a minimum estimation would be equal to the government expenditures on school and health facilities previously consumed. An operational estimate would be to average these two values and include this amount as indirect benefit to the mining enterprise.

II Community Infrastructure Investments by Mines in Populated Regions

On many occasions mining companies do invest in community infrastructure which will be used by both the employees of the mine and the indigenous people in the area. It is generally the case when a mine operates in such a community that it will utilize the local unskilled labour, but will draw skilled labour to the area from other communities.

The community services the mine provides to skilled migrants should be evaluated in the way outlined in section I. However, the benefits accruing to the existing population requires further examination.

In the analysis which follows the assumption is made that the company builds or operates the facility but does not discriminate in determining who in the community can use the service. We will also assume the mining enterprise is as efficient in providing these services as is the government department which has the primary responsibility for providing such services in the country.
For such expenditures as hospitals and schools the externality received by the previous inhabitants of the area can be approximated by the total expenditures made on these items by the company times the proportion of the total users of the facilities that are non-migrant. Expenditures made on such items as road and electricity are more difficult to analyze as they are primarily developed for the use of the mine itself.

Road Improvements

To evaluate the benefits received by the local population from the use of an improved road it is first necessary to determine the frequency \( Q^O_L \) of travel between the points the road connects if no road improvement had been made. It is also necessary to estimate the costs in terms of fuel, maintenance and the value of time required to complete the journey without the road improvement \( C^O_L \). Finally we require an estimate of the costs that would be incurred by travellers on the improved road and the frequency of use of the improved road. This information will allow us to estimate the annual net benefits received by the community from the mine's expenditures on road improvement. The benefit received in one year is shown in Figure 5 as the shaded area \( C^O_L ABC^I_L \), and can be expressed as in equation (4).

\[
(4) \quad \text{Net Benefits from Improved Road in year } t \quad = \quad (C^O_L - C^I_L)_t \, (Q^O_L)_t \, + \, \frac{1}{2} (C^O_L - C^I_L)_t \, (Q^I_L - Q^O_L)_t \\
\]

Change in road maintenance costs borne by local community or government because of mining activity.

Where \( Q^O_L \) is the number of vehicle miles travelled on the road by the local community if no road improvement project were
undertaken by the mine, and $Q'_L$ is the number of vehicle miles that is travelled by local residents after the road is improved. The full costs of the road improvement should be included as a cost to the mine with the above net benefit serving as a partial offset to these expenditures.

**Rural Electrification**

The benefit from rural electrification projects are particularly interesting to analyse because such projects
involve the provision of a substitute to fuel oil and kerosene which are often provided at a subsidized price in developing countries. Figure 6A illustrates the market for fuel oil or kerosene. Prior to the introduction of electricity the quantity $Q_k^0$ is being consumed at a price per unit of $P_k$. This fuel is being subsidized by an amount per unit of $(M - P_k)$. With the introduction of electricity there will be a decrease in the quantity of fuel oil or kerosene consumed, thus the government gains the subsidy payments it would have had to make, as represented by the shaded area ABCD in Figure 6A. Because electricity is usually offered at a very low rate to consumers there will likely be some consumer surplus generated in the market for electricity. This is illustrated by the shaded area $P_e EF$ in Figure B.

Figure 6
Measuring the Benefits from Rural Electrification

A: Market for Fuel Oil or Kerosene  

![Diagram A: Market for Fuel Oil or Kerosene]

B: Market for Electricity

![Diagram B: Market for Electricity]
This area can be approximately measured as:

\[
\begin{align*}
\text{Consumer} & \quad (\text{The maximum any local}) \\
- & \quad (\text{The quantity}) \\
& \quad (\text{consumer would pay to}) \\
(5) \text{ Surplus} & \quad (\text{have electricity where}) \\
& \quad (\text{of electricity}) \\
& \quad (\text{fuel oil or kerosene}) \\
& \quad (\text{is available at the}) \\
& \quad (\text{consumed}) \\
& \quad (\text{subsidized price - the}) \\
& \quad (\text{price the local}) \\
& \quad (\text{consumers have to pay}) \\
& \quad (\text{for electricity})
\end{align*}
\]

As in the case of roads the full cost of providing electricity should be included in the cost of the mining operation. However, the mine should count as indirect benefits from providing electricity to the local community both the revenue it receives from the sale of electricity, the decrease in government subsidy on kerosene, and the increase in consumer surplus from the sale of electricity.

III Roads and Other Development Activity

It has been suggested that an externality is created when a road is built for the purposes of mining, but this road also makes possible of other activities such as timber harvesting. The externality created by the road is not equal to the entire value added of this secondary activity. The net benefits that should accrue to the road project from the new activities such as timber harvesting is equal to the maximum amount that could be charged to the timber activity for the use of the road before this timber enterprise would either not wish to undertake operations in the area or would choose an alternative form of transportation. It is a common error to credit the road for the value added of the labour and capital
that are used in conjunction with the transportation services to produce and market these other products. Only the transportation benefits measured in the above way should be included as indirect benefits to the mining enterprises expenditures for the road.