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Estimating the Social Profitability of India's Rural Roads Program

A Bumpy Ride

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Abstract

India's rural roads program, *Pradhan Mantri Gram Sadak Yojana,* aims to draw villagers into the mainstream by improving not only their terms of trade, but also their educational attainments and health. Treating each all-weather feeder road as an isolated element within the larger network, and using shadow prices to value the main components of costs and benefits, the paper demonstrates that further investments in the program are, with high probability, socially profitable, especially in poorer and more densely settled regions. Taking the entire set of new individual roads together, qualitative arguments suggest that their external and spill-over effects on the system as a whole probably generate some net additional benefits, but of very uncertain magnitude.

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Estimating the Social Profitability of India's Rural Roads Program: A Bumpy Ride

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1 Introduction

In the year 2000, the Government of India embarked on the ambitious program *Pradhan Mantri Gram Sadak Yojana* (hereinafter PMGSY), whose ultimate aim is to draw India's villages into the mainstream, especially in three domains. First, with improved, all-weather connections to markets, villagers should face more favorable prices for inputs and outputs, which will raise their incomes and sharpen their incentives to cultivate more intensively, pursue new activities and invest in new methods. Second, by reducing the time spent traveling to and from school (and in the rainy season, by making the trip actually possible), an all-weather road should improve the attendance, not only of pupils, but also of their teachers, thus promoting the formation of human capital and the growth of productivity over the long run. Third, by likewise improving the villagers' access to timely treatment, especially in the event of accidents and bouts of acute sickness, the connection should lower mortality and morbidity. Improvements in these domains will, if realized, reduce poverty and increase productivity in both the short and the long run.

By any measure, PMGSY is a very large undertaking. As originally planned, all habitations with populations exceeding 500 persons (250 in hilly and desert areas) were to be connected by 2015. At that time, about 170,000 habitations were eligible; at this time of writing, over 40 percent have their road. By the end of 2010, accumulated expenditures had amounted to about US $14.6 billion, and it is now estimated that a further US $40 billion will be required to complete the program by 2020 (World Bank, 2010). It was supposed to be wholly financed by a special cess on high-speed diesel, but as the proceeds proved to be quite inadequate, there has been extensive resort to other sources, including loans from the World Bank and the Asian Development Bank. The latest installment from the World Bank involves a credit in the amount of US $1.7 billion, which was approved by the Bank's Board in December 2010.

Three big questions arise. First, in view of the fact that what has already been spent represents sunk costs, how are the resulting benefits best sustained and even enhanced? Second, is a continuation of PMGSY according to past practice socially profitable? Third, if a stop is out of the question, how can one improve on past practice? This paper is primarily concerned with the second and third questions, but there will be some closing remarks on the first.

The salient elements of an economic evaluation of this program are as follows.

1. The feeder roads must be constructed, and thereafter maintained, to some de-

sired engineering standard. This public investment activity also involves making choices among alternative techniques of construction (machines vs. labor), sequences of connections, tendering processes and financing.

2. Upon completion, a feeder road will reduce transportation costs and otherwise enlarge villagers' economic opportunities. Farmers may respond by changing their cropping patterns and techniques, as well as what and how much they market. These decisions depend on the village wage rate, which is itself endogenous. Local laborers can commute more easily to work in other connected villages and towns – and outside laborers can also compete more easily for local jobs. All villagers will also enjoy better access to various services provided elsewhere, often in towns. Of central importance here are schools and health facilities.

3. All these changes need to be valued. If the villagers' preferences are known, one can, in principle at least, compute the equivalent variation (EV), which is the lump-sum payment such that they would be indifferent between having the more favorable environment produced by the feeder road and going without it but receiving the payment instead. In an economy distorted by taxes, subsidies and market imperfections, however, this is not the end of the story. For shadow prices will then diverge from market prices, and it is at the former that the road's social profitability must be calculated.

4. Each feeder road forms part of a network, which is potentially subject to so-called 'technological' externalities. Connecting one village to the nearest secondary or main road will typically lower the costs of connecting other nearby villages to the same, depending on the sequence chosen. Yet extending the network in this way is virtually certain to increase the volume of traffic on the main roads, and hence to increase not only wear and tear, but also the number of accidents thereon. Since much of the additional traffic will have a town as its destination, congestion and pollution will increase, too. It follows that the effects of the whole program are not simply additive in those of its individual (project) components, and in the absence of corrective taxation, some of the potential benefits may be dissipated.

5. There remain the so-called 'pecuniary' externalities. Connecting one or two villages to the main road is unlikely to have a measurable effect on the prices of goods ruling in the nearest towns; but connecting many may have significant repercussions. The prices farmers receive may actually rise if larger marketed volumes promote market efficiency. It is also possible that some technologies for

producing other urban goods exhibit decreasing unit costs and that these potential increasing returns cannot be exploited by a resort to international trade, so that aggregate domestic demand comes into play as a factor in determining the profitability of these technologies. PMGSY is so large that these pecuniary effects cannot be ignored *a priori*.

Any attempt at a full-blown analysis of such an investment program would be a formidable undertaking, demanding resources and time on a scale wholly incompatible with the process of preparing a loan proposal. Some fairly drastic simplifications are, therefore, unavoidable. The approach adopted here is to begin by treating each PMGSY road as an isolated element in a wider system, so that, at the first stage, the loan program involves just a bundle of such unrelated elements, each with its own particular characteristics and catchment villages. At the second stage, the effects of the bundle on the wider system are taken up, albeit largely qualitatively. It will be argued that these external and spillover effects probably yield some net additional benefits, but of very uncertain magnitude.

Taking each road by itself, the central problem is to estimate the benefits it generates for the villagers in its catchment area. The classical, direct approach is to establish (or forecast) the levels of traffic with and without the road, together with the associated reductions in trip-costs. There are two drawbacks to this approach when applied to poor, backward areas. First, village resources may not be fully employed and the changes in the prices of goods bought and sold may be large, so that the road induces a reallocation so great as to cast doubt on estimates derived in this way. Second, the lion's share of the benefits arising in the domains of education and health is likely to be missed, so that arriving at an estimate of these benefits by other means is essential. To deal with the first, I shall adopt an alternative approach, in which the change in real village income serves as the measure of the benefits generated in the 'commercial' domain of village life. This, too, has its weaknesses, which will be discussed. To deal with the second, I shall employ methods that attempt to capture the benefits in education and health more fully by explicitly incorporating the formation of human capital. There is also the so-called 'capitalization' approach, in which changes in land values are deemed to reflect the willingness to pay for the resulting improvements in profitability and access to amenities. This certainly has its proponents; it is discussed in Section 7, but with reservations. Whatever be the choice of approach, however, there remains the practical difficulty that the actual roads that will make up the package to be financed will serve villages for which relevant data are not available, so that some resort to (statistical) inference based on previous experience is unavoidable.

It must be remarked that India's system of public finances has a potentially decisive influence on the program's social profitability. First, PMGSY contains no provisions for road maintenance beyond the first 5 years following initial construction. Thereafter, maintenance becomes the responsibility of the state in question. Since the states' fiscal condition is a parlous one, there could be a dramatic fall in the quality of these roads, and hence in the benefits they generate, if no system of secure, long-term financing is put into place. Second, since PMGSY roads are part of a wider network, their social profitability depends on the condition of that network. The district roads and state highways are often in an unsatisfactory, and sometimes deplorable, state; so that the larger fiscal question arises here, too. Much of past investment in PMGSY will be wasted, and further investments will be markedly less profitable, if the wider policy framework is deficient.

Given PMGSY's sheer scale, it is natural to ask whether there are extant evaluations of its social profitability. Neither a search of the literature nor presentations at some of India's leading research institutions uncovered any. There are certainly general investigations into the effects of investments in rural roads on villagers' well-being, broadly interpreted. Two well-known studies of the sub-continent are Binswanger *et al.* (1993), which is largely concerned with output and investment in rural India, and Fan *et al.* (2000), which addresses welfare more directly, in that it also investigates the effects of government spending on rural poverty. More directly connected to the central question posed in this paper is Khandker *et al.* (2009), which analyzes two panels of data in connection with Bangladesh's Rural Roads and Market Improvement and Maintenance Projects, which were undertaken in the late 1990s. Transport costs were much reduced, output and net prices were boosted, as were agricultural wages and per capita household consumption. Boys' and girls' schooling rose, too. Where consumption is concerned, the distributional pattern turned out to be favorable, or at least broadly neutral, so that there was a substantial associated reduction in poverty. There is evidence that providing all-weather roads also reduces poverty in south-east Asia. Between 1997-98 and 2002-03, the headcount ratio in rural Laos fell by 9.5 percentage points: Warr (2010) estimates that 13 percent of this decline is attributable to the conversion of dry- into all-weather roads. Geographically farther afield, Escobal and Ponce (2002, pp. 37-8) estimate that the rehabilitation of motorized rural roads in Peru's rugged terrain yielded the beneficiaries \$120 each annually, or 35 percent of the average per capita household income in the control group.

The findings of these serious studies are all well and good, and they suggest that further investments in PMGSY may well be socially profitable, but they do not establish as much. For what must be demonstrated is that spending yet more billions on PMGSY will yield a greater improvement in welfare than like spending on the next best alternative.

The plan of the paper is as follows. Section 2 deals with three key shadow prices (SPs), namely, the social discount rate, the premium on public income and the conversion factor for road-building. Section 3 describes the planned extension of the network and estimates the cost, at SPs, of a representative feeder road over an assumed 30-year lifecycle. Estimating the benefits is altogether much harder. In keeping with the three broad domains of commerce, education and health, Section 4 is split into three corresponding subsections. Various methods and sources are used, notably a survey of 30 villages in Orissa's poor uplands (hereinafter, the Orissa Survey). Those forms of benefits that have defied my attempts to measure them are indicated and briefly discussed. The costs and measured benefits are compared in Section 5. If the former exceed the latter, the difference is the smallest contribution required of all non-measured benefits such that the project be socially profitable. In other words, the difference then measures the leap of faith involved in asserting such profitability. Section 6 takes up the program's external effects on the wider economy, and I argue that, on balance, these will be beneficial. Alternative approaches to the measurement of benefits are briefly discussed in Section 7. The main conclusions concerning social profitability and the complementary policies needed to ensure it are drawn together in Section 8.

2 Shadow Prices

Market prices depart from shadow prices for various reasons: market failure, externalities and, especially important in the present setting, the presence of distortionary taxes and subsidies as well as a social desire for greater equity than that yielded by market forces. There is no certainty whatever that replacing market prices with shadow prices will make a project socially profitable; but given the considerations involved, doing the accounting at SPs is strongly desirable. The practical difficulty is that estimating a complete set of SPs is very demanding of time and resources, and no such set is available off the shelf. Some short-cuts are, therefore, unavoidable. Three central 'prices' demand attention, namely, the social discount rate, the premium on public income relative to private income, and the cost at shadow prices of building and maintaining a representative rural feeder road.

The discount rate usually plays a decisive role in determining the profitability of long-lived projects. In order to estimate the social discount rate, ρ, I appeal to the (approximate) rule that, in a state of steady growth, $\rho = |\eta| \cdot g_c + \delta$, where $1/\eta$ is the inter-temporal elasticity of substitution in consumption (in other contexts, η is the elasticity of the marginal utility of consumption), g_c is the rate of growth of per capita consumption and δ is the rate of pure impatience. It is common to assume logarithmic inter-temporal utility, which implies $\eta = -1$. As for g_c, India's GDP per head has been growing rapidly for more than two decades, with the initial acceleration occurring in the early 1980s. Private per capita consumption has grown almost as fast, and the gap in their future rates is likely to be small. The current pace of about 4.5 percent annually will probably continue for at least another three decades. On ethical grounds, δ should be no more than 1 percent p.a. These assumptions yield a social discount rate of 5.5 percent. It might be argued that, especially in poor economies, consumption in one period is a poorer substitute for consumption in another than $\eta = -1$ implies. Consider, therefore, the rather extreme value $\eta = -2$, which implies $\rho = 10$ percent. It is rather hard to justify a test discount rate any higher than this.[1] The real market rate in India, r, is much lower, and this will matter, even though the gestation period of feeder-road projects is unlikely to exceed one year. Indeed, the government always has the option of investing in high-quality bonds in international capital markets, wherein real rates are likely to remain at historically low levels for some time to come. The proposed rule $\rho = |\eta| \cdot g_c + \delta$ is, therefore, a conservative choice.

Valuing the benefits, which will accrue overwhelmingly to households, requires much more than simple tinkering with shadow prices. It is not enough to value the underlying inputs and outputs at shadow prices; one must also value the (money-metric) benefits accruing to households relative to public income, which is the source of finance for the road and on which there should be a premium – unless the beneficiaries are sufficiently poor. The calculations are long and involved, quite apart from the necessity of estimating the SPs themselves. For present purposes, what matters most is the premium on public income. This is arguably close to zero where poor communities are concerned, for the government should then be indifferent between making a transfer to them and keeping the money for other purposes. In the participating states, the great majority of the communities that are scheduled to get a road surely fall into this category, so that the monetary value of the benefits their members receive will be accorded the

[1] An independent study by Murty and Goldar (2007) also yields this upper estimate.

same social value. The only obvious exception is Punjab, whose general population enjoys comparative affluence and wherein the project will involve much upgrading of existing roads rather than the construction of new ones. In Punjab, it is arguable that private benefits should be discounted somewhat (see below). The same applies to some communities in Himachal Pradesh.

Constructing and maintaining roads in India is a pretty labor-intensive business, so there are good grounds for adjusting the corresponding costs at market prices. Theory and empirical estimates in various developing countries suggest that the so-called conversion factor for such construction work is typically 0.8 to 0.85, with a corresponding reduction in the present value of lifetime costs at any given discount rate, so there will be some help from this quarter where social profitability is concerned.

3 The Cost of Construction and Maintenance

Let the construction of a single feeder road take one year (in $t = 0$) and cost K at market prices. Routine maintenance thereafter costs m percent of K annually; the black-top must be renewed every ten years, at a cost of $m + m'$ percent of K. Thirty years after completion of the initial construction, let wholesale reconstruction be necessary, albeit with a salvage value that is κ percent of the initial outlay, which represents the right-of-way and any useful residual structures, including the road-bed. We can then confine the calculations to the first 30-year cycle. The present value of the entire stream of expenditures at SPs is

$$PV^*(I;\rho) = \pi_K K\left[1 + \frac{m}{\rho}(1-(1+\rho)^{-29}) + \frac{m'}{(1+\rho)^{11}} + \frac{m'}{(1+\rho)^{21}} - \frac{\kappa}{(1+\rho)^{30}}\right] \quad (1)$$

where π_K denotes the conversion factor for such construction.

We turn to the actual numbers, at least as forecast. The SWAp loan budgets a total expenditure of \$3.014 billion to construct 48,736 km. of roads in the participating states of Jharkhand, Himachal Pradesh, Rajasthan, Meghalaya, Uttarakhand, Uttar Pradesh and Punjab (World Bank, PAD, 2010, Tables 2.2 and 3.3), which implies an average cost of \$61,820 per km. This addition to the network will connect 14,274 habitations. Taking the habitation as the unit of analysis, we have $K = \$211,000$ for a link-length of 3.41 km. Associated estimates are $m = 0.01, m' = 0.35$ and $\kappa = 0.25$.

Setting $\pi_K = 0.825$, (1) then yields

$$PV^*(I; \rho = 0.055) = 0.825 \times 211,000 \times 1.398 = \$243,400, \text{ and}$$

$$PV^*(I; \rho = 0.10) = 0.825 \times 211,000 \times 1.248 = \$217,200.$$

Although there is some uncertainty about costs at market prices, these estimates of the average social cost of connecting a habitation are surely not too far off the mark.

As a preliminary to Section 4, observe that to any estimate of $PV^*(I; \rho)$ there corresponds a flow of annual benefits, growing at the constant rate g_b over the lifetime of the project following completion, such that the project just breaks even at the chosen discount rate. Denoting the said flow by $B_t^+ = (1+g_b)^t B_1^+$, where B_1^+ denotes the level of the flow in year 1, we require

$$B_1^+(\rho, g_b) = \frac{\rho - g_b}{1 - [(1+g_b)/(1+\rho)]^{29}} PV^*(I; \rho). \tag{2}$$

For the limiting case in which the flow fails to grow, we have $B_1^+(\rho = 0.055, 0) = \$17,000$ and $B_1^+(\rho = 0.10, 0) = \$23,180$. Since such roads are effectively pure public goods when viewed as isolated elements, their social profitability depends heavily on the number of beneficiaries. Denoting by H the number of households in the habitation, the 'representative' household must enjoy a benefit of at least B_1^+/H a year for the project to pass muster at the chosen social discount rate. With the hurdle's height thus established, we now investigate whether the project will clear it.

4 Estimating the Benefits

The participating states under the SWAp loan vary greatly in their levels of economic and social development. Jharkhand is poor and backward, most of its villages are but little commercialized, and traffic volumes are low. Punjab has the highest state domestic product per head in the whole Union, its agriculture is highly commercialized, rural traffic is heavy, and its social indicators are now well above average. A new all-weather road in Jharkhand is therefore unlikely to generate the sort of commercial benefits flowing from one in Punjab; but such roads may also be valued quite differently by their respective beneficiaries. These forms of heterogeneity demand careful treatment.

Viewed in isolation from the rest of the network, each road affects only those who live within its catchment area. The villagers enjoy benefits in three broad spheres, namely, ‘commercial’, education and health, which are taken up *seriatim*. The first lends itself much more readily to estimation than the other two; but even in the commercial sphere, there are considerable uncertainties. Indeed, the empirical basis for estimating the main effects leaves much to be desired. The only available primary sources that provide reasonably reliable evidence are field-notes on a tour of Assam, Himachal Pradesh and Orissa (Bell, 2009a), a special re-survey of 240 households drawn from 30 villages in Orissa’s uplands (Bell and van Dillen, 2012), and materials on agricultural marketing provided by Grahame Dixie.[2] A useful secondary source is Khandker et al. (2009), which yields estimates of certain effects of rural roads in Bangladesh. The secondary literature is otherwise disappointingly thin for present purposes. In keeping with the aim of developing a robust estimate of the Project’s social profitability, we adopt some extreme alternatives, as near polar as possible.

4.1 Commercial

The household is endowed with labor, land and other resources. As a consuming unit, it has preferences over goods and leisure. Faced with the prices $\mathbf{p}$ ruling in the marketplaces in which it trades, it draws up a production plan $\mathbf{y}$ and a consumption plan $\mathbf{x}$. The difference $\mathbf{y} - \mathbf{x}$ is the vector of its net exports, and its total outlay on transportation is $\mathbf{c} \cdot |\,\mathbf{y} - \mathbf{x}|$, where the vector of associated unit costs of transporting goods to and fro is $\mathbf{c}$. If there is complete market integration, the farmgate price of a good that is exported (imported) will be $q_i \equiv p_i - c_i$ ($q_i \equiv p_i + c_i$). An all-weather feeder road is now built, which reduces the vector of unit transport costs from $\mathbf{c}^1$ to $\mathbf{c}^2$, where the superscripts 1 and 2 denote the village environment without and with the road, respectively.[3] Leaving aside transactions in the spheres of education and health, what value does the household place on this change in its environment?

At one extreme, let the household’s resources be fully employed, the opportunity cost of leisure being the going wage rate w. If the household sticks with its original plan $(\mathbf{y}^1, \mathbf{x}^1)$, which remains feasible after the road has been provided, and there is full market integration, its (full) income will increase by the amount of the savings in transportation costs. If, however, the new prices and opportunities induce it to make any adjustment to that plan, then it must do strictly better, though the resulting whole gain in (full) income cannot exceed the total savings at the net export vector with the

[2] Private communication.

[3] The provision of an all-weather road may sharpen competition among traders who buy at the farmgate, and so improve the farmer’s net price independently of any reductions in $\mathbf{c}$. It is also possible that increasing the number of all-weather roads will affect $\mathbf{p}$. See Section 6.

road. Hence, denoting by M^c the monetary value the household places on having the road's services,

$$\Delta\mathbf{c} \cdot |\,\mathbf{y}^1 - \mathbf{x}^1| \equiv (\mathbf{c}^1 - \mathbf{c}^2) \cdot |\,\mathbf{y}^1 - \mathbf{x}^1| \leq M^c \leq \Delta\mathbf{c} \cdot |\,\mathbf{y}^2 - \mathbf{x}^2|, \tag{3}$$

where M^c is just the corresponding equivalent variation. A full analysis of the household's decision problem is to be found in Bell (2009b), in which it is argued that if the reductions in unit transport costs are sufficiently small relative to the ruling prices $\mathbf{p}$, then the interval defined by these upper and lower bounds will also be small. Illustrative calculations with commonly employed functional forms and a range of broadly plausible parameter values indicate that, when unit transport costs are halved, the lower bound is about 3 – 3.5 percent lower than the EV and the upper bound is about 6.5 – 7 percent higher, which point to the relevant compensated demand and supply schedules being convex. At all events, this finding suggests that a very simple formula using suitable, one-shot survey data covering villages with and without all-weather roads will yield a defensible and rather precise estimate of the benefit accruing to a sampled household as a result of reductions in the costs of transporting the goods making up $(\mathbf{y}, \mathbf{x})$.

An alternative is to make no particular assumptions about how land and other nonlabor resources are supplied, nor about the extent of market integration, but to leave open the possibility that labor is under-employed. With the usual convention that the elements of $\mathbf{y}$ that are inputs take a negative sign, the household's income from production is $\mathbf{q}^k\mathbf{y}^k$, $k = 1, 2$. To any improvement therein must be added the benefit arising from changes in the prices of the goods consumed, viz. those in $\mathbf{x}$, which is analogous to that appearing in (3). We have

$$M^c \in \left[(\mathbf{q}^2\mathbf{y}^2 - \mathbf{q}^1\mathbf{y}^1) - (\mathbf{q}^2 - \mathbf{q}^1)\mathbf{x}^1,\, (\mathbf{q}^2\mathbf{y}^2 - \mathbf{q}^1\mathbf{y}^1) - (\mathbf{q}^2 - \mathbf{q}^1)\mathbf{x}^2\right], \tag{4}$$

where the fact that households are intensive consumers of farm outputs, whose farmgate prices are higher with the road, leaves open whether $(\mathbf{q}^2 - \mathbf{q}^1)\mathbf{x}^1$ exceeds $(\mathbf{q}^2 - \mathbf{q}^1)\mathbf{x}^2$, or conversely. In this alternative, the upper and lower bounds on the total benefit incorporate any changes in the production plan induced by the road.

One can be more precise by imposing some restrictions on households' preferences. Let the indirect utility function be written $v(\mathbf{q}, M)$, where M denotes the level of lump-sum income. Then, by definition, M^c is such that $v(\mathbf{q}^2, M) = v(\mathbf{q}^1, M + M^c)$. If preferences are quasi-homothetic, the indirect utility function can be written

$$v(\mathbf{q}, M) = \frac{\mathbf{q} \cdot \mathbf{y} + M - \mathbf{q} \cdot \gamma}{\phi(\mathbf{q})},$$

where γ denotes the 'subsistence' bundle and $\phi(\cdot)$ is an exact (Könus) cost-of-living index, which includes the opportunity cost of leisure, even if this does not vary. Hence,

$$M^c = \frac{\mathbf{q}^2\mathbf{y}^2 + M}{\phi(\mathbf{q}^2)} - \frac{\mathbf{q}^1\mathbf{y}^1 + M}{\phi(\mathbf{q}^1)} - \left(\frac{\mathbf{q}^2 \cdot \gamma}{\phi(\mathbf{q}^2)} - \frac{\mathbf{q}^1 \cdot \gamma}{\phi(\mathbf{q}^1)}\right). \tag{5}$$

Aggregating over all households in the village yields the total 'commercial' benefit $B^c = M^cH$. It is seen that transactions between villagers, whether in the form of tenancy, or labor services, draught animals, animal feed, or whatever, simply net out; so that the resulting sum is just the village's domestic product plus any net factor income from its dealings with the rest of the economy, that is to say, gross village income (analogously to gross national income). Any changes in the aggregate production plan involve mainly changes in the purchases of inputs that the village cannot supply itself, such as artificial fertilizers, pesticides, motor fuel, certified seeds and the like, with an allowance for the costs of additional credit when needed. There is, however, a snag in employing (5) in practice. Whereas an exact cost-of-living index will duly incorporate the value of leisure, the standard indices do not; nor, moreover, is leisure measured in the surveys available for present purposes. Changes in the real cost of the subsistence bundle are also ignored. Hence, estimates of B^c derived from (5) using, say, the consumer price index for agricultural laborers (CPIAL) and data on household incomes, as the surveys define income, will involve errors; but if the changes in leisure are small, these are unlikely to be serious.

Each of these alternatives is now illustrated with actual examples, drawing on Bell (2009a). The community in Himachal Pradesh enjoys a good standard of living and is heavily commercialized, the principal crop being apples. A stretch of some 12 km. of all-weather road was completed under PMGSY in the middle of 2009, at a cost of about Rs 30 million. It serves five villages, whose combined population is about 2000 persons, living in some 350 or more households. Ten percent have no orchard; the rest own, on average, about 400 trees, which yield about 500 boxes at 25 kg. to the box in a normal year. Before the road was constructed, there was just a *kutcha* track, which truckers were rarely prepared to enter, and portage (usually by Nepalis) over footpaths was arduous, often exceeding 1.5 km. In 2008, the average cost was Rs 20 a box; in the 2009 season, thanks to the road, it fell to Rs 7 a box, the average distance to the pick-up point now averaging 250 meters. Richer horticulturists have their own pick-ups or even trucks. Those with smaller orchards usually band together in groups to make up a truckload for long-haul trips. In an interesting development, the villagers have started to diversify into pears, kiwis and cherries, all more delicate fruits requiring good packing and fair roads if spoilage is to be kept low. The road has given this development a strong impulse, and without the need to grub up apple trees to make way for the new stands, some spare land being available.

Applying (1) with the maintenance costs $m = 0.0095, m' = 0.345$ and salvage parameter $\kappa = 0.25$, we obtain $PV^*(I; \rho = 0.055) =$ Rs 34.32 million and $PV^*(I; \rho = 0.10) =$ Rs 30.71 million. Turning to the benefits so generated, an average household saves about Rs 6500 ($= 500 \times (20 - 7)$) a year in transport costs for the marketing of its main crop. Summing over the 315 households who own orchards yields an aggregate of Rs 2.05 million a year, whose present value (allowing for the period of construction) at $\rho = 0.055$ is Rs 29.38 million. This is certainly smaller than the lower bound on M^c, first, because other goods besides apples are traded and, second, because diversification into other crops is occurring. Hence, even if one restricts the benefits to those in the commercial domain, the road is almost surely socially profitable at the discount rate of 5.5 percent.

This finding prompts the question, how big must the benefits not included in the above calculation be if (bare) profitability is to be maintained at the stiffer test rate of 10 per cent? Since $B_1^+(\rho = 0.10, 0) = 0.10\,(1 - 1.10^{-29})^{-1} \cdot 30.71 = 3.28$ million, the answer is, at least Rs 1.23 ($= 3.28 - 2.05$) million annually, or just over one half of the savings in transporting the current main crop. This sum is not beyond the realms of the possible; but in the light of the modest volume of trade in other commodities and the fact that the villagers already enjoyed good access to education and health facilities before the road was constructed, it seems rather doubtful that help from this quarter would ensure profitability at the test rate of 10 percent. No allowance is made, however, for the possibility that the value of the total benefits will grow over the life of the road, a possibility taken up in Section 5.

To illustrate the results for the alternative, in which changes in leisure and the opportunity cost of labor are ignored, I draw once more on Bell (2009a), this time in connection with Orissa's impoverished uplands. The following calculations are a little rough, but arguably convey a fair idea of what more refined methods and data might well yield. This field-trip covered six PMGSY roads, all recently constructed and typically costing Rs 20 - 30 million. The populations so served – some directly, others indirectly – varied somewhat in size, from about 5,500 to 9,000 according to the 2001 Census. Assuming an average household size of 5.5, and allowing for population growth in the interim, the typical catchment area contains about 1,400 households. Deflate this to 1,200 to allow for the fact that as many as one half enjoy only an indirect connection. To arrive at an estimate of the benefit per household, I employ a related estimate from Khandker *et al.*'s (2009) study of rural roads in Bangladesh, namely, that the 'commercial' benefit is 11 percent of per capita household consumption. In 2001, the average household income in the 30-village sample referred to above was Rs 16,600 (van Dillen, 2008). Since average savings rates in these communities are surely low, set average household consumption at Rs 15,000, thereby yielding a corresponding commercial benefit of Rs 1,650 a year, or about Rs 2,250 in 2008 prices. Scaling up by the effective number of households in the catchment, we obtain an aggregate annual benefit in the commercial sphere alone of Rs 2.70 million. At $\rho = 5.5$ percent, the present value thereof is Rs 38.70 million, which handsomely exceeds the present value of the investment costs in the range of Rs 22.9 – 34.4 million. At $\rho = 0.10$ percent, the present value of the 'commercial' benefits is Rs 25.30 million, which lies in the middle of the range of $PV^*(I; \rho = 0.10)$, namely, Rs 20.5 – 30.7 million. With the benefits in the spheres of education and health still to come into the reckoning, there is every prospect that all these roads will indeed pass at the test rate of 10 percent, even if the flow of benefits does not grow.

By way of comparison with the first alternative, Bell and van Dillen (2012) estimate that the unit transport costs for goods are reduced by about 5 percent of the net price received for commodities marketed. Khandker *et al.* (2009) obtain a similar estimate for rural roads in Bangladesh, once an allowance is made for greater volumes marketed. The latter also estimate that the farm-gate price of fertilizers declined by 5 percent. This similarity supports the 'importation' of the estimated (proportional) effect on family consumption in Bangladesh to arrive at the same in Orissa.

4.2 Education

The provision of an all-weather road can affect the formation of human capital through formal education in a variety of ways. If there is no school in the village itself, the savings in the time children spend traveling to and fro can be devoted to other pursuits, not least homework, and attendance may be better in adverse weather. The same holds for their teachers wherever the school be located, unless the teachers live very close by. Such a road may also reduce morbidity among children by improving access to health care, and so improve school attendance. To express all this formally, let τ denote the fraction of each day spent going to and fro, d^1 the fraction of each school year (of, say, 180 days) lost to illness, and ξ that lost to other involuntary absences, whether of pupils or their teachers. Taking a whole cohort of children, the fraction of the years of school-age that can be devoted to actual schooling, allowing for eating, bathing and suchlike in the waking hours, is then $\bar{e} \equiv (1 - d^1)(1 - \xi)/(1 + \tau)$. Improvements in the accessibility of facilities may, by increasing $\bar{e}$, produce permanent growth effects (Bell, 2011); they may also lead to lower drop-out rates in the short run. Lastly, there is a potentially powerful indirect effect: by raising incomes, the road will increase households' capacity and willingness to invest in education, and so ultimately attain $\bar{e}$. As before, we must try to estimate the value that households place on this enlargement of their opportunities.

Starting as in Section 4.1 with the full-employment, neo-classical alternative, the value of a small reduction in travel-time for children attending school is proportional to the opportunity cost of their time, as assessed by the household – provided parents choose $e < \bar{e}$. If their choice is actually limited by $\bar{e}$, an additional term arises in connection with the associated Lagrange multiplier. An analogous expression holds for a small reduction in morbidity. The exact expressions in a three-generation OLG-setting are derived in Bell (2011), whereby both fully reflect the indirect effect of the road on income. Since the current cohort averages six years of completed schooling, the children are effectively of secondary school age; so that the said opportunity cost is arguably the going wage for juvenile workers, pro-rated up to 365 days a year.

Involuntary absences from school due to bad weather, which the road surely reduces, might seem to involve smaller losses. For if parents choose $e < \bar{e}$, sufficiently small departures of the decision variables from their optimal values will have only second-order effects on the value of the objective function; so that one could argue that the costs of such involuntary absences are also small: when not at school, the children will have other things to do. The accumulation of 'small' absences over a run of years can, however, result in the need to repeat a class, or to dropping out, neither of which is a small event. Taking a cohort as a whole, it seems defensible to do a calculation along the lines of that for savings in travel-time and then to take some fraction of the number that emerges: to be cautious, one-half would be the upper limit. If, however, parents choose $\bar{e}$, every involuntary absence can be very costly.

Bell and van Dillen's (2012) estimates of (d^1, ξ, τ) with and without an all-weather road for a poor, upland region of Orissa are employed here. They are, respectively,

$(0.020, 0.011, 0.040)$ and $(0.020, 0.050, 0.080)$, where it should be noted that the failure of morbidity to improve is almost surely attributable to the fact that the roads in question were very new. The corresponding values of $\bar{e}$ are 0.902 and 0.862, respectively, a difference that implies a substantial growth effect. Estimating the benefits generated by these changes will involve estimating those stemming from reductions in mortality. A combined estimate is provided in Section 4.3.

4.3 Health

The role played by the all-weather road in this sphere is like that in the sphere of education. If there is no doctor or clinic in the village, the sick and injured can be brought to one without excessive delay, or the doctor himself may come in good time, whereby the ubiquitous cell telephone now places taxis and ambulances alike on call. In a grave emergency, timely treatment and a fairly smooth ride on the way can make the difference between life and death; and in less acute cases, such treatment can restore the patient more swiftly to full health. With a shorter and less tiresome journey, the chronically sick may present themselves more frequently, as may the healthy for routine check-ups and immunisations. The distinction between morbidity and mortality is not only important analytically, but putting a value on the former turns out to be easier than doing so on the latter.

Beginning, therefore, with morbidity, it should be remarked that it is improbable that the provision of the road in itself will alter the villagers' disease environment, unless, for example, the excavation work leaves behind fine breeding grounds for mosquitoes, or the easier access to towns and markets increases their exposure to communicable diseases. Taking the disease environment as given, the change in the accessibility of treatment will normally lead people to make more use of it. Treated patients should be back on their feet and able to work or go to school that much sooner, as well as spared some pain and suffering. Where sheer capacity is concerned, the savings in time so lost can be valued at the sick person's opportunity cost thereof, analogously to Section 4.2; but valuing less pain and suffering admits of no such short-cut. However they be valued, both of these benefits are 'produced' by paying for the treatment. Road or no, therefore, the damage caused by a bout of illness or an injury is the sum of the value placed on time lost, pain and suffering and the costs of treatment.[4] Here, it should be noted that without the all-weather road, it may be simply impossible to get any treatment at all, at least in a timely way, so that the household is then effectively

[4]Excluding pain and suffering, this is the so-called cost-of-illness in the health economics literature.

rationed. Yet as long as the damage done by a bout of illness is sufficiently small in relation to full income, the value placed on having the road's services will be the resulting reduction in that damage. Given the difficulty of estimating it, let the cost of pain and suffering be excluded, which will leave us with quantities we can measure to yield a correspondingly conservative estimate of the (money-metric) benefits generated.

Turning to the very real possibility that the road will make all the difference in a life-and-death emergency, there is no such ready simplification where mortality is concerned. For the household's preferences and the formation of expectations about future levels of mortality now appear explicitly when the Envelope Theorem is applied to the corresponding Lagrangian (Bell, 2011). It follows that there is no avoiding the need to explore some numerical examples in order to obtain some feel for the size of the value placed on reduced mortality relative to that of other benefits, even if one were to treat the savings in time in the classical way.

As in Section 4.2, Bell and van Dillen's (2012) empirical estimates are employed. They find no evidence that the disease environment differed between villages with and without an all-weather road, nor that there were any differences in morbidity – as noted above, with the *caveat* that the roads were very new. The estimated morbidity rates for the three, 20-year age groups are $(0.02, 0.04, 0.08)$. The evidence concerning reductions in mortality is mixed: the individual life histories suggest there were none, but the respondents in each village were adamant that two or three lives had been saved annually. The latter claim implies a reduction in premature adult mortality of 20-25 percent. In the base case reported below, the rather conservative reduction of 10 percent (*not* 10 percentage points) is employed. Together with the estimated improvements in the prices for goods set out in Section 4.1 and those in the sphere of education in Section 4.2, this reduction in mortality completes the description of the improvement in the village environment brought about by the provision of an all-weather road.

The next task is to value all these various components, paying particular attention to the relative contributions of those in the commercial and non-commercial spheres, respectively. The framework involves three overlapping generations, each spanning 20 years (Bell, 2011). The EV for young adults at the start, when the road is provided in period 1, is obtained by finding lump-sum payments such that they would attain the same level of expected utility were they confronted instead with the less favourable environment ruling without a road. Since most will survive into old age and, in this model, there are no financial instruments beyond pooling in the form of the extended family, it is desirable to smooth the payments. For simplicity, let there be one payment in period 1, T_1^2, which each young adult will enjoy for sure, and another of equal size in period 2, conditional on the individual surviving into old age.

The model yields the following estimate of the magnitude of the combined benefits in the spheres of education and health relative to those in the 'commercial' sphere, with the caveat that its calibration involves much that is somewhat tentative and speculative. Given that the road reduces the prevailing mortality rate among prime-age adults by 10 percent, the ratio of commercial to non-commercial benefits in the first period of 20 years is about two to one, falling to four to five in the next such period. If the reduction in the said mortality rate were, instead, 15 percent, the ratios would be about three to two and two to three, respectively. Since estimating the willingness to pay in the commercial sphere is practicable, as laid out and actually implemented in Section 4.1, applying these ratios yields an estimate of the *total* money-metric benefit generated by an all-weather road that has a clear empirical anchoring. Thus armed, we proceed to do the accounting for individual roads.

5 Summing Up

Continuing to treat the village as an isolated element in a wider system, recall from (2) that the total benefits received by its inhabitants annually must be at least as large as B_1^+ if the provision of its all-weather feeder road is to be socially profitable. Measuring some forms of benefits is evidently far easier than others, or least involves much less speculation. We begin, therefore, where the going is easier, in the hope that B_1^+ will be reached before strong appeals to more debatable contributions become necessary.

Recalling (2), the growth of benefits over the lifetime of the road must now be brought into the reckoning. There is a potential pitfall here. For if the social discount rate is derived on the premise that a mere increase in population contributes nothing to social welfare, as is implicitly assumed in Section 3, then only benefits *per capita* (or household) are to be counted, scaled up by the *original* size of the population to yield the aggregate in any period. The polar alternative is to let numbers count in full, so that even if per capita benefits were constant, total benefits would still grow at the same pace as the population. Although some scholars take this radical Benthamite position, I do not, and it will not be considered further in this paper.[5]

[5]Given this ethical view, $\rho = |\eta| \cdot g_c + \delta - n$, where n is the (constant) rate of population growth. Introducing n to obtain the total benefits in any year after the first would therefore involve double-

There is every reason to suppose that per capita (in the present framework, per household) benefits will grow as a result of changes in the rest of the economic environment, and good ones to suppose that an all-weather road will enable those living in its catchment area to exploit these opportunities more fully. As agricultural productivity increases, so will the volumes of goods traded within and across the catchment's boundaries, as will the numbers of trips taken by individuals, for the purposes of business, work, education, health and pleasure. As their incomes rise, individuals will, moreover, place higher values on education and health. In the light of these considerations, it is plausible that providing a village with an all-weather road has a continuing effect on the growth rate of incomes rather than just on their levels, where the latter correspond to $B_1^+(\rho, 0)$. How big is this growth-effect likely to be? In a careful study of a panel of thousands of households drawn from 240 villages spread over 15 of the biggest states, Foster and Rosenzweig (2004) found that per capita incomes rose by 70 percent over the period 1982-1999, implying an average annual growth rate of 3.1 percent. Much of this growth stemmed from increased earnings from non-agricultural activities, for which transport connections are important. In the coming decades, this overall pace is likely to accelerate somewhat, as the economy becomes better integrated. This does not imply, of course, that the growth-effect that concerns us here is at least 3.1 percent a year; for what we are seeking is the size of an inter-action effect between changes in the rest of the economy and the provision of a road to the villages in a particular catchment area. Given the prospect of faster growth in the future than during the period 1982-1999 and the enabling effect of all-weather roads, I hazard the guess that g_b will average 2 percent a year over the next 30 years.

With this preliminary, it is instructive to return to the actual examples in Section 4.1. The estimated value of $B_1^+(\rho = 0.10, 0)$ for the affluent village in Himachal Pradesh is Rs 3.28 million a year. A conservative estimate of the aggregate commercial benefits is Rs 2.05 million, leaving Rs.1.23 million to be found in other forms. As noted earlier, the villagers had rather good access to education and health facilities even before the road was completed, so help from those quarters may well be limited. Data of the kind provided by the Orissa Survey are lacking, moreover, which adds to the uncertainties in the calculations that follow. There are about 2,000 persons in some 350 households, with a school-age population of, say, 500. In the light of the findings for Orissa, the annual savings in travel-time and reductions in days lost due to bad weather are unlikely to exceed 5 days each per child. Suppose the daily wage rate for juveniles in

counting. Since the discount rate also affects the present value of costs, it is essential to modify ρ; but the per capita benefits may not be scaled up. In what follows, we do neither.

this region is Rs 40 and that all the days lost due to bad weather are likewise valued. Then, at this opportunity cost, the total annual savings for the whole village amount to Rs 0.20 million, whereby the limit $\bar{e}$ will not reached until 20 years will have passed. The Orissa Survey data suggest that while, in the short-run at least, the road will have little effect on morbidity, there is substantial willingness to pay for treatment. Putting a value on the latter is difficult, however, so we leave it aside for the moment. Turning to mortality, the assumption that the road will reduce the rate among prime-age adults by 10 percent (see Section 4.3), while conservative in Orissa, may be on the optimistic side for Himachal Pradesh. Suppose, therefore, that a reduction of only half as much will result. Since the changes are quite small, the components making up the EV do so approximately linearly; so that, in the first 20-year period, the two-to-one ratio will shrink to four-to-one – in the extreme case that the estimated Rs 0.20 million associated with school attendance is also halved. The aggregate 'measurable' annual benefits at this stage are, therefore, Rs 2.69 ($= 1.25 \times (2.05 + 0.10)$) million, leaving us still Rs 0.59 million short.

One way of finding this missing sum is, first, to list what has not been measured and valued: in the commercial sphere, trade in commodities other than the main crop and substitution into more valuable crops when there is land to spare; in that of education, the fact that producing better educated citizens arguably also yields a public good; and in that of health, any reductions in pain and suffering or in infant and child mortality. The second step involves an assertion of belief, namely, that the sum of these benefits for the community in question is at least Rs 0.59 million a year. If doubts persist on this score, then recourse must be made to the existence of net external benefits that arise in the economic system as a whole (see Section 6 below).

The sceptical reader will stick with that which has been measured with some confidence, and on that basis establish the discount rate at which the project would just pass muster. Setting the annual stream of benefits at Rs 2.69 million, he or she will obtain $\rho = 7.0$ percent, which also establishes how great the leap of faith must be when the bar is set at 10 percent. Does $g_b = 0.02$ supply the required boost? Eq. (2) yields $B_1^+(\rho = 0.10, 0.02) =$ Rs 2.77 million. This is still not quite enough, but now only very modest help from elsewhere is needed.

The poor villages in Orissa's uplands are much less commercialized, but labor there is also arguably under-employed. Recall from Section 4.1 that in a sample of 30 such villages, the estimated aggregate annual commercial benefits average at about Rs 2.70 million. Proceeding as before, the Orissa Survey yields estimated savings in travel-time and reductions in school-days lost due to bad weather at about 6 and 10 days per child, respectively. Suppose the daily wage rate for juveniles in this poor region is Rs 30 and that all the days lost due to bad weather are likewise valued. Then, at this opportunity cost, the total annual savings for the whole village amount to Rs 0.34 million. In this less healthy environment, an all-weather road should have a greater impact on premature adult mortality: as argued in Section 4.3, let this rate decline by 10 percent instead of the 5 pe cent in Himachal Pradesh. The aggregate 'measurable' annual benefits at this stage are, using the two-to-one ratio, Rs 4.31 $(= 1.5 \times (2.70 + 0.17))$ million. The present value thereof at $\rho = 0.10$ over the 30-year cycle is Rs 40.34 million, which greatly exceeds the upper end of the estimated range of $PV^*(I; \rho = 0.10)$, namely, Rs 30.8 million. No help is needed from any other quarter.

One can argue, of course, that the implicit assumption of a zero opportunity cost of labor is too strong, so that the estimated commercial benefits are too high. Suppose, in a drastic step, we were to halve them, so that the present value of the 'measurable' annual benefit stream of Rs 2.28 million at $\rho = 0.10$ would be Rs 21.36 million, which is somewhat above the low end of the estimated range of $PV^*(I; \rho = 0.10)$, namely, Rs 20.5 million. Some help is now arguably needed from other quarters. Taking the middle of the range for $PV^*(I; \rho = 0.10)$, the value of $B^+(\rho = 0.10)$ is Rs 2.71 million, so that Rs 0.43 million must be found from elsewhere. If none can be, the project will just pass at $\rho = 7.4$ percent.

In fact, the Orissa Survey provides strong support for the contention that the benefits in the domains of education and health are even more substantial relative to the 'commercial' ones. The respondents in those villages that had received an all-weather road by December 2009 were asked to rank the three domains – commercial, education and health – according to the size of the corresponding benefits they had enjoyed from the new road thus far. The commercial and health domains were roughly equally ranked (with 31 and 29 first, and 23 and 28 second ranks, respectively), whereas education lagged far behind (Bell and van Dillen, 2012). It is possible that the latter reflects the fact that 28 of the 30 villages have their own primary school, but only two have a secondary school, whereby these poor families may place little value on secondary education. The respondents were also asked to rank the benefits stemming from the commercial domain against those from education and health combined: 24 ranked the former first, 18 put them on a par, 28 ranked the latter first, and one expressed no opinion. These rankings suggest that in the respondents' eyes, the benefits in the domains of education and health are roughly as large as those in the commercial domain, which are much more readily measurable to outsiders. These self-reported assessments are also broadly consistent with the results yielded by the OLG-model, as reported in Section 4.3. One need not shy, therefore, from following the drastic step of halving the commercial benefits by simply doubling them once more to yield the estimated *total* benefit of Rs 2.70 million, which implies that the project will just about pass at $\rho =$ 10 percent, even without an appeal to $g_b = 0.02$. On the basis of these rather cautious assumptions, one can claim with some confidence that all-weather roads in Orissa's uplands are indeed socially profitable.

6 Externalities, Spillovers and Other System-wide Effects

The individual feeder road is, of course, only an element in a wider network, and viewing it in isolation, as we have done thus far, is but a first step and a provisional simplification. In general, a new feeder will have effects that ramify through the whole system in ways that are complicated and hard to estimate. What follows is, therefore, sketchy and strictly qualitative.

First, since the very aim of connecting villages to the mainstream involves increasing the movement of goods and people to centers of activity in the main network, it also involves more wear and tear, congestion, pollution and accidents therein, all of them adverse effects on existing users and hence additional items on the cost side of the ledger. Second, to the extent that there are economies of agglomeration in these centers – and there is some evidence that this is indeed a source of decreasing unit costs in many urban activities – connecting villages to them will induce benefits external to the local catchments served by the feeders themselves. Third, there is substantial evidence that larger traded volumes are associated with lower marketing margins on agricultural products, so that farmers receive higher prices, but not wholly at the expense of urban consumers. Fourth, inasmuch as a rural road makes life in its catchment area more attractive, it will tend to slow the pace of rural-urban migration, and so relieve the growing pressures on urban infrastructure and amenities. Since the dense populations of cities also promote the pools and propagation of numerous communicable diseases, there are external benefits on this score, too. Fifth, and closely related to the fourth category, if the villages are well-connected, non-farm work can be brought to them, as it was in the putting-out system in Japan's industrialization.

Listing and signing effects is one thing, weighting them to produce a net result is altogether something else. It seems safe to say, however, that using the findings of a purely 'local' analysis of a rural feeder road is not obviously heavily biased one way or the other where assessing its social profitability is concerned. The external costs are, perhaps, more tangible and thoroughly researched than the corresponding benefits; but if pressed, I think the latter will outweigh the former in the present setting.

One other form of 'externality' must be mentioned. There are numerous reports that once a road has been built, politicians and bureaucrats take a sudden interest in visiting the communities it – and they – serve. This development is to be welcomed, though no attempt will be made here to put a (money-metric) value on it.

7 Other Approaches: Capitalization

Those who own land in a new road's catchment area will benefit from it in various ways, and if the markets for this land and credit function well, the willingness to pay for such benefits will be fully reflected in the resulting changes in land prices. This so-called 'capitalization' approach to estimating the benefits (net of any costs entailed by ownership, such as land taxes) is well-established in the regional and urban economics literature; but there are drawbacks when applying it to poor rural regions. First, credit markets are very imperfect and the land market is usually thin. When respondents are asked what particular plots are worth, their answers are therefore bound to be rather speculative, especially if a road has been built only recently. Second, the new road may affect other factor markets. The ensuing effects on landowners are fully captured in the values of their plots, in the textbook version at least. Yet whilst households that depend mostly on agricultural labor almost invariably own a small house-plot and garden, any changes in their welfare stemming from changes in wage rates and employment possibilities will not be captured by summing up the changes in the values of individual landholdings in their communities. Third, of all the wider effects outlined in Section 6, only the chance that new non-farm activities will arise in the catchment area will be covered in such an accounting. Fourth, as a purely practical matter, mapping all the land in a catchment and assigning it a rental gradient before and after the advent of a road is likely to be a burdensome affair, more so than identifying the communities and sampling their inhabitants. It is worth remarking, however, that one careful study of Madagascar (Jacoby and Minten, 2009) arrives at the conclusion that the 'capitalization' approach yields a much larger estimated benefit than that pursued in Section 4, whereby the former is naturally rather sensitive to the discount rate.

Reports that land prices begin to rise sharply as soon as there is a credible announcement that construction has been sanctioned are commonplace. The subject came up almost always in Bell's (2009a) discussions with villagers in Assam, Himachal Pradesh and Orissa, in which quite startling claims, often of many-fold increases, were usually followed by remarks to the effect that there had been very few, if any, actual sales. Quite some time must elapse after construction before settled valuations based on transactions displace speculative guessing. One hopes that enough panel surveys will be carried out to reveal how things actually develop over the whole course of events, from *before* any announcement to full maturity many years afterwards. For such evidence would provide an invaluable check on the estimates derived from the approach pursued in this paper.

8 Conclusions

The three big questions posed in the Introduction are addressed *seriatim.*

Preserving and enhancing current benefits

The benefits generated by past investments will continue undiminished only if the PMGSY roads are properly maintained. The associated outlays will be very modest in comparison, and the consequences of neglecting to make them can be readily experienced by taking a ride at random on the district and state highways to which the PMGSY roads are connected.

The technical capacity to keep this extension of the network up to scratch appears to be adequate, but the outlook for actually financing the work is poor. Although the five-year provision in the contracts is helpful, it is seen to be just a stop-gap measure when viewed against the roads' economic lifetime. Many engineers claimed that the funds allocated to the maintenance of the P.W.D. network are but a fraction of the amount needed to keep it in good order – one-third at best, often a quarter or less.

The villagers in Assam, H.P. and Orissa with whom I spoke on my field-trip had not only a firm opinion of where the responsibility lies, but also a blithely optimistic assessment of the states' finances. In fact, each link is an almost ideal local public good, whose beneficiaries are readily identifiable and ought to contribute to its management and upkeep, supported by a matching grant from the state government that is suitably calibrated to their community's economic condition. All the classic problems of provision and collective action arise: the villagers will (and did) protest their poverty, the burden must be distributed among them, and that hardy perennial, 'the lack of political will', will smother efforts to take real action at higher levels of government. Yet India's constitution provides for communities to raise taxes as part of its design to further local democracy. Since a start must be made sometime, why not now?

Enhancing the benefits generated by past investments requires exploiting certain opportunities that arise within public infrastructure as a whole. In the wider road network, for example, the miserable state of most district roads limits the gains from PMGSY, since most trips involve a stretch of travel on both. Rural roads complement certain other forms of investment, in the sense that the joint returns are larger than the sum of those yielded by the separate components. Intuition suggests that this is especially so for irrigation, but it is likely to hold also for electricity and drinking water. Rural roads are, in contrast, good substitutes for local health facilities and schools. There is no need to have a primary health centre in every cluster of villages when a taxi or ambulance can be quickly summoned by telephone, nor a middle and high school when adolescents can easily cycle up to 8 km in little more than half an hour – and all of them would benefit from such daily exercise. A planned system of hubs will produce big savings, even if the bikes are provided free from the public purse.

Is a continuation of PMGSY socially profitable?

This question must be posed, even if a stop is politically unthinkable. For there are always alternative uses of public funds, and scrutinising any given proposal using a common procedure imposes a measure of discipline on the thinking that leads up to decisions, if not on the decisions themselves.

The calculations in Sections 4 - 5 indicate that providing roads to villages in the hilly states is probably not socially profitable at the discount rate of 10 percent. Yet the net returns in the other participating states easily make good these shortfalls, even without an appeal to 'growth effects' generated by the larger economy, or to the existence of net, positive external effects produced by rural roads on the larger economy. On balance, Section 6 suggests that there are such effects, but the magnitude of the net benefit is shrouded in uncertainty.

The formal estimates of the benefits generated in the spheres of education and health are substantial in size, though the method used to arrive at them has its weaknesses. The respondents in the Orissa survey ranked these benefits roughly on a par with the commercial ones, as did many of the villagers with whom I spoke on my field-trip. When a passable road may well be decisive in life-and-death emergencies, people will indeed value it highly. At all events, it is reassuring that two such radically different approaches to estimating a vital magnitude yield broadly similar results.

Improving the social profitability of future investment

All the points about preserving and enhancing the benefits generated by past investment are relevant here. Particularly important are, first, reforming the system of local taxation so that the panchayats will begin to assume responsibility for the provision of local public goods, and second, ensuring co-ordination among departments in advance in order to exploit complementarities and avoid overlaps when different forms of investment are substitutes.

When designing the roads, the engineers are sometimes unduly constrained by the central guidelines and their inability to acquire land under eminent domain. These restrictions can affect not only the geometry of the road, but also its durability. The present emphasis appears to be on keeping initial outlays on construction low, with the implicit goal of maximizing the rate at which connections are made. A better decision criterion would be to minimize a road's capitalized lifetime cost – ideally at shadow prices. This would encourage design with an eye on durability and the long-term traffic load the road is likely to carry.

PMGSY is already generating more traffic in the rest of the network. At maturity, the extra volume is likely to be large. Given the existing volume of traffic and the numerous 'choke points' along any extensive stretch of national or state highway, this extra traffic will result in even more congestion, pollution and accidents. A reform of traffic policy, including road pricing, is in order.

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