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**OBSERVATIONS ON "PROYECTO 10"**

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Memorandum Prepared for the  
Undersecretariat of Public Investment & Social Expenditures  
Ministry of Economics and Public Works & Services  
Government of Argentina

May 1998

**Introduction**

This memorandum represents a very quick set of observations concerning the project in question. They should be thought of as guidelines for further thinking and research on the project, not by any means as definitive judgments. If such further thinking and research is done by others than myself, I am in principle willing to serve as an adviser and/or as an external referee with respect to such efforts.

In preparing this memorandum, I worked mainly from a report by Apogee/Hagler Bailly, Inc., entitled Proyecto 10: Economic Feasibility Study -- Analysis and Findings (Arlington, VA, April, 1998), supported by a companion document subtitled Compilation of the Literature: Executive Summary and by a totally separate study by Pardo Rabello Consultora, S.A., entitled Proyecto 10: Estudio de Factibilidad Tecnica -- Memoria Descriptiva. If there are companion studies to these, or other parallel studies of similar importance concerning Proyecto 10, I believe they should be used as inputs for one or more other memoranda similar to this one.

My overall impression concerning the three background documents mentioned above is that they appear to have been written in a tone of advocacy rather than one of cool and critical judgment. There is nothing in principle wrong with such a tone or spirit -- without ardent advocates, very little of importance would be accomplished in this world. Nevertheless, most people who are as yet unpersuaded concerning such a project typically prefer to see an analysis that takes as its starting point a position of skepticism, but with an open mind. This is the attitude which I will attempt to maintain here.

### **The Analysis of Highway Improvements: Basic Principles**

Projecto 10 is by its very design an almost perfect example of a highway improvements project. The great bulk of the project consists of converting existing 2-lane highways into limited access divided highways of 4 lanes, with the possibility of further widening as traffic growth warrants.

The key feature of all highway improvement projects is that they start from a base in which there already exist traffic flows between and among the various modes served. Hence the essential benefits of the improvement are limited to the reduction in travel cost (or its counterpart, the increase in convenience and ease of travel) along the routes in question.

In addition to this reduction in travel cost, there are potential externalities to be taken into account. The first and most obvious set of externalities consists of those on related roads. When a highway improvement project is built, one can expect that traffic will increase on the access roads to that project, and will decrease on alternative routes (if any) between any origin-destination pair served by the project.

It is a well-known property of highway traffic analysis that the phenomenon of congestion is typically present, except at traffic volumes that are very low, relative to the "capacity" of the road. Here the word "congestion" is being used in a technical sense, not in the sense that the throughput of vehicles has reached its absolute limit. Congestion in a technical sense sets in as soon as the addition of incremental traffic ( $\Delta V$ ) to an existing volume of traffic ( $V$ ) causes the average speed of the vehicles on the road to fall. So long as this is the case the "new" traffic ( $\Delta V$ ) is forcing incremental costs on the "old" traffic ( $V$ ). These costs are mainly the extra time costs that the traffic  $V$  must bear, given that its speed has been reduced from  $s_0$  to  $s_1$ .

In a simple, textbook case, one can say that a highway improvement causes negative external effects by adding to congestion on access (complementary) roads and causes positive external effects by reducing congestion on alternative (substitute) roads.

The Argentine case is more complicated, however, because of the height of the already-existing taxes on gasoline and diesel fuel. The theoretical "solution" to the problem of congestion externalities is to have an "optimal toll", the purpose of which is to make each vehicle owner (or driver) perceive and internalize the damage he/she is causing to others. One can think "in theory" of an idealized optimal toll, which changes as the volume of traffic varies, being high when the traffic is dense (and congestion effects therefore serious) and low when the traffic is light (and congestion effects relatively minor). This idealized optimal toll would always face owners/drivers with the true costs of the damage they are imposing on others, so their private choices would be socially optimal, at least insofar as congestion externalities were concerned. Now any actual toll could only try to approximate the theoretical optimal toll, if for

no other reason than that the latter is continuously changing through time. Any fixed toll would normally tend to be too high (i.e., above the momentary optimum) when traffic is extremely light, and might well be too low when traffic is extremely heavy. In the Argentine case, the most important "toll" is the quasi-toll represented by the gasoline tax. This tax is extremely heavy, leading to a price of gasoline that rivals those of several European countries, and being more than three times the price prevailing in the United States.

I believe a study of congestion externalities on existing Argentine roads would be extremely worthwhile, especially as an analytical input into the analysis and evaluation of Proyecto 10. However, given the very high level of the gasoline tax in Argentina, and given the fact that congestion is most serious on urban access roads during rush hours (and not on the interurban and rural stretches that are the focus of Proyecto 10), I believe it is a fair working assumption that the Argentine fuel taxes more than compensate for existing levels of congestion on the relevant roads. Thus, the extra traffic on access roads that is induced by Proyecto 10 will yield positive externalities (in the form of incremental tax revenues that more than compensate incremental congestion on these roads). Similarly, the reduction in traffic on alternative (substitute) roads, that comes as a consequence of Proyecto 10, will yield negative externalities, because the loss of tax revenue will be greater than the benefits produced by the induced decongestion of these substitute roads. A priori, I feel quite confident that induced traffic on complementary roads will exceed displaced traffic on substitute roads by a considerable margin.

### **Other Externalities (Not Related to Highway Congestion or Fuel Taxes)**

There has always been a tendency in the economic evaluation of projects for advocates to exaggerate the external benefits that their favorite projects will generate. This applies not only to highways but to irrigation projects, bridges, subway systems, airports, etc., etc. Thus arise the "dreams" of irrigation making the desert bloom, of subway systems almost doing away with surface traffic congestion, of improved airports turning their cities into tourist meccas and major convention centers. Most such dreams have proven to be not just a little false, but vastly false in practice, so, particularly with a major and expensive project like Proyecto 10, one must make every effort to guard oneself against making exaggerated claims of this type.

The key lesson concerning alleged "other externalities" is that they very often simply represent a double counting of part or all of the direct benefits of a project. I once saw an analysis of an irrigation project in which the benefits were alleged to be: (1) the value of the extra water the project provided, plus (2) the increment in value of crops in the project area, plus (3) the increase in the wages bill paid by farms in the project area. The correct answer in this case was (1), and only (1). If one has an independent, direct estimate of the value of the extra water, that is all one needs. An alternative way to estimate the value of the extra water is to take the increment of value of crops minus the increment of associated costs -- i.e., minus incremental capital costs, minus incremental costs of material inputs, and minus incremental labor costs. There is never any basis for considering the increment of wages paid as a benefit to the project. It is always and everywhere a cost. Even if all the workers absorbed by the project were initially unemployed, the extra wages bill paid by farmers would always be a cost to the farmers concerned, which might be partially offset by: a) the excess of the wage rate

actually paid over the voluntary net-of-tax supply price of the workers concerned, and b) any saving in unemployment compensation payments that is induced when these workers are absorbed.

Consider the case of investment that might be induced by Proyecto 10 in some region. Assuming the funds for such investment are raised in the capital market they will typically have three sources:

- (i) displacement of other investments, at a cost equal to their gross-of-tax (future) marginal productivity ( $\rho$ ), which is foregone
- (ii) newly stimulated savings by Argentine residents, at a cost equal to their net-of-tax supply price of these funds, and
- iii) new capital drawn in from abroad, whose marginal cost to the nation ( $MC_f$ ) will be greater than the interest or profit rate ( $r_f$ ) actually paid on these funds, so long as the country faces an upward rising supply curve of foreign funds.

A rough guess as to the overall "economic opportunity cost of capital funds" that results from these three sources would be, for a country like Argentina, probably in the range of 10% to 15%, real. (A recent careful study for Mexico arrived at a conservative estimate of 18% for the real annual rate that represented the true economic opportunity cost of capital).

The only externality to be associated with the incremental investment induced by the project would stem from such investment having an economic marginal productivity in excess of the economic opportunity cost of capital funds. Such a discrepancy would emerge, for example, if the taxes (e.g., corporation income and property taxes) expected to be paid by the induced investment were to exceed the taxes and other externalities (e.g.,  $MC_f$  minus  $r_f$ ) imbedded in

the economic opportunity cost of capital funds. I believe such a discrepancy often exists, but that it is likely to be of minor magnitude compared to the overall flows of costs and benefits of a project like Proyecto 10. Moreover, the difficulty of estimating its likely future amount makes it a weak reed upon which to rest the case in favor of a major highway investment program. The question is then, does one have to rely on this type of evidence in order to justify major highway investments in Argentina over the coming decades?

**Will Proyecto 10 Bring About Major Increases in Argentina's GDP?**

The first point to be made here is that a highway (or other) project can be worthwhile, and have a high economic rate of return, even if it has no impact whatsoever on GDP as we measure it. The pleasure given to users by a public park does not enter into the calculation of GDP. Likewise the time saved by commuters in traveling on an improved road is not counted in our GDP measures. Yet both of these are genuine benefits, which, if of sufficient magnitude, are themselves capable of justifying a project. The big lesson here is that cost-benefit analysis (and applied welfare economics in general) are deeper and more subtle concepts than GDP. So we should not treat GDP as the decisive metric to use in assessing the worthwhileness of a project.

The second point to be made is that, in all project evaluation and other similar welfare analysis, the proper comparison is not after versus before the project. It is rather a comparison between what the world would look like, period by period through the project's life with the project and what the world would look like in each given period without the project.

How a country "gets" a higher GDP is through the use of more basic resources -- more raw labor, more human skills (human capital), more physical and working capital -- and through

greater efficiency in their use (real cost reduction). If we wish to attribute a higher GDP to a project, we should be able to do so by tracing its likely effects on each of these, the main "sources of growth".

### **The Labor Contribution (Including Human Capital)**

With respect to labor, both unskilled and skilled (e.g., including human capital), the standard (and I believe correct) assumption used in applied welfare economics is that labor markets, as well as other markets are typically "cleared" -- i.e., that prices and wage rates typically respond to market forces so as to produce an equilibrium of supply and demand. The main way this assumption is used is in thinking about the middle- and long-term future. It is absolutely wrong to think that if "our" project will be hiring 1000 workers during each year from 2005 to 2020, then without our project unemployment would be greater by 1000 persons in each of those future years. It is much more appropriate to assume that the labor markets for different skills will clear, in each of those years, with or without our project. This means that any labor used by our project should be assumed to be drawn from other employments, or perhaps in a small fraction of cases, induced to abandon an "out of the labor force" status and enter the labor market. When workers are drawn from other employments, the main externalities involved are the taxes that they (or their employers) pay on the basis of their employment or productivity. If wages and conditions of work are similar in "source" and "use" sectors, then it is likely that these externalities will approximately cancel -- i.e., taxes lost in the source sectors are gained back as the labor in question is employed in the sectors of use (typically, "our" project). But one should be alert to the possibility of differences here. If the project in question pays lower-than-average wages for given skill categories (perhaps because of



pleasant working conditions or other amenity values), then there will be a net negative externality, not because of the lower wages as such (presumed to reflect amenity values) but because the taxes lost (based on wages in the "source" sectors) exceed the taxes gained (based on wages in the "use" sectors). It is the other way around if project jobs are high-paying because of difficult and/or unpleasant working conditions (amenity values lower than average, or even negative). Here higher taxes will be paid on the project based on wages or productivity of its workers than would have been paid in the "source" sectors. The difference in such taxes is a net positive externality attributable to the project.

Sometimes the project in question will pay wages that are above the market-clearing level. This may come about because of union agreements, because of legislated minimum wage levels, or for other, more firm-specific reasons. In such cases there will likely be a positive tax externality, with taxes based on labor being higher in project jobs than the taxes "lost" in the source sectors. But in this case there is an additional externality based on the fact that workers typically gain a "surplus" when they are lucky enough to get a job at a wage that is above the market-clearing level. This surplus is an externality because the wage actually paid is treated as an economic cost by the employer (the "project"), whereas only part of that cost (the voluntary supply price of the workers concerned) is real, the rest being a surplus accruing to the workers in question, or going to the government in the form of taxes.

### **Projects That Absorb Unemployed Workers**

Argentina now finds itself in what one hopes is an unusual and abnormal situation of open unemployment in excess of the "normal" levels dictated by market frictions. There appears to be under way a process of gradual absorption of this unemployment. The unemployment rate

has moved down in the last couple of years from over 17% to around 13% as this memorandum is being written. It is the consensus of most Argentine economists that with continued favorable economic growth, the process of absorption will continue, and that it will be complete by perhaps the year 2003 or 2004. Hence it is likely that during the next several years the issue of unemployment absorption will be a real one.

The important fact to recognize is that it is practically never true that creating 1000 new jobs will absorb 1000 unemployed. Periods of increasing demand for labor generally produce rising real wages in some if not in all segments of the labor market, and rising real wages themselves are sufficient to trigger the displacement of existing workers. Moreover, we have the phenomenon of "churning" in the labor market. Workers are released not only by firms facing declining demand, but also by firms that have encountered labor-saving ways of reducing real costs. These, plus each year's new additions to the labor force, create a constant source of "available" workers, many of whom find new jobs without passing through any significant period of open unemployment. The new demands for labor that appear, coming from growing firms and from new projects like Proyecto 10, absorb most of these new and displaced workers, as well as some who came from the ranks of the openly unemployed.

The best way to conceive of how the labor market functions in these respects is to consider the "churning" to be working all the time, as a natural part of labor-market processes. These considerations are relatively easy to incorporate into our analysis in cases where the size of the pool of unemployment is in the process of being reduced over time. This is what is expected to happen in Argentina over the next several years, which makes it relevant for our analysis. In such a case I would consider that the fraction of Proyecto 10's new workers that represented net

reduction in unemployment would be approximated by the fraction (net reduction in total unemployment/total number of new hires in the period). Thus, if in a given year there was a 5% turnover of the old labor force plus a 2% net entry of new workers, plus a 1% reduction in the rate of unemployment, I would assume that one-eighth of the workers hired by Proyecto 10 in that period would have come from the ranks of the unemployed.

In considering the unemployment issue it is essential to think of doing exercises of this type for each important segment of the labor market separately, for computer specialists and engineers can be very scarce at the same time as substantial unemployment exists among construction workers.

Once the absorption of unemployed workers of each given type has been estimated, or better, very roughly approximated, one must turn to the size of the externality associated with their absorption. In most advanced countries, the saving of unemployment compensation payments is without doubt the most important source of externality, sometimes amounting to 60% (or more) of the standard wage of the lower skill categories. In Argentina, however, this is likely to be of relatively minor magnitude.

A second source of externality is the gap between the gross-of-taxes wage paid by the employer and the voluntary net-of-tax supply price of the workers concerned. The tax part of this externality is always present. The other part is the "surplus" perceived by the workers. This is the difference between the actual net-of-tax wage that they receive on the one hand, and their voluntary net-of-tax supply price on the other. Thus the gross-of-tax wage might be \$6 per hour, the net-of-tax wage \$5.20, and the previously unemployed workers' voluntary supply price \$4. In this case we would have a tax externality of \$0.80 per hour and a "worker surplus" of

\$1.20.

Where one is talking about the straightforward absorption of the unemployed, it is important also to provide in the analysis for a phasing out of these external benefits. This stems from the presumption that labor market equilibrium would come about anyway in a given period of time or by a certain point in time. The easiest assumption to make is that the unemployment absorption externalities associated with the hirings of any one period, get dissipated over the next couple of period. One assumption would be to assign the full \$2 externality in the period of hiring (say 1998), then half of that in the subsequent period (1999) and a quarter in the following year (2000), after which no further externality would be counted. An alternative would be to set a date (say 2002) by which one presumes normal labor market conditions to be restored, and impose an exponential process which continues (regardless of when it started) all the way to that date, and is then extinguished.

The above scheme could probably be improved by assuming that, as the labor market improved, the voluntary supply price of the unemployed would move gradually upward, getting to equal the market price in the year (here 2002) where labor market equilibrium is restored. It is important for readers to realize that most of the unemployed will reject wages that are substantially below the market level for their category of labor. It is not at all appropriate to attribute to them (as used to be done by some economists in the 1950s and 1960s), a "social opportunity cost of labor" of zero, simply because they are unemployed. Much work has been done showing that this is not the case. The bottom line to this particular debate is simply "it is quite OK to assume a zero opportunity cost for a class of unemployed labor, just so long as they are in fact willing to work for zero, and even better, if that is what they actually get paid for

working. Otherwise, choose their voluntary supply price."

The end result of all this discussion is that it is likely that some unemployment-connected externality is likely to be present if Proyecto 10 is implemented during the next 3 or 4 years, but that it will not be of such a magnitude as to make it a major determining factor for the desirability or economic viability of the project.

### **Capital's Contribution to Growth**

The same caveat is relevant concerning capital's contribution to growth as applies in this case of labor's contribution. To repeat, in evaluating a project one must compare the situation of the economy with the project with an alternative situation without the project. Unless otherwise clearly foreseen and specified, the economy should be presumed to be in equilibrium in both these circumstances.

This means that the capital employed in a project will always have an economic opportunity cost, which is likely to be substantial. When we do standard project evaluations we use the estimated real opportunity cost of capital as the real discount rate that we apply to the project's flows of benefits and costs. Doing so, we end up with a net present value of the project, which summarizes the "profitability" of the project from the point of view of the national economy as a whole.

If, as a consequence of a project like Proyecto 10, the rate of investment in other (non-project) sectors of the economy increases, there may or may not be externalities attributable to Proyecto 10. Whether these externalities exist or not depends on whether the real rates of return on the "induced" investments differ from the economic opportunity cost of capital. If the difference is positive this will give rise to positive externalities, but it is essential to bear in

mind that these externalities are concerned with the "excess rate of return" of the induced investment, not with their total real rate of return.

### **Real Cost Reduction and Economic Growth**

Real cost reduction is one of the most powerful engines of economic growth, yet at the same time probably the most imperfectly understood. The problem here is that there is almost an infinity of ways in which real cost reduction can be brought about. Entrepreneurs and managers, scientists and engineers are in a process of constant search for new avenues of real cost reduction. Their successes in these endeavors are responsible for a large part of economic growth in most countries. Moreover, differences in the contribution of real cost reduction to the growth rate account for an even larger share of the difference between good growth experiences and bad ones.

It is very easy to see how road improvement can help a firm reduce its costs -- simply by lowering its costs associated with road transportation. Such cost reductions are part of the direct benefits of a highway improvement project, and should properly be an important element in any cost-benefit analysis of it. In principle, any attribution of additional real cost reductions -- beyond those involved in its direct benefits -- to the highway project is likely to involve double counting.

One way to see this is by imagining a situation in which we were able to collect fully for the direct benefits of a highway project. In this way all transportation cost savings would be paid for by the beneficiaries, so they would be in no better situation than without the project. The project authority would, of course, have captured these benefits through its collections. It is hard to see, in this example, how after a factory or store has paid in full for the benefits it

receives in the form of cheaper and better transportation, it can achieve further cost reductions based on the highway improvement project. Certainly no persuasive case concerning the existence of such extra benefits can be made ex ante, and it is therefore unwise to introduce them into the justification of an important and costly investment project.

#### **AN ILLUSTRATIVE EXERCISE BASED ON PROYECTO 10**

In this section I attempt to outline how I believe cost-benefit analysis should be applied in assessing the merits of Proyecto 10. Readers will see that I attempt at every stage to make only very prudent, consciously conservative assumptions concerning the underlying facts and parameters. This is a wise course to follow, if only because it adds greatly to the probability that doubters and skeptics will be convinced by the analysis.

I have chosen for this exercise a case in which the two-lane highway in question is assumed to carry an initial traffic level of 4,000 vehicles per day. This amounts to about 1.5 million vehicles per year. I further assume that as a consequence of the project, the average speed of traffic is expected to rise from 75 kph to 100 kph. I am aware that traffic on 4-lane divided highways often travels faster than 100 kph, but I would emphasize that we are here talking about average speeds over the whole route, and over all times and weather conditions.

To value the savings of time through increased average speeds of traffic, I have assumed that the drivers of trucks and buses earn \$5 per hour. For private automobiles and vans I have assumed a similar value of \$5 per vehicle hour. This may strike some readers as low, but there is a great deal of evidence to the effect that people value their travel time at rates much lower than their average hourly wage. This includes commuting time, which was the specific object of study in several cases. Consider, for example, people who live in the suburbs, and undergo

for that reason an extra one hour of commuting time (each way), compared to living near their workplace. Suppose their commuting time were valued at \$10 per hour. That would mean their commuting time cost would be around \$5,000 per year  $\$10 \times 2 \times 250$ , an enormous amount if their wage were itself \$10 per hour (which yields a before-tax income of only about \$20,000 per year). For bus passengers I have taken \$1 per hour as the value of their travel time, and made the assumption of 20 passengers per bus.

To estimate the various effects associated with the incremental traffic induced by moving from a 2-lane to a 4-lane highway, I have made two assumptions. First, I followed Apogee/Hagler Bailly, Inc. They use 0.5 as the elasticity of travel with respect to increased lane miles. In our case, over a hypothetical road segment to be upgraded from 2 to 4 lanes, this implies a 50% increase in traffic. I have assumed that half of this is diverted (in one sense or another) from other roads, while the other half is a net increment to total vehicle-miles traveled.

To estimate reduced vehicle operating costs I have worked solely with the concept of depreciation based on mileage. This is a simple conception, and one that fits neatly into an exercise carried out on a per-kilometer-mile basis. The basic assumption I have made is that, owing to the higher quality of highways, the effective life of a vehicle would be increased by 25%. (That is, one truck spending its entire life on the old highways would last, say, 400,000 km, while another truck, spending its entire life on the new highways would last in this case 500,000 km. The result is that the per kilometer figure for depreciation would be reduced by one quarter. When we do our analysis, this benefit is only assigned to the travel expected to be done, on the stretch of road being analyzed.) One can also consider that the cost reductions we use here are proxies both for the longer vehicle life and for savings in maintenance costs.



For the various vehicle classes I have used the following vehicle values (when new) and fuel consumption (km/ℓ).

Automobiles and Vans	\$20,000	12
Regular Trucks	100,000	3
Large Trucks (con Acoplado)	130,000	3
Semi Trailers	130,000	3
Buses	200,000	3

For accident externalities I have only considered fatalities. I have again roughly followed Apogee/Hagler Bailly (Analysis and Findings, p. 14). They report a current fatality rate of 10.47 deaths per 100 million VKT on the routes that will be affected by Proyecto 10. They also report that the U.S. fatality rate on interstate highways is 1.22 per 100 m.VKT, compared with 2.41 on highways not part of the interstate system. I take this to be an indication that the fatality rate might be cut in half by shifting an Argentine highway from 2-lane to 4-lane divided. Using round numbers, I take fatalities to be 10 per 100 million VKT without the project, and 5 with the project (for traffic that would otherwise have traveled anyway). For newly generated traffic using the project roads (i.e., for induced traffic that represents new trips -- not "diverted trips"), I apply the "new" fatality rate of 5 per 100 million VKT.

For most of this exercise it is not necessary to specify the investment cost of the project highways, as this cost only enters the calculation at its final stage. But nonetheless it may be helpful to bear in mind that the projected investment cost associated with Proyecto 10 is now calculated at approximately \$1 million per kilometer of road to be upgraded.

The above cost does not, as far as I can judge, include the costs of 14,142 km of feeder roads (colectoras). If it does include these costs, then an additional benefit should be added reflecting the excess of the fuel tax externality for traffic on these roads over the expected level of the congestion cost externality on these same roads. If the colectoras are being treated as separate projects, then this same benefit should be assigned to them rather than treated as an additional benefit of Proyecto 10.

A. Benefits In the Form of Time Savings:

A11	<u>Existing Traffic</u>	= 1.5 million VMT/yr.
	<u>Value of the Vehicle Hour</u>	= \$5/hr.
	<u>Time Cost at 75 kph (= \$5/75)</u>	= .0667
	at 100 kph (= \$5/100)	= .0500
	<u>Saving of Time Cost for 1.5 million VMP/yr.</u>	= <u>\$25,000/yr.</u>
	(= \$.0167 × 1,500,000)	
A12	<u>Extra Saving For Bus Passengers:</u>	
	Bus Traffic (= 4% of total)	= 60,000/yr.
	Passengers per bus = 20	
	Value of passenger time	= \$1/hr.
	Saving of time cost for passengers	
	(.0167 ÷ 5) × 20 × 60,000	= <u>\$4,000/yr</u>
A1	<u>Total Benefits From Time Saving on</u>	= \$29,000/yr.
	<u>"Existing Traffic"</u>	

A2 Benefits From Time Saving on InducedIncrease in Traffic

Induced Increase = 50% of base traffic

Benefit Assigned = 1/2 of normal (measured  
by triangle, not rectangle)Total Benefit From Time Saving on "InducedTraffic" (= \$29,000 × 50% × 1/2) = \$ 7,250/yr.AT Grand Total of Time Saving Benefits(= \$29,000 + \$7,250) = \$36,250/yr.B. Benefits of Longer Vehicle Life

(reduced depreciation/km)

B1 Autos and Vans

Assumed vehicle cost	\$ 20,000
Assumed vehicle life	
not on project roads	200,000
on project roads	250,000
Depreciation cost	
not on project roads	\$.10 per km
on project roads	<u>.08</u> per km
Saving per vehicle km	\$.02 per km
Number of vehicle km/yr	600,000
(existing traffic)	

B11	Saving Per Year - existing traffic	<u>\$12,000/yr.</u>	
	Induced increase in traffic	300,000	
	Saving per vehicle km on induced increase in traffic (= 1/2 of normal-triangle vs. rectangle)	\$ .01 per km	
B12	<u>Saving per year - increase in traffic</u>	<u>\$ 3,000/yr.</u>	
B1T	<u>Total Saving Per Year - Auto and Vans</u>		<u>\$15,000/yr.</u>
B2	<u>Trucks and Buses</u>		
	Assumed vehicle cost (approximate weighted average)	\$120,000	
	Assumed vehicle life		
	not on project roads	800,000 km	
	on project roads	1,000,000 km	
	Depreciation cost		
	not on project roads	\$.15 per km	
	on project roads	<u>.12</u> per km	
	Saving per vehicle km	\$ .03 per km	
	Number of vehicle km/yr (existing traffic)	900,000	

B21	Saving Per Year - existing traffic	<u>\$27,000/yr.</u>	
	Induced increase in traffic	450,000	
	Saving per vehicle km on induced increase in traffic (= 1/2 of normal-triangle vs. rectangle)	\$ .015 per km	
B22	<u>Saving per year - increase in traffic</u>	<u>\$ 6,750/yr.</u>	
B2T	<u>Total Saving Per Year - Trucks and Buses</u>		<u>\$33,750/yr.</u>
BT	<u>Grand Total - Benefits From Longer Vehicle Life</u>		<u>\$48,750/yr.</u>

C. External (Tax) Benefits From New Traffic

Assumption is that taxes are the same on project roads for "existing traffic", with & without proj.

Also for traffic newly generated on project roads but at the expense of traffic on other roads

Externality exists with respect to genuinely "new" traffic.

C1 Cars and Vans

Volume of "new" traffic

(= 600,000 × 1/4)

150,000 veh/km

Existing taxes - regular gas \$ .47/lt.

premium gas      \$.59/lt.

diesel              \$.18/lt.

Tax per km @ 12 km/lt.

regular gas        \$.04

premium gas      \$.05

diesel              \$.015

Weighted average tax per km      = \$.04/km

(wgts = .3, .5, .2)

C1T Tax Externality on New Traffic -      = \$6,000/yr.

Cars and Vans

C2 Trucks and Buses

Volume of "new" traffic

= 900,000 × 1/4                      225,000 veh/km

Existing tax (diesel)                  \$.18/lt.

Tax per km @ 3 km/lit.              = .06/km

C2T Tax Externality on "New" Traffic      \$13,500/yr.

Trucks and Buses

CT Grand Total of Tax Externality on New Traffic                      \$19,500/yr.

D. Benefits From Reduced Fatalities

D1 Traffic Affected by Reduction in Fatalities

1.5 million VKT of "old" traffic

.375 million VKT of induced traffic transferred

\_\_\_\_\_ from other roads

1.875 million VKT/year

Reduction in fatalities at rate of 5 fatalities

per 100 million VKT (= .05 per million)

Absolute reduction in fatalities

$$.05 \times 1.875 = .09375$$

D1T Value of Benefit @ \$300,000

$$\text{per fatality averted} = \underline{\$28,125/\text{yr.}}$$

D2 Traffic Affected by Increased Fatalities

.375 million VKT of induced "new" traffic

Level of fatalities on improved road =

5 fatalities per 100 million VKT

Absolute level of fatalities generated

$$.05 \times .375 = .01875$$

D2T Value of Cost (-) @

$$\$300,000 \text{ per fatality generated} = \underline{-\$ 5,625/\text{yr.}}$$

DT Net Value of Benefits From Reduced

$$\underline{\text{Fatalities}} = \underline{\underline{\$22,500/\text{yr.}}}$$

#### SUMMARY OF GRAND TOTALS

AT Grand Total of Time Saving Benefits \$ 36,250/yr.

BT Grand Total of Benefits from Longer Vehicle Life \$ 48,700/yr.

CT Grand Total of Tax Externality on "New" Traffic	\$ 19,500/yr.
DT Net Value of Benefits from Reduced Fatalities	\$ <u>22,500/yr.</u>
TOTAL NET BENEFIT	\$217,000/yr.

### **Reflections Concerning the Exercise**

From the calculations of the preceding exercises, it is easy to see how the benefits of a highway improvement project depend critically on the level of traffic that will be affected by the improvement. In this case, with an assumed initial traffic level of 4000 vehicles per day, the estimated benefits of \$127,000 per year seem to be adequate to justify the immediate construction of the project, but if the initial level were 2000 vehicles per day, such justification simply would not exist, and if it were 3000 vehicles per day the justification would be dubious at best. These statements assume the investment cost of the project is \$1 million per kilometer.

When I speak in this way about "justifying" the project, I refer, of course, to the hypothetical example, and not to Proyecto 10 as a whole, or even those parts of Proyecto 10 on which existing traffic is at or above the level of 4000 vehicles per day. Even with this caveat, readers may reasonably ask how one can reach a judgment about a whole project with information just on its construction cost and on a single year's flow of benefits.

The answer is that highways represent a rather special case of project analysis, in that the typical pattern of benefit flows for a typical highway project will steadily increase through time. Thus if the first year's benefits represent (as in this case) a 12.7% rate of real return on the investment (assumed to have been carried out in year "zero"), then the second year's benefits will represent a higher return, and the third year's benefits a still higher one. In such a setup, if the rate of return represented by the first year's benefits passes the critical test, all subsequent



years' benefits will also do so, and by a wider margin. Hence the project as a whole will pass the critical test. An important implication of this characteristic is that, if project construction costs (in real terms) remain constant through time, then the proper moment at which to construct the project is when the first year's benefit flow first exceeds the critical level given by the economic opportunity cost of investible funds.

The reason why highway benefits are expected to rise with time is that the baseline level of traffic without the project is normally expected to increase with time. In the Argentine case, with expectations of healthy economic growth not only in the immediately coming years but also for the longer-term future, the prospect of steadily increasing traffic on most routes (origin-destination pairs) becomes a virtual certainty.

With the above information as background, I now turn to an examination of how traffic is in fact distributed among 262 different highway segments that are included in Proyecto 10. Table 1 shows the distribution of "likely times of readiness" for upgrading to 4-lane divided highway of these segments. Not surprisingly these times of readiness vary amply among the segments. But it is notable that fully 65 segments already had in 1996 traffic volumes greater than 4000 vehicles per day. These are the projects that should be subjected to immediate detailed study and evaluation.

### **ISSUES OF POLICY AND STRATEGY**

In this section I attempt to present some observations and judgments that are relevant at the policy level. Some of these are based on the example of the preceding section and the situation of road transit in Argentina at the present time. Others are more general, and are based on many years of observations and experience in the policy arena.

TABLE 1

Highway Segments Distributed According To  
Data At Which Estimated Traffic First Exceeds

4000 Vehicles Per Day

(Figures are Number of Segments)

	Initial Traffic (1996)	ESTIMATED FUTURE TRAFFIC (Without Proyecto 10)					
		2000	2005	2010	2015	2020	Later
I-1	1	-	-	-	-	3	3
I-2	4	-	5	1	-	-	-
I-3	3	-	3	3	1	-	-
II	2	-	-	-	2	1	3
III	7	-	-	3	3	4	9
IV	5	-	1	3	4	2	7
V	5	-	-	-	-	-	1
VI	8	1	6	3	3	2	2
VII	3	2	5	6	2	-	-
VIII	-	1	7	-	8	1	3
IX	6	2	15	2	12	3	22
X	6	-	2	5	4	4	8
XI	-	2	1	-	-	1	-
XII	15	-	-	-	-	-	-
<b>TOTALS</b>	<b>65</b>	<b>8</b>	<b>45</b>	<b>26</b>	<b>39</b>	<b>21</b>	<b>58</b>
<b>BY PERIOD</b>							

### **On the Need to Treat Each Segment Separately**

One of the first and most important lessons in the formal study of project evaluation is the "principle of separable components". According to this principle, if component B is separable from the project ABCDE, B should be studied separately in two senses. It may be that the joint project ABCDE does not pass the requisite tests, but B alone does. In this case it should explicitly be separated out and should be constructed by itself. On the other hand, it may be that the project ACDE is worth doing by itself. In this case the question is whether the separable component B should be made a part of it. The answer here is yes, if the project ABCDE has a higher net present value than project ACDE, and no otherwise. If the NPV of ABCDE is indeed greater, this fact implies that the incremental benefit that component B adds to the joint project exceed the incremental cost of doing so.

Nothing is more separable than the separate components of a road improvement project. It is very simple to upgrade 20 or 30 or 50 kilometers of a given highway while leaving the rest of it untouched. And this might indeed be the correct strategy to follow, if the traffic on one piece of the road is much greater than that on its remaining segments.

Different segments of a road should in principle be improved to different levels and at different times if their traffic flows and/or their construction costs are very different from one another. Thee conditions become more similar, there is no more reason to build the road to a given technical and engineering standard.

Another approach to the same problem of separability stems from the fact that, because of the special characteristic of highway projects (with benefits from a road improvement typically growing steadily through time), the key issue with respect to highway projects is typically when

to do them. The big mistakes come when one does them way too early or way too late. There is therefore a need to have vigilance by technically competent people, continually watching as traffic flows evolve, and continually striving to set in motion the necessary technical studies and evaluations, so that each road segment can be properly upgraded at the proper time.

### **Considerations That Dictate Careful Study of Each Segment**

Suppose that we agree, on the basis of the example of the preceding section, that the right moment to upgrade the "typical" 2-lane highway to 4-lane divided is when its traffic volume is just reaching (crossing) the 4000-vehicle-per-day mark.

What are some of the reasons why this judgment should not be applied across the board, in blanket fashion?

1. Higher construction costs than average. Construction costs are usually determined by type of terrain and climate conditions. Roads in dry, flat country are typically very inexpensive; mountainous country, swampy subsoil, lots of bridges, expensive land assembly -- these are but a few of the sources of costs that may run to 2 or more times the average level.

2. Many accidents on existing road. When this is the case there is a special need to deal with the problem. Of course, there is always the possibility of finding ad hoc remedies through special mini-projects (e.g., straightening out dangerous curves) but the presence of the problem typically means a greater benefit (of reducing fatalities) to a regular upgrading of the type we have been considering.

3. High wear and tear on vehicles using existing road. Where this is greater than average, there will be extra benefits of Type B, and hence a presumption that upgrading should be done earlier.

4. Higher-than-average values of travel time of road users on some segments. This would cause expected benefits of Type A to be greater, and hence tend toward doing the upgrading at an earlier point in time. A word of caution, however: construction costs tend to be higher in regions with high income per capita, and lower in regions where the per capita income is low. Thus there may be forces at work in opposite directions on given road segments -- high values of user time tending to accelerate the optimum time of construction, high construction wages tending to delay it.<sup>2</sup>

