The Macro-Economic Effects Of The Investment in Roads

Under the Transport Operational Programme

Prepared as part of the Mid-Term Evaluation of the Transport Operational Programme.

by

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Section 1: **Introduction**

This study is made up of two parts. The first is a paper by DKM which seeks to estimate the main supply side impacts of the OPTRANS expenditure for the period 1994 to 1996. While all expenditure is considered, only the expenditure under Measure N1 for national primary roads is quantified. The expenditure under N1 for the period in question is £423 million. The annual benefit of this (to the extent that it can be quantified) is £57 million, or £130,000 per million pounds spent. An appendix to the paper also estimates the benefit in future years. Not surprisingly, given the expected growth in traffic, future benefits are significantly higher than current benefits.

The second part of the study is a paper by John Fitz Gerald and Fergal Shortall of the ESRI. This estimates the macro-economic impact of Measure N1 of the OPTRANS 1994-1996 over the period to 2010, using the ESRI Medium Term Model of the economy. It incorporates the expenditure under N1 and the supply-side benefits of this expenditure, as estimated in part 1. This finds that there are significant medium term benefits to the economy from the Measure. GDP and employment are roughly 0.2 per cent higher per annum as a result.

Part 1

The Main Supply Side Impacts of the OPTRANS, for the Period 1994-1996

by

DKM Economic Consultants Ltd.

Section 2: **Summary of Part 1**

This paper builds on the Mid Term Evaluation of the OPTRANS, which attempted to quantify the economic benefits of the investment carried out in the years 1994 to 1996. Each of the transport modes impacted by the OPTRANS is considered - Section 3 deals with roads, while Section 4 covers rail, ports and airports.

The major emphasis is on National Primary roads, where the bulk of the expenditure is concentrated; this is the only expenditure for which we quantify benefits. We consider the position as at 1996, and are able to quantify supply side benefits of £57 million per annum, or £130,000 annually per million pounds spent. Many benefits are not quantified due to lack of information, so this can be considered an underestimate.

In an Appendix II to the paper we also estimate the benefit of the 1994-1996 National Primary roads investment, in the year 2011. Given the expected growth in the economy over the coming decade or so, it is reasonable to assume that the benefits of the investment will increase over time.

Assuming annual increases in traffic of 3 per cent, our estimates indicate that the annual saving in 2011 will be £174 million, or £411,000 per million pounds spent (in 1996 prices). Again, many benefits are not quantified. These numbers indicate that the benefits from the investments in National Primary roads will increase at an average annual rate of 7.8 per cent over the period 1996 to 2011. If traffic increases at a higher rate, then these higher savings will be achieved sooner.

Section 3: **Roads**

The main measure for roads was for national primary roads (Measure N1), on which £423.2 million was spent between 1994 and 1996. A further £175 million was spent on other road measures over the period. We have information on the journey time savings on some of the routes completed under N1, and we use this to estimate the benefit to the economy of the expenditure under this measure. We do not have information on benefits generated by the other road measures, and it is inappropriate to extrapolate the N1 benefits to the other Measures.

The main savings are as follows -

- Time savings for road users - these involve a reduction in average journey times, and also a reduction in the variability of journey times as road improvements remove bottlenecks. The beneficiaries include commercial vehicle users, private motorists (on business travel, leisure, or commuting), and bus passengers.
- Commercial fleet cost savings - reductions in fleet size, fuel, wear & tear, possibly insurance.
- Rising levels of savings in future years.
- Increase in supply of labour due to the reductions in costs (monetary and time) of travel
- Reduced accidents.
- Reduced environmental impacts.
- Increased land values near new infrastructure.

3.1 Time savings for commercial vehicles

3.1.1 Reductions in Average Journey Times

The main benefit of this is the labour cost saving. The savings to the heavy commercial fleet were estimated in the Mid Term Evaluation (MTE) of the OPTRANS (February 1997) for improvements up to the end of 1996 as £6.8 million per annum, for the improvements under measure N1 only. This was calculated as follows:

Hours saved per day by HCVs[1] on 7 sections for which time savings measured	1177
Hourly rate for HGV[1] driver per hour (£340 for a 40 hour week, incl. PRSI)	£8.53
Total wage saving per annum on these routes (8.53 x 1177 x 365)	£3.6 Million
Gross up for total expenditure under N1, 1994-1996 (3.6 x 423.195/224.69)[2]	£6.8 Million

[1] HCVs are Heavy Commercial Vehicles, and include HGVs, miscellaneous goods vehicles, agricultural vehicles and buses; HGVs are Heavy Goods Vehicles, i.e. trucks and articulated lorries.

[2] Time savings were measured on 7 improved section in 1995. The cost of the relevant improvements was £224.69 million. In the period 1994-1996 the total expenditure under the OPTRANS Measure N1 was £423.195 million.

This was based on usage of improved roads by Heavy Commercial Vehicles (HCVs). HCVs include trucks, articulated lorries, buses, agricultural vehicles and miscellaneous goods vehicles (the last of these being vehicles with more than 6 tyres, and from discussions with NRA personnel would roughly represent vehicles of more then 1.5 tonnes unladen weight).

Unfortunately we do not have a breakdown of AADT data into the individual vehicle types; however, we do know the fleet size for each type, and this is given in the following table. As can be seen, 37 per cent of goods vehicles are excluded from the definition of HCVs used by the NRA.

Table 3.1: Fleet of Commercial Vehicles (per 1996 Bulletin of Vehicle & Driver Statistics)

	Number of Vehicles	Percentage of Total
Trucks & Articulated lorries & misc. goods vehicles	61,445	
buses	6,744	
agricultural vehicles	74,280	
total HCVs included in NRA counts	142,469	63%
Other commercial vehicles (i.e. <1.5 tonnes)	85,156	37%
Grand total	227,625	

If we assume that traffic volumes reflect fleet size, then on the face of it the saving calculated above needs to be increased by 59 per cent (i.e. 37/63). However, labour costs are likely to be lower for the drivers of light commercial vehicles (LCVs) than for heavier vehicles. It is also generally accepted that a certain proportion of these vehicles (i.e. "car vans") may be used as private vehicles.

Furthermore, using the labour costs for HGVs (i.e. large trucks) for all HCVs may also overstate the situation, though agricultural vehicles are unlikely to feature very much in the AADT numbers, while wage rates for bus drivers are unlikely to be much lower than for HGV drivers.

Given all of this, we have increased the savings estimated above by 2/3's of 59 per cent, to obtain an estimate of the full savings achieved. This would give an annual saving of
£6.771 million x [1 + (.59 x2/3)] = £9.43 million.

3.1.2 Reduction in variance of travel time

As well as reductions in average journey times, reductions in variability of journey times will also have a benefit. Where punctuality is important, road users must allow not only for the average journey time, but for any uncertainty in that time. An example is a truck carrying goods overseas which must connect with a ferry, which departs, say, once every 12 hours. The cost of missing the ferry is very high, so it is worthwhile leaving some excess time for the journey to minimise the possibility of arriving late at the ferry terminal. This cost is likely to be higher for Irish exporters than for those in other EU countries, since most of the EU is linked by land borders, and where ferries are used, higher traffic densities justify a greater frequency of ferry departures. Punctuality is likely to be important for some of the commercial traffic working exclusively within the island of Ireland, though it is less critical because the time lost through missing a ferry is not a factor.

The more uncertain the journey time, the more time must be allowed, requiring the greater use of labour and equipment. As this uncertainty is reduced, labour and equipment can be used more efficiently, reducing costs in the economy. The table below shows that the standard deviation of journey times has been reduced drastically on road improvements on the 4 main corridors over the period end-1993 to end-1995[1].

Table 3.2: Average Transit Times, and Standard Deviations for Improvements on the Main Corridors, 1994-1995

Corridor	Journey times			Std. Deviation of Journey Times		
	Before minutes	After minutes	Saving minutes	Before minutes	After minutes	Reduction minutes
North/South	11.8	7.6	4.2	2.2	0.4	1.8
Southwest	23.8	11.9	11.9	3.1	0.2	2.9
East/west	40.3	15.9	24.4	15.3	0.6	14.7
Western	13.7	7.3	6.4	4.1	0.5	3.6
Total	89.6	42.7	46.9	24.7	1.7	23.0

(Source: NRA)

We know that this will convey some benefit on the users of commercial road transport, but how much is not certain. There are two basic questions:

1) For what percentage of journeys is punctuality critical?

2) In theses cases, how do fleet managers estimate the extra time needed to avoid being late?

As for the first question, we do not have comprehensive information, but we know from the CSO's 1994 Road Freight Transport Survey that 8 per cent of the tonnes carried on Irish roads by goods vehicles (i.e. vehicles over 2 tonnes unladen weight) were on import /export work (including to Northern Ireland).

As regards the importance of punctuality for traffic exclusively within Ireland, we have no information. This is likely to be increasing over time as industry is increasingly adopting such systems as Just In Time (JIT) manufacturing.

We are forced to make an assumption - let us assume that punctuality is important for 50 per cent of HGV journeys. Our data relates only to HCVs, which includes non-HGVs, so we reduce the percentage for which punctuality is important to 40 per cent.

The second question is also difficult to answer. A review of the literature did not reveal any satisfactory model for this. There are two unknowns - the level of likelihood of lateness that fleet managers are prepared to live with, and the distribution pattern for journey times. If for example, the fleet manager wanted to be 90 per cent certain of being on time, and the distribution pattern of journey times was "normal" in statistical terms, then the time given for the journey would be the average time plus one standard deviation thereof. If 95 per cent certainty of punctuality was required then the planned journey time would be the average plus twice the standard deviation.

[1] Note that the reductions in standard deviations relate only to the improved segments of road along a particular route. The improvement in standard deviation of journey times for the entire route may not be the same as for the improved sections. However, for want of better information we assume in this paper that they are.

In reality the distribution pattern is unlikely to be normal, but we have no information as to what it might actually be. For want of better data, we assume that the extra time allowed for journeys where punctuality is important is one standard deviation.

The following table shows the estimation of the benefit of the reductions in variability in journey times. This shows that the benefit is perhaps £2.1 million per annum.

So between the reduction in average journey times and the reduction in variability of journey times, it appears that a saving of £11.5 million per annum accrues to commercial vehicles.

Table 3.3: Savings due to Reduction in Variability in Journey Times

Project and section No.	AADT	%HCV	No. HCVs (average)	Reduction in Standard Deviation	
				Minutes	Hours/day
N11 Enniscorthy - Wexford					
Section 3/1	6,489	16%	994	0.4	7
Section 4/1	6,332	15%			
N25 Carrigtohill by-pass					
Section 41/1a	17,499	13%	2,275	1.1	42
N7/N9 Newbridge/Kilcullen					
Section 19/1	6,838	21%	1,436	2.8	67
N18 Setright's Cross					
Section 14/1a	19,901	13%	2,263	0.1	4
Section 15/1a	17,822	11%			
N4 Leixlip/Maynooth/Kilcock BYP					
Section 35/1	15,234	12%	2,060	13.2	453
Section 36/1	17,729	13%			
N4 Longford by-pass					
Section 20/1	3,070	10%	312	7.6	40
Section 21/1	3,500	9%			
N24 Clonmel Relief Road	3,800	14%	532	3.5	31
Totals			9,873		643
Annual total					234,666
At £8.53/hour					IR£2,002,000
Factored up for total N1 Measure					IR£3,770,000
Factored up to include LCVs as above					IR£5,253,000
By 40 % of vehicles for which punctuality is important					IR£2,101,000

3.1.3 Other Benefits of Time Saved

There may also be inventory savings and reduced spoilage of goods carried due to reduced travel times, though these are difficult to estimate. A review of the literature identified one attempt to estimate these savings, using Belgian data[2]. This study estimates a value of an hour saved in transporting commodities, by examining the cost and speed of road versus inland waterway transport, with the value of the commodities, and comparing it with the market share of each mode for a range of commodities. While the estimation was incomplete and the results were not wholly satisfactory, they found that one hour of time saving was valued at 0.0000848 times the value of the commodities.

Differences between Irish and Belgian circumstances, weaknesses in the estimation procedure, and lack of data on the weight and values of goods transported on the routes in question, make it unfeasible to use the above estimate with any degree of confidence. However, we can use it to get a rough indication of the order of magnitude of savings that might be involved. Using the data on the number of HCVs and the time savings on the routes in question, and assuming an average value per load of £10,000, gives a total annual saving of less than £1 million. Given the uncertainties involved we will not consider it.

3.2 Commercial fleet cost savings

The main saving here is in terms of reduced fleet size, as the same amount of transport can be supplied for less equipment inputs, or more can be supplied for the same inputs. In effect, firms may be able to extend their market/distribution area, or rationalise their distribution systems. Other savings are reduced fuel usage and wear and tear, due to better roads and more efficient usage of equipment, from driving at optimum speeds. Insurance and accident costs may also fall, due to fewer accidents on the improved roads (reduced accident costs would be reflected in the insurance premia). Accident costs are considered under a separate heading.

The MTE estimated that 1177 hours per day were saved by HCVs on the 7 routes considered. Ascertaining fleet costs for this range of vehicles is complicated, but we can estimate figures for a top-of-the-range 40 tonne truck suitable for hauling in Continental Europe. Such a truck costs roughly £65,000 (net of VAT)[3], and would be used on the Continent for 4-5 years before being traded in. If we make the simplifying assumption that the truck is written off completely over 5 years, on a straight line basis, then a year's haulage costs £13,000. Added to this is £5,000 per annum for insurance and £1,500 for road tax (per Mr Jimmy Quinn of the Irish Road Hauliers Association). So the total standing costs of a truck amount to £19,500 per annum. If the truck is on the road 50 weeks per year, and for 40 hours per week, then the standing cost of a truck is £9.75 per hour.

Given that these trucks would be top of the range of vehicles under consideration here, a figure of perhaps half this - £5.00 per hour - might be a rough average. Time savings on journeys reduce the fleet size requirement, and hence every hour saved per vehicle per day in journey time might save the national commercial fleet £5.00.

In addition, there may be savings in maintenance costs as a result of improved roads. Mr Quinn estimates that maintenance costs £100 per week and tyres £3,500 per annum. So total

[2] BLAUWENS, G. and E. VAN DE VOORDE, 1988. "The Valuation of Time Savings in Commodity Transport", in the International Journal of Transport Economics, Vol. 15, No.1, February 1988, pp.77-87.

[3] The rough cost of a 400 horsepower, 40 tonne "high spec" Volvo truck, per Irish Commercials Limited.

maintenance costs amount to £8,500 per annum per truck. This equates to £4.25 per hour[4]. If, say, a 10 percent saving can be achieved due to better roads, then the saving might be 40p per hour. Once again, this would be an upper range for the vehicles under consideration, so half this, i.e. 20p, is used.

Therefore total capital and maintenance savings would amount to, say, £5.20 per hour per vehicle.

Grossing this up for the 1177 hours saved by HCVs each day on the measured routes, then for all N1 routes, and finally for the light commercial vehicles not measured by the NRA, as in section 3.1 above, gives an annual saving of £6.7 million, as per the following table.

Reductions in variability of journey times are relevant here also. We saw from Table 3.3 above that the standard deviation of journey times was reduced by 643 hours per day for commercial vehicles, 40 per cent of which leads to a saving. This can be factored up as before to give a saving of £1.5 million per annum, as the following table shows.

Table 3.4: Savings for Fleet Costs

	Average	**Std Deviation**
Saving per hour	5.2	5.2
# hours/day	1177	643
x 365 days and grossed up for total N1 measure (423/225)	£4,208,000	£2,299,000
Increase for all commercial vehicles (x 1.59)	£6,690,000	£3,655,000
Relevant saving for those for whom punctuality is important (x 40%)		£1,462,000
Total	£8,152,000	

Therefore the total fleet costs savings would be £8.2 million per annum.

3.3 Savings to car users

There are a number of types of car users - those on business trips, commuters, tourists, and others. Far more cars use the roads than HCVs. In 1995 private car and light commercial vehicles on the 4 corridors measured by the NRA amounted to 63,304 per day, as opposed to 9,872 HCVs. Full statistics on the percentage of motorists who travel on business are not available at the moment, though NRA data indicate the following rough split-up of purpose of journey[5]:

4 Strictly speaking, tyre costs relate to distance travelled rather than time, but we use time here as an approximation.

5 The level of business travel indicated here is considerably higher than previously thought. The level normally used up to now, which was based on a survey carried out a number of years ago, was 30-40 per cent.

Business	50%
Commuting	15%
Tourism	20%
Other	15%
	100%

Valuing time savings for the motorists on business trips is generally done by reference to their wage rates. Lower journey times will increase the effective supply of labour in the case of journeys taken on work time. A 1994 DKM study[6] of Cost Benefit Analysis of transport projects, recommended that a rate of £9.20 per hour (1994 prices) should be used for working time saved as a result of infrastructure improvements. CSO data[7] indicate that wage rates for all industrial workers have increased by 5 per cent between March 1994 and September 1996: this is a rate of 2 per cent per annum, so up-dating the DKM estimate from 1994 to 1996 gives £9.60 per hour.

Time savings on commuting journeys are generally valued at less than business journeys. The 1994 DKM study recommends using a rate of £3.70 per hour for savings on leisure-related journeys, in 1994 prices. Using a similar inflation rate as for working time gives £3.85 per hour.

As for tourism and other journeys, the benefit is in terms of increased consumer surplus, and it is difficult to incorporate this into a macroeconomic model. We have not put values on this in this paper. However, a discussion of the issue is contained in Appendix I.

Based on 1995 AADT data, we can estimate the number of private cars using the relevant routes, and split them between business, commuting and other motorists. The AADT data only give us the total vehicles and the percentage that are HCVs. We assume that 90 per cent of the rest are cars, to factor out the presence of LCVs[8]. The estimations are contained in Tables 3.5 and 3.6 on the following pages.

These show that the daily saving by business and commuting motorists is £35,000. Grossing up for the year and the full N1 measure gives an annual saving of £24.2 million.

There would also be a saving for motorists arising from the reduction in variability of journey times. We again have to make an assumption on the importance of punctuality. We assume that, as with commercial vehicles, punctuality is important for 50 per cent of journeys, and motorists are satisfied with a 90 per cent chance of being on time. The calculations are shown in Table 3.7. This indicates that the annual benefit is £7.2 million.

So the total benefit to business and commuting motorists amounts to £31.4 million per annum.

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[6] *CBA Parameter Values and Application Rules for Transport Infrastructure Projects*, prepared for the TAP Steering Committee of the OPP, February 1994.

[7] *Industrial Earnings and Hours Worked, December 1996 (Provisional) and September 1996*, 20th June 1997.

[8] In the 1996 Bulletin of Vehicle and Driver Statistics, the total number of goods vehicles of less than 1.5 tonnes was 85,000, while the total number of cars was 1,057,000. LCVs therefore represent 7.5 per cent of the total of these vehicles; however, it is reasonable to assume that LCVs would travel more than cars.

Table 3.5: Estimation of numbers of private cars on roads, on business and leisure travel, 1995							
Project and section No.	**AADT**	**%HCV**	**No. HCVs (average)**	**No. Cars =balance x 90%**	**Cars on business 50%**	**Cars Commuting 15%**	**Other Journeys 35%**
N11 Enniscorthy - Wexford							
Section 3/1	6,489	16%	994	4,875	2,437	731	1,706
Section 4/1	6,332	15%					
N25 Carrigtohill by-pass							
Section 41/1a	17,499	13%	2,275	13,702	6,851	2,055	4,796
N7/N9 Newbridge/Kilcullen							
Section 19/1	6,838	21%	1,436	4,862	2,431	729	1,702
N18 Setright's Cross							
Section 14/1a	19,901	13%	2,263	14,938	7,469	2,241	5,228
Section 15/1a	17,822	11%					
N4 Leixlip/Maynooth/Kilcock BYP							
Section 35/1	15,234	12%	2,060	12,979	6,490	1,947	4,543
Section 36/1	17,729	13%					
N4 Longford by-pass							
Section 20/1	3,070	10%	312	2,676	1,338	401	936
Section 21/1	3,500	9%					
N24 Clonmel Relief Road	3,800	14%	532	2,941	1,471	441	1,029
Totals			9,873	56,973	28,486	8,546	19,940

Table 3.6: Estimation of time saved by private motorists and valuation thereof per day								
	Minutes saved	**business cars**	**Time saved by business motorists**	**Valuation of time saved (per hour)**	**Cars Commuting**	**Time saved by cars on leisure**	**Valuation of time saved (per hour)**	**Total value of time saved**
		per day	**hours**	**IR£9.60**	**per day**	**hours**	**IR£3.85**	**per day**
N11 Enniscorthy - Wexford	1.2	2,437	49	468	731	15	56	524
N25 Carrigtohill by-pass	3	6,851	343	3,288	2,055	103	396	3,684
N7/N9 Newbridge/Kilcullen	11.7	2,431	474	4,551	729	142	548	5,098
N18 Setright's Cross	0.2	7,469	25	239	2,241	7	29	268
N4 Leixlip/Maynooth /Kilcock BYP	19.7	6,490	2,131	20,455	1,947	639	2,461	22,916
N4 Longford by-pass	4.7	1,338	105	1,006	401	31	121	1,127
N24 Clonmel Relief Road	6.2	1,471	152	1,459	441	46	176	1,634
Total		28,486	3,278	31,466	8,546	983	3,786	35,252

Table 3.7: Savings due to Reduction in Variability in Journey Times - business and commuting motorists						
Project and section No.	**AADT Business cars**	**AADT Commuters**	**Reduction in St. Deviation Minutes**	**Business cars Hours/day**	**Commuters Hours/day**	**Total**
N11 Enniscorthy - Wexford	2,437	731	0.4	16	5	
N25 Carrigtohill by-pass	6,851	2,055	1.1	126	38	
N7/N9 Newbridge/Kilcullen	2,431	729	2.8	113	34	
N18 Setright's Cross	7,469	2,241	0.1	12	4	
N4 Leixlip/Maynooth/Kilcock BYP	6,490	1,947	13.2	1,428	428	
N4 Longford by-pass	1,338	401	7.6	169	51	
N24 Clonmel Relief Road	1,471	441	3.5	86	26	
Totals				1,951	585	
Annual total				712,002	213,601	
Valuation				£6,835,000	£822,000	
Factored up for total N1 Measure				£12,874,000	£1,549,000	
By 50 % of vehicles for which punctuality is important				£6,437,000	£774,000	£7,211,000

3.4 Savings to Users of Public Transport

The users of bus transport will also benefit from the improvements in journey times. From Table 3.1 it can be seen that the total number of buses in the country is modest in terms of the total number of road vehicles. However, each has the capacity to carry up to 50 passengers, so the potential saving could be substantial.

Unfortunately, we don't have data on passenger numbers or on the purpose of journey, or the time value of the journey. It is likely that a large amount of journeys are not work related, and that those that are are not time sensitive. Therefore we have not attempted to estimate the monetary benefit for these savings. Appendix I deals with some of the issues relating to the valuation of saved leisure time.

3.6 Rising levels of savings in future years

As the economy grows strongly the usage of infrastructure will increase over the coming years. With increased usage, the benefits from the improved infrastructure will increase also. Indeed, given the non-linearity of congestion costs as traffic levels increase, it is possible that the future savings vis à vis a benchmark position of no infrastructure investment could be very substantially bigger than current savings.

It is very difficult to estimate this saving from the current standpoint, not only because of uncertainties about future growth rates and non-linearities in the impacts of this growth, but also because it is difficult to define the benchmark position with which the investment can be compared. Is the benchmark a situation of no investment in roads into the foreseeable future, one where the investment is delayed for some unknown number of years, or where more modest investments are undertaken?

We will also need to discount future savings back to the present day, if we are to include them in any estimations of benefits. For these reasons, although we can be confident that the benefits of the investment are likely to increase in future years, it is difficult to make an objective estimate of this benefit from the current standpoint. The issue is dealt with in more detail in Appendix II.

3.7 Increase in supply of labour due to the reductions in costs (monetary and time) of travel

Reducing the cost in monetary and time terms of commuting will enable workers to seek employment over a wider area, increasing the effective labour supply, which should reduce wage levels because of increased competition for jobs. This impact would be expected to be stronger for low-skill jobs, where wages are lower and high commuting costs would represent more of a barrier. While the impact might not be important in an economy with high unemployment and with a plentiful supply of labour in all areas, it is possible that with the continued growth of the Irish economy labour shortages might occur in certain areas. If this is the case then increasing the mobility of labour has a positive impact.

Unfortunately we have no data on which to base an estimate of this saving. However, estimating the saving for commuters of the improvements in the road network may account for some of the saving in question here.

3.8 Reduced accidents

It is possible that accident rates would be reduced by new infrastructure, if the safety of routes is enhanced. On the face of it, it is not clear that this is the case with the improvements considered here, since many of them are by-passes of urban areas. It is possible that more serious accidents might occur, where high speeds are being achieved on the new stretches of road.

The National Roads Needs Study Interim Report No.1[9] for the NRA estimates accident costs for various road types as follows. It can be seen that accident costs fall as the standard of road increases, notwithstanding that higher speeds might be expected to cause more severe accidents.

Table 3.7: Accident Costs on Various Road Types (1996 values)

	£ Per vehicle km
Urban road	0.0413
Unimproved rural 2-lane	0.0297
Improved 2-lane rural road (by-pass)	0.0264
Dual carriageway (divided)	0.0157
Motorway	0.0082
(Source: NRA)	

We can use these data to estimate the savings from the road improvements carried out under the OPT to the end of 1996, as the following table shows.

[9] M.C. O'Sullivan and Scetauroute (1997).

Table 3.8: Estimation of value of savings in accident costs as a result of road improvements, annually										
Route	**Description**	**Accident rate**		**Road length after**	**Average AADT**	**No. of vehicles per annum**	**Accident costs before**	**Accident costs after**	**Accident costs savings**
		£ Per vehicle km		**km**			**£m per annum**	**£m per annum**	**£m per annum**
		Before	**After**						
N11 Enniscorthy - Wexford	single carriageway realignment	0.0297	0.0264	8.3	6,411	2,339,833	576,792	512,704	64,088
N25 Carrigtohill by-pass	dual carriageway	0.0297	0.0157	10.6	17,499	6,387,135	2,010,798	1,062,947	947,851
N7/N9 Newbridge/Kilcullen	motorway by-pass	0.0297	0.0082	18.5	6,838	2,495,870	1,371,356	378,623	992,732
N18 Setright's Cross	bridge & road	0.0297	0.0264	1	18,862	6,884,448	204,468	181,749	22,719
N4 Leixlip/Maynooth/Kilcock BYP	motorway	0.0297	0.0082	17.6	16,482	6,015,748	3,144,552	868,193	2,276,359
N4 Longford by-pass	single carriageway	0.0413	0.0264	5.4	3,285	1,199,025	267,407	170,933	96,474
N24 Clonmel Relief Road	single carriageway	0.0413	0.0264	8.5	3,800	1,387,000	486,906	311,243	175,664
Total							8,062,278	3,486,392	4,575,886

As can be seen, the saving in the above estimation amounts to £4.6 million per annum. This however assumes that all the vehicles on the improved road segment travel the entire length of the segment. This is obviously an over-estimate, though given the nature of the improvements, most vehicles probably travel most of the segment. If we assume that the average vehicle travels 2/3's the length in question, then the saving is £3.1 million per annum.

We can then gross this figure up, as before, for the full expenditure on the National Primary roads, to a figure of £5.7 million per annum.

3.9 Reduced environmental impacts

Where new infrastructure by-passes an urban area, there are likely to be a number of environmental benefits for the town/city in question. Emissions, noise, vibrations and severance will all be reduced and the quality of life is likely to be improved as a result. While there will be increased pollution and loss of countryside on the new road, it is likely that there will be a net environmental benefit, as the urban pollution will have had a considerably greater impact on people than the pollution along the new route. The above AADT data give an indication of the numbers of vehicles that are being diverted by the new routes - many of these are by-passes and hence have the potential to generate urban environmental improvements. Putting a value on these is, however, very difficult. There are many uncertainties and a lack of basic data on, for example, emissions. Surveys could be carried out on the residents of by-passed areas, to get an indication of how they value the benefits, but these are expensive and the methodologies are not without controversy. Hence it is not practicable to put a value on the benefits in the current context.

3.10 Increased land values near new infrastructure

Land along the route of new infrastructure will become more valuable, as it becomes more accessible (witness the increase in land prices along completed sections of the M50). This increase in value capitalises some of the benefits listed above, so there would be an element of double counting if they were counted separately, and we have not done so.

3.11 Summary

The savings that arise and that we have been able to quantify are as follows:

Table 3.9: Total Quantified Saving and Savings per £ million Spent

	£ '000
Time savings by Commercial Vehicles per annum	11,500
Maintenance and capital savings by Commercial Vehicles per annum	8,200
Time savings by cars per annum	31,400
Reduced accident costs	5,700
Total savings per annum	56,800
Total expenditure on OPT National Primary projects to end 1996	423,195
Annual savings per £ million spent in 1994-1996	134

In addition, there are savings that have not been quantified, due to lack of information. These are:

- rising levels of savings in future years (see Appendix II)
- beneficial impacts on labour supply (partly included)
- environmental benefits
- savings accruing to private motorists on leisure trips and to users of public transport
- savings due to quicker supply of goods (small but positive)
- the benefits of the investment under N2, N3 and S1, which are likely to be substantial.

So the above table under-states the benefit.

Section 4: Other Modes

4.1 Rail

Just as in the case of roads, improvements in other transport infrastructure will generate a range of benefits to the economy. In the case of rail, the main savings are:

- reductions in travel times, for both business and leisure travellers, including possibly some improvements in reliability
- reduction in travel times for freight carriage
- possible reduced operating costs for CIE
- modal shift from roads, encouraged by improved train services, will reduce road congestion.

The expenditure under the OPTRANS between 1994 and 1996 amounted to MECU 62, MECU 1 less than the planned expenditure, and related to the purchase of 22 locomotives and 14 carriages.

In addition, under the Cohesion Fund, MECU 270 is due to be spent on track improvements over the lifetime of the OPTRANS.

The major benefits, in terms of time savings, will not manifest themselves until the track improvements have been completed. As of the time of writing, none of the routes had been completely up-graded. For instance, the Dublin-Belfast line is not expected to be completed for another year. In fact it appears that times have tended to disimprove, due to the disruption arising from the works carried out.

So it is not possible at this stage to evaluate the savings, more than to state that some savings are likely to accrue for the 8.2 million mainline rail passengers per annum. Savings will also accrue if some road users move to using rail because of the improvements in the latter, and thus relieve congestion on the roads. It is not possible to estimate this benefit at this stage.

4.2 Seaports

In relation to the seaports, the major benefit is in terms of reduced costs and throughput time, as a result of improved facilities, and also as a result of more effective competition between ports.

In addition, there are expected to be increases in passenger and freight numbers through the ports as a result of the investment, though this is not a supply-side improvement *per se*.

The total cost of the seaports OPTRANS measures is £79 million in 1994 prices. By the end of 1996 £20 million of this had been spent.

Estimating the cost reductions is the subject of a study financed by the TAP that is at draft stage at the moment. The draft final report indicates that in general port charges have increased in line with inflation or at a slightly higher rate over the period 1993 to 1996. However, the authors of the report were not able to be very precise in this regard, as complete information was not available. What charges would have been in the absence of the investments under the OPTRANS is unknown. The report also shows that costs in Irish ports are slightly higher than they are in a sample of ports in the Southern and Western UK.

For the period 1993-2000 (8 years), freight traffic throughput is projected to increase by 41 percent (5 percent per annum). By the end of 1995 (3 years into the period), 36 percent of the targets had been met. Growth was strongest in Ro-Ro traffic, to a lesser degree in Lo-Lo, and was relatively weak in Bulk.

For the same period, passenger numbers increased by 3.4 percent per annum, as opposed to a projected increased under the OPTRANS of 5 percent per annum.

In summary, it seems that reductions in costs have not materialised in Irish ports over the years of the OPTRANS, though the information is imprecise, and it is impossible to say what costs would have been in the absence of the OPTRANS. Unfortunately, we also have no information on reductions in throughput time or sailing time reductions as a result of the investments.

Therefore we are not in a position to put values on the benefits flowing from the investment in ports under the OPTRANS.

4.3 Airports

The expenditure under the OPTRANS on State airports is modest. Actual expenditure to the end of 1996 amounted to MECU 19.5. A further MECU 29 was planned to be spent by 1999 under the OPTRANS, but in the mid-term review of the programme this was diverted to other projects, mainly in roads. Aer Rianta's own capital investment programme, announced in 1996, is much larger at £187 million (of which £11 million is funded under the ERDF).

The expenditure under the Programme is aimed at enhancing airport facilities, to cater for increases in passenger and freight growth. Time savings, improvements in reliability and reductions in airport charges are the expected impacts of the programme.

Actual growth, especially for passengers, has far exceeded expectations, especially at Dublin and Cork.

We do not have performance indicators for time savings or improvements in reliability before and after the expenditure. Airport charges have fallen over the last number of years; however, the increase in traffic would have contributed to this, and it is in any case not practicable to identify how much of the fall would be due to investment under the OPTRANS.

Therefore we are not in a position to put values on the benefits flowing from the investment in airports under the OPTRANS.

Appendix I

Valuing the Leisure Time of Private Motorists

In general, leisure time saved is valued at less than work time. The benefit is an increase in consumer surplus. The valuation of this is not straightforward, and there are conflicting views on how to approach the problem. The 1994 DKM study recommends using a rate of £3.70 per hour, in 1994 prices. Using a similar inflation rate as for working time gives £3.85 per hour in 1996. If we were to apply this to the savings in car travel time on leisure trips we would get the following.

Table IA: Estimation of time saved by private motorists and valuation thereof per day

	Minutes saved	Cars on leisure travel per day	Time saved by cars on leisure hours/day	Valuation of time saved each day £3.85/hour
N11 Enniscorthy - Wexford	1.2	3,169	63	244
N25 Carrigtohill by-pass	3	8,906	445	1,714
N7/N9 Newbridge/Kilcullen	11.7	3,160	616	2,373
N18 Setright's Cross	0.2	9,710	32	125
N4 Leixlip/Maynooth/Kilcock BYP	19.7	8,436	2,770	10,664
N4 Longford by-pass	4.7	1,739	136	525
N24 Clonmel Relief Road	6.2	1,912	198	761
Total		37,032	4,261	16,405

Grossing this up for a full year and for the full expenditure under N1 gives £11.3 million per annum.

There would also be a saving due to reductions in the variability of journey times. However, we are not in a position to put a value on this in the case of leisure journeys.

A 1986 ESRI study of cross-border shopping estimated that price savings of 21p per mile travelled were needed to justify such shopping. If we take that wages have increased by roughly 50 per cent in the intervening period, then in today's terms the required saving would be 32p/mile. At 35 miles per hour this converts to a required saving of £11.00 per hour. Deducting costs for petrol, wear and tear, etc., of perhaps 20p per mile in today's terms, then the saving required to compensate purely for time would be £11 - £7 = £4.00 per hour. So our use of £3.85 per hour does not appear unreasonable.

Appendix II

Saving in Future Years

Table 3.2 of the main paper gives the reductions in journey times and standard deviations for the road segments improved under the OPTRANS up to the end of 1995.

These were generated by an NRA model, which has also been used to generate the same figures for the year 2011, given a 3 per cent per annum increase in traffic volumes (a 60 per cent increase over the entire period), and a before situation of no investment in the road. The results are as follows.

Table IIa: Average Transit Times and Standard deviation for Improvements on the Main Corridors, in 2011

Route	Journey times			Standard deviation of journey times		
	Before minutes	After minutes	Saving minutes	Before minutes	After minutes	Reduction minutes
N4	*	23.0		*	0.8	
N9	*	11.4		*	0.2	
N11	7.1	5.7	1.4	0.8	0.4	0.4
N18	1.1	0.9	0.2	0.1	-	0.1
N24	23.9	6.9	17.0	13.0	0.5	12.5
N25	21.2	2.2	19.0	14.2	0.1	14.1
Totals		50.1			2.0	

* denotes implausibly large journey times and standard deviations.

As can be seen, on the N4 and N11, figures are not given, because the journey times before improvement are implausibly high. Motorists would change their behaviour before such long journey items were reached, and the model cannot cope with this adequately.

The question arises, with these two routes, what would be the maximum journey times that motorists would accept, or more relevantly, what would be the "equilibrium" level of journey time and variability on these routes, in the absence of improvements. This is subjective; having discussed the matter with NRA personnel, we have decided to use the following figures. Given the uncertainties involved, the numbers should be considered illustrative only.

Table IIb: Average Transit Times and Standard Deviation for Improvements on the Main Corridors, in 2011

Route	Journey times			Standard deviation of journey times		
	Before minutes	After minutes	Saving minutes	Before minutes	After minutes	Reduction minutes
N4 Longford	20.0	4.8	15.2	10.0	0.2	9.8
N4 Kilcock/Leixlip	50	11.6	38.4	18	0.7	17.3
N9	40.0	11.4	28.6	30.0	0.2	29.8

We can now estimate an illustrative saving in the year 2011, in the same way as we estimated it in the year 1996. All values are in 1996 £s. We will not account for inflation or for real increases in wages. We are ignoring those savings that we did not quantify in the main body of the paper, though they will also be relevant in future years.

Table IIc: Estimation of numbers of Vehicles on roads, by Type and Purpose, 2011

Project and section No.	No. HCVs (average)	No. of Cars	Cars on business	Cars Commuting	Cars on Other Journeys
			50%	15%	35%
N11 Enniscorthy - Wexford	1,595	7,823	3,911	1,173	2,738
N25 Carrigtohill by-pass	3,650	21,987	10,994	3,298	7,696
N7/N9 Newbridge/Kilcullen	2,304	7,802	3,901	1,170	2,731
N18 Setright's Cross	3,632	23,972	11,986	3,596	8,390
N4 Leixlip/Maynooth/Kilcock BYP	3,306	20,828	10,414	3,124	7,290
N4 Longford by-pass	501	4,294	2,147	644	1,503
N24 Clonmel Relief Road	854	4,720	2,360	708	1,652
Totals	15,842	91,424	45,712	13,714	31,999

From the above vehicle numbers and route time savings, we can estimate the total daily time savings by vehicle type. We list the savings made by vehicles on leisure journeys, though we do not put a value on these in this appendix.

Table IId: Average Time Savings per Route per Motorist Type, Hours

	HCVs	Cars on business	Cars Commuting	Cars on other journeys
N4 Longford by-pass	127	544	163	381
N4 Leixlip/Maynooth/Kilcock BYP	2,116	6,665	1,999	4,665
N7/N9 Newbridge/Kilcullen	1,098	1,859	558	1,302
N11 Enniscorthy - Wexford	37	91	27	64
N18 Setright's Cross	12	40	12	28
N24 Clonmel Relief Road	242	669	201	468
N25 Carrigtohill by-pass	1,156	3,481	1,044	2,437
Totals	4,788	13,349	4,005	9,345

We can also work out the benefits of the reduction in standard deviations of travel times, assuming that the saving is the equivalent of one standard deviation.

Table IIe: Time Savings due to reduction in Standard Deviation of Journey Times, per Route per Motorist Type, Hours			
	HCVs	Cars on business	Cars Commuting
N4 Longford by-pass	82	351	105
N4 Leixlip/Maynooth/Kilcock BYP	953	3,003	901
N7/N9 Newbridge/Kilcullen	1,144	1,937	581
N11 Enniscorthy - Wexford	11	26	8
N18 Setright's Cross	6	20	6
N24 Clonmel Relief Road (est.)	178	492	147
N25 Carrigtohill by-pass	858	2,583	775
Totals	3,232	8,412	2,524

We can now estimate the benefit of the time savings, firstly for commercial vehicles, as in the main body of the paper:

Table IIf: Time Savings for Commercial Vehicles		
	Average Time	Standard Deviation
Hours saved per day on 7 sections for which time savings measured	4,788	3,232
Total wage saving per annum on these routes (x 8.53 x 365)	£14.9 M	£10.1 M
Gross up for total expenditure under N1, 1994-1996 (x 423.195/224.69)	£28.1 M	£19.0 M
Grossed up for all commercial vehicles (x [1+(.59x 2/3)])	£39.1 M	£26.4 M
Adjusted for 40 % of fleet for which punctuality is important		£10.6 M
Total saving in 2011	£49.7 M	

In terms of cars on business and commuting, the savings are as follows:

Table IIg: Value Time Savings for Cars, in 2011

	Cars on Business		Cars Commuting	
	Average Time	**Standard Deviation**	**Average Time**	**Standard Deviation**
Hours saved per day on 7 sections for which time savings measured	13,349	8,412	4,005	2,524
Relevant hourly wage rate	9.60	9.60	3.85	3.85
Total annual saving per annum on these routes	£46.8 M	£29.5 M	£5.6 M	£3.5 M
Gross up for total expenditure under N1, 1994-1996 (x 423.195/224.69)	£88.1 M	£55.5 M	£10.6 M	£6.7 M
By 50 % of vehicles for which punctuality is important	£44.1 M	£27.8 M	£5.3 M	£3.3 M
Total saving in 2011		£80.4 Million		

The savings will also generate fleet cost savings for the commercial fleet, as follows:

Table IIh: Savings for Fleet Costs

	Average	Std Deviation
Cost saving per hour	5.20	5.20
# hours/day	4,788	3,232
Grossed up for a full year and all routes	£17,117,000	£11,553,000
grossed up for all commercial vehicles	£27,216,000	£18,370,000
% for whom time saving is relevant		40%
Relevant saving		£7,348,000
Total	£34,564,000	

As regards accident costs, we estimated that these would be £5.7 million annually, in 1996. This figure is directly related to the traffic levels, and if we assume that traffic will increase at 3 per cent per annum to the year 2011, then savings due to reduced accidents in that year should be £9.2 million annually.

Note that this uses valuations of accidents as at the present time. These valuations tend to be sensitive to the level of wealth in society, so over the period to 2011 one would expect that the valuations would go up. Therefore the figure of £9.2 million is likely to be an under-estimate. Due to lack of information we have not accounted for this.

In summary, the following table lists the quantified annual savings in the year 2011, from the expenditure under OPTRANS in the period 1994-1996. The total savings per annum are £174 million, or £411,000 for every £ million spent. These compare with £57 million and £134,000 in 1996. This represents an annual increase in the value of savings of 7.8 per cent.

Table 3.9: Total Quantified Saving and Savings per £ million Spent, 2011

	£ Million
Time savings by Commercial Vehicles per annum	49.7
Maintenance and capital savings by Commercial Vehicles per annum	34.6
Time savings by cars per annum	80.4
Reduced accident costs	9.2
Total savings per annum	173.9
Total expenditure on OPT National Primary projects to end 1996	423.2
Annual savings per £ million spent in 1994-1996	0.411

As mentioned, other savings that we have been unable to value in the main body of the report are also relevant here. So the above is likely to be an under-estimate of the total benefit.

It is also worth noting that the savings estimated here are based on traffic volumes increasing by 3 per cent per annum. This is the NRA's assumption of traffic growth. A recent study by DKM[10] predicts that this figure might be closer to 5 per cent. Should the higher figure turn

[10] "Update of Forecasts of Vehicle Numbers and Traffic Volumes", March 1998.

out to be the case, then the above savings, estimated to be achieved in 2010, will actually materialise by the year 2006. This will represent an annual increase in the value of the savings of 12 per cent.

Part 2

The Macro-Economic Effects Of The Investment in Roads

Under the Transport Operational Programme

by

John Fitz Gerald and Fergal Shortall of the ESRI

Section 5: Introduction to Part 2

5.1 Introduction

The Transport Operational Programme covers a wide range of different investment projects which are designed to improve the infrastructure of the Irish economy. While some of the investment is in infrastructure at airports or seaports or in railways, the single biggest area of expenditure over the review period 1994-96 has been on the road system. In this paper we consider the likely macro-economic impact of investment in primary roads under the OP over the 3 years 1994-96. In examining the direct impact of the investment on demand for goods and services in the economy we have used additional information on the input composition of investment in roads. We have also collected and used a range of new information on the long-term benefits of such infrastructural investment. This has allowed us to quantify the supply side benefits of the investment in a new and more satisfactory fashion than was possible in previous studies.

The analysis in this paper uses the methodology first developed by the ESRI for evaluating the Macro-economic impact of the EU Community Support Framework (CSF) on the Irish economy. Details of this methodology are given in the ESRI report *The Role of the Structural Funds*. This methodology was developed further in conjunction with DKM in analysing the impact of the OP for Peripherality under the last CSF. This paper makes extensive use of the information collected by DKM as the external Evaluator of the Transport OP.

In this paper the effects of the structural fund expenditure for the years 1994-96 is compared to the situation where no such expenditure took place.[11] No account is taken of expenditure under the earlier CSF or of expenditure likely to be undertaken under the current programme in later years. All the results are presented as changes compared to a benchmark "what would otherwise have been" scenario where it is assumed that no such investment would have taken place. In each case we consider the impact of the total expenditure on primary roads under the OP - both the direct EU funded component and the expenditure co-funded by the Irish government.

5.2 Methodology

Investment in roads or other elements of physical infrastructure will affect the economy through two different channels:

- Through the demand for goods and services in building the infrastructure and
- Through the effects on the competitiveness of the economy of the infrastructure.

Using the ESRI Medium-Term Model a benchmark scenario was first constructed running out to the year 2010. The long time scale is necessary in such a study as the major beneficial

[11] In the review carried out in conjunction with DKM of the OP for Peripherality under the last CSF, the effects of the CSF expenditure were compared to the situation where EU funded investment had continued at the 1988 level. It was also assumed that the investment would continue indefinitely. It is felt more realistic in this study to use a zero basis for comparison rather than the 1993 level. In order to evaluate the spending under the current OP it is also felt desirable to make no assumptions about levels of investment post 1999.

effects from such an investment programme on the output potential of the economy can be expected to take a long time to mature. Having established the benchmark scenario, the effects of the roads investment are arrived at by adding the key changes which the investment will bring about and running the model again to see how the economy performs with the benefit of the increased infrastructure. The change between the benchmark and the alternative scenario is then attributed to the investment.

The model handles the actual demand side effects of the investment in a straightforward manner. In so far as the investment involves increased building it increases demand for the output of that sector. To the limited extent that it involves increased purchases of machinery and equipment it increases import demand (the bulk of machinery and equipment is imported). The model then handles the second round effects as incomes, employment, wages, and prices adjust to the change in demand.

However, the more important long-term effects of the investment can be expected on the supply side of the economy as the efficiency of the productive sector improves. The improved infrastructure will reduce the costs of industry below the level they would otherwise have been. This will improve the sector's competitiveness on foreign markets. In addition, the costs of distributing goods within the economy will fall and there can be expected to be some fall in the prices faced by consumers.

While the channels through which this improvement in efficiency will impact on the economy are well known, there has until now been limited information on the magnitude of these effects. This study represents an advance on earlier work in that additional information has been collected which makes it possible to provide a quantification of some of the supply side benefits likely to arise from investment in roads. However, further research is needed to allow more precise estimates of the rate of return in the long run.

No account is taken of the consumer surplus which will arise from the infrastructural investment (the travel time saved by private motorists). This consumer surplus is likely to be considerable, as much of the time saved will accrue to private individuals using their own motor vehicles. As discussed later, this omission of the direct benefits to consumers means that the supply side effects are possibly biased downwards.

The time savings to the transport sector are estimated under a number of headings in Part 1. These savings from improved infrastructural investment are converted into savings in labour inputs and machinery and equipment. It is assumed that all of these savings are passed on to the sectors using transport services (perfect competition is assumed). The ultimate benefit of the savings in inputs then flow to either the tradable sector, which sees enhanced profitability from lower input costs, or to the household sector as the cost of transporting goods to retail markets falls. This allocation of the benefits of time savings between a reduction in consumer prices and a reduction in the cost of production in the tradable sector is carried out on the basis of information in the Input-Output table for Ireland.

Finally, allowance is made for the flow of funds from the EU to the Irish government, which serves to improve the balance of payments and the government's budgetary position. The results are considered under the assumption that the government uses the indirect improvement in its finances from the higher level of economic activity to co-fund the investment and to repay debt.

5.3 Outline of Paper

Section 6 considers the nature and input composition of the investment in roads. Part 1 of this study sets out the new evidence of the likely cost savings to the domestic productive sector from the enhanced infrastructure. This information is used as a key input into the macro-economic model to estimate the likely demand and supply side impacts of the expenditure in the review period. In Section 7 the likely demand side impact of the structural funds investment in roads is considered. In section 8 the model is used to estimate the combined effects of the demand side impact and the likely long-term (supply side) impact of this expenditure on the major economic aggregates.

Section 6: Expenditure under the OP

6.1 Expenditure

In the first 3 years of the current Operational Programme total EU spending on primary roads came to just over £420 million. This amounted to 1.1% of GNP in 1996 or around 0.4% of GNP a year. This paper analyses the impact of this expenditure on the Irish economy.

In analysing the demand side impact of the investment on the economy it is important to know the input content of the different types of expenditure. For example, investment in roads tends to be much less labour intensive, in terms of numbers employed, than building investment generally (which includes housing). While the CSO's Input-Output Table gives details of the average input content of building investment in 1985 more detailed information on the composition of investment is desirable for such an exercise. Fortunately the 1993 report to the Department of the Environment, *A Note on the Employment Content of Major Road Improvement Schemes* (DKM & Fitz Gerald, August 1993) describes a survey of four major road improvement schemes to determine their input content. Here we use this information as the basis for our analysis of the road investment under the OP (Table 6.1). This assumes that input breakdown for the road projects carried out under the present Operational Programme is similar to that undertaken under the previous OP.

The results from the survey of road projects indicate that:

- The average cost of labour is higher in road building than in building generally because substantial numbers of skilled and professional workers are employed in design.

- The proportion of total output, which is accounted for by labour and material inputs respectively, is different from the rest of the building sector. Both the materials and the labour content of road building is lower than the average for the building industry, the production process being much more capital intensive.

- The survey data suggest that the direct and indirect import content of the materials used in road building is lower than the average for the building industry as a whole[12].

- There are substantial compensation payments made for the purchase of land used for road building.

- In the new benchmark the wage rate in the building industry was modified to correspond with the results obtained from the survey. This means that for any given expenditure on labour, the impact on employment is rather lower than the average observed for the building industry in 1989 (the survey year). For simplicity, in this paper all the off-site employment is included as building sector employment though some of it might more properly be classified as market services employment.

[12] See Curtis J. and J. Fitz Gerald, *The Changing Structure of the Irish Economy: As Reflected in the 1985 Input-Output Table*, ESRI Technical Series No. 8, 1993.

- For simplicity we have treated machinery as being consumed in the year of purchase. In reality the machinery input will be met through investment which is then depreciated over the lifetime of the asset. This assumption will have no impact on the assessment of the longer-term impact of the CSF, while greatly simplifying the exposition.

Table 6.1: Input Content of Roads Investment under the OP 1994-1996, % of Total

	Roads
compensation	13.5
labour	24.6
materials and machinery	49.9
other (depreciation/profits)	3.1
VAT	8.9

The allowance made for profits is clearly an underestimate and some adjustment has been made for this problem in actually implementing the analysis.

6.2 Destination of Output of Transport Sector

In order to assess the likely beneficiaries of any savings in transport costs it is necessary to consider who are the major users of commercial transport services. To do this we rely on the 1985 Input-Output (I-O) Tables published by the Central Statistics Office. These data suffer from a number of problems of which the most significant is the fact that where sectors of the economy provide their own transport services these services do not show up in the table as part of the transport sector per se. However, the I-O Tables provide the best available information on this important issue.

Table 6.2: Destination of Output of Transport Sector, £m, 1985

	Manufacturing + Exports	Distribution	Total of these Sectors	Excluded
Inland Transport	110.9	83.3	194.2	334.5
Auxiliary Transport	147.6	1.1	148.7	16.8
Total	258.5	84.4	342.8	351.4
% of Included Sectors				
Inland Transport	57.1	42.9		
Auxiliary Transport	99.3	0.7		
Total	75.4	24.6		

Table 6.2 shows the destination of the output of the inland transport and the auxiliary transport sectors. Because the data on time savings are based on the improved productivity of the transport of goods we are not considering the effect on passenger transport services provided directly to the household sector. As a result, Table 6.2 excludes sales of transport services directly to personal consumption. For simplicity it also excludes a limited amount of services provided to other productive sectors in the economy. The effect of these simplifications is to assume that all the benefits from savings in transport costs accrue to either the manufacturing sector (75%) or to the household through lower distribution costs (25%).

The allocation of transport cost savings assumes that there is perfect competition in the transport sector and in manufacturing. In the case of the transport sector this means that all savings which accrue are passed forward in a reduction in the cost of transport services. In the case of the manufacturing sector it is assumed that the sector is a price taker on world markets so that any cost advantage or disadvantage shows up in the short-term in changes in profitability.

Where the cost savings result in a reduction in employment in the transport sector there is no change in the volume of transport services provided. However, the increased productivity results in a fall in the price of those services. To the extent that the lower costs benefit manufacturing there is a corresponding increase in the price of value added of that sector (reflecting increased profitability) leaving output in the economy unchanged. Where the benefits accrue to consumers the price of consumption falls.

Where the increased productivity in the transport sector results from a reduced use of inputs (better utilisation of the transport fleet) there is an increase in the volume of value added in that sector and a corresponding fall in the volume of imports (all vehicles are imported). The benefits of the increased productivity are passed on in a similar manner to the reduction in labour inputs as a fall in the price of transport services.

Section 7: The Demand Side Effects

7.1 Introduction

The spending of the money generates the demand side effects. The purchase of goods and services within the economy persists so long as the expenditure persists. This initial impact effect is generally substantially larger than the supply side effect. However, it only lasts while the expenditure continues and the long-term impact of the investment will ultimately be determined by the increase in the potential output of the economy.

This Section discusses how the Medium Term Model was used to analyse the demand side effects of the investment. The supply side benefits are discussed in the next Section.

The effects of the roads investment are analysed by first modifying certain key model parameters and re-estimating a *benchmark* projection for the economy for a number of years, in this case 1994-1996. Then the effects on the economy of the investment are analysed using this version of the model with modified parameters. The model is resimulated incorporating the increase in investment with care taken to ensure that the composition of the inputs of this investment matches the survey data. The results are compared to the *benchmark* run to derive the demand side effects of road building.

7.2 Model Results

The magnitude of the expenditure under the OP was noted in Section 6 (a total of just over £420 million over the years 1994-96). The transfers from the EU to finance the investment (over £240 million) are included as part of the simulation. We consider the situation where both the EU funded and the Irish government co-funded expenditure is included (£423 million).

The investment is assumed to begin in 1994 and to end in 1996 and the effects of the expenditure are compared to a benchmark where no such investment takes place.

It is assumed that the government makes no changes to rates of taxation or expenditure (other than the co-funded investment) as a result of the OP; the borrowing requirement is treated as endogenously determined and any improvement in the government's financial position as a result of the OP is used to repay debt.

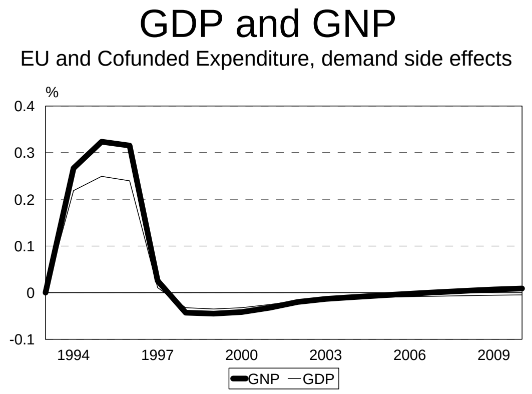
The compensation payments (for land purchased) are assumed to be paid to the household sector. In this paper we have assumed that households treat these payments as an increase in disposable income. As a result, a substantial part of these payments find their way directly into personal consumption in the year the investment in roads takes place. In reality, the impact of the payments may be much slower to materialise. From the point of view of the individual consumer whose land is acquired their net wealth may not change; they have sold an asset and received the market value of that asset in return. For many households the receipts may be reinvested in another alternative asset. The eventual impact of this transfer to the household sector must remain uncertain. As a result, the approach taken here probably overestimates the immediate demand side impact of the transfers.

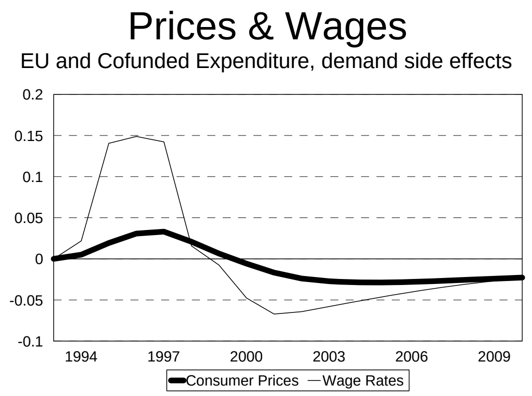
Table 7.1: Demand Side Effects of EU and Co-funded Expenditure Change Compared to Benchmark

		1994	1995	2000	2010
GNP	%	0.2669	0.3234	-0.0414	0.0089
GDP	%	0.2186	0.2491	-0.0323	-0.0048
Consumer Prices	%	0.0050	0.0193	-0.0058	-0.0227
Wage Rates	%	0.0218	0.1404	-0.0477	-0.0233
Balance of payments surplus	% points	-0.0492	-0.0174	0.0456	0.0195
Government Borrowing	% points	-0.0616	0.0241	-0.0291	0.0066
Labour Force	%	0.0551	0.0941	0.0592	-0.0053
Employment	%	0.2384	0.2384	-0.0229	-0.0116
Unemployment Rate	% points	-0.1548	-0.1253	0.0710	0.0054
Debt/GNP Ratio	% points	-0.2584	-0.3576	0.1071	0.0341

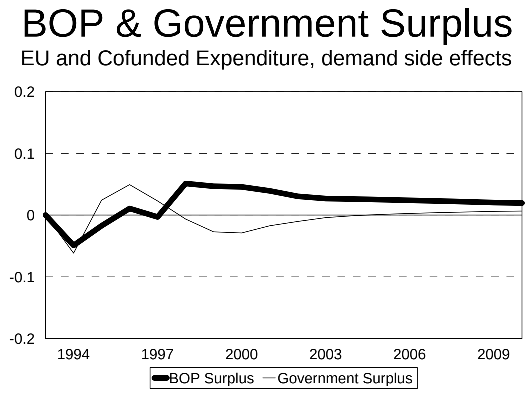
Figure 1

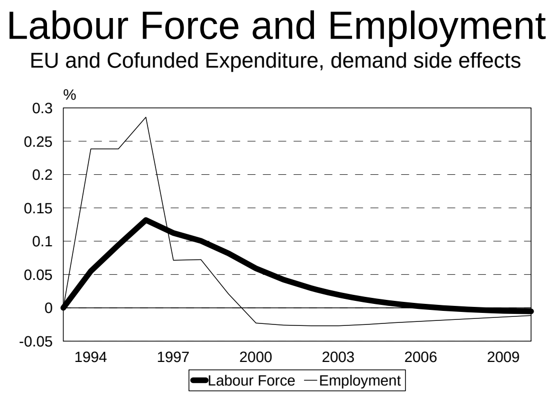
(a) (b)



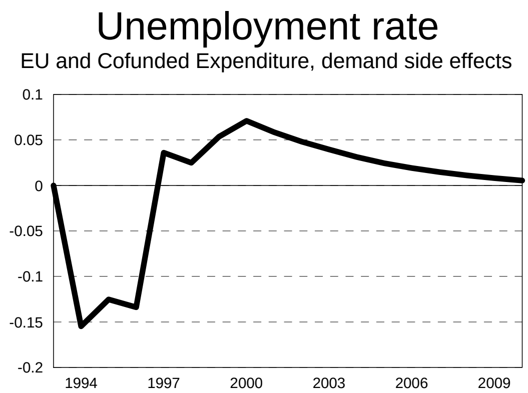


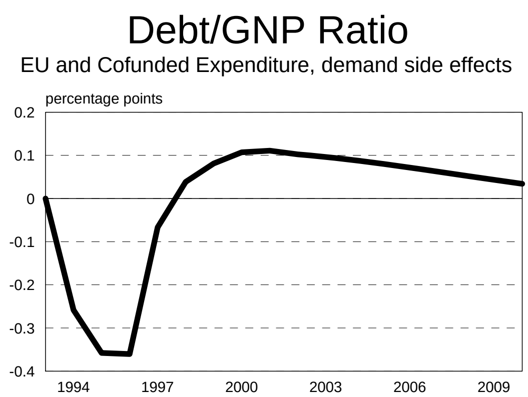
(c) (d)


BOP & Government Surplus
EU and Cofunded Expenditure, demand side effects
0.2
0.1
0
-0.1
-0.2
1994
1997
2000
2003
2006
2009
BOP Surplus
Government Surplus


Labour Force and Employment
EU and Cofunded Expenditure, demand side effects
%
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
1994
1997
2000
2003
2006
2009
Labour Force
Employment

(e) (f)


Unemployment rate
EU and Cofunded Expenditure, demand side effects
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
1994
1997
2000
2003
2006
2009


Debt/GNP Ratio
EU and Cofunded Expenditure, demand side effects
percentage points
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
1994
1997
2000
2003
2006
2009

The effect of the expenditure was to raise the level of GNP in 1996 by just over 0.3% compared to the benchmark (Table 7.1 and Figure 1a). The level of prices and wages is not greatly affected by the demand side impact of the investment. In the relevant years the economy had the capacity to absorb the increase in investment without placing undue strain on the productive capacity of the building sector.

The impact effect of the investment was to increase employment by over 0.25%, especially building sector employment (Figure 1d). The labour force was also raised by the investment as returning emigrants filled some of the new jobs. There was also an appreciable reduction in the unemployment rate (Figure 1e).

In this case, the effect of the stimulus is to raise tax revenue and this largely covers the cost of the co-funding provided by the Irish exchequer. The net effect is very little change in the exchequer surplus or deficit (Figure 1c). The balance of payments surplus also shows very little change, with the increased EU transfers largely covering the additional cost of the imports needed to undertake the investment.

The net result of the rise in GNP, combined with little change in government borrowing, was that the debt/GNP ratio was reduced by between 0.3 and 0.4 percentage points between 1994 and 1996 (Figure 1f). The long term impact on the debt/GNP ratio is close to zero so that the financing of the additional infrastructure provided under the Transport OP has no long term implications for the public finances.

Section 8: **The Supply Side effects**

8.1 Introduction

In this Section we concentrate on the supply side effects of the roads investment under the Operational Programme for Transport. The potential benefits from the infrastructural investment under the OP can be expected to arise through a number of different channels. In the first place the ability of private individuals to travel faster and safer throughout the country[13] as a result of the investment represents the single most important effect of the investment. As discussed in Part 1, motorists driving cars have garnered the biggest measured time savings. In many cases the car journeys are related to work activity and the benefits can be expected to affect the economy's productive potential.

While the time savings for private individuals (not on business) are clearly very important, it is difficult to integrate them into any overall assessment of the effects of the OP on the economy. Measurement of the time savings is relatively clear-cut but it is notoriously difficult to put a value on leisure-time savings by private individuals. Whatever valuation is put on such savings it is even more difficult to assess how private individuals will respond to an increase in well being in the form of reduced travel time.

Will private individuals treat this saving as "income" in some sense? If they do will they react in a similar fashion to other external factors which change their disposable income such as, for example, taxes? In the case of the latter there is evidence that reduced taxes translate partly into reduced wage demands and, as a consequence, into enhanced competitiveness. Could the same be expected to happen in response to increases in welfare from improved transport infrastructure?

One area where improved infrastructure, including urban infrastructure, may benefit the economy and its productive potential is in the supply of unskilled labour. While in the past this may not have been considered an important issue with high levels of unemployment, the situation may be different in the future. There is anecdotal evidence of localised shortages of unskilled labour in the face of continuing high levels of unemployment. This is not surprising given the significant costs of commuting to work (including the cost of the time spent commuting). If the investment under the OP can reduce these costs (or stop them rising) then it may affect the price of labour and the overall competitiveness of individual firms and ultimately of the economy as a whole.

We have no evidence on which to form a balanced judgement on this matter of the consumer surplus accruing to the household sector and, as a consequence, with the exception of work related journeys, we are not including any valuation of these direct private sector benefits in our overall assessment of the benefits of the OP. However, it should be recognised that this will bias downwards the estimated value of the supply side effects of the OP on the Irish economy.

In earlier evaluations of the peripherality OP we made arbitrary assumptions about the rate of return on the transport investment and converted these into estimated savings in transport costs to the productive sector of the economy. This was not a satisfactory approach, though the best available under the circumstances then prevailing. In this paper we have used the evidence, discussed in Part 1, to make an initial estimate of some of the actual savings to

[13] That is, faster and safer than they would have if the investment had not taken place. With increasing traffic, even with the investment, there may in some cases be an absolute deterioration in travel times.

business. The estimate in that report of a rate of return of over 13% is much greater than previously assumed, but in this case it is grounded in reasonably firm evidence.

The improvement in transport infrastructure will have a range of different effects on the business sector of the economy:

- By reducing the time taken for goods to travel to or from factories or their ultimate markets (the retail sector or exports) it will reduce costs, increasing productivity and competitiveness. There will be fewer person hours needed driving; fewer vehicle hours tied up in transporting a given bundle of goods; there may be less wear and tear on vehicles and less energy consumed (and emissions); there may be fewer accidents.

- In the case of time savings it is not just the direct time savings but also the reduction in uncertainty which occurs through removal of potential bottlenecks. Firms have to provide extra resources to be prepared for traffic congestion, even if it is not always endemic. In a sense they have to cover part of the expected standard error in travel time to be relatively certain of meeting necessary delivery schedules. Even if there is no major change in average travel times a reduction in the standard error of travel times may have a similar impact in reducing travel costs.

- Business travel represents a significant cost to firms and a reduction in travel time represents a corresponding increase in availability of (generally skilled) labour. It will account for around half of the hours saved by private motorists.

- For firms, the potential availability of adequate transport infrastructure may be important, even if they do not generally use it.[14] For example, the availability of the DART appears to have had a significant effect on property valuations in its proximity. This increase in valuation is worth much more than the actual expenditure on DART services by commuters. Similarly firms may require the availability of adequate transport infrastructure as a precondition for establishment even if the normal savings to them from it are relatively small. The argument here is rather similar to the case where firms have to cover for volatility in transport time: occasionally there may be a very high cost to inadequate facilities, even if this is not normally the case.

- In this paper we have used the measured savings to travellers at the time the investment comes on stream. However, there are very significant non-linearities in modelling travel time. If the transport infrastructure is put in place ahead of needs then blockages will not occur. While rising traffic volumes may initially have a small impact on travel time, a point may be reached where a small increase may cause a severe deterioration. In Part 1 an estimate is given of the potential savings in the next decade when traffic volumes will be much greater than to day. This suggests that the estimates used here, based on current time savings, are likely to be a significant underestimate of the supply side benefits.

We feel that the approach documented in this section represents a significant improvement on the crude approach used in earlier evaluations. It allows a proper estimate of the potential gains to the tradable sector using actual data rather than assumed rates of return.

8.2 Quantification of Supply and Demand Side Benefits

[14] In a sense, this is the option value of the availability of good infrastructure.

As indicated earlier we concentrate here on the benefits to the productive sector from the investment. Having obtained an estimate of the savings to the commercial transport sector from the investment (see Part 1) the next task is to apportion these savings to the different sectors of the economy. Here we assume that perfect competition holds good for the market in transport services so that all the benefits of the savings are passed on to other sectors of the economy which use transport services. The allocation of these savings over the production sector of the economy is discussed above in Section 6.

In the case of manufacturing it is assumed that firms are price takers so that the reduction in the cost of production is reflected fully in the sector's competitiveness. In the case of the distribution sector it is assumed that competition sees the benefits passed on to consumers.

The model is used to assess this impact. The impact will come from 2 channels:

- Enhanced competitiveness for manufacturing will see increased output for export.
- Lower consumer prices will affect wage rates and competitiveness indirectly.

The simulation of the impact of the change in transport costs is relatively straightforward. The estimated savings in labour costs are translated into a fall in the numbers employed in the sector. The volume of output is not changed as the same volume of transport services is supplied; the labour saving represents an increase in productivity. The benefits are passed on as a reduction in the output (value added) price deflator. The model feeds this cost reduction through as a reduction in production costs in manufacturing and as a reduction in consumer prices, consequent on cost reductions for the distribution sector.

Where the savings occur in machinery and equipment inputs (numbers of goods vehicles) there is a reduction in the volume of material inputs into the sector. This shows up as an increase in the volume of value added in the sector while the price of output falls. There is a corresponding reduction in the volume of imports (of goods vehicles). Unlike the case of saving in labour inputs, a saving in imported inputs directly affects the volume of net output (GNP) in the economy. The knock on effects on the rest of the production sector of the economy of the reduction in the cost of transport services is identical to the case where there is a saving in labour inputs.

Table 8.1: Supply and Demand Side Effects of EU and Co-funded Expenditure Change Compared to Benchmark

		1994	1995	2000	2010
GNP	%	0.4202	0.5253	0.1633	0.1095
GDP	%	0.3778	0.4475	0.1820	0.1785
Consumer Prices	%	-0.2126	-0.2992	-0.3822	-0.4369
Wage Rates	%	-0.1504	-0.0751	-0.3175	-0.3747
Balance of payments surplus	% points	0.0506	-0.0046	-0.0120	-0.0506
Government Borrowing	% points	-0.0337	0.0520	-0.0150	0.0047
Labour Force	%	0.0862	0.1592	0.2375	0.2218
Employment	%	0.3732	0.4253	0.2305	0.2300
Unemployment Rate	% points	-0.2422	-0.2308	0.0060	-0.0071
Debt/GNP Ratio	% points	-0.2208	-0.3210	0.0720	0.0056

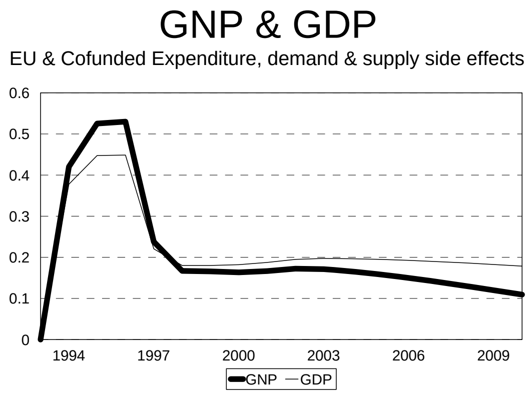
Table 8.2: Supply and Demand Side Effects of EU funded Expenditure Alone Change Compared to Benchmark

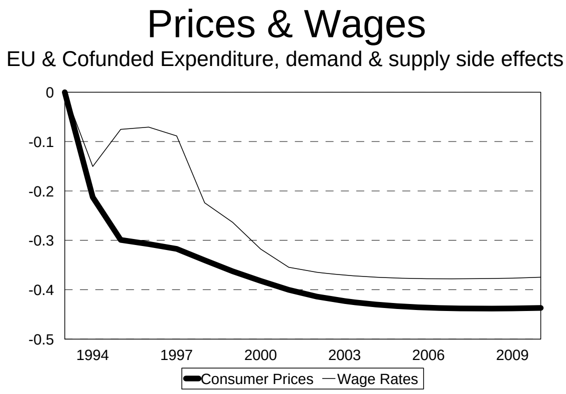
		1994	1995	2000	2010
GNP	%	0.2031	0.3147	0.1119	0.0854
Balance of payments surplus	% points	0.1310	0.1106	0.0095	-0.0170
Government Borrowing	% points	0.0843	0.1340	0.0070	0.0155
Employment	%	0.1807	0.2566	0.1324	0.1329
Debt/GNP Ratio	% points	-0.1173	-0.1456	0.0043	-0.0042

The results for the combined demand and supply side effects are shown in Figure 2 and Table 8.1 for GNP, employment, the public finances (where the government repays debt), and the BOP. The demand side effects come through in the first 3 years while the supply side effects take some time to build up. The unit cost of production in manufacturing industry is reduced in line with the assumed reduction in transport costs. This, in turn, improves Ireland's competitiveness and results in an increase in long-term capacity output and employment. The adjustment pattern is quite slow in manufacturing industry as the reduction in transport costs takes time to gain credibility.

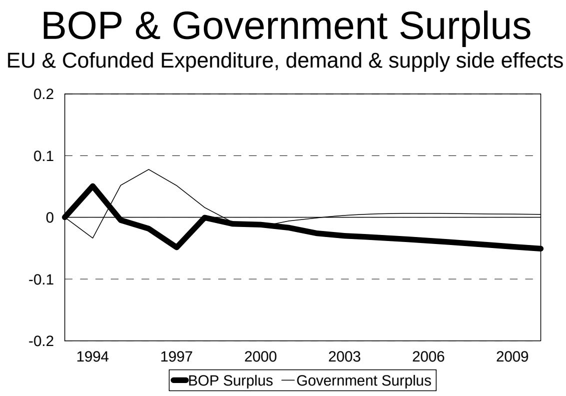
Figure 2

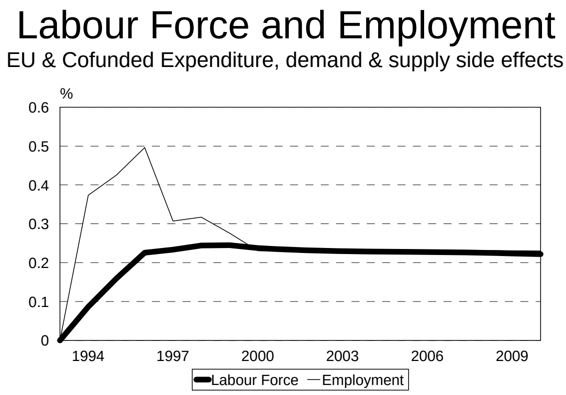
(a) (b)



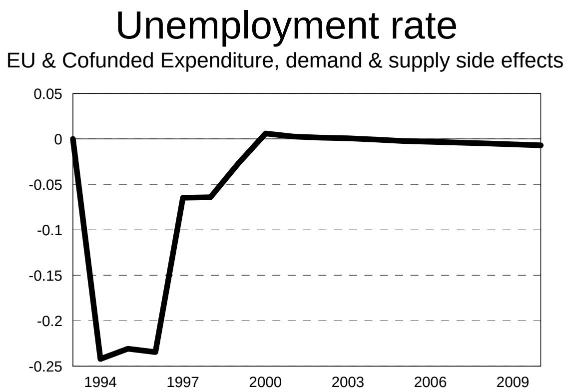


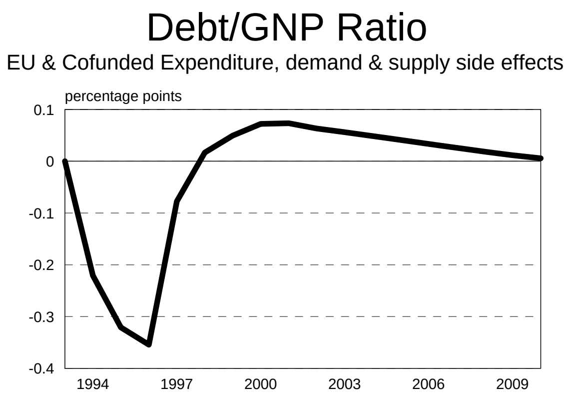
(c) (d)


BOP & Government Surplus
EU & Cofunded Expenditure, demand & supply side effects
0.2
0.1
0
-0.1
-0.2
1994
1997
2000
2003
2006
2009
BOP Surplus
Government Surplus


Labour Force and Employment
EU & Cofunded Expenditure, demand & supply side effects
%
0.6
0.5
0.4
0.3
0.2
0.1
0
1994
1997
2000
2003
2006
2009
Labour Force
Employment

(e) (f)


Unemployment rate
EU & Cofunded Expenditure, demand & supply side effects
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
1994
1997
2000
2003
2006
2009


Debt/GNP Ratio
EU & Cofunded Expenditure, demand & supply side effects
percentage points
0.1
0
-0.1
-0.2
-0.3
-0.4
1994
1997
2000
2003
2006
2009

The relatively high estimate of the valuation of time savings by the business sector of the economy suggested by the evidence described in Part 1 means that the changes in the major aggregates shown here are quite large relative to the size of the stimulus. The increased value added in the transport sector arises from the savings in imported materials and this means that GNP (Figure 2a) rises at the beginning of the period when the infrastructure improvements are assumed to come on stream. This increase adds to the demand side effects, discussed earlier. Even after the demand side effects are finished (in 1997) the level of GNP is significantly higher than it would have been without the investment (between 0.1% and 0.2%).

The increased efficiency results in a significant long-term reduction in the level of prices and wage rates (Figure 2b). The budgetary situation shows little change, even after the demand side effects are finished, (Figures 2c and 2f) as the increased tax revenue arising from the stimulus covers the cost of the investment co-funded by the Irish government. The debt/GNP ratio falls initially as the demand side effects raise the value of GNP. However, in the long run, as these effects are completed, there is little impact on the ratio, reflecting the fact that the co-funded element of the investment was largely funded through revenue buoyancy.

The demand side effects on employment dominate the supply side effects in the first few years. However, in the long run the numbers employed are around 0.2% above the benchmark level (Figure 2d). As shown in Figure 2d the rise in the labour force in the long run is equal to the rise in employment so that the long run effect on the unemployment rate is negligible (Figure 2f). The rise in the labour force reflects some immigration as well as a rise in female participation rates, consequent on the improved labour market environment.

Generally these results for the supply side highlight the sensitivity of any such analysis to the data used on cost savings arising from infrastructural investment. While these results differ in magnitude from those in the earlier evaluation of the OP on peripherality, the difference arises from the new information on time savings in Part 1. If all the issues discussed above were taken into account then it seems likely that the supply side benefits could be even greater than estimated here.

Table 8.2 shows the effects where the EU funded investment is considered on its own, without including the investment co-funded by the Irish government. In this case, because of the smaller volume of investment, the effects on GNP are also smaller. However, there is a significant positive effect on the public finances through increased tax revenue (and lower social welfare payments) arising from the higher level of economic activity. This is an additional benefit to the economy over and above the effects on GNP. As indicated above, if the increased tax revenue is considered as financing the government co-funded investment, then the results in Table 8.1 can be considered as a more complete estimate of the effects of the EU funding of investment in primary roads.

Section 9: **Conclusions**

This paper serves to identify the channels through which the Transport OP will affect Irish competitiveness and the productive potential of the economy. It also identifies the areas in which additional information is needed to better evaluate the rate of return on the investment.

It is clear from this analysis that the investment in primary roads under the Operational Programme for Transport has had a significant demand side impact on the Irish economy over its first 3 years of operation. At its peak GNP has been over 0.5% above the level it would have been without the OP. The existence of the OP and the related EU funding has meant that the Irish government sector has been enabled to undertake the infrastructural investment under the OP, including the co-funded investment, without incurring any additional borrowing. The revenue buoyancy from the demand stimulus has been more than sufficient to fund the Irish government contribution.

Using new evidence on the benefits of the investment to the productive sector of the economy, we estimate a much higher rate of return than had previously been estimated. The long-term impact on output and employment is likely to prove quite substantial, even compared to the demand side benefits.

The available evidence also suggests that this rate of return may be an underestimate. While the investment in primary roads is unusual in the range of projects undertaken as part of the CSF, this detailed analysis raises the possibility that some of the assumed rates of return used in evaluating the overall impact of the structural funds could prove too low. Undoubtedly the Transport OP has served to increase the productive potential of the Irish economy.

The fact that the Irish medium-term growth rate appears to be significantly above that envisaged at the time the OP was drawn up means that the rate of increase in traffic, and in the demand for transport services, is also greater than envisaged. This makes it all the more likely that the OP will serve to reduce major congestion below the level it would otherwise be, resulting in an enhanced rate of return on investment. However, it also means that if the OP was adequate to the expected needs of the economy when drawn up in 1994, it is now likely to prove less than adequate to a more buoyant economy with a higher expected population.