Development and investments in the road sector. A methodological approach to determine the correlation between these variables

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Synopsis

The augmented generalisation of mobility and the necessity for the creation of interconnection systems is an argument in favour of investments in transport infrastructures. It thus appears necessary to determine the level and destination of investments to improve the economy and infrastructures system in its entirety. Investments in transport infrastructures produce a circular process.

They produce an impact on a nation’s development, as well as on its economic structure and productive activities and thus increase mobility, which in turn leads to the need for new investments in infrastructures.

The relationship between infrastructure and development thus appears to be biunique. Many studies have shown that there is not always a correspondence between infrastructures and economic development.

The main purpose of this work is to evaluate the increase in mobility with respect to development and to establish if and how expenditures in the road sector influence the demand for mobility. A further consideration is how such expenditures influence economic development.

This paper describes functional ties between increases in mobility and expenditures in the road construction sector. Macroeconomic variables influencing, or related to private passenger, road network extension, number of vehicles per person and, GDP were first identified.

Secondly, the possible relationship between the variables were analysed. Cointegration, which was developed by Johansen in 1988-1990, was the procedure used to find the relationship between the different variables. It studies both short- and long-term relationships between the variables of the system. Time series were reproduced for the variables, capital outlay and current outlays for road infrastructures and transport. Cointegration was applied after standard tests on the stationariness of time series had been performed. All this aimed at evaluating the influence and possible time-spread between the overall development of national wealth and the ensuing demand for mobility and between investments and mobility.

The final objective of this research work was the formulation of analytical functions capable of describing the phenomenon. Also a series of social and economic time variables were verified, e.g. how mobility is influenced or can exert an influence on the general pattern of development.

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INTRODUCTION

The augmented generalisation of mobility and the necessity for the creation of interconnection systems is an argument in favour of investments in transport infrastructures.
It thus appears necessary to determine the level and destination of investments to improve the economy and transport system in its entirety.
Investments in transport infrastructures produce a circular process.
They produce an impact on a nation's development, as well as on its economic structure and productive activities and thus increase mobility, which in turn leads to the need for new investments in infrastructures.
The relationship between infrastructure and development thus appears to be biunique. Many studies have shown that there is not always a correspondence between infrastructures and economic development.
The main purpose of this work is to evaluate the increase in mobility with respect to development and to establish if and how expenditures in the road sector influence the demand for mobility. A further consideration is how such expenditures influence economic development.
A typical observation concerning plans for new transport infrastructures deals with their potential in promoting economic development in the areas involved by reducing transport costs.
The desirability of a particular area depends on its accessibility, which is linked to the quality and quantity of transport infrastructures. Because of these considerations, states and local governments wishing to stimulate economic development have had to encourage investments in transport infrastructures.
History is rich in examples where investments in the transport context were encouraged, with a single goal in mind: to promote the economic development of a given area.
However, it must be remarked that one of the highest social costs, in terms of mobility, paid by a country derives from injuries to persons and damage to property and the environment caused by the circulation of vehicles.
Thus, we should ask ourselves if, and up to what point, it is correct to favour an investment in the road sector to gain an increase in mobility, if this leads to an increase in the number of vehicles, or if it would be wiser to invest in road infrastructures.
All these considerations lead to further questions.
In particular, if and how the lack of development is caused by:

- insufficient infrastructures. Otherwise the reason must be searched for in other factors, both endogenous and exogenous to the region, but it must be different from infrastructural deficiencies in the truest sense of the word;
- the contribution of infrastructures could be evaluated, in terms of efficiency of the transport system with respect to the characteristics of the regional context. Then, introducing data on the demand for mobility near to supply, rather than as an evaluation of the impact of a generic public investment in infrastructures.

In the light of all these issues, the present study aims at formulating analytical functions that regulate existing interrelations between economic development and the need to create new transport infrastructures, both in the short and long period, by analysing variables that may have a predominant influence on requests for funds for new infrastructures.
However, it is necessary to point out that because of our present limited knowledge of the connection between past and future events, the forecast is not a certain datum.
Indeed, it is impossible to create a model capable of explaining a phenomenon including in itself all variables and the necessary relations for a complete interpretation, and which in any case would contain a margin of phenomenological uncertainty.
Thus, it is possible to affirm, although no certain predictions can be formulated, that it is possible to associate a given degree of probability with each indication for the future.
This can be done by using models in which at the first assume relations that have been verified in the past and are valid for the future. Thus, the continuity hypothesis is valid.
Then, assuming changes in explicative variables of the model, possible scenarios for dependent variables can be defined.

By using this kind of model it will be possible to define alternative policies for national economic growth based on different hypotheses for growth in mobility (and vice versa), which have a certain connection with reality (in other words, probables, from the statistic viewpoint).
This will minimise both hazards caused by a mistaken planning policy and expenditures necessary to obtain the maximum economic development.
This hypothesis is feasible in studying different possible scenarios, choosing the one that is considered the most advantageous both monetarily and in terms of short- and long-term economic development.
Indeed, investments in infrastructures may incorrectly anticipate evolutions in demand caused by a poor planning policy.
Keeping in mind that one of the highest social costs is represented by the cost of accidents, the present study will investigate what kind of connection exists between investments in roads and variations in the number of vehicles.
From previous studies made in the same sector it has in fact emerged that an increase in mobility frequently generates an increase in the number of vehicles.
The goal is to find out, on the basis of available data, if there are precise relationships between variables (such as mobility, number of vehicles and stock of capital).
Such relations allow us to establish up to what point it is convenient to invest in infrastructures to increase mobility, taking into account the fact that this generates an increment in the number of vehicles.

THE MODEL

In economy, many time series are submitted to the same type of trend. This hindrance can often be bypassed by calculating the first difference to obtain stationary series. However, this is not always the most viable solution since if prime differences are applied, long-term solutions cannot be found, because a differentiated series would not contain information related to the long period.
The ideal solution is to utilise models where short- and long-term relations coexist together and all involved variables are also stationary. It can be said that variables are cointegrated when a long-term relationship exists between two or more non-stationary variables on the one hand and deviation in the long term is stationary on the other. In other words, cointegration means that there is a long period relationship between time series, which must be integrated in the same order.
The methodology was developed by Engle and Granger (1987), and the process is based on two phases:

1. an integration test made with the Augmented Dickey Fuller (ADF), which is used to establish if series are stationary, and also, to identify their integration order;
2. a cointegration test used to establish if there is any long-term relationship between two series. If so, these can be integrated in the same order or each one can be developed in two different ways.

This method consists of operating a regression between no stationary variables at the levels and afterwards of testing the residuals of this regression with the ADF.
If the results of this test give stationary residuals, then it is possible to affirm that there is a cointegration relationship between variables; otherwise, if residuals are not stationary, then it implies that the variables are not cointegrated.
Nevertheless, the method developed by Engle and Granger is not exhaustive, because:

- it identifies only one cointegration vector, but more than one may exist;
- results can be different depending upon the chosen dependent variable, but it is possible to use other techniques (Johansen 1988). These allow consideration of all endogenous variables;
- it is possible to test the adjustment vector by using techniques like the one elaborated by Johansen.

Johansen's method (1988) stems directly from the theory of the autoregression vector (ARV). It formulates a system in which endogenous and exogenous variables do not have to be previously identified but all variables are first treated in the same way. Only after data analysis can it be said whether there is any relationship and, if so, what kind.
Indeed, the existing relationship between variables can be of different natures: in the short and/or long period.
The classic theory can also be applied to non-stationary series only if there are short period relationships between variables, but they must occur at first differences, assuming variables at differences instead of levels by operating a simple VAR.
In any case, this kind of approach, although it marks the existence of short-term relations, does not allow the capturing of long-term relations.
The system is formulated as follows:

$$\Delta Y_t = \mu + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-1} + \Pi_p Y_{t-p} + \varepsilon_t \qquad (1)$$

where short-term relationships are represented by $\Gamma\iota$ and long-term relationships by $\Pi\pi$.
Johansen's method is very useful when applied to time series.
Since these series are non-stationary, they give out spurious regressions.
Therefore, it becomes essential to test the cointegration vector.
Assuming the following autoregression representation of an n-variables vector:

$$Y_t = \mu + \sum_{i=1}^{p} \Gamma_i Y_{t-1} + \varepsilon_t \qquad (2)$$

this is a system in reduced form, where a regression is performed on each variable of the vector Y_t, it is done on both, its own delayed values and on the other system variables.
This model can be reparametered in a VECM (*Vector Error Correction Model*) which includes stationary variables:

$$\Delta Y_t = \mu + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-1} + \Pi_p Y_{t-p} + \varepsilon_t \qquad (3)$$

This method of system specification contains both short- and long-term information respectively, given by estimation of Γ_i and Π_p.
Matrix Π_p can be factored in two matrixes:

$$\Pi_p = \alpha \beta' \qquad (4)$$

where α represents adjustment velocity versus equilibrium, and β is a matrix of a long-term coefficient, so that $\beta' Yt\text{-}k$ represents (n - 1) cointegration relationship on the multivariate method.
Assuming that vector Y_t is non-stationary and variables are all I(1), then all terms composing ΔY_{t-1} are I(0), the term $\Pi_p Y_{t-k}$ must also be stationary, so that the term ε_t could be I(0), thus becoming 'white noise'.
Depending on the rank of matrix Π_p it is possible to obtain three different results:

- Π_p has full rank (r = n); in this case, any linear combination of Y_t will be stationary and all the variables of the vector are stationary;
- Π_p has zero rank (r = 0); each linear combination of Y_t is not stationary, thus cointegration does not exist between variables and the estimate of a VECM in the first differences solves the problem of non-stationariness of each single variable;
- Π_p has an intermediate rank (0 < r < n); there are r linear and stationary combinations independent of the elements of Y_t.

The cointegration test consists of finding the r-number of independent linear columns of Π_p. It is equivalent to testing whether or not the last (n - r) columns of α are equal to zero or significantly null.
The method of maximum likelihood used by Johansen consists of performing a regression of a reduced rank, which gives n autovalues $\lambda_1 > \lambda_2 > .... > \lambda_n$ and their correspondent autovector V = (v_1,............, v_n).
The r elements in V, which determine linear combination of stationary relationships, could be indicated as β = (v_1,............, v_r); thus single combinations given by the product $v'_i y_t$, which produces another correlation with stationary elements ΔY_t, are cointegration vectors, since they themselves must be I(0) to reach an elevated correlation.
The fact that each vector v_i has a correspondent autovalue means that quantity λ is a measure of how cointegration relationship $v'_i y_t$ (also indicated as $\beta_i' y_t$) is correlated with the stationary part of the model.
The other (n - r) combinations obtained by means of the Johansen approach, $v'_i y_t$ (for i = r,......, n) indicate no stationary combination, and theoretically they are not correlated with stationary elements of the VECM (Vector Error Correction Model).
Thus, we have $\lambda_i = 0$ (for i = r+1,....,n) for autovectors corresponding to no stationary part of the model.
Therefore, testing the null hypothesis has no more than r cointegration vectors and thus (n - r) unit roots means:

H_0: $\lambda_i = 0$ for i = (r + 1),...., n *null hypothesis* (5)

where only the first λ_i (for i = 1, ..., r) are not null.
To verify this hypothesis, two statistical tests can be used:

- $\lambda_{traccia}$ *trace statistic*
- λ_{max} *maximum autovalue statistic.*

These two tests verify the hypothesis that there are r cointegration vectors against the opposite hypothesis that cointegration vectors are in numbers of (r + 1).

Once the number of cointegration vectors has been established, then one proceeds to evaluate cointegration vectors by normalising their values with respect to coefficients of β and evaluating corresponding values of $\tilde{\alpha}$

The values of α express adjustment velocity of that part of the model versus equilibrium.

ANALYSIS FOR THE ROAD SECTOR

This procedure is divided into two phases: the first one focuses on the analysis of time series of mobility and of social and economic data; the second establishes a relationship between data on mobility and data capable of involving any change and variation in mobility itself.

Many statistical calculations have been performed in order to have a general understanding of this phenomenon. Additionally, unit root tests are carried out to verify series stationariness. Our analysis was limited to the period 1980-2000 due to problems in finding homogeneous data.

Like other surveys on mobility, this one considered social and economic indicators that may influence the demand for transport, although the choice is conditioned by the availability of wide time series. Development indicators are Grosse Domestic Product (GDP) and population.

In order to have steady data over the years, all monetary variables - social, economic and expenditure indicators - were adjusted to 1985 constant prices. Transport expenditure, as reported in CNT, is broken down into current expense and capital outlay. Macro-sectors and their variables are identified and their pattern and unit root are analysed.

Cointegration was used to identify functional relationship. Therefore, the analysis was not developed by imposing transport demand as a dependent variable and social and economic factors and expenditure as independent variables. On the contrary, all variables in the model were considered as exogenous.

The study of correlation was made on data related to road transport mode and supplied a demand only passengers. As a result, mobility patterns are represented as both a function of the same mobility variables considered in the preceding periods and as macroeconomic and expenditure variables, considered in the delayed differences (short-term relationship) and in the delayed levels (long-term relationship). For road private transport elements to be considered were: user mobility, capital outlay for user transport, current expense related to user transport. User mobility shows an almost regular and steadily-growing trend.

Another variable considered was the number of vehicles.

Data sources

The initial difficulty lay in finding historical series broken down at regional level, since only national-level data were available. Laborious data search was thus carried out, first by consulting official sources (ISTAT, EUROSTAT, EURISLES, BBS), then by means of highly detailed searches on the Internet, in libraries, and visits to responsible agencies in this field. This wide-ranging effort made it possible to collect a huge amount of data, whose type of detail however did not always match our requirements. Therefore, we compared similar data and extrapolated, often with some difficulty, the historical series we were seeking. We refer in particular to the socio-economic variables reconstructed by CRENOS[1], taking into account the changes made to the aggregates over the years. Among the variables, we considered GDP based on 1995 prices and resident population. The GDP historical series was especially difficult to reconstruct, because GDP is an indicator commonly used to summarise the capacity for producing goods and services in a given area, but only a few public agencies are able to provide a long term historical series disaggregated by region. On the other hand, reconstruction of the population's historical series was fairly straightforward.

The other historical series we considered are made up on the other hand, of exclusively transport-type variables. They were reconstructed mainly based on data from *Conto Nazionale dei Trasporti* (National Transport Account).

The variables considered refer to some regional transport parameters, and the expenditure of the Regional Government of Sardinia for road infrastructure, split into current expenditure and capital account expenditure; finally, passenger mobility using data based on car transport mode, also considering the historical series of total circulating vehicles.

Since we did not have access to all issues of the Conto Nazionale dei trasporti, in order to complete some historical series we often consulted - especially as regards the historical series of the Regional Government's expenses - the closing balance of the Regional Departments of Transport and Public Works.

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[1] Centro Ricerche Economiche Nord Sud (University of Cagliari)

The expenditures on road sector

The variables we took into account in order to express the expenditure of Regione Sardegna for road infrastructure are divided into current expenditure and capital account expenditure. The series of said variables were transformed into outlay at constant prices based on 1995 levels. Since CNT publishes constant-price expenditure only on a national basis, in order to carry out this transformation we used the historical series of the added value of transport in Sardinia, and extrapolated the index or revaluation of expenditure variables. The series of value added to transport are those published by CRENOS.

For every good or service, the final added value is made up of the sum of the values added at each stage of production. The sum of final values of all the goods and services produced within the country in any one year makes up the (GDP) at market prices. Said product does not factor in the intermediate costs borne in the various stages of the production process; on the other hand, it includes the value of production by foreigners who operate in Italy.

The added value of transport services at market prices thus represents the final value of services to third parties provided by transport companies operating in Italy.

On the national scale, between 1990 and 1998 the added value of the transport sector based on cost factors recorded a sustained growth trend, with substantial impact on GDP. However, the real incidence of the value of transport on GDP can definitely be greater, since the National Accounting estimates only record data on firms providing transportation services to third parties, leaving out the activity of all those firms which perform transportation services on their own account, as part of their own activity. All the countries that have created Satellite Transport Accounts, indicating the overall contribution of the sector to the national economy, the share of transport in the added value and job creation was double that estimated by the national accounting tables.

The ratio between the value added to transport at current prices and the value added to transport at constant 1995 prices was used as a deflator so as to bring expenditure variables to 1995 prices.

Current expenditure is the money spent to maintain regular public and private operations, for aims that are not directly productive. As a rule, it makes up the larger part of overall expenditure. Capital account expenditure, on the other hand, is the outlay aimed at upgrading a sector’s productive capabilities, thus it also includes expenditure for investment purposes.

Tab 1: Expenditure in road infrastructure in the Region of Sardinia (million £ 1995)

TIME	CURRENT EXPENDITURE.	EXPENDITURE IN CAPITAL ACCOUNT
1980	125.268	45.368
1981	155.929	104.912
1982	136.193	94.808
1983	154.025	85.867
1984	115.530	91.554
1985	174.029	123.823
1986	178.387	142.675
1987	218.867	154.106
1988	229.531	132.700
1989	236.535	119.494
1990	229.714	155.208
1991	225.655	218.908
1992	267.615	184.726
1993	213.162	228.977
1994	178.371	205.892
1995	128.494	143.425
1996	114.890	116.983
1997	105.989	140.300
1998	73.713	81.003
1999	56.877	73.650
2000	41.680	52.660

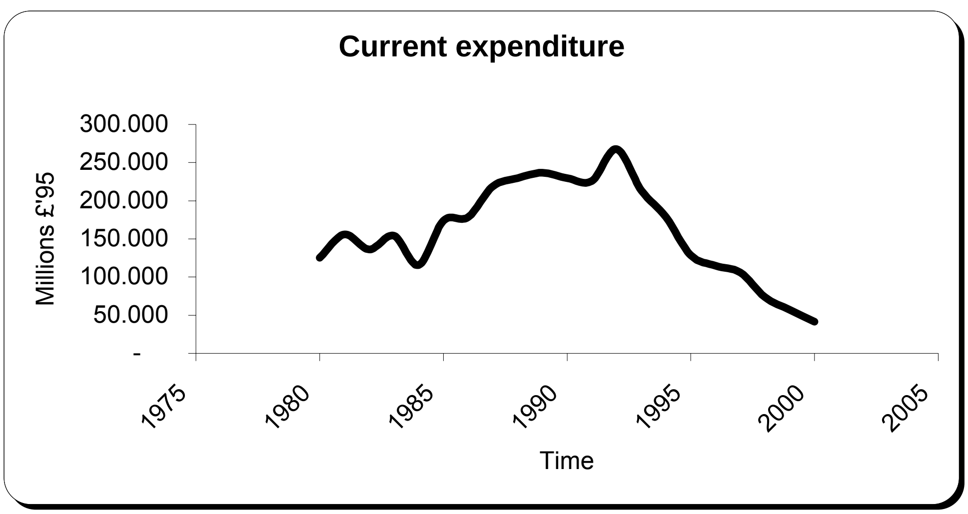

Figure 1: Current expenditure

We may observe that the series do not follow a regular trend. The historical series of current expenditure follows a discontinuous trend, peaking in the year 1992.

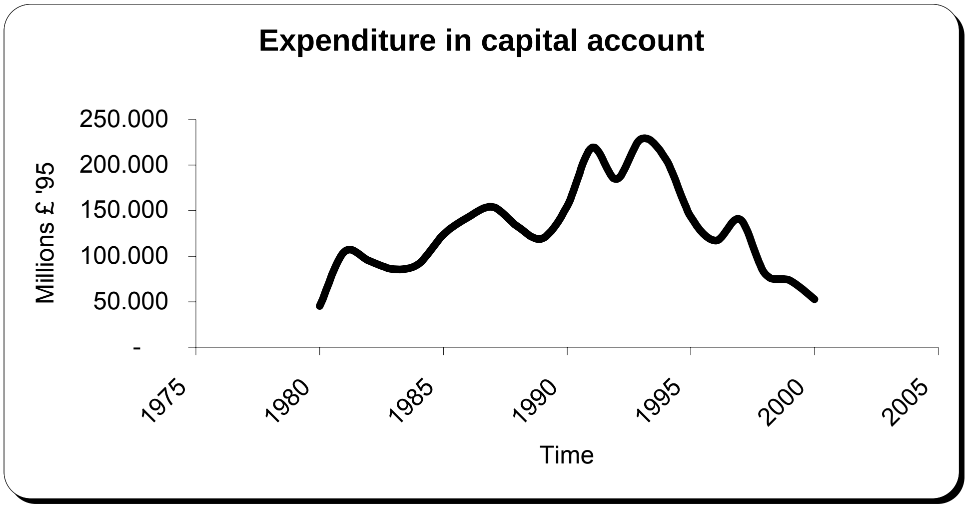

Figure 2: Expenditure in capital account

The same remarks hold true for capital account expenditure. In this case we find two peaks, in 1991 and 1993. Looking at expenditure variables we considered separately the historical series of current expenditure and capital account expenditure for infrastructure. We found a certain degree of discontinuity in these series.

Passenger mobility

Mobility data are restricted to private transport. For analysis purposes we reconstructed the total series of circulating vehicles, including motorbikes. Up to 1998, the term 'circulating vehicles' was used to indicate the vehicles liable for payment of vehicle property tax. Since 1999, the total number of these vehicles is based on the results of checks on legal status, taken from the Public Automobile Registry or P.R.A.

This series displays a sharply rising trend, matching the overall trend of this variable. By dividing the number of circulating vehicles by the population, we obtain vehicle ownership. Since in the same period of time population growth was very low, the vehicle ownership rate between 1990 and 1999 increased from 482.2 to 587.5 vehicles per 1000 inhabitants. This quantity gives us an idea of the varying range of families' spending capacity in the purchase of motor vehicles and motorbikes. Sardinia has a vehicle ownership rate that is just below the Italian average, but is among the highest for Southern Italy.

Tab 2 : Time series for passenger mobility

Time	Person-km	Vehicles
1980	6650	428879
1981	7107	468113
1982	7780	506507
1983	7658	553270
1984	7942	563347
1985	8742	614140
1986	9536	658931
1987	10138	665963
1988	11384	708167
1989	11792	723891
1990	13994	802580
1991	14223	822670
1992	16130	853326
1993	15505	859378
1994	16131	876017
1995	16395	897902
1996	16724	905909
1997	17376	930824
1998	17756	964008
1999	17948	971194
2000	19331	1042488

(*)Estimates, expressed in million passengers-km

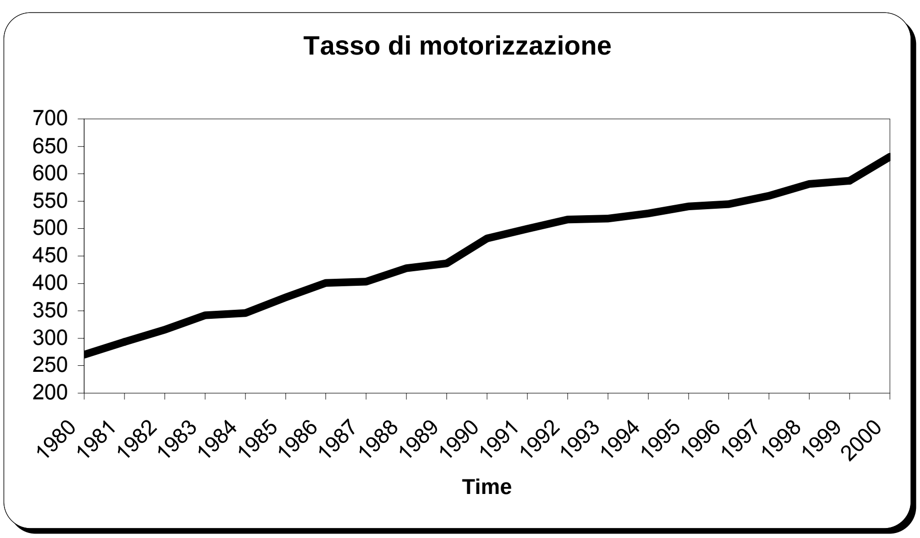

Figure 3: Trend in vehicle ownership in Sardinia

The series pertaining to passengers-km in private transport shows a significant upward trend. This confirms the well-known general preference for moving around in private vehicles. In fact, the car offers clear benefits in terms of comfort. Thus the greatest part of the increased mobility demand recorded in recent years has been met by private transport.

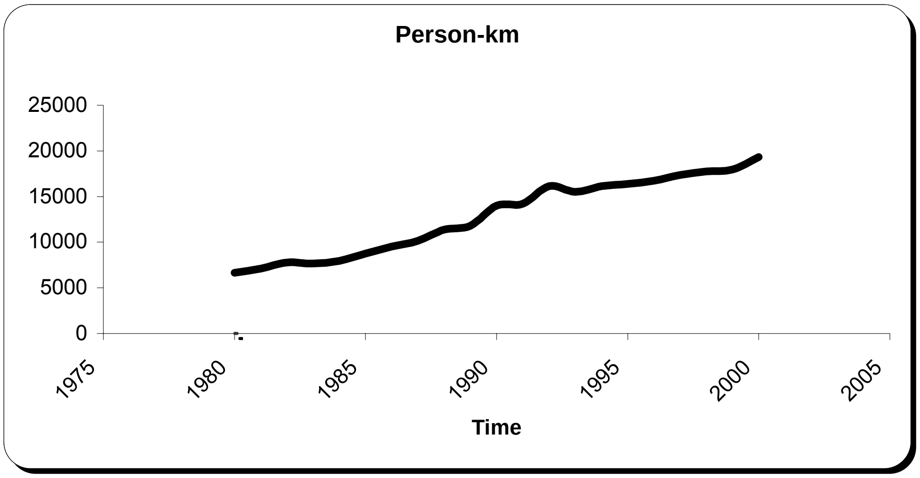

Figure 4: Passenger mobility

The socio-economic variables

The variables we held to be representative of the social and economic condition of Sardinia in the framework of our research were GDP (Gross Domestic Product) and population.

Tab 3: Time series for the socio-economic variables

	GDP	POPULATION
1980	22526	1588960
1981	22156	1594627
1982	22567	1605410
1983	23209	1617265
1984	24236	1628690
1985	24194	1638172
1986	25184	1643789
1987	25619	1651218
1988	26498	1655859
1989	27080	1657562
1990	27935	1664373
1991	29055	1646771
1992	29347	1651902
1993	29208	1657375
1994	29153	1659466
1995	29142	1660701
1996	28666	1662955
1997	29854	1662200
1998	30036	1658000
1999	30183	1653200
2000	30294	1651888

Both series were reconstructed starting from data published by CRENOS.
Since CRENOS data were only available up to the year 1996, the series were completed by drawing data for the missing years from other sources and integrating them with CRENOS figures. We examined two socio-economic variables only, due to the difficulty in finding other data: initially, we had considered including other variables such as industrialization rate, activity rate, and employment rate. However, regional-scale data on those indicators have only become available in recent years. Despite these limitations, we believe that as regards passenger transport alone, GDP and populations are sufficiently representative variables. This conviction is supported by studies[2] showing that private mobility is strongly related to these two parameters, more than to the other economic parameters we have mentioned. Said studies also show that industrialization rate is the variable that has the greatest impact on goods mobility.
The GDP series is calculated in ITL 1995, i.e. it is the real GDP, measuring effective growth, not due to price increases.

[2] Ramanathan, 1990.

This series shows a generally sustained growth trend, with the sole exception of a slight fall in the years between 1993 and 1996. Between 1980 and 2000 GDP on the island increased by 26.4% overall, with mean annual growth rate of 1.45%. The peak year was 1983 with 4.23%, while negative growth values, albeit almost always by less than one percent point, were recorded in the years from 1992 to 1995.

Figure 5: Gross Domestic Product

The population series was reconstructed based on ISTAT data on the resident population of Sardinia as at 31 December of each year. This series also shows a positive trend, turning to minus only in 1991 and, to a lesser degree, in 1998. The first fall was probably due to a review of the estimates made up to then by ISTAT, based on the results of the census carried out that year.

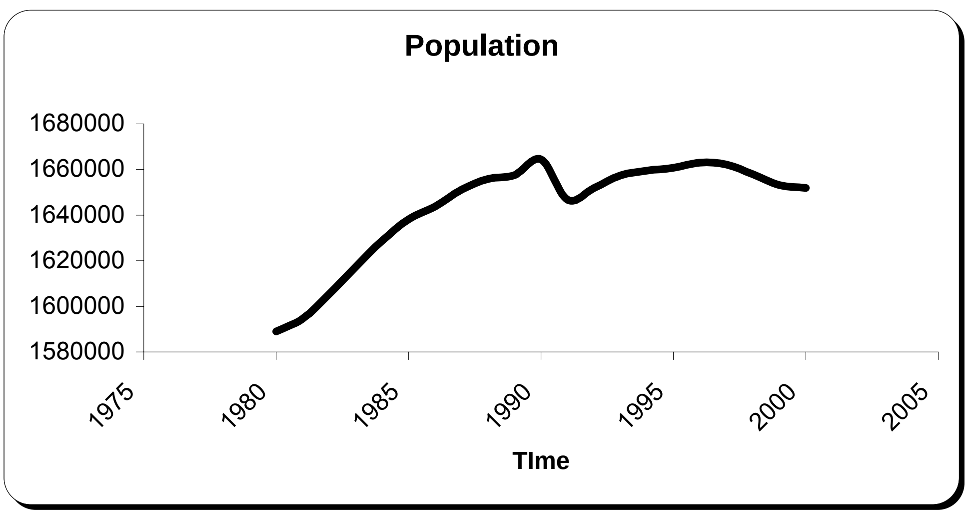

Figure 6: Population

For the purpose of carrying out subsequent stationariness analysis, all series were reconverted into series of index figures, taking as baseline for each series the year 1980. Naturally, the trend of the series was not affected by this step, which is useful to clarify increments or decrements in the values of the series themselves.

THE STATISTIC METHOD FOR THE TIME SERIES

On studying the behaviour of historic series, normal relationships used for statistic interference are found to be a function of time, which implies great inconvenience from the theoretical point of view, and also in concrete applications. By using a simplified hypothesis, called "*Stationariness*", it is possible to overcome this obstacle.

Stationariness is based on the idea that certain statistical properties of a series are invariable with respect to a translation versus time. In other words, steadiness is based on the idea that some properties do not change with time. Therefore, their value at time t_1 is equal to the value at time t_2, and so on. Different types of steadiness exist, because steadiness can reach only mean values but not other moments, thus only variance and not other moments. No steadiness is more frequent and it is given by the mean of no steadiness, or better, is caused by a trend which, in the case of economic phenomena, is usually towards an increase. For data analysis in the present study, problems deriving from no steadiness of the considered series were taken into account.

It has been demonstrated that if analysed series are not steady then normal methods of statistical interference can lead to the conclusion that there is a long-term relationship between the variables considered, even if these are increasing for different reasons and with a different rate of growth.

Therefore, with the aim of obtaining a correct evaluation of the long-term relationship, first of all, a test of unit root was made on all variables to verify the dynamic properties of the time series.

Augmented Dickey Fuller's (ADF) test was used. It consists of an analysis of regression of prime differences of each variable on its own delay, and possibly on an intercept and on a trend.

Assuming only one delay, considering neither trend nor intercept, the equation to estimate is the following:

$$\Delta y_t = (\rho_\alpha - 1)y_{t-1} + u_t \qquad (6)$$

which comes from the substitution of the variables with their previous values.

$$y_t = \rho_\alpha\, y_{t-1} + u_t \qquad (7)$$

The acceptance of the null condition H_0: $\rho_\alpha = 1$, against the alternative H_1: $\rho_\alpha < 1$, implies that series are *not steady* or, in other terms, they follows a casual path, where at each time the variable's value is determined by the value calculated in the previous period plus a purely casual error (white noise). Vice versa, if the steady hypothesis has been accepted, the series are stationary3. .

In the case of non-stationariness the statistic t did not allow the use of the distribution t standard, but it was necessary to consider the Dickey-Fuller distribution. Therefore, the statistical t values could be compared to the critical values of the Dickey-Fuller tables.

If in absolute values statistical t is found to be smaller than the critical value, one cannot reject the hypothesis of non-stationariness and thus this fact confirms the existence of unit root.

It can be concluded that the series is non-stationary and that it is integrated in the first order or superior. A time series integrated in the first order I(1) becomes stationary if it carries out the first differences.

The unit root test, carried out for all considered variables, is performed by first considering a number of delays equal to two4 and secondly, on the basis of the results by Akaike Information Criterion, by Schwarz Bayesian Criterion and by Hannan-Quinn Criterion, an optimum number of delays is chosen as the series stationariness.

The unit root test for the variables carried out showed that the variables are not stationary at the levels.

In Table 4 it is possible to see the values of statistical t and the critical values of the Dickey-Fuller distribution to see if the series are stationary. The results of the test, at the levels and at the differences, show that all the series are integrated in the first order, so all series become stationary at first differences.

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3 The case $\rho_\alpha > 1$ was not considered because the time series exploded.

4 This number is imposed because the time series is made from a sample of reduced dimensions.

Tabella 4 – The ADF test for variables analysing

	0 lag	***1 lag***	***2 lag***
Critical value (5%)	***-3,029***	***-3,04***	***-1,963***
Critical value (1%)	***-3,83***	***-3,857***	***-2,716***
Variable	ADF	ADF (-1)	ADF (-2)
GDP	**0,11555**	**-4,0862**	
Population	-3,5618	-3,0358	
Passengers mobility	-0,20384	-6,1996	
Number of vehicles	-0,97578	-5,4080	
Expenditure in capital account	-1,7343	-4,5623	
Current expenditure	-0,299	-4,3374	

THE RESULTS OF THE COINTEGRATION ANALYSIS

After the unite root test on all time series it was proceed with the cointegration analysis. The steps are:

1) to make a VAR considering the variables in the differences, for to acquire the optimum number of delay that is necessary to put in the following analysis;
2) to carry out a cointegration analysis (considering the number of delay that to find out from the analysis below) putting the all variables in the system;
3) to evaluate the analysis results and, second the obtained values for the rank matrix Π and for the α and β, to test the nullity restrictions (beta restrictions) for to verify if some variables not more significant can be eliminate from the model;
4) to individuate the new formulation for the system and to repeat the cointegration analysis;
5) when the cointegration vector is individuate, it is necessary to impose the exogenity restrictions (alpha restrictions); the goal is to verify the dependencies between the variables;
6) to verify what the model interpret the estimated series.

The results of cointegration analysis[5] find out one cointegration vector between the variables, with a value for the correspondent autovalue of 0,97.

The restrictions on β does not permit to eliminate the variables "GDP", or "expenditure in capital account" or "number of vehicles"; it is possible to delete from the system the variable "population", the variable "current expenditure" and the "passengers-kilometres". In fact, the restriction on β is accepted for this variables.

The analysis on the system after to have delete the variable "population" the "current expenditure" and the passengers-kilometres, show that exist again a cointegration vector, with a value for the correspondent autovalue of 0,79.

The restrictions on α relatives on the "expenditure", does not allow to put α_{scc}=0, and $\alpha_{n°vei}$=0.

This fact implies that the variables "expenditure in capital account" and "number of vehicles" are variables exogenous respect of the others.

The data are elaborated obtaining the values for the coefficients reparametered in function of β_{vei} = 1.

[5] Elaboration from PcFiml Version 9.0 (by Juurgen A. Doornik and David F. Hendry): A module for empirical econometric modelling of dynamic systems.

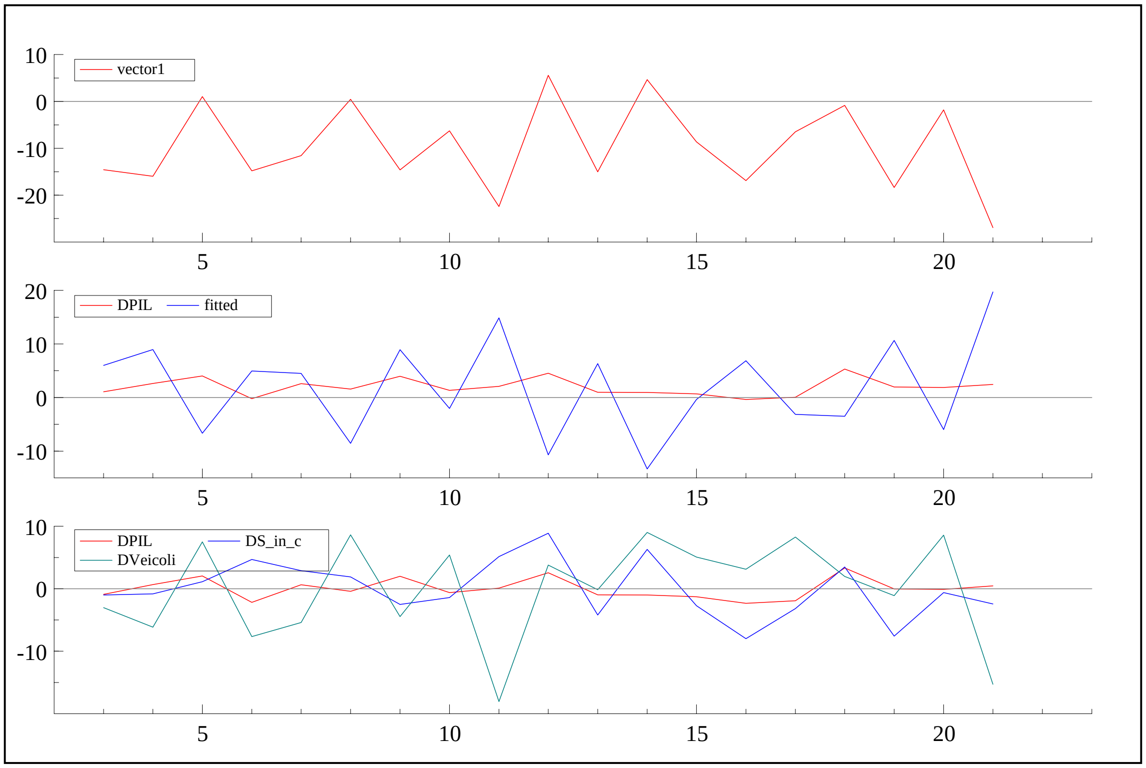
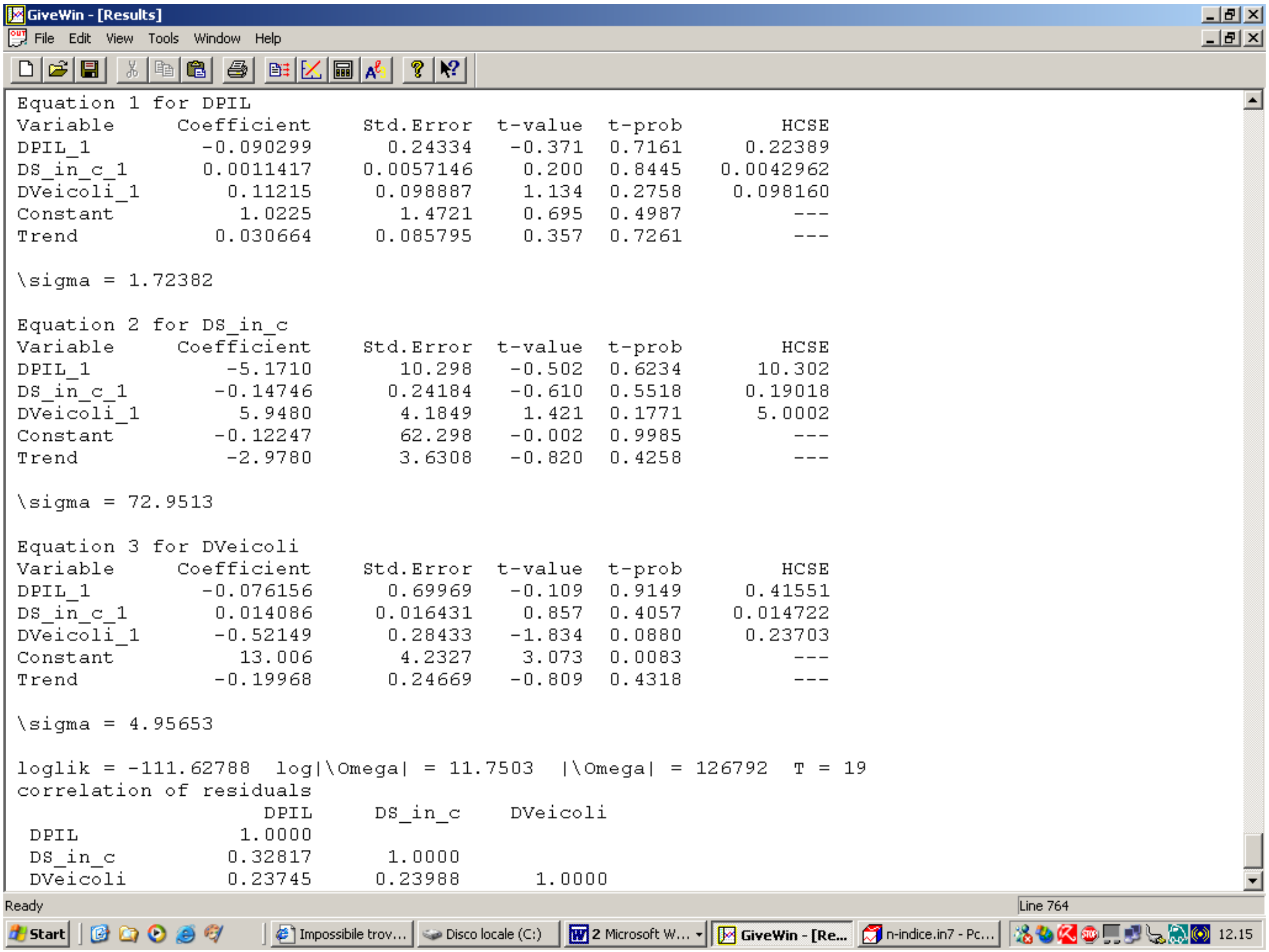


Figure 7: Cointegration graphics (cointegration relations, actual and fitted, components)



```
Equation 1 for DPIL
Variable      Coefficient    Std.Error  t-value  t-prob       HCSE
DPIL_1          -0.090299      0.24334   -0.371  0.7161     0.22389
DS_in_c_1       0.0011417    0.0057146    0.200  0.8445   0.0042962
DVeicoli_1        0.11215     0.098887    1.134  0.2758    0.098160
Constant           1.0225       1.4721    0.695  0.4987         ---
Trend            0.030664     0.085795    0.357  0.7261         ---

\sigma = 1.72382

Equation 2 for DS_in_c
Variable      Coefficient    Std.Error  t-value  t-prob       HCSE
DPIL_1            -5.1710       10.298   -0.502  0.6234      10.302
DS_in_c_1        -0.14746      0.24184   -0.610  0.5518     0.19018
DVeicoli_1         5.9480       4.1849    1.421  0.1771      5.0002
Constant         -0.12247       62.298   -0.002  0.9985         ---
Trend             -2.9780       3.6308   -0.820  0.4258         ---

\sigma = 72.9513

Equation 3 for DVeicoli
Variable      Coefficient    Std.Error  t-value  t-prob       HCSE
DPIL_1          -0.076156      0.69969   -0.109  0.9149     0.41551
DS_in_c_1        0.014086     0.016431    0.857  0.4057    0.014722
DVeicoli_1       -0.52149      0.28433   -1.834  0.0880     0.23703
Constant           13.006       4.2327    3.073  0.0083         ---
Trend            -0.19968      0.24669   -0.809  0.4318         ---

\sigma = 4.95653

loglik = -111.62788  log|\Omega| = 11.7503  |\Omega| = 126792  T = 19
correlation of residuals
                    DPIL     DS_in_c    DVeicoli
 DPIL             1.0000
 DS_in_c         0.32817      1.0000
 DVeicoli        0.23745     0.23988      1.0000
```

Figure 8: Elaboration from PcFiml Version 9.0 (by Juurgen A. Doornik and David F. Hendry): A module for empirical econometric modelling of dynamic systems.

CONCLUSION

The procedure followed in this research work has produced results different from those obtained with the classic procedure. Traditional methods, where regression of mobility is made on non-stationary social, economic and expenditure variables considered in each bracket, dependence between mobility and other variables find. The value of the determination coefficient is very high (almost equal to the unit). It has been shown that if regression of non stationary variables is performed, this leads to identification of long-term relationships between variables which otherwise would be independent. It is possible to apply cointegration to an analysis if variables are non-stationary and if any possible existence of short- and/or long-term relationships can be verified in them. These relationships are usually observed in long-term variables and almost never in short-term ones.

In particular, it must be stressed that mobility, like GDP, appears to be a leading variable within this system. It cannot be affirmed that mobility is generated by investments produced in the road sector, while it can be said that there is in reality a long-term relationship between these variables.

Additionally, not all the variables appear to be significant. They also vary depending on the kind of transport, whether freight or passenger. Analyses carried out in this sector have led to the statement that a relationship over the long period surely exists.

In any case, this type of analysis requires further studies because data are considered as a single whole - especially expenditures – while it would be necessary to isolate the portion of expenditure allocated to infrastructure only and verify to what extent this desegregated variable may involve a larger of smaller variation in road mobility. This procedure allows modelling of the transport system without incurring in errors due to non-stationariness of time series and evaluation of the existence of relationships between variables even when a final model is not always fully formulated.

The other steps necessary in concluding the analysis process and forecasting the pattern of mobility evolution concern the development of possible scenarios in the hypothesis of the evolution of independent variables. Indeed, once the pattern of independent variables is set as a hypothesis playing a role in the evolution of mobility, it is possible to proceed to the formulation of different forecasts. These hypotheses are, however, one element in the dynamic evolution of the model because it will be necessary to verify that the latter always responds to time variations in macroeconomic and expenditure variables.
This method finds useful application both in the planning stage and for the purpose of checking the profitability of investing in any given structural project, not only in terms of financial return on investment but also as regards its social benefits.
Indeed, we can consider variables linked to social and economic development: these may be measured and weighed with reference to infrastructural investment.

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