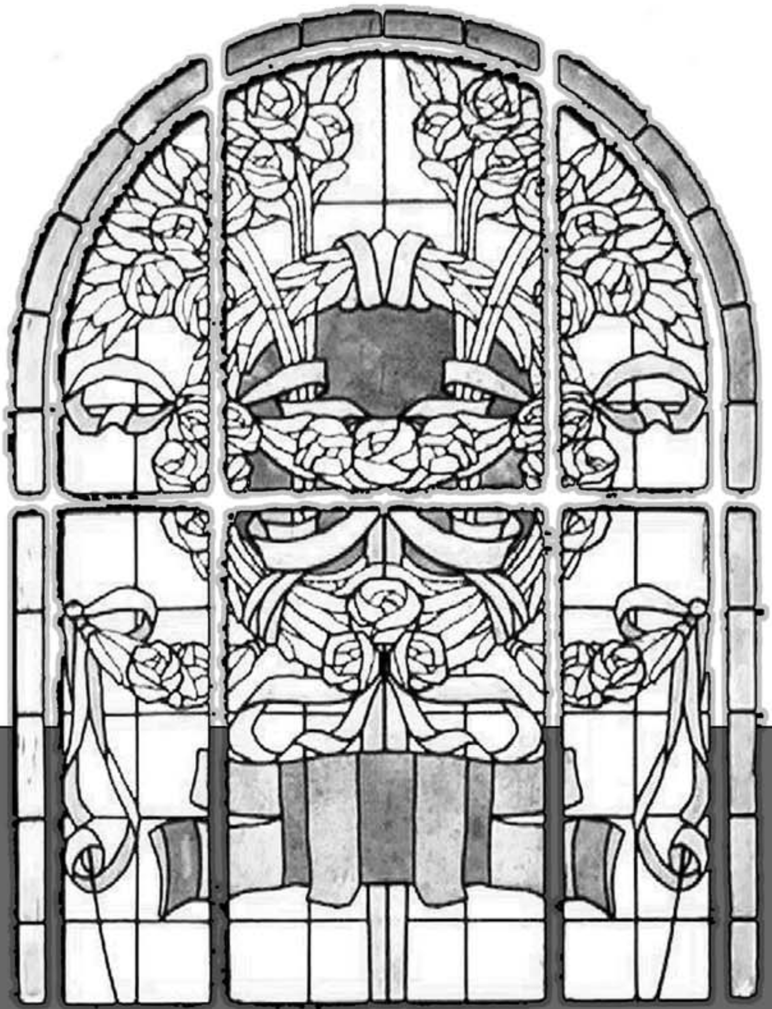

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THE FORECASTING SYSTEM FOR PUBLIC INVESTMENT EXPENDITURE: THE CASE OF PROJECTS IN THE FRAMEWORK PROGRAMME AGREEMENTS

C. Amati, F. Barbaro, F. De Angelis, M. A. Guerrizio, F. Spagnolo

Ministero dell'Economia e delle Finanze
Dipartimento per le Politiche di Sviluppo
Unità di Valutazione degli Investimenti Pubblici

The *Public Investment Technical Evaluation and Verification Unit*, which comprises the *Evaluation Unit* (UVAL) and the *Verification Unit* (UVER), established with its actual structure and form in 1998, in the context of the wider restructuring of development policy functions, under the overall responsibility of the Ministry for the Economy and Finance, which resulted in the establishment of the Department for Development and Cohesion Policies (DPS). Each Unit is staffed with a maximum of 30 members, coordinated by a Unit Head, and reports directly to the Head of the Department for Development and Cohesion Policies. (see D.M. 19 december 2000, *Modifiche al riassetto organizzativo dei dipartimenti centrali del Ministero del Tesoro, del Bilancio e della Programmazione Economica*). The Unit provides technical support to government departments and is part of the network of national and regional evaluation and verification units. More specifically, UVAL develops, tests and disseminates ex-ante, ongoing and ex-post evaluation methods for public investment projects and programmes, with a view to optimising the use of European structural funds and providing evaluations of various aspects of investment programmes and development projects, including their relevance to and consistency with economic policy guidelines, their economic and financial feasibility, their compatibility and cost effectiveness compared with alternative solutions, including their socio-economic impacts in the geographical areas they aim to support. UVER is responsible for verifying and promoting the implementation of the investment projects and programmes of government departments, agencies and other entities receiving public funding. Its verification, support and assistance activities fall into two interconnected categories: the first comprises informational activities, which are directed at fostering adequate understanding and knowledge of public investment issues, observing budget constraints and estimating the social and economic effects of the investment projects; the second involves advisory and executive activities, which consists in identifying, assessing and implementing proposals for initiatives to be undertaken to overcome the operational limitations that affect the satisfactory performance of project expenditures.

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Editorial Director: Laura Raimondo
Editorial Team: materialiuval.redazione@tesoro.it
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The forecasting system for public investment expenditure: the case of projects in the Framework Programme Agreements

Abstract

The development of a tool to forecast yearly expenditure on public investments in a systematic manner was prompted by the need for an ever more efficient allocation of the available resources and their optimal utilisation. In order to provide informational support to the public investment decision-making process, the Unit for Verification of Public Investments of the Ministry for the Economy and Finance – Department for Development Policies – (UVER) has developed a forecasting system for public infrastructure projects. Thus, policy-makers have access to a tool that yields a forecast of the distribution of the annual expenditure for each project, making it possible to conduct analyses at different territorial and sectoral aggregations.

An initial application of the forecasting system, illustrated in detail in this paper, involves the projects included in the sectoral Framework Programme Agreements (APQs), which constitute the main instrument for planning national additional resources dedicated to regional development policy. Each administration in charge of APQ projects is responsible for the regular updating of the APQ monitoring database, which is used to feed the forecasting system developed by UVER.

An analysis of the forecasts highlights a number of issues meriting special attention. For example, the results show a major time shift in expenditure with respect to the plans reported for each project in the APQ monitoring database. This indicates that the administrations systematically underestimate the duration of the projects' development cycles.

Il sistema di previsione della spesa per gli investimenti pubblici: un'applicazione agli interventi degli Accordi di Programma Quadro

Sommario

La costruzione di uno strumento per anticipare in modo sistematico l'andamento della spesa annua per investimenti pubblici nasce dall'esigenza di una sempre più efficace allocazione delle risorse disponibili e di un utilizzo ottimale delle stesse. Al fine di fornire un supporto informativo al processo decisionale in tema di investimenti pubblici, l'Unità di Verifica degli Investimenti Pubblici del Ministero dell'Economia e delle Finanze – Dipartimento per le Politiche di sviluppo – (UVER) ha sviluppato un apposito sistema di previsione della spesa pubblica per interventi di carattere infrastrutturale. Il decisore pubblico dispone, dunque, di uno strumento che consente di stimare l'articolazione dei volumi di spesa annuale per il singolo intervento e di effettuare analisi a diversi livelli di aggregazione territoriale e settoriale.

Una prima applicazione del sistema di previsione, illustrata dettagliatamente nel presente lavoro, riguarda gli interventi inseriti negli Accordi di Programma Quadro (APQ), il principale strumento attuativo della programmazione delle risorse aggiuntive nazionali per la politica di sviluppo regionale. Le singole Amministrazioni responsabili degli interventi previsti dagli APQ sono tenute all'aggiornamento di una banca dati di monitoraggio, utilizzata per alimentare il sistema di previsione elaborato dall'UVER.

L'analisi delle previsioni ottenute segnala alcuni elementi particolarmente rilevanti. Si evidenzia, ad esempio, un significativo slittamento temporale della spesa rispetto a quanto indicato nei piani di spesa dei singoli interventi contenuti nel sistema di monitoraggio degli APQ. Ciò indica la presenza di una sistematica sottostima della durata dei progetti, da parte delle Amministrazioni coinvolte.

Authors: Carlo Amati, Francisco Barbaro, Fabio De Angelis, M. Alessandra Guerrizio, Francesca Spagnolo, Public Investment Verification Unit (UVER), DPS, MEF.

This document describes a work in progress, characterised by continuous improvements suggested by increasingly detailed analyses aimed at perfecting the forecasting system.

The work was partly developed under the aegis of the "Knowledge Dissemination Programme", an initiative of the Department for Development Policies intended to support and enhance the effectiveness of public investments carried out with the Fund for Under-Utilised Areas by way of initiatives to innovate and modernize the network of government departments and provide technical assistance.

The authors wish to thank Carla Carlucci and Pietro Cova for their daily contribution to the dialogue on the issues examined in the paper, as well as Antonio Caponetto and Aldo Mancurti, who generously offered their constant support as heads of UVER.

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A special thanks goes to Prof. Renato Coppi for his numerous suggestions, which contributed to improving the methodology we adopted.

Finally, our thanks go to Simona De Luca for her invaluable support in preparing the final version of the document and to Laura Raimondo for including the paper in the "Materiali UVAL" series, which she directs.

Brendan Jones has assisted with the translation into English of the original Italian version of the paper.

Contents

I. The system in brief

I.1 Assumptions and objectives

The construction of a tool that makes it possible to systematically anticipate trends in annual public investment spending was prompted by the need for an increasingly effective allocation of available resources and for ensuring their optimal use. In order to provide sufficient information support to the decision-making process with regard to public investment, the Public Investment Verification Unit (UVER) of the Ministry for the Economy and Finance's (MEF) Department for Development Policies (DPS) has developed a specific system of forecasting infrastructure expenditure.

Thus, policy-makers have access to a tool that yields a forecast of the distribution of the annual expenditure for each project, making it possible to conduct analyses at different territorial and sectoral aggregations.

The need for early identification of spending trends for each individual initiative, which is accentuated by the systematic underestimation of project costs and length found in the data provided by the various monitoring systems, has, over time, led to the transformation of a simple prototype model for expenditure forecasting into an entire system of models, thanks to constant improvements in sources and tools. Such a comprehensive system, which is currently being used with initiatives that are a part of the Framework Programme Agreements (APQs), gives a more detailed picture of the complexity of the implementation of each initiative and provides increasingly accurate and reliable statistical results.

The methods and time required to implement a project depend on both the performance of the procedures that precede the actual start of a project itself and the actual progress made on the project and the resultant trends in expenditure. This is the basic assumption of the *forecasting system for public investment expenditure*, which has a twofold objective, namely:

1. to forecast the start date for work to begin for the various initiatives while the projects are still in the preparatory phase; and
2. to anticipate the spending developments for all projects, both those that are under way and those that have yet to begin.

Based on the information available for projects with a history regarding length and expenditure already carried out, the system first enables identification of the projects that have not yet begun which are most likely to be delayed in the early stages, then to determine a potential start date, and, finally, to calculate the forecast spending as from either the project start date or, for projects already under way, the most recent state of progress report.

I.2 The public investment universe

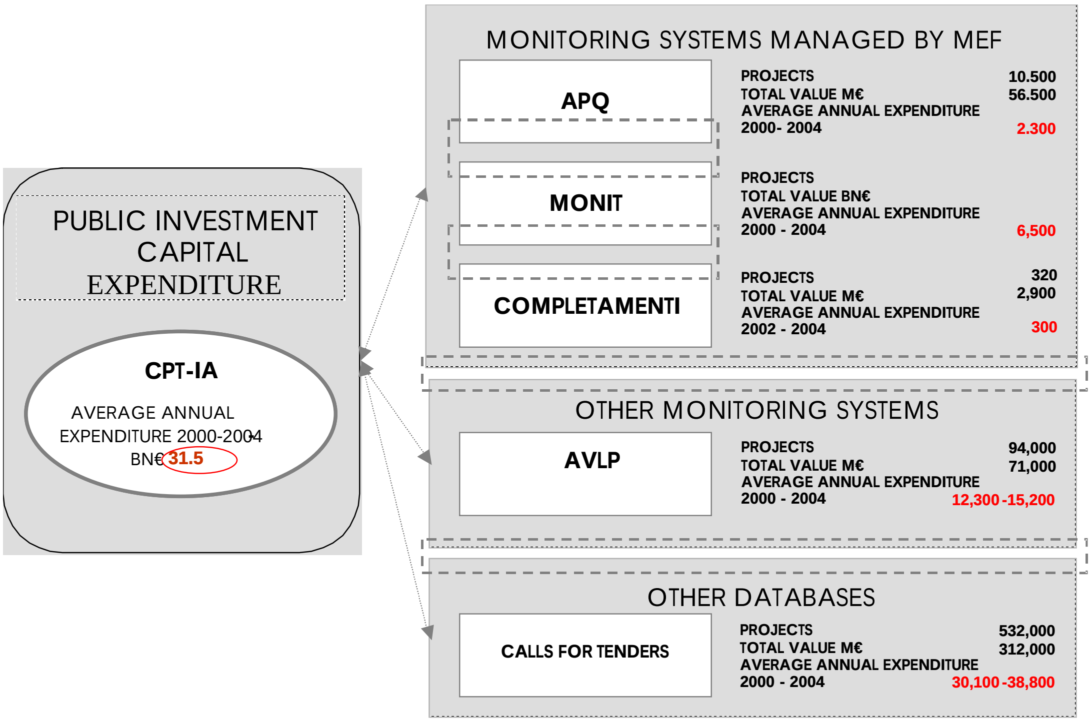
UVER's scope of operations extends to the entire universe of public investment, which is made up of the investment programmes of the various government entities involved. The investment programmes, which are generally linked to a particular type of funding, can involve projects that, in part,make them overlap. In other words, a single project might be funded with resources from more than one programme. As a result, project information may be found in a set of databases managed by different entities, each of which with its own purposes and specific characteristics.

Nonetheless, a unified vision of government spending is provided by the data from the Regional Public Accounts (RPAs),[1] a project designed to measure financial flows at the regional level throughout Italy. The RPAs provide information regarding overall inflows and outflows (both current and capital expenditures) for within government entities by individual region. The most recent RPA figures are for the year 2003, while statistical estimates have been calculated for 2004 using the public capital expenditure leading indicator.[2] Capital expenditure by general government on tangible and intangible infrastructure is the reference universe for this paper.

RPA figures provide various interpretive keys, but they cannot be used to identify the individual public investment projects to which the financial flows refer. This information is gathered from other databases, none of which, however, provides full coverage of the entire universe. Figure I.1 provides a diagram which compares the RPA spending data with that of the initiatives found in the main public investment databases.

[1] For more information see http://www.dps.tesoro.it/cpt/cpt.asp
[2] See F. Barbaro et al. (2004)

Figure I.1 The main public investment project databases



Source: UVER

The databases related to the monitoring systems managed by the MEF are related to their respective investment programmes. APQ is the database managed by the DPS's Regional Development and Agreements Unit (SPSTI) regarding the initiatives covered by the Framework Programme Agreements;[3] MONIT is the database regarding projects financed with European Community funds for the 2000-2006 programming period;[4] and COMPLETAMENTI is the database regarding projects within the programme funded by the Interministerial Committee for Economic Planning (CIPE) in 1999 for the completion of unfinished infrastructure works.[5]

Also available are the databases of the Public Works Observatory, maintained by the Public Works Oversight Authority (AVLP), and of calls for tender provided by a private organization. The universe of the AVLP database covers all public works tenders (excluding contracts for goods and services) for which the oversight body gathers a set of information from government departments as required by public works regulations.

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[3] For more information see http://www.dps.mef.gov.it/intese.asp
[4] For more information see http://www.dps.mef.gov.it/fondistrutturali.asp
[5] For more information see http://www.dps.mef.gov.it/UVER_linee_completamenti.asp

The database of calls for tender, on the other hand, contains information on the tenders for tangible and intangible infrastructure organized by public entities in Italy.

For each database, information is provided regarding both the number of projects it contains and the corresponding total value, i.e. the amount of resources needed to implement the projects themselves and average annual expenditure, which is the average amount of funds spent during the period in question.

At this point, we need to clarify the significance of spending in the various databases. RPAs and MONIT are comprised of actual payments made by government to third parties, whereas the other databases represent the economic value of the activities performed. In the case of APQ, the government departments themselves provide the data on their spending, whereas in the other cases, the numbers are UVER estimates.

The databases regarding the monitoring systems managed by the MEF also include the expenditure flows for the individual projects and provide a direct measurement of the expenses incurred annually. As such, due to the specific nature of the various data sets used, and although there are certain areas of overlap, the data cover at most 20 per cent of the total spending of the RPAs.

Even the AVLP database records the state of progress of projects, but is limited to actual works-related spending. In this case, it is therefore necessary to estimate a spending number that can be compared with those of the monitoring and RPA databases, which, as can be seen in Figure I.1, is shown as the range of most possible values. The AVLP database covers roughly 40-50per cent of total expenditure, both because it excludes contracts for goods and services and because it is reasonable to assume that the coverage of tenders is not entirely complete.

The database of calls for tender, on the other hand, does not follow project implementation and progress, but only records the main data available at the time the contract is awarded. As a result, the data includes no actual spending flows of any kind and total spending must be estimated within a range of most possible values. According to our preliminary estimates, this database would even cover more than capital expenditures, given that it also includes non-investment spending, which could only be separated out afterwards with a more in-depth analysis.

The databases shown in Figure I.1 are not unconnected. The AVLP database and that on calls for tender are related to broader data sets and generally include the various investment programmes. Furthermore, as mentioned above, there are also areas of overlap between the databases of the specific investment programmes, as a given project can be funded by more than one programme (e.g. APQ projects co-funded by the European Community will also be found in the MONIT database).

Of the monitoring databases, the one that is currently best suited to feeding a forecasting system is that of the APQs. This database is of particular importance to the DPS in that the APQs are currently the most important tools for programming the nation's additional resources for regional development policies.

Moreover, the APQ database has recently been significantly improved in terms of the availability, reliability, and timeliness of the data it provides, thanks, in part, to the introduction of new rules in 2002, which have established a system of incentives to encourage government entities to submit the data, as well as to the strengthening of the entire process of validating the data itself.

The application of the forecasting system presented here has, therefore, been based on the APQ database.

I.3 Project implementation

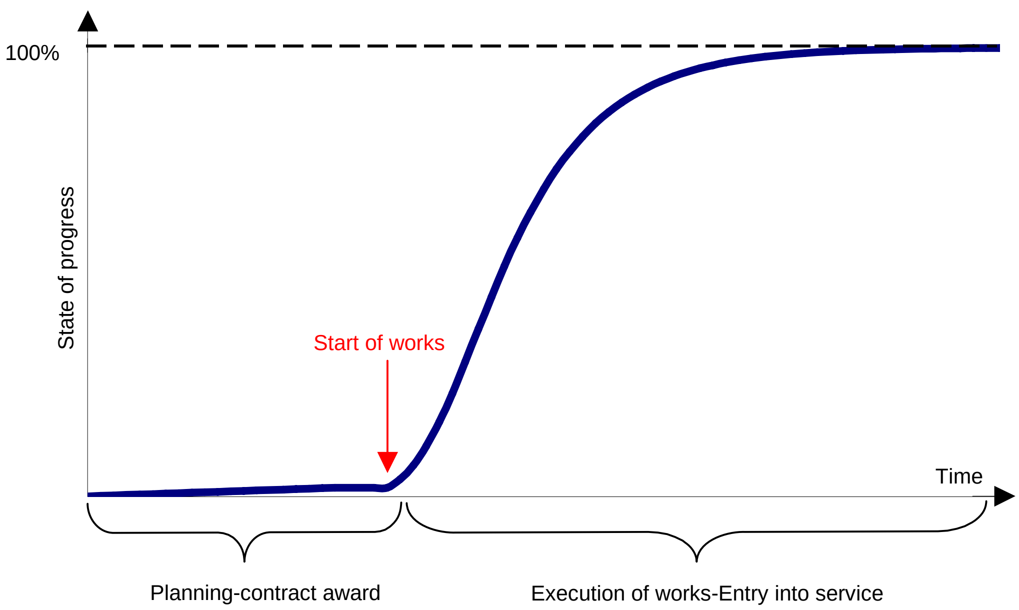
The configuration of the forecasting system begins with the observation that each project evolves along a generic path (Figure I.2) which can be divided into a series of typical phases: planning, awarding the contract, project implementation, and start of operations. This path is best applied to infrastructure investments, but is also sufficiently applicable to investments of other types (i.e. contracts for goods and services), which only account for a minority of APQ projects.

The planning phase, when the project is defined, involves the preparation of a series of increasingly detailed documents. As all of the necessary authorizations must be obtained in this phase, the timing of the project may lengthen significantly. At the end of the planning phase, or when a sufficient amount of progress has been made, the project enters the contract award phase, which involves selecting the contractor that is to perform the actual work once planning has been completed. At this point, the work can begin, and this is the phase in which the greatest amount of project resources will be spent. Once the work has been completed, testing, inspections and any other requirements are carried out in order to make the project fully operational.

Accordingly, the overall path of implementation can also be broken down into two broader macro-phases:

- the first of these runs from planning through to award of the contract. In this phase, actual project implementation is very limited and the impact on the territory is essentially of a "design" nature (i.e. technical, economic, social, etc.), and the prevalent project dimension is that of time;
- the second phase runs from the execution of the work to be done through to making the project operational. This is the phase in which more concrete progress is actually made in the project and which involves methods that are influenced both by the territorial context and relations (often involving a great deal of interdictions) between the awarding entity, the contractor, and the other parties concerned.

Figure I.2 Hypothetical path of implementation for a generic project



Source: UVER

In line with this breakdown of the path of implementation, the expenditure forecasting system is a combination of multiple statistical models with the following objectives:

- to forecast the date on which work is to begin for projects that have yet to start, based on the times recorded for projects under way;

- to forecast the trajectory of total spending for projects still to be started and the remaining expenditure for those that are under way,based on the trajectory of spending recorded for projects under way.

I.4 Application of the APQ database

Because the information and results presented here refer to projects included in the APQ database, it is necessary to describe the content of the database used to train the system before moving on to a description of the forecasting system itself.

Nonetheless, because of its structure and the configuration of its component models, the system may be applied to a generic set of projects for which an adequate set of information is available.

I.4.1 The APQ universe

The Institutional Programme Understandings are the tool used in planning the national additional resources for regional development policies and serve to coordinate the activities of both central government and local governments (regions or autonomous provinces) in defining the objectives, sectors and areas in which local development infrastructure projects are to be implemented. Theseunderstandings were reached with all of the regions and autonomous provinces between 1999 and 2001.

The APQs represent the means of implementing these Understandings. For each infrastructure area (whether it be integrated water systems or transportation, cultural heritage or land protection, with differences from region to region), an APQ must be drafted to define, in detail, the projects and related funding, while also activating monitoring procedures.

The Understandings are funded annually with the resources of the Fund for Under-Utilized Areas (APQ)[6] as assigned by CIPE, and over time, multiple APQs may be established for the same sector (with those that follow being referred to as "supplemental instruments") in order to program the new resources to be allocated. Nonetheless, FAS resources only account for 25 per cent of the total value of all APQ projects, over 50 per cent of which is funded by ordinary resources (national and

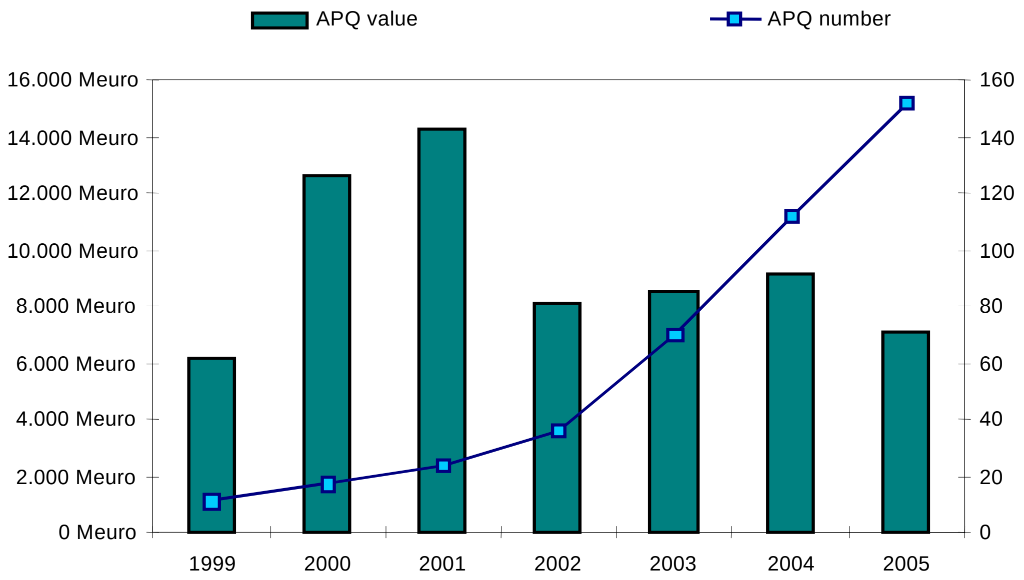
[6] For more information see http://www.dps.mef.gov.it/fas.asp

regional), with the remainder coming from European Community or private resources.[7] As alluded to in section I.2 above, the overlap of the various sources of funding also corresponds to an overlap of the respective databases, with the projects co-funded by European Community resources generally also being found in the MONIT database.

Overall, as of 31 December 2005, the database used contained 422 APQs, for a total of 13.088 projects and a total value of €65.85 billion. The number of APQs is slightly different from the figure given in the DPS's 2005 Annual Report because a number of APQs are counted as one at the programming level, but are divided for the purposes of monitoring. Nonetheless, the dataset essentially coincides with the figures shown in the DPS Report,[8] although our focus has been placed primarily on the latest update to the data, as opposed to the Report, in which the programming data is given greater importance.

Figure I.3 below shows the number and value of APQs found in the database by year of signing of the agreement.

Figure I.3 Number and value of APQs found in the database by year of signing



Source: UVER analysis of APQ data (monitoring as of 30.06.2005 and agreements signed as of 31.12.2005)

[7] See Dipartimento per le Politiche di Sviluppo (2005)
[8] With the exception of 4 APQs, totally about €1.2 billion, which have been excluded because they have not been monitored for more than 3 years

The number of APQs has grown constantly, while the amount of corresponding resources has remained at between €7 and €9 billion since 2002. Over the same period, the average size of the projects has fluctuated from between €2 and €4 million, with the percentage of small projects (i.e. those of less than €1 million) exceeding 50 per cent of the total, although this proportion is declining.

I.4.2 The APQ project monitoring system

The monitoring system, which provides constant verification of a project's state of progress and a means of identifying any critical issues that may arise, gathers information on the structural characteristics of a project, its time schedule, and its financial plans.

In particular, a project's financial plan includes information on the estimated total cost (i.e. the declared cost) and the cost of the work and other activities already completed as of the monitoring date (i.e. the actual cost to date). The declared cost and the actual cost to date are broken down by year for the entire period over which the project is expected to take place. At each monitoring date, the government entities update the financial plans with the actual numbers as of that date and may also update their forecasts for the subsequent years. In some cases, this revision can be of such significance that it is, in fact, one of the main reasons for which the UVER forecasting system was developed.

In the APQ monitoring system, the cost numbers do not equate to book expenditures for a project, but rather to the *value of activities carried out* regardless of whether payment has actually been made. These numbers are taken from the detailed accounting records for the work site and from additional expenses incurred, and include any expenses for planning-related activities.[9]

The definition of cost adopted by the APQ monitoring system corresponds precisely to the concept of project progress shown in Figure I.2; therefore, in the statistical models used to describe and forecast the path of project implementation, the dependent variable is constructed on the basis of actual cost to date.

[9] See Servizio per le Politiche di Sviluppo Territoriale (2003)

I.4.3 Monitoring system data

The monitoring system contains both the FPA data as of the signing of the agreement and the related semi-annual updates, which are carried out on 30 June and 31 December of each year.[10] While the monitoring data is updated semi-annually and is available about three months after the monitoring date, the information regarding the new FPAs is entered into the system before the agreement is actually signed.

For our purposes here, we have used all information in the database as of 31 December 2005. Therefore, it includes the monitoring data as of 30 June 2005 and all APQs for 2005.

The monitoring data for 30 June 2005 are available for 93 per cent of the APQs, accounting for 91 per cent of the resources. In order to fully understand how the monitoring system has evolved and how the timeliness of data collection has improved, it should be pointed out that, just one year ago, the data available as of the latest monitoring update accounted for just 47 per cent of the resources.

According to the update, spending totalled €14.32 billion, equal to 22 per cent of the total value of initiatives of €65.85 billion (see section I.4.1). Expenditure is on the rise, and, in the period 2000-2004, it increased from just under €900 million to more than €3.5 billion, for an average annual spending figure of €2.3 billion euros (see Figure I.1).

It is also important to specify that each monitoring update provides the entire series of annual spending data and, as such, also includes the figures for past years. Therefore, once the latest full update is available, the set of data on spending to date is automatically complete.

The structural and contextual characteristics of the individual initiatives, which are used as explanatory variables in the various models, are as follows:

- **Cost:** the total amount required to implement the project; within the total set of projects, costs vary greatly, from just a few thousand euros to more than 3 billion;

- **Geographic area** (North, Centre, Southwest, Southeast, Islands): the area of Italy to which the project refers;

[10] Monitoring of an APQ begins six months after the signing date.

- **Type of project** (New construction, Recovery/restoration, Other type of project, Services): the type of work to be done;

- **Expected duration of work** (less than 1 year, from 1 to 2 years, 2 to 3 years, more than 3 years): the expected number of years it will take to complete the work as declared at the time;

- **CIPE resolution** (No FAS, Previous resolutions, 36/02-17/03-20/04-35/05): indicates whether or not the project is funded by FAS resources and, subsequently, to which set of rules it is subjected; as of resolution 36/02, new rules designed to accelerate spending have been introduced;

- **Type of promoting body** (Regional governments, Other local governments or entities, Concession holders or network and infrastructure operating companies, Ministries, Other): the type of party, normally a general government entity, promoting the initiative to be included in the APQ;

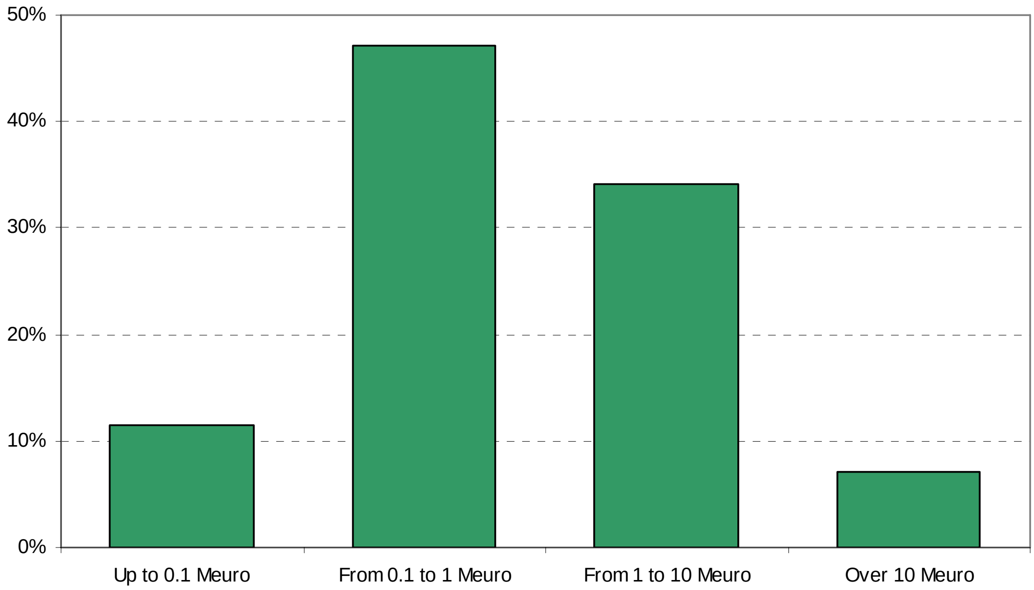
- **Type of implementing body** (Regional governments, Other local governments or entities, Concession holders or network and infrastructure operating companies, Ministries, Other): the party responsible for implementing the project, generally the awarding body;

- **Planning as of signing** (None indicated, No planning, Feasibility study, Preliminary, Definitive, Executive): the level of study or planning completed and approved prior to signing the APQ;

- **Sector** (Other transport, Environment, Assistance and charity, Integrated water system, Culture and recreational services, Building, Energy, Education/Training/R&D, Industry and services, Waste management, Health, Telecommunications, Tourism, Roads, Other): the category of infrastructure within which the project falls, based on the classification used for the RPAs (see section I.2).

Figure I.4 shows the percentage of projects (in terms of number) by cost category. The cost category is used only in the expenditure model, with the other models using logarithm of the Cost variable.[11]

Figure I.4 Distribution of the number of projects by cost category



Source: UVER based on APQ data (monitoring as of 30/06/2005 and agreements as of 31/12/2005)

It is worth noting that, although projects with a value of more than €10 million account for only around 7 per cent of the total number of projects, they account for more than 75 per cent of total resources.

Table I.1 below shows the distribution of projects based on the various variables of interest.

[11] Because the standard deviation of the cost distribution is much greater than the average value, it is appropriate to use the logarithm of cost.

Table I.1 Project distribution by structural and contextual variable

Variable	Level	% of projects	% of value
Geographic area	North	20.2	18.6
	Centre	23.7	26.7
	Southwest	17.6	15.0
	Southeast	21.4	11.8
	Islands	17.1	27.8
Type of project	Other	17.7	11.4
	New construction	46.5	74.7
	Recovery/restoration	30.0	12.6
	Services	5.8	1.3
Expected duration of work	Less than 1 year	51.5	8.3
	From 1 to 2 years	32.9	22.4
	From 2 to 3 years	11.5	22.4
	More than 3 years	4.1	46.9
CIPE resolution	No FAS	46.9	71.9
	Previous resolutions	22.3	13.0
	36/02-17/03-20/04-35/05	30.8	15.2
Type of promoting body	Regional govt.	68.1	42.5
	Other local govt. or ent.	13.6	5.3
	Conc. or net./infr. mgmt co.	2.6	20.3
	Ministries	8.4	15.7
	Other	7.3	16.2
Type of implementing body	Regional govt.	10.6	11.1
	Other local govt. or ent.	53.3	14.1
	Conc. or net./infr. mgmt co.	9.6	32.8
	Ministries	8.2	5.4
	Other	18.3	36.5
Planning as of signing	None indicated	0.6	0.3
	None	30.2	24.4
	Feasibility study	8.0	10.7
	Preliminary	29.1	28.0
	Definitive	14.2	18.8
	Executive	17.9	17.8
Sector	Other transport	5.4	30.0
	Environment	16.7	3.3
	Assistance and charity	2.1	0.4
	Integrated water system	22.2	10.6
	Culture and recreational serv.	18.9	4.6
	Building	1.6	0.5
	Energy	3.2	1.5
	Education/training/R&D	3.4	1.3
	Industry and services	3.5	6.3
	Waste management	0.6	0.7
	Health	1.0	2.5
	Telecommunications	3.7	2.1
	Tourism	0.8	0.9
	Roads	13.9	32.4
	Other	3.2	2.9

Source: UVER based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

These characteristics of the individual projects make it possible to conduct analyses from a variety of perspectives that are not limited to the categorizations used for the model estimates and can be at a greater or lesser level of detail. For example, although the model uses a geographic area variable with 5 levels, analyses can be done by macro-area (e.g. South and Centre/North), as well as by region, province or municipality. Naturally, this possibility also applies to the results of the forecasting system (see section III.3.1).

II. Forecasting system structure

II.1 General methodology

The forecasting system is made up of three interconnected statistical models:

- a **logistic regression** model to forecast start-up delays;
- a **duration** model to forecast the extent of the delay;
- a **linear regression** model to forecast the expenditure profile for all projects beginning from the start date of the work to be done.

The combination of the first two models provides an estimate of the start date for projects that have not yet begun.

The statistical models that make up the forecasting system involve a set of parameters, which are estimated using the history of projects implemented as of the date of the last available update. As such, it is important to note that these estimates are based solely on actual project implementation data and do not depend on forecasts by the government entities.

The modular nature of the forecasting system also applies to the selection of the set of projects for which to calculate the forecasts. Only APQs with monitoring data are used in determining parameter values, whereas the parameters are applied to all APQs of the given set when calculating forecasts. This means that it is only possible to update the parameters following the two semi-annual monitoring updates, whereas forecasts can be integrated with those of the new APQs as they are signed, simply by applying the currently available parameters. In this way, the most up-to-date forecasts are available immediately with the availability of the data on the new APQs.

Table II.1 below shows a breakdown of the set used to estimate the parameters as compared with the total on which forecasts are calculated. The projects used to estimate the parameters (assuming there is sufficient history available) number 10,712 and total €59 billion. The table also shows that the cost to date for the projects not used to determine the parameters is extremely limited.

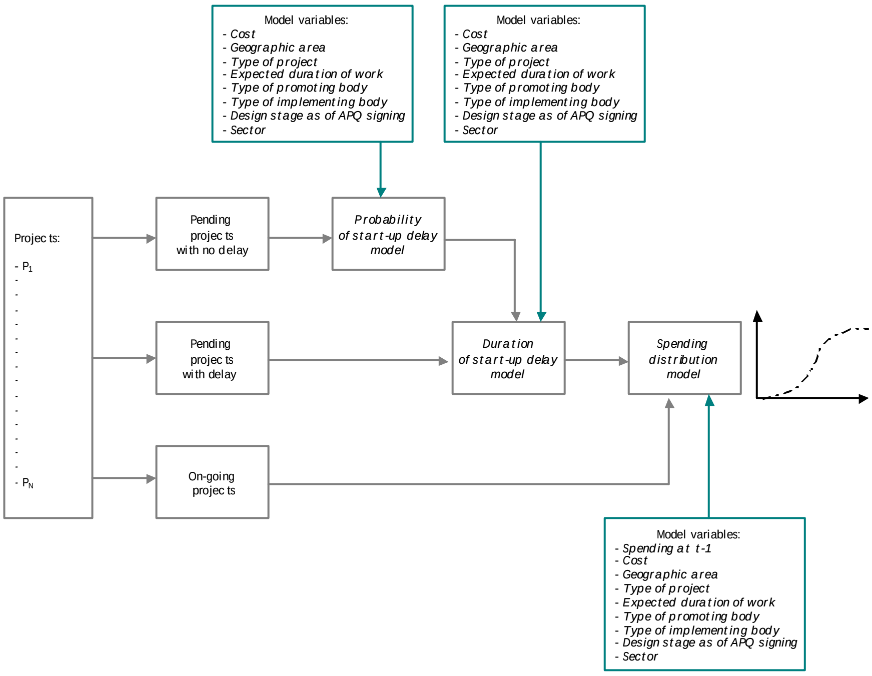
Table II.1 Breakdown of projects based on their use in estimating parameters

Category	Number of APQs	No. of projects	Cost (millions of euros)	Cost to date (millions of euros)
With monitoring data (for parameters)	267	10,712	59,049	14,205
With signing data[12]	155	2,376	6,796	118
Total	**422**	**13,088**	**65,845**	**14,323**

Source: UVER based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

Figure II.1 below is a diagram of the overall structure of the model system.

Figure II.1 The model system used to forecast public investment spending



Source: UVER

[12] The projects for which only agreement data as of signing is available are those of APQs signed in 2005 (with 2 exceptions which have already begun monitoring) and those of a further 5 APQs signed previously but which failed to provide monitoring data.

The projects are used in the various models based on whether or not they have been started[13] or have experienced delays beyond the start date indicated at the time the related APQ was signed.

The first model assigns pending and on-schedule projects a probability of start-up delay, and the second model assigns a duration to this potential delay. As such, applying the first two models provides a start date for all projects, either actual (for projects that have already started) or expected (for pending projects). The third model assigns all projects a spending trajectory, which begins with the expected start date in the case of pending projects and from the date of the last monitoring update and spending level already reached in the case of projects already under way.

The characteristics of the system and its models will first be presented in general terms, followed by a more detailed description of their application to the specific projects in question.

II.2 The start-up delay probability model

II.2.1 The theory

In order to calculate the expenditure forecasts for each project, it is first necessary to set the start date for the work to be done for all projects. This date may be later than the one specified at the time of signing the agreement due to delays in the planning and contract award phases. For this reason, the start date for all pending projects is based on the estimated length of any delays occurring during the pre-execution phases.

For pending projects that have not yet accumulated any delays as of the most recent monitoring date, it is necessary to forecast whether they will begin on time or will experience delays and be unable to meet the initially declared start date for the execution of the work to be done (in which case, the spending forecast will begin from the date forecast by the delay duration model).

To that end, a logistic regression model estimates the likelihood of a delay for each individual project. This model uses both the projects that are already under way and those that are still pending but which are already delayed, and can be expressed as follows:

---

[13] Projects are considered launched when the start date is prior to the monitoring date, even if indicated as expected in the timetable.

$$\pi_i = \frac{\exp y_i}{1+\exp y_i} = \frac{\exp(\beta_0 + \beta_1 x_{1i} + ... + \beta_n x_{ni})}{1+\exp(\beta_0 + \beta_1 x_{1i} + ... + \beta_n x_{ni})} \quad (1)$$

$$\Rightarrow y_i = \log\frac{\pi_i}{1-\pi_i} = \beta_0 x_0 + \beta_1 x_{1i} + ... + \beta_n x_{ni} = BX_i \quad (2)$$

where:

$\pi_i = \Pr(z_i = 1)$, $z_i =$ 0 if the project is still on time; 1 if the project is delayed

$x_0 = 1$

X_i : explanatory variables vector for the i-th project

$B = (\beta_0, \beta_1, ..., \beta_n)$: unknown parameters vector

The results of the model are applied to all pending projects that are still on schedule, thereby assigning each project a "probability of delay" estimate based on the values observed for the explanatory variables.

Therefore, all projects for which the estimated probability is greater than 0.5 will be considered delayed. For these projects, and for the other pending projects that are already delayed, the start date is forecast by applying the duration model.

II.2.2 Applying the model to the APQ projects

The model that estimates the likelihood of a delay was applied to 9,346 projects found in the APQ database.[14] Of these, 7,090 launched and pending projects (76 per cent) were delayed, with 2,256 starting as scheduled. The model excluded 1,366 pending projects that were still on schedule (see Table II.2).

[14] The final model was obtained by excluding outliers, i.e. the observations that contribute most to discordance between observed values and the values predicted by the model. The criteria followed in identifying outliers are based on the amount of change in the deviation that results from eliminating the observation. Specifically, observations were excluded when they corresponded to a change in the deviation greater than the 90th percentile of the relative distribution.

Table II.2 Project delays

Category	Number	Total
Delayed (launched and pending)	7,090	
On schedule (launched)	2,256	
Projects included in the model		**9,346**
On schedule (pending)	1,366	
Projects excluded from the model		**1,366**
Total projects monitored		**10,712**

Source: UVER based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

The explanatory variables used included: Log cost, Geographic area, Type of project, Expected duration of work, CIPE resolution, Type of promoting body, Type of implementing body, Planning as of signing, and Sector. Both simple effects and first-order interaction effects were taken into consideration.

II.2.3 The results

The likelihood of a delay is clearly influenced by the explanatory variables (and certain interactions between them) used in the model, which are highly significant (Table II.3).

Table II.3 Explanatory variables included in the logistic model

Variable	Significance[15]
Log cost	***
Geographic area	**
Type of project	***
Expected duration of work	***
CIPE resolution	***
Type of promoter	***
Type of implementer	***
Planning as of signing	***
Sector	***
Log cost * Geographic area	**
Log cost * Type of project	***
Log cost * Planning as of signing	***
Geographic area * Expected duration of work	***

Source: UVER forecasting system based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

15 ***, **, * indicate significance level of 1, 5 and 10 per cent , respectively.

The percentage of concordant, discordant, and tied pairs (Table II.4)[16] indicates that the logistic model has strong predictive power.

Table II.4 Association between probability estimates and observed values

Pairs	%
Concordant	97.1
Discordant	2.9
Tied	0.0
Number of pairs: 10,015,569	100.0

Source: UVER forecasts on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12. 2005)

Table II.5 below shows the estimated parameters for the individual variables. For the purposes of interpreting the values obtained, all other factors remaining constant, for categorical variables, the higher the value the greater the likelihood of a delay; whereas for continuous variables, a positive value indicates that an increase in the variable corresponds to an increase in the likelihood of delay.

[16] For all possible pairs with values different from z (0 or 1, where 1 is the event concerned), a pair is said to be *concordant* if the probability estimated by the model for the observation where z=0 is less than the estimate for z=1; otherwise, it is said to be *discordant*, unless the probability is identical, in which case it is said to be *tied*.

Table II.5 Logistic model for the probability of delay

Variable	Level[17]	$\hat{\beta}$	Significance[18]
Intercept		-7.94	***
Log cost		0.74	***
Geographic area	North	-1.67	*
	Centre	0.81	
	Southwest	-2.77	**
	Southeast	0.48	
	Islands	*0.00*	
Type of project	Other	4.00	***
	New construction	1.81	**
	Recovery/restoration	-5.13	***
	Services	*0.00*	
Expected duration of work	Less than 1 year	1.54	***
	From 1 to 2 years	1.47	***
	From 2 to 3 years	0.30	**
	More than 3 years	*0.00*	
CIPE resolution	No FAS	-2.03	***
	Previous resolutions	0.53	***
	36/02-17/03-20/04-35/05	*0.00*	
Type of promoting body	Regional govt.	0.04	
	Other local govt. or ent.	-0.52	***
	Conc. or net./infr. mgmt co.	-0.30	
	Ministries	-0.50	***
	Other	*0.00*	

(cont.)

[17] The levels in italics are those chosen as reference.
[18] ***, **, * indicat significance level of 1, 5 and 10 per cent , respectively.

(cont.)

Variable	Level[19]	$\hat{\beta}$	Significance[20]
Type of implementing body	Regional govt.	-0.69	***
	Other local govt. or ent.	0.66	***
	Conc. or net./infr. mgmt co.	1.34	***
	Ministries	-1.29	***
	Other	*0.00*	
Planning as of signing	None indicated	3.74	**
	None	0.26	
	Feasibility study	-2.73	*
	Preliminary	-3.79	***
	Definitive	-2.01	
	Executive	*0.00*	
Sector	Other transport	-0.06	
	Environment	0.64	***
	Assistance and charity	-2.62	***
	Integrated water system	-0.40	**
	Culture and recreational serv.	-0.03	
	Building	4.05	***
	Education/training/R&D	-2.37	***
	Industry and services	-0.62	*
	Waste management	1.10	
	Telecommunications	-0.30	
	Tourism	-2.00	***
	Other	2.46	***
	Roads	*0.00*	
Log cost * Geographic area	North	-0.07	
	Centre	-0.03	
	Southwest	0.21	***
	Southeast	-0.06	
	Islands	*0.00*	
Log cost * Type of project	Other	-0.35	***
	New construction	-0.06	
	Recovery/restoration	0.43	***
	Services	*0.00*	
Log cost * Plan. as of signing	None indicated	-0.53	***
	None	-0.08	
	Feasibility study	0.33	**
	Preliminary	0.46	***
	Definitive	0.26	**
	Executive	*0.00*	

(cont.)

[19] The levels in italics are those chosen as reference .
[20] ***, **, * indicate significance level of 1, 5 and 10 per cent , respectively.

(cont.)

Variable	Level[21]		$\hat{\beta}$	Significance[22]
Geo. area * Exp. duration of work	North	Less than 1 year	0.79	***
	North	From 1 to 2 years	-0.34	*
	North	From 2 to 3 years	-0.32	
	North	*More than 3 years*	*0.00*	
	Centre	Less than 1 year	-0.22	
	Centre	From 1 to 2 years	-0.79	***
	Centre	From 2 to 3 years	0.04	
	Centre	*More than 3 years*	*0.00*	
	Southwest	Less than 1 year	-0.46	**
	Southwest	From 1 to 2 years	1.19	***
	Southwest	From 2 to 3 years	-0.99	***
	Southwest	*More than 3 years*	*0.00*	
	Southeast	Less than 1 year	0.26	
	Southeast	From 1 to 2 years	0.44	*
	Southeast	From 2 to 3 years	0.52	**
	Southeast	*More than 3 years*	*0.00*	
	Islands	*Less than 1 year*	*0.00*	
	Islands	*From 1 to 2 years*	*0.00*	
	Islands	*From 2 to 3 years*	*0.00*	
	Islands	*More than 3 years*	*0.00*	

Source: UVER forecasting system based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

Below is a detailed analysis of the individual variables:

- **Log cost:** the likelihood that a project will be delayed generally increases as the cost of the project increases. However, the effect of this variable varies based on the geographic area, type of project, and the planning as of signing, with the effect being accentuated in the Southwest, as the positive value of this parameter indicates. The effect is also greater for recovery and restoration work, while it is lower for "Other". Furthermore, the effect of total cost is greater for projects that have been added to the APQs after completion of the feasibility study and/or the preliminary or definitive plan;
- **Geographic area:** the parameters, which are to be analyzed together with those of the expected duration of the work, for which the interaction effect has been calculated, show that there is the least likelihood of delay in the Southwest and that the likelihood increases progressively in the North, the Islands, Centre, and in the Southeast, where the likelihood of delay is greatest. However, considering the interaction effect with cost, this phenomenon diminishes;

[21] The levels in italics are those chosen as reference.
[22] ***, **, * indicate significance level of 1, 5 and 10 per cent , respectively.

- **Type of project:** compared with Services, which was set as the reference level, recovery and restoration and new construction generally show a greater likelihood of delay. However, the interaction effect with cost indicates that the difference between the various categories narrows as total costs increase, given that the parameter associated with the interaction between the various types of projects and the logarithm of cost has the opposite sign to that of the simple effect on its own;

- **Expected duration of work:** the longer the expected duration of a project, the lesser the likelihood it will experience a delay. The interaction effect with geographic area shows that this phenomenon is more accentuated in the North and Southeast than it is in central Italy, whereas in the Southwest, this regularity is interrupted by projects with durations in the range of 1 to 2 years, which have a greater likelihood of delay that projects of less than 1 year;

- **CIPE resolution:** on the whole, projects that are not covered by FAS resources are less likely to experience delays than those that are financed in accordance with recent resolutions (36/2002, 17/2003, 20/2004, and 35/2005). These, in turn, are less likely, although to a lesser extent, to experience delays than projects related to previous resolutions;

- **Type of promoting body:** projects promoted by non-regional local authorities or ministries are less likely to experience delays than those promoted by other entities. The parameter is also negative for concession holders and network and infrastructure operators, but the value is not significant;

- **Type of implementing body:** with regional governments and ministries, there is a lesser likelihood of delay. For the other implementing bodies, however, the effect is the opposite of that of the corresponding promoting body level, with the parameters for other local authorities and entities and concession holders and network operators being positive;

- **Planning as of signing:** compared with the projects that had already completed the executive plan by the time of the signing of the related APQ, those without planning or for which there is no information are more likely to experience delays in the start of the related work. Conversely, projects that have a minimum amount of planning, i.e. feasibility studies, are less likely to experience delays. However, the effect of the level of planning varies with the size of the project, and we have seen a general attenuation of the differences between the various categories as the cost increases. In fact, the parameters related to the interaction effect of this variable with cost are of the opposite sign from those of the simple effect on its own;

- **Sector:** the sectors with the lowest likelihood of delays are assistance and charity, education/training/R&D, and tourism, while building and other show the highest probability of delay.

Extending the results of the model to the projects that are still on schedule, with delayed projects being those with an estimated probability of delay of greater than 0.5, it turns out that 90 per cent of the projects are delayed, while only the remaining 10 per cent are expected to start as scheduled.

II.3 The delay duration model

II.3.1 The theory

Hazard models have been used in order to forecast the start date for the execution of the work to be done for delayed projects that have yet to begin. With this type of model, it is possible to use the data of both launched projects for which the start date and delay are known quantities and of those that are still pending, for which the delay is cumulative and all that is known is that the actual start date will be subsequent to the latest observation date. The former are referred to as *uncensored*, while the latter are known as *censored* observations.

This type of model parameterises the risk that a given event will occur at a certain point in time *t*, assuming that it has not yet occurred as of $t-\Delta t$. We indirectly obtain an estimate of the amount of time *t* until the event will occur.

The hazard function is expressed as follows:

$$h(t)=\lim_{\Delta t\to 0}\Pr(t\le T<t+\Delta t\,|\,T\ge t) \qquad (3)$$

where T is the random variable that measures the time of occurrence of the event. The function *h(t)* can be interpreted as the instant probability that a given event that has not yet occurred will occur.

In duration models, it is assumed that the logarithm of the hazard function *h(t)* is a linear function of time *t* and a series of explanatory variables, $x_1,...,x_n$, which represent the characteristics of the projects:

$$\log[h(t)] = f(t, x_1,....,x_n) = \beta_0 t + \beta_1 x_1 + ... + \beta_n x_n \qquad (4)$$

Assumptions as to the probability distribution of the random time variable *T*[23] correspond to specific hypotheses as to the dependency of the risk *h(t)* on time. These are known as parametric models, and the most common distributions are exponential or Weibull.

Because we are interested in estimating the duration of the delay, which, in our case, is equivalent to the random variable *T,* it is possible to consider the effect of the explanatory variables on *T*, rather than on risk. As such, we can write the equation as:

$$\log T = \alpha_0 + \alpha_1 x_1 + ... + \alpha_n x_n + \sigma\varepsilon \qquad (5)$$

This equation, which we use in our system, does not allow us to directly estimate a value for *T*, but for the parameters of its distribution, as observations of *T* can be censored. The α_i are unknown parameters associated with the explanatory variables x_i[24], α_0 is the intercept and σ is the parameter associated with the random variable ε, which presents the distance of the value of log *T* from the linear portion of the model.

From the results of the model, we can obtain an estimate of the duration of the start-up delay using the median value[25] of the *T* distribution. Therefore, the expected start date is obtained by adding the estimated duration of the delay to the date declared upon signing the agreement.

[23] D.R. Cox (1972) proposed an alternative "semi-parametric" model which requires no assumption for the probability distribution of the time variable *T*.

[24] There is a direct relationship between the parameters β_i of (4) and the a_i of (5), which depends on the assumed distribution of *T*. In general, given that β_i measures the effect of the variable x_i on the hazard function and a_i the effect of the same variable on the time that has passed since the event occurred, the higher the value of the first, which corresponds to a high probability that the event will occur, the lower value of the second, which is associated with rapid occurrence times. See D. Collett (1994).

[25] In the case of duration models, in which censored observations are considered along with the actual uncensored durations, it is more appropriate to use the median duration, rather than the mean, as the estimated mean survival duration cannot always be calculated in non-parametric models in cases in which the frequency of censored durations is particularly high.

II.3.2 Applying the model to the APQ projects

In order to estimate and forecast the duration of the start-up delay, a parametric hazard model was used.

In the case of the APQs, we set the duration of the delay to the time T from the expected start date at the time the agreement was signed to the actual start date. As such, for launched projects we have uncensored durations, while for pending projects the durations are censored and are calculated based on the time that has passed up to the most recent monitoring date.

We have assumed a Weibull distribution for T, which corresponds to a monotonic risk distribution $h(t)$.

This decision was based on an analysis of the relationship between the observed survival function, $S(t)$, and the time t. On the assumption that T is a Weibull distribution, the following relationships apply:

$$f(t) = -\lambda\gamma \exp(-\lambda t^{\gamma}) \qquad (6)$$

$$S(t) = \exp(-\lambda t^{\gamma}) \qquad (7)$$

where λ and γ are scale and shape parameters, respectively.

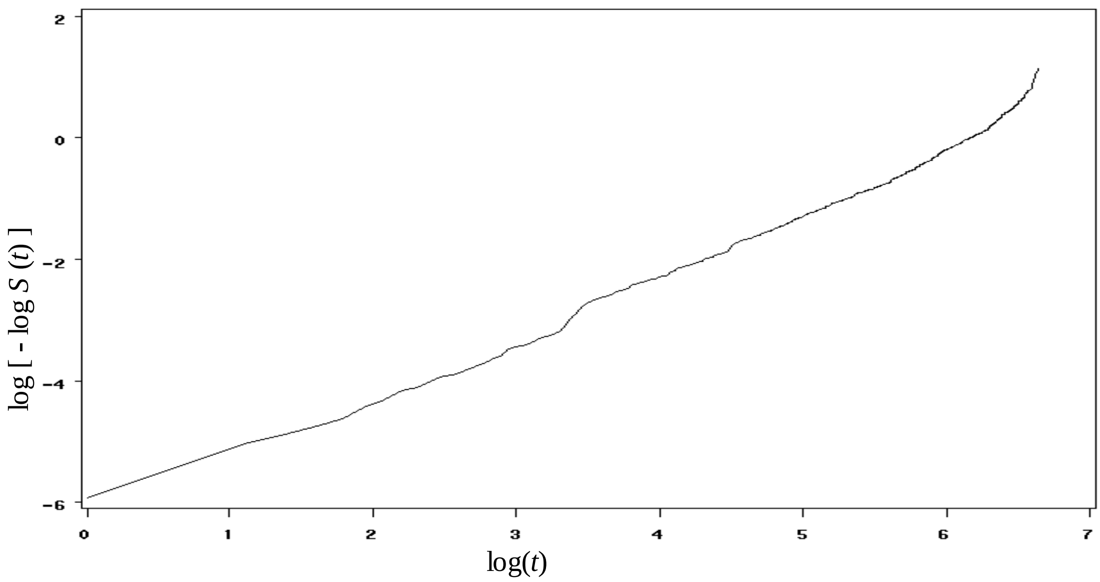
In particular, beginning with the definition of the survival curve $S(t)$, if the assumption of a Weibull distribution for T holds true, then the following relationship applies:

$$\log[-\log(S(t))] = \log\lambda + \gamma \log t \qquad (8)$$

so a graph of the pairs of values $\log[-\log(S(t))] = \log\lambda + \gamma \log t$ is a straight line.

Figure II.2 below shows the graph obtained based on the observed data, from which we can deduce that the assumption that T is a Weibull distribution is essentially acceptable.

Figure II.2 Negative log-log of the estimate of the survival function based on the logarithm of duration



Source: UVER based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

The data is based on 7,090 projects (see Table II.1), both launched and pending, that were delayed as of the latest available monitoring update.[26]

Of the projects with uncensored delays (i.e. those with an actual start date), the distribution of the observed delay was rather dispersed, with an average of 304 days and a standard deviation of 282 days. Taking account of the duration of censored delays (i.e. those of the delayed but pending initiatives), comparable values are obtained. Given that the censored delays continue, by definition, to increase, the average actual delay is also destined to grow.

Because the duration model used falls under the category of "proportional hazard" models, we have verified the validity of the assumption of the proportionality of observed hazard in relation to the various modalities taken into consideration.[27]

The explanatory variables used in the model included: Log cost, Geographic area, Type of project, CIPE resolution, Type of implementing body, Planning as of signing, and

[26] Outliers (i.e. projects with delays above the 90th percentile) have been excluded from the estimate. Excluding these observations provided a better fit of T to the Weibull distribution.
[27] See D. Collett (1994).

Sector. Both simple effects and first-order interaction effects were taken into consideration.[28]

II.3.3 *The results*

The duration of the delay is clearly influenced by the explanatory variables (and certain interactions between them) used in the model, all of which are highly significant (Table II.6).

Table II.6 Explanatory variables included in the duration model

Variable	Significance[29]
Log cost	***
Geographic area	***
Type of project	***
CIPE resolution	***
Type of implementing body	***
Planning as of signing	***
Sector	***
Log cost * Type of initiative	***

Source: UVER forecasting system based on APQ data (monitoring as of 30.06. 2005 and agreements as of 31.12.2005)

Table II.7 below shows the estimated parameters for the individual variables. For the purposes of interpreting the values obtained, all other factors remaining constant, for categorical variables, the higher the value the greater the duration of the delay; whereas for continuous variables, a positive value indicates that an increase in the variable corresponds to an increase in the duration of the delay.

[28] For this model, the type of promoting body was not used because it was found to be not significant.
[29] ***, **, * indicate significance level of 1, 5 and 10 per cent , respectively.

Table II.7 Start-up delay duration model

Variable	Level[30]	$\hat{\alpha}$	Significance[31]
Intercept		3.69	***
Log cost		0.14	***
Geographic area	North	-0.63	***
	Centre	-0.43	***
	Southwest	-0.29	***
	Southeast	-0.28	***
	Islands	*0.00*	
Type of project	Other	0.60	
	New construction	1.75	**
	Recovery/restoration	0.57	
	Services	*0.00*	
CIPE resolution	No FAS	0.19	***
	Previous resolutions	0.24	***
	36/02-17/03-20/04-35/05	*0.00*	
Type of implementing body	Regional govt.	0.17	***
	Other local govt. or ent.	-0.18	***
	Conc. or net./infr. mgmt co.	0.52	***
	Ministries	0.10	
	Other	*0.00*	
Planning as of signing	None indicated	-0.75	***
	None	0.42	***
	Feasibility study	0.50	***
	Preliminary	0.40	***
	Definitive	0.28	***
	Executive	*0.00*	
Sector	Other transport	-0.10	
	Environment	-0.02	
	Assistance and charity	-1.41	***
	Integrated water system	-0.11	**
	Culture and recreational serv.	0.00	
	Building	-0.05	
	Energy	1.06	***
	Education/training/R&D	0.06	
	Industry and services	0.08	
	Waste management	0.29	*
	Health	0.33	***
	Telecommunications	-0.03	
	Tourism	0.63	**
	Other	0.17	
	Roads	*0.00*	
Log cost * Type of project	Other	-0,04	
	New construction	-0,10	*
	Recovery/restoration	-0,01	
	Services	*0,00*	
Weibull shape		1,27	

Source: UVER forecasting system based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

[30] The levels in italics are those chosen as reference.
[31] ***, **, * indicate significance level of 1, 5 and 10 per cent , respectively.

Below is a detailed analysis of the individual variables:

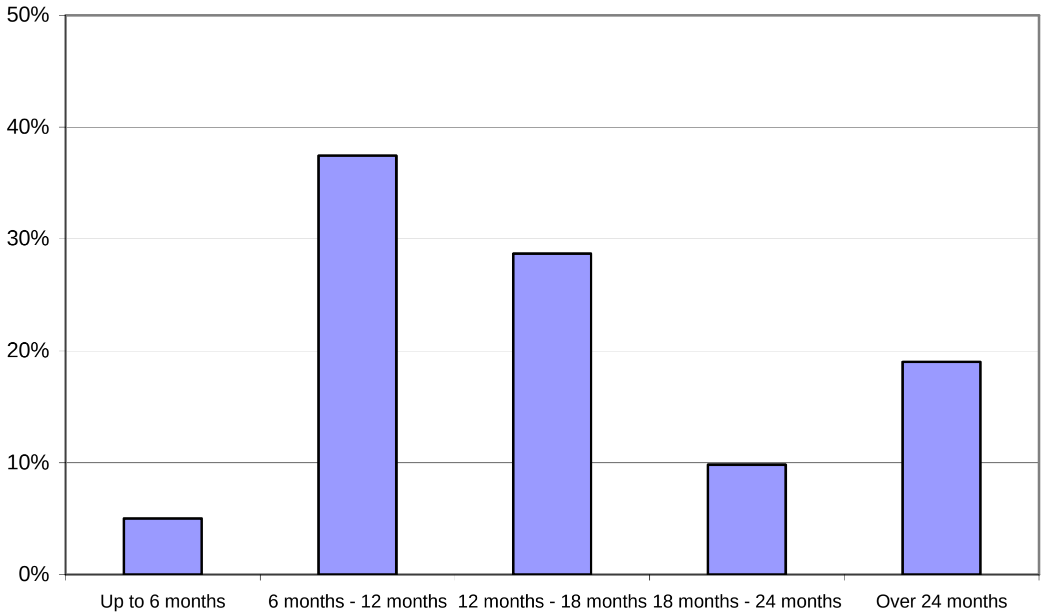
- **Log cost:** the positive parameter indicates that,as cost increases, the delay also increases;
- **Geographic area:** the start-up delay is greatest for the Islands and progressively declines as we go from the South to Central and then to Northern Italy, where the negative value is highest is absolute terms;
- **Type of project:** new construction recorded the greatest delays, with services having the shortest delays, but when observing the interaction effect with cost, we see that the difference between the various types tends to narrow as total cost increases;
- **CIPE resolution:** the duration of the start-up delay is highest for the initiatives without FAS resources or funded with resolutions prior to 36/02, as compared with those that are related to more recent resolutions, confirming the positive effect of the new rules;
- **Type of implementing body:** projects implemented by non-regional local governments generally experience shorter delays than those implemented by other entities, whereas the delays are higher for concession holders, network and infrastructure operators, and the regional governments;
- **Planning as of signing:** projects with less advanced planning experience greater delays that those with executive plans. As would be expected, the delay decreases as the level of planning increases. However, the projects for which no information was available experienced shorter delays. This is due to the fact that often, when the amount of planning as of the signing date is not specified, the project is already at a more advanced stage of implementation;
- **Sector:** the sectors with the greatest delays are energy, tourism, health, and waste management, whereas assistance and charity and, to a lesser extent, integrated water system generally experience shorter delays.

The parameter γ, equal to 1.27, indicates that the hazard function *h(t)* and, therefore, the likelihood of a delay, increase over time in progressively smaller increments.

As such, the duration of the delay estimated in this manner is only used for projects which, according to the above model, have a probability of delay which is greater than

0.5. We should also clarify that, for the pending projects in APQs signed less recently, the model's forecasts may not sufficiently represent the actual delays experienced.[32] In such cases, it has been decided to maintain the estimated start date as set by the government entities in question. Figure II.3 is a graph of the percentage of projects in the various categories of delay.

Figure II.3 Distribution of the number of projects by estimated delay (pending projects with an estimated probability of delay of greater than 0.5)



Source: UVER forecasting system based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

Therefore, the forecast is for just over 40 per cent of all delayed projects to be delayed by less than 12 months, with nearly 30 per cent being between 12 and 18 months and a further 10 per cent not exceeding 24 months. Finally, a significant portion – about 20 per cent – is expected to start more than 24 months after the originally scheduled start date. The distribution of the delays estimated by the model has an average value of 687 days and a standard deviation of 421 days, which is greater than that of the delays actually recorded (see section II.3.2). In other words, on average, it is expected that the pending projects will experience greater start-up delays than those that have already begun.

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[32] This was actually encountered in 16 per cent of all projects, to a degree increasing with the length of time since the signing of the related APQ.

II.4 The expenditure model

II.4.1 The theory

The model is based on information on the annual expenditure carried out for each project.

The dependent variable is the cumulative percentage of expenditure carried out[33] up to time *t*. In the model, time is introduced using an index that identifies the reference period and makes it possible to express expenditure on a project as a function of the corresponding expenditure carried out up to the previous period. Essentially, this gives:

$$y_t = f(y_{t-1}, \overline{X}) \tag{9}$$

where y_t is the cumulative percentage of expenditure carried out up to time t and $\overline{X}$ is a vector of explanatory variables.

The difference equation representing logistic growth in spending, according to the assumed model of reality (see section I.3), is the following:[34]

$$y_t = \frac{\lambda y_{t-1}}{1 + (\lambda - 1) y_{t-1}} \tag{10}$$

Using the transformed logit:

$$\tilde{y}_t = \text{logit}(y_t) = \log \frac{y_t}{1 - y_t} \tag{11}$$

(10) can be rewritten as:

$$\tilde{y}_t = \log \lambda + \tilde{y}_{t-1} \tag{12}$$

that is:

$$\tilde{y}_t - \tilde{y}_{t-1} = \log \lambda = \alpha \tag{13}$$

In other words, assuming that the progress of a project follows a logistic growth curve is equivalent to stating that the difference between the two successive values of the transformed logit of the curve is constant over time. In actual fact, an analysis of the data observed shows that this assumption does not actually hold up, since for each

[33] Expressed in relative terms, i.e. between 0 and 1.
[34] See E. C. Pielou (1977).

project the values of the difference $\tilde{y}_t - \tilde{y}_{t-1}$ recorded for the various timeframes are not concentrated around their mean value. In fact, the corresponding divergences from the mean follow an essentially uniform distribution within the interval [-1, 1].

Further analysis shows that the increments $\tilde{y}_t - \tilde{y}_{t-1}$ decrease as time t increases. Consequently, a further term that decreases over time is introduced in (13):

$$\tilde{y}_t - \tilde{y}_{t-1} = \alpha - (1-\beta)\tilde{y}_{t-1} \quad (14)$$

and enables the equation for estimation to be rewritten as:

$$\tilde{y}_t = \alpha + \beta\tilde{y}_{t-1} \quad (15)$$

The parameters (α, β) can therefore be estimated on the basis of the explanatory variables $\overline{X}$ using a linear regression.

II.4.2 Reconstruction on a quarterly basis

The observations available to estimate the parameters are limited by two constraints.

The first concerns the fact that the model uses a difference equation. In this case, each observation used to estimate the parameters involves both $\tilde{y}_t$ as a dependent variable and $\tilde{y}_{t-1}$ as explanatory. Consequently, projects with expenditure in just e year, cannot be used to estimate the parameters as only their $\tilde{y}_t$ values are available, while the corresponding $\tilde{y}_{t-1}$ value is missing.

The second constraint arises from the fact that when y_t takes the value 0 or 1, in the case respectively of nil expenditure or completed expenditure, the corresponding transformed logit diverges. This situation is caused by the fact that the progression described by a pure logistic curve reaches 100 per cent only for infinitely long time periods, whereas the projects are actually completed in finite time periods. In other words, the assumed model of reality does not adapt to extreme values of the progression, which are therefore excluded from the analysis.

As a solution adopted to apply the analyses to finite and comparable values, [0.05, 0.95] is considered as a new interval of definition for y_t, to which corresponds a range of variation for the transformed logit of [-2.94, 2.94]. All y_t values outside the interval [0.05, 0.95] are therefore discarded.

To minimise the reduction in observations, and therefore projects, imposed by the constraints, the information base is expanded by reconstructing the expenditure data series on a quarterly basis using linear interpolation. This procedure also makes it possible to retrieve all the projects with spending concentrated in just one year, for which the annual y_{t-1} is not available and which would therefore have been excluded from the parameter estimation if a quarterly basis had not been used. This procedure, which is necessary to obtain an artificial increase in the number of observations, does not detract from the reliability of the forecests, since the measures of the goodness of fit of the model, based solely on the data actually observed, are very satisfactory (see section II.4.4).

For APQ projects, therefore, t denotes the quarter under consideration[35] and the model estimate refers to the cumulative expenditure incurred up to generic quarter t. Spending forcests were subsequently re-adjusted to annual time intervals.

II.4.3 Application of the model to APQ projects

The data used to estimate the model refer to 15,549 observations concerning 3,182 projects under way[36] at the latest monitoring date. Reconstructed spending data for quarters preceding the start date have been excluded.

As explanatory variables, in addition to the transformed logit of the percentage of expenditure incurred up to quarter t–1, the following were also considered[37]: Cost (in level),Geographical area, Type of project, Expected duration of works, CIPE resolution, Type of promoting body, Type of implementing body and Sector. The effects of the interaction between the lagged dependent and cost and the Expected duration were also considered.

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35 The index t is included in the interval [0, ∞).

36 The total number of projects launched is 6,308. Of these, 1,057 have spent nothing and cannot be considered in the model, while 2,069 have been excluded as a result of the cuts required on the transformed logit. It should be noted that if the data were not considered on a quarterly basis, the number of useful initiatives would be further reduced from 3,182 to 1,099.

37 The dichotomous variable indicating project start-up delays was initially considered as another explanatory variable. However, this variable was not to be significant and has therefore been excluded from the model.

II.4.4 The Results

Speed of expenditure is clearly influenced by the explanatory variables (and a number of interactions between them) included in the model, all of which are highly significant (Table II.8).

Table II.8 Explanatory variables included in the expenditure model

Variable	Significance[38]
Cost	***
Geographical area	***
Type of project	**
Expected duration of works	***
CIPE resolution	*
Type of promoting body	
Type of implementing body	***
Sector	***
$\tilde{y}_{t-1}$	***
$\tilde{y}_{t-1}$ * Cost	***
$\tilde{y}_{t-1}$ * Expected duration of works	***

Source: UVER forecasting system based on APQ data (monitoring as of 30.12.2005 and agreements as of 31.12.2005)

Table II.9 shows the estimated parameters for individual variables. Other factors being equal, to interpret the values obtained, for categorical variables not associated with cumulative expenditure at time *t*-1, higher values of the parameters correspond to faster expenditure. For categorical variables present both alone and associated with cumulative expenditure to time *t*-1 (cost, expected duration of works), the effect of variations in the parameters on the speed of expenditure is not immediately visible. In fact, this effect varies as a function of the percentage of expenditure already incurred.

More specifically, if we define:

$$\tilde{y}_{threshhold} = -\Delta\alpha / \Delta\beta \qquad (16)$$

we have an increase in speed if the condition:

$$(\tilde{y}_t - \tilde{y}_{threshhold})\Delta\beta > 0 \qquad (17)$$

is satisfied and vice versa.

[38] ***, **, * indicate a significance level of 1, 5 and 10 per cent respectively.

The overall effect of the differences between the levels for these variables is shown in Table II.10.

Table II.9 Expenditure model

Variable	Levels[39]	Estimated parameter	Significance[40]
Intercept		0.27	***
Cost	Up to 0.1 M euros	0.38	***
	From 0.1 to 1 M euros	0.24	***
	From 1 to 10 M euros	0.09	***
	More than 10 M euros	*0.00*	
Geographical area	North	0.03	
	Centre	-0.07	***
	South-West	-0.03	
	South-East	-0.02	
	Islands	*0.00*	
Type of project	Other	0.09	**
	New construction	0.09	***
	Recovery-restoration	0.11	***
	Services	0.00	
Expected duration of works	Up to 1 year	0.26	***
	From 1 to 2 years	0.15	***
	From 2 to 3 years	0.07	***
	More than 3 years	0.00	
CIPE resolution	No FAS	-0.08	***
	Previous resolutions	-0.02	
	36/02-17/03-20/04-35/05	*0.00*	
Type of promoting body	Regional govt.	0.05	
	Other local govt. or ent.	0.10	***
	Conc. or net./infr. mgmt co.	0.05	
	Ministries	0.06	
	Other	*0.00*	

Cont.

[39] The levels indicated in italics are those chosen as reference.
[40] ***, **, * indicate a significance level of 1, 5 and 10 per cent respectively.

Cont.

Variable	Level[41]	Estimated parameter	Significance[42]
Type of implementing body	Regional govt.	0.02	
	Other local govt. or ent.	-0.05	***
	Conc. or net./infr. mgmt co.	-0.13	***
	Ministries	-0.04	
	Other	*0.00*	
Sector	Other transport	0.00	
	Environment	-0.06	***
	Assistance and charity	-0.18	***
	Integrated water system	-0.08	***
	Culture and recreational serv.	-0.12	***
	Building	0.03	
	Energy	0.05	
	Education-training-R&D	-0.05	
	Industry and services	-0.13	***
	Waste management	-0.31	***
	Health	-0.24	***
	Telecommunications	-0.07	
	Tourism	-0.02	
	Other	-0.15	***
	Roads	*0.00*	
$\tilde{y}_{t-1}$		0.90	***
$\tilde{y}_{t-1}$ * Cost	Up to 0.1 Meuros	-0.09	***
	From 0.1 to 1 Meuros	-0.04	***
	From 1 to 10 Meuros	0.01	
	More than 10 Meuros	0.00	
$\tilde{y}_{t-1}$ * Expected duration of works	Up to 1 year	-0.08	***
	From 1 to 2 years	-0.02	**
	From 2 to 3 years	0.00	
	More than 3 years	*0.00*	

Source: UVER forecasting system based on FPA data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

[41] The levels indicated in italics are those chosen as reference.
[42] ***, **, * indicate a significance level of 1, 5 and 10 per cent respectively.

Table II.10 **Effect on the speed of expenditure of variations in the cost and expected duration of works parameters**

Variable	Change in levels	$\Delta\hat{\alpha}$	$\Delta\hat{\beta}$	$\tilde{y}_{threshhold}$	$y_{threshhold}$
Cost category	from [0-0.1] to [0.1-1] meuros	-0.14	0.05	2.77	94 %
	from [0.1-1] to [1-10] meuros	-0.15	0.05	3.28	96 %
	from [1-10] to *More than 10 meuros*	-0.09	-0.01	-10.24	0 %
Exp. dur. works.	from [0-1] to [1-2] years	-0.11	0.05	1.97	88 %
	from [1-2] to [2-3] years	-0.08	0.02	3.32	97 %
	from [2-3] to *More than 3 years*	-0.07	-0.00	660.45	100 %

Source: UVER forecasting system based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

If we analyse the results for the explanatory variables, the following observations can be made:

- **Cost**: as expected, the speed of expenditure diminishes more or less systematically as the amount of funding increases (see Table II.10). In effect, as the variable in question is the cumulative percentage of expenditure which, other values being equal, can represent a wide range of sums,as the total amounts of the project may range over different orders of magnitude, the parameters confirm the reasonable hypothesis that smaller sums will be spent more quickly;
- **Geographical area**: other factors being equal, only projects in central Italy are significantly slower than all the others;
- **Type of project**: other factors being equal, only services are significantly slower than all other types of project;
- **Expected duration of works**: in line with the results for the total amount involved, for the expected duration of the works the combined effect of the parameters (see Table II.10) indicates that the speed of expenditure diminishes systematically as the duration increases;
- **CIPE resolution**: the speed of expenditure is lower for non-FAA projects; the additional improvement seen for recent resolutions is not statistically significant;
- **Type of promoting body:** initiatives by non-regional local authorities show faster expenditure than all the others;

- **Type of implementing body**: for non-regional local authorities, the negative parameter partly offsets the greater speed of expenditure indicated in the case of the promoting body; for concession holders or network and infrastructure operators the negative parameter indicates slower expenditure;
- **Sector**: other factors being equal, the fastest rate of expenditure is found for projects in transport-related sectors (traffic and road networks and other transport). Sectors with lower speeds are, in order: waste management, health, assistance and charity, industry and services, culture and recreational services, integrated water systems and environment.

III. Spending forecasts

III.1 Combining the models

The final forecasts are the result of combining the three models presented. The yearly spending forecest is obtained for each project, the cumulative quarterly expenditure forecest obtained by (15).

For quarters in which actual expenditure was carried out the observed value:

$$\hat{y}_t = y_t \qquad (18)$$

was considered.

Moreover, since the projections depend on the initial conditions of the projects, for those not yet under way the following decisions had to be made with respect to the start-date and amount spent in the first quarter:

- start-date: for projects with a start-up delay the first quarter is taken to be the quarter corresponding to the estimated start date using the duration model. If this pre-dates the one declared in the latest monitoring, then the latter is considered. For all other projects the quarter in which the start-date indicated at the time of signing considered.
- expenditure for the first quarter y_0 : the inclusion of the lagged dependent variable y_{t-1} in the model requires a value to be set for quarter $t=0$ during the forecasting stage, from which to begin the spending forecast. For all projects in

which no expenditure was actually made,[43] an arbitrary initial expenditure value of y_0=0.01 is set. For projects in which expenditure was carried out before the start of the works the cumulative percentage of expenditure already incurred was taken as the starting value.

From the quarterly cumulative percentage, obtained by inverting (11), the percentage breakdown of expenditure carried out on an annual basis is reconstructed:

$$\hat{y}_a = \hat{y}_{t+4} - \hat{y}_t \tag{19}$$

and from this, the annual spending forecest in absolute terms:

$$\hat{s}_a = \hat{y}_a * \text{Cost of the project} \tag{20}$$

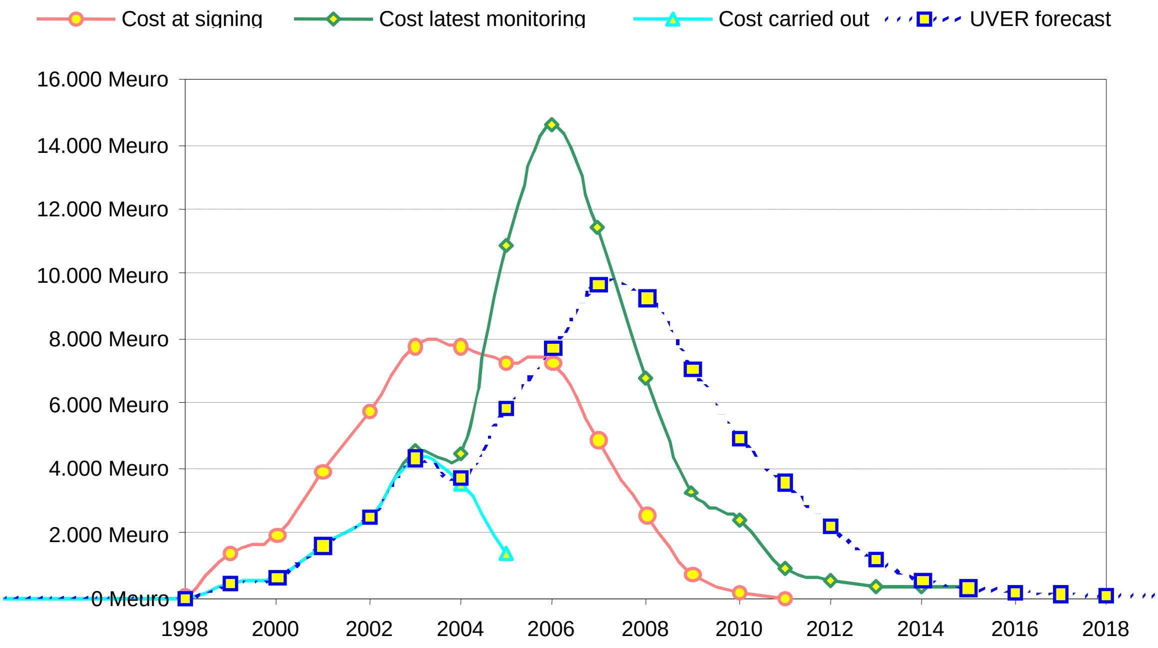
III.2 The spending curve

The forecast spending curve, obtained as the sum of the results of the entire forecasting system for each project, is shown in Figure III.1, along with the corresponding curves for expenditure plans at time of signing the agreement and at the latest monitoring.

It should be noted that the forecast are obtained using only the actual data for projects that already have a history of implementation (see section II.1). No direct connection therefore exists between the aggregate curve of the UVER forecast and the curves for spending plans at signing and at the latest monitoring.

[43] This approximation is needed because in this case the logit function does not take finite values, i.e. logit(0) = -∞.

Figure III.1 Spending distributions of APQ projects



Source: UVER forecasting system based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

Before analysing the system forecasts, we can already observe a shift in the cost curve at the latest monitoring from the cost at signing. This depends both on the late start of the projects and on a more gradual trend in expenditure carried out, on which basis the entities involved have reviewed the initial, overly optimistic, expenditure plans. However, the profile for the latest declarations appears to be more concentrated as though to indicate some expectancy of recovery.

The forecasting system curve shows an even greater delay, which suggests that even the government departments' most up-to-date projections continue to be overestimated. Moreover, spending appears to be distributed over a longer time span: according to the forecasts, it will not end in 2015, as currently envisaged by the departments, but will extend until about 2018.

Another factor that emerges is the considerable reduction in the maximum amount of expenditure in any given year which, compared with monitoring values of just under €15 billion, does not actually arrive at even €10 billion, according to the forecast.

III.3 Use of the forecasts

The forecasts make it possible first and foremost to anticipate spending data before they are actually available. It is possible, for example, to obtain an estimate for total expenditure for 2005 well before March 2006, the month when the data from the 31 December 2005 monitoring will be available. More specifically, compared with the available half-yearly figure for 2005, of about €1,300 million, the forcest indicate an estimated expenditure of about €5,800 million for the year as a whole.

Another important feature is the possibility of reconstructing missing data by substituting expected values. Figure III.1 shows that, for 2004, the figure for actual spending carried out does not coincide with that of the monitoring exercise. This can be explained by the fact that for a limited number of projects the update at 31 December 2004 is not available: in such cases the forecasting system makes it possible to fill in the missing data to obtain a more realistic total expenditure figure with respect to the monitoring plans.

The availability of forecast and monitoring data for individual projects enables multi-level analyses to be conducted by aggregating projects on various dimensions. It is therefore possible to read the data on a local rather than sectoral basis, or by type of project rather than source of funding, and so on. An attempt to conduct an in-depth analysis at the regional level on a specific set of financial resources, using a purpose-built index, is described below.

III.3.1 The shift index

The Shift Index (SI) provides a measure of the degree to which one expenditure distribution profile diverges over time from another, for the same overall amount of spending.

It is constructed as the sum of the differences between the cumulative spending profiles. If we consider two generic profiles of cumulative expenditure as y_1 and y_2, the divergence index for curve y_2 with respect to curve y_1 is given by:

$$SI = \sum_t (y_{2t} - y_{1t}) \qquad (21)$$

The unit of measurement of the shift index is given by the size of the interval indicated by index *t*. As the expenditure distributions are generally observed on an annual scale (see Figure III.1), the *SI* too will be expressed in years.

An index value of 1 is equivalent to saying that spending profile y_2 is shifted forward "on average" by one year with respect to profile y_1. It should be noted that the index does not express a delay in completion but an average delay in the distribution of spending.

If we return, for example, to Figure III.1, we can calculate a divergence index of 1.02 between the system forecest and the data for the latest monitoring. In other words, according to the forecesting system the expenditure will on average be incurred one year later with respect to the declarations made at the latest monitoring.

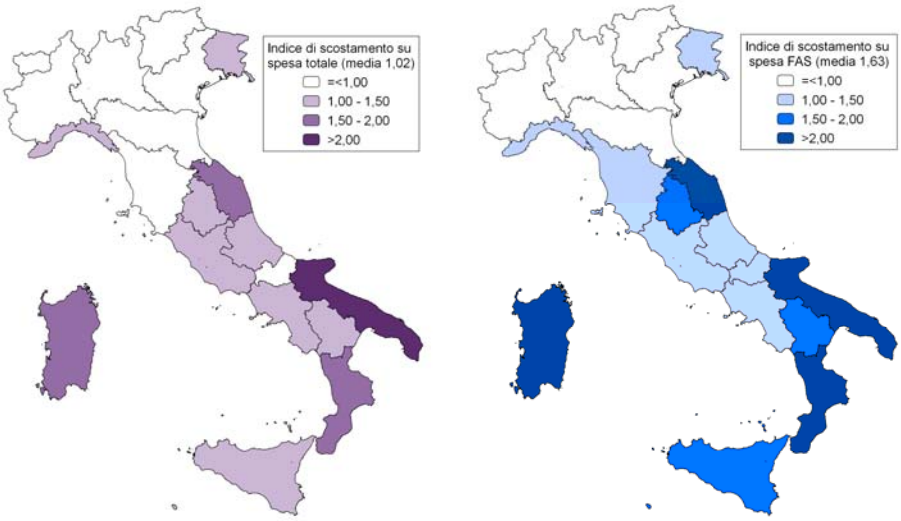
This index is calculated over the entire time period of the expenditure: the two profiles therefore are superimposed during the initial part (where the curves coincide, by definition, with the actual data), whose contribution to the index is nil. In other words, a correlation exists between the values of the index and a the residual spending. This means that the lower the residual expenditure, the lower the shift index will be: low shift indices may therefore depend in part on a high rate of advance in expenditure. In effect, for the expenditure of FAS resources[44] only we have a shift index of 1.63: this indicates that FAS expenditure is shifted an average of 7 months ahead of overall expenditure. This partly depends on the fact that significant values of FAS expenditure only began to be recorded in 2002.

It should be noted that, since the system forecasts take into account any differences in the distribution of expenditure as well as possible extensions of the time required for the pre-contractual stage, a positive value for the shift index of the system's forecest curve with respect tomonitoring plans corresponds to an estimate of the government departments' reliability, i.e. of how "optimistic" they tend to be. The shift index can therefore also be viewed as a measure of potential problems.

In the light of this interpretation, an analysis of the shift index with respect to regional values is interesting. The regional values for the index are shown in the left-hand part of Figure III.2; the right-hand part shows the shift index calculated taking only FAS resources into consideration.

[44] For each project this is computed using the ratio of FAS funding as a share of total project funding.

Figure III.2 Shift index for overall resources and FAS resources



Source: UVER forecasting system based on APQ data (monitoring as of 30.06.2005 and agreements as of 31.12.2005)

If we scan the country from north to south we find, with few exceptions, an increase in the index: the northern part is where plans diverge least from the system forecasts, while the regions with the largest induces, both for total expenditure and FAS expenditure, are the Marches, Puglia, Calabria and Sardinia. While emphasising that regional differences depend largely on the specific nature of the projects, it should be noted that the three southern regions with the largest shift indices absorb over 40 per cent of the FAS resources intended for the Agreements in Southern Italy:[45] to speed up expenditure, or at least make the government entities projections more realistic, specific action for these regions appear to be necessary.

III.3.2 Other uses

In general, the forecast can also be used to:

- identify and prevent potential anomalies and problems for the projects: by identifying the risk factors it is possible to take corrective action during the project;

[45] FAS resources are divided 85:15 between Southern Italy and the Centre-North.

- establish benchmarks that make it possible to classify a project's spending performance, based on the information specific to that project.

These are, however, applications that extend beyond the scope of this report and are not therefore studied in detail here.

IV. Conclusions and future developments

The forecasts make it possible to anticipate expenditure trends and consequently, insofar as they can be considered sufficiently reliable, to evaluate the extent to which project implementation corresponds to the programme objectives.

We have seen that, in general, the monitoring systems do not contain expenditure projections. However, in the case under consideration, where the government entities include their spending plans in the monitoring date, these undergo substantial revisions from one monitoring date to another, and prove to be rather unreliable. A forecasting system has therefore been constructed which, by feeding the main structural and contextual features of a set of projects and the developments actually observed, in terms of project length and expenditure, into a series of statistical models, provide a new spending profile for each project.

The results of the forecasting system applied to projects included in theAPQs (Framework Programme Agreements) suggest that the expenditure projections made by government departments are systematically overestimated. On the basis of the findings to date, annual spending volumes will be markedly lower than indicated at monitoring and, as a consequence, the expenditure will be distributed over a longer time period.

The forecasting system presented here is constantly being updated, improved and extended to enable the use of new information sources and achieve an increasingly close match with the complex reality of public expenditure projects.

At present, new features in the system are developing along two main lines.

The first involves methodological developments, which envisage the evaluation of alternative formulations for the models and the possibility of including in the system a model for forecasting the probability of "incidents", or non-ordinary events, that slow progress.

In the second case, the aim is to extend the universe under consideration, both for acquiring more knowledge on the system and for applying the forecests. The model parameters can, in fact, also be estimated through the information available for other sets of projects, for example those present in the database of the AVLP(Public Works Oversight Authority), which is the most comprehensive repository of information on developments in public works at the national level. The forecest can be extended to the entire universe of public infrastructure investments, identified by integrating different databases where necessary. By linking the information from different databases, such as the call for tenders database, a fuller view of the implementation path for each project can be obtained and the quality of the data improved.

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