# A forecasting system for the expenditure of public investments

Carlo Amati[1], Francisco Barbaro, M.Alessandra Guerrizio, Francesca Spagnolo

Unità di verifica degli investimenti pubblici
Dipartimento per le Politiche di Sviluppo
Ministero dell'Economia e delle Finanze
Via Sicilia, 162 – 00187 Roma, Italia

## Abstract

In order to provide the policymakers with a reliable scenario on public investment expenditure, we have developed a forecasting system for public infrastructure projects. The system, built as a combination of statistical models, yields a forecast of the spending distribution for a generic project, given past behaviour of similar projects, and can be applied both to on-going and new projects.

In this paper we apply the forecasting system onto projects included in the sectorial Framework Programme Agreements, commonly referred to as APQs (Accordi di Programma Quadro), which represent the main instrument of planning national "additional" resources committed to regional development policy.

The analyses carried out on the forecasts highlight the positive impact of new regulation on the expenditure and the need for improvement of the spending plans laid out by the Administrations in charge of the projects.

Keywords: Public investment, Spending forecasts, Panel data

## 1. Introduction

The creation of a tool that makes it possible to systematically anticipate trends in annual spending on public investment stems from the need for an increasingly effective allocation and optimal use of available resources. In order to have sufficient information for the decision-making process regarding public investment, the Public Investment Verification Unit (UVER) of the Department for Development Policies, which belongs to the Ministry of Economy and Finance (MEF), has developed a specific forecasting system for infrastructure spending.

Our goal is to provide policymakers with a tool that enables them to estimate annual spending volumes down to individual project, as well as to conduct analyses on specific subsets or dimensions.

The need for early identification of spending trends for each individual project has led, over time and thanks to constant improvements in sources, methods and tools, to the transformation of a mere prototype of one spending forecast model into an entire system of models. Such a comprehensive system, which is currently being applied onto the projects that are part of the Framework Programme Agreements (or APQs, Accordi di

[1] Corresponding author: carlo.amati@tesoro.it.

Programma Quadro), makes it possible to understand, in a more timely manner, the complex expenditure path followed by each project.

In the next section we first illustrate the system of public investment in Italy, with a particular focus on infrastructures and the on implementation path of a typical project; we then introduce the APQ programme and its monitoring system. In Section 3, we describe the statistical models that make up the forecasting system. Section 4 is devoted to the analysis of the results and to some further applications.

## 2. The system of public investments

UVER's operational domain extends to the entire system of public investments, which is made up of the investment programmes of all public bodies in Italy. At the national level, the main investment programmes are generally linked to a particular type of financial resource and can include projects of different sizes that may cover overlapping time spans. The single project might be funded by the resources of more than one programme. Therefore, in general, project information is to be found in a set of databases managed by a variety of parties, each with its own purpose and specific characteristics.

The resources allocated for public investments are part of the capital account expenditure, along with transfer payments, such as incentives to households and firms, and can be traced back to three different kinds of sources: "ordinary" resources, national "additional" resources and European "additional" resources. Whereas ordinary resources lie in the domain of each public body, additional resources carry the objective of rebalancing the territorial development and are therefore allocated in the under-utilised area, namely all 8 southern regions and scattered areas in the rest of the country.

A unique representation of government spending is provided by the data from the Regional Public Accounts (or CPT, Conti Pubblici Territoriali), a project designed to measure the flow of public funding at the regional level. CPT provides information regarding the whole of inflows and outflows (both current and capital expenditure) within the public administration by individual region and sector for the years from 1996 to 2003.
Among the stated objectives of the development policies, besides the growth of capital expenditure, particular weight is given to the rebalancing of its components towards direct expenditures, i.e. public investments, which directly affect the supply of services available to enterprises and citizens, as opposed to capital expenditure transfers (incentives) which are mainly targeted at the productive system.

Therefore, only capital expenditures by public bodies on tangible and intangible infrastructures (i.e. "investments" as used herein) are considered as the reference universe for this paper.

The CPT series starts in 1996; the most recent CPT figures are for the year 2003. Statistical estimates are available for 2004 and have been calculated using a set of leading indicators. As the current estimates are based on a redistribution of the outflows, even the most accurate estimate cannot be turned into a forecast for future years. In addition, CPT figures provide various access keys, but they cannot be traced back to the individual public investment project that generated the flows. Information on individual projects with indications on future expenditure is gathered from other databases, none of which, however, provide full coverage of the complete set of public investment projects.

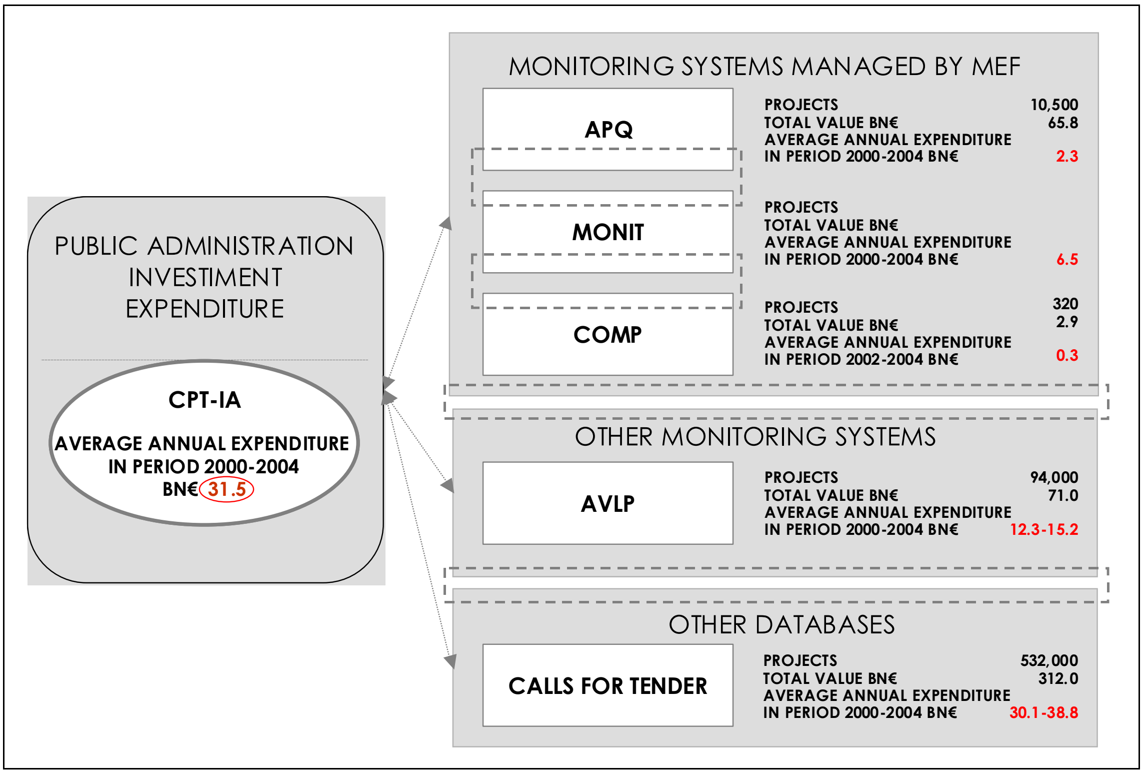
Among the most important monitoring databases at the national level are those linked, respectively, to national additional resources and European additional resources.
They are both managed by MEF and they are commonly known as APQ (national funds) and MONIT (European funds). APQ stands for "Accordi di programma Quadro", namely the Framework Programme Agreements which represent the main instrument of planning national additional resources for regional development policy; MONIT is the database for projects financed with European Union funds for the 2000-2006 programming period. A smaller monitoring database, yet with extensive data, is labelled COMP, for "Completamenti" and spans a few hundred projects funded before the start of APQ for the conclusion of incomplete infrastructure projects.

The other major monitoring system is provided by the Public Works Observatory, belonging to the Public Works Supervisory Authority (or AVLP, Autorità per la Vigilanza sui Lavori Pubblici) and covers all public works contracts, excluding goods and services. Recent national regulation has endorsed the European directives on public procurements, thus extending the scope of the Authority onto goods and services, giving way to the most complete nationwide monitoring system on public investments.

Also available is the database on public calls for tender managed by a private company, not a monitoring system in itself, but an updated directory of the tenders for works, goods and services organised by public entities in Italy.

Figure 1 below is a diagram which compares the CPT expenditure data with that of the projects found in the main public investment databases detailed above.

Figure 1: The main databases on public investment projects



For each database, we provide both the number of projects covered, the corresponding total value, i.e. the amount of resources needed to implement the projects, and the average annual expenditure, which is the average amount of funds spent during the period in question. When spending data is not directly available within the database, we rely upon UVER interval estimates.
It is also worth to clarify that the significance of spending in the various databases can change: CPT and MONIT contain actual payments made by the public entities to third parties, whereas the other databases encompass the economic value of the activities performed.

It can be observed that, due to their specific scopes, none of the monitoring databases covers more than 40-50 percent of the total spending reported in CPT. Only the call for tender database seems to be matching the CPT figure: according to our preliminary estimates, this database covers even more than the total capital expenditure; in fact, it also includes non-investment spending, which can only be removed after an in-depth analysis.

The databases shown in Figure 1 above are not separate from each other. Overlapping areas exist between the different databases, as a given project can be funded by more than one investment programme (e.g. APQ projects co-funded by the European Union will also be found in the MONIT database). This gives rise to a data-integration problem, which is among the up-coming UVER activities. Only the AVLP database and that on the calls for tender embrace broader sets of projects and generally tend to include the various investment programmes. Unfortunately, these are not the best candidates for the training of a forecasting system, despite their larger size, as the AVLP database presently suffers from major data-quality issues and the calls for tender one does not follow projects through their life-cycles. The MONIT database contains more projects than APQ, but the observed set is less stable over time as the key variable is financial spending and projects move in and out of the database according to emerging needs.

In fact, the monitoring system that is currently best suited to feed a forecasting system is that of the APQs. This database is of particular importance to the Department for Development Policies as it covers an important share of national additional resources for regional development policy. Moreover, the APQ database has recently improved a lot 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 incentive bonuses to encourage government agencies to submit the data, and which have contributed as well as to the strengthening of the entire process of validating the data.

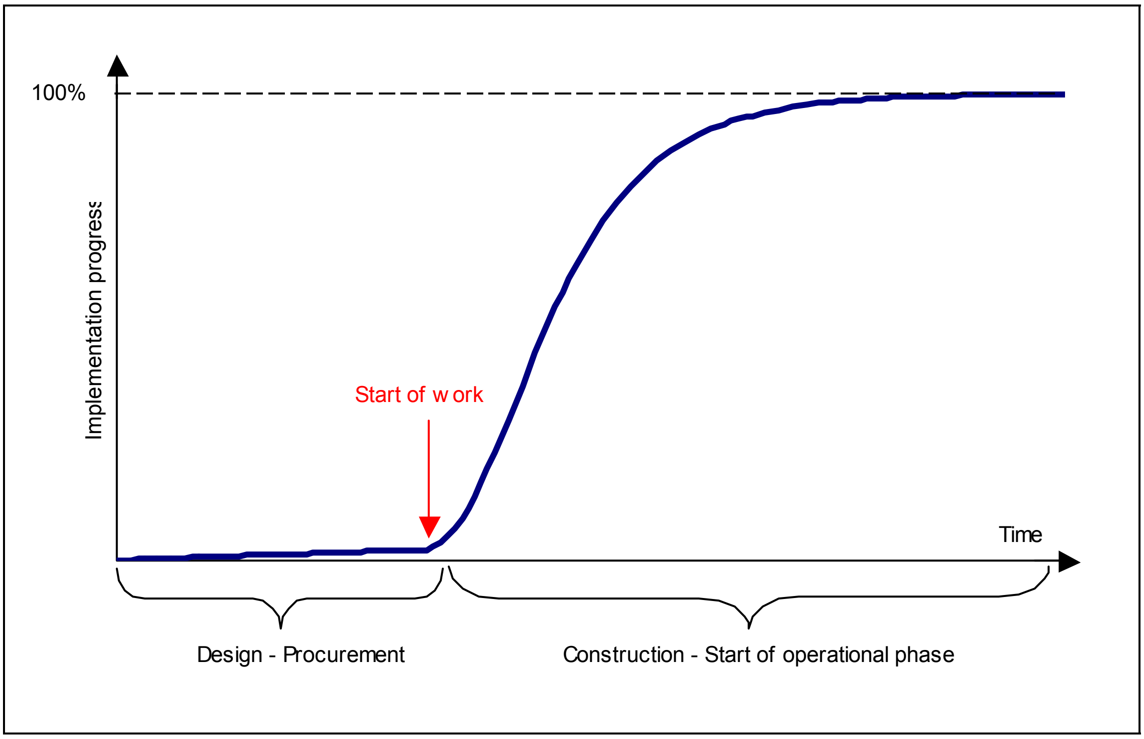
For the above reasons, the application of the forecasting system presented herein has been based on the APQ database. Nonetheless, because of its structure and the configuration of its component models, the system may be applied to a generic set of projects for which an adequate collection of information is available.

## 2.1. Path of implementation of a project

The structure of the forecasting system rests on the fact that each project evolves along a generic path that can be broken down into two main phases (see Figure 2 below):

- the first one runs from planning through to assignment of the contract. In this phase, actual project implementation is more of a technical/administrative nature and can be measured on a timescale;
- the second phase runs from the execution of the work to be done through to making the project operational. In this phase progress can be measured on a spending scale, under the influence of the territorial context and the relations among all the stakeholders.

Figure 2: Hypothetical path of implementation of a generic project




In line with the twofold path of implementation, the forecasting system is a combination of various statistical models with the following two objectives:
- to forecast a date on which work is to begin, based on the times recorded for projects under way;
- to forecast a distribution of total spending, based on the spending profiles recorded for projects under way.

As the information and results presented herein refer to projects included in the APQ database, it is convenient to describe the content of the database used to feed the system, before moving on to a description of the forecasting system itself.

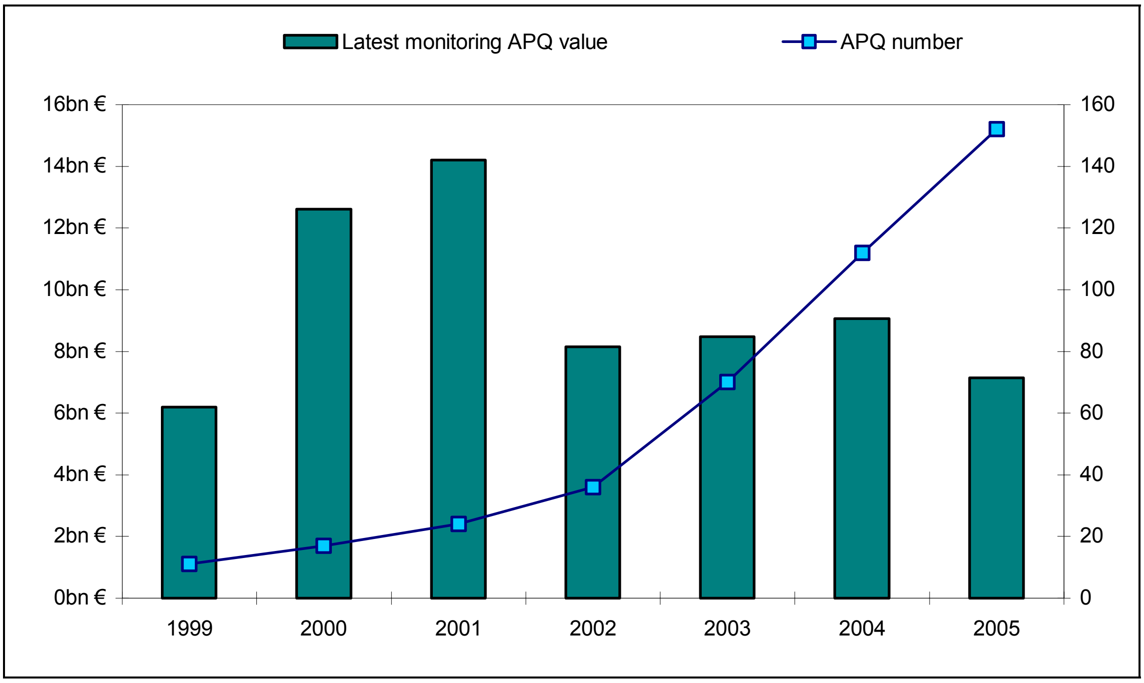
## 2.2. The APQ projects and their monitoring system

The Institutional Programme Understandings (or IIP, Intese Istituzionali di Programma) are one of the main normative frameworks used in the planning process of national additional resources. Their main goal is to coordinate the activities of both central government and the regional government agencies in defining the objectives, sectors, and areas in which local infrastructure development projects are to be implemented. All IIPs were established in accordance with the regions and autonomous provinces in the period 1999-2001, thus defining the institutional context used as a reference when signing the APQs.

For each region and infrastructure sector (be it related to the water systems or transportation, cultural heritage or environment), an APQ is signed when the projects and the necessary funding resources are identified, while also activating monitoring procedures; over time multiple APQs may be signed for the same sector.
The APQs are used to allocate a relevant share of the resources that have been converging since 2003 on a yearly basis into the Fund for Underutilised Areas (or FAS, Fondo per le Aree Sottoutilizzate). The allocation of resources is made by the Interministerial Committee for Economic Planning (or CIPE, Comitato Interministeriale per la Programmazione Economica) with specific resolutions that identify the beneficiary programmes of the resources and the rules that they must follow.
Nonetheless, each APQ project can be funded by a different combination of funding sources so that, as of signing, FAS only accounts for 25 percent of the total value of all APQs: over 50 percent is funded by ordinary resources (national and regional), with the remainder coming from the European Union or private resources.

As a whole, as of 31 December 2005, the database contains 422 APQs, for a total of 13,088 projects and a total value of 65.8bn euros. Figure 3 below shows the number and value of APQs in the database by year of signing.

Figure 3: Number and value of APQs in the database as of 31.12.2005, by year of signing




The number of APQs has posted constant growth, while the amount of corresponding resources has remained at between 7bn and 9bn euros since 2002. For the same period, the average size of the projects has oscillated with a range of between 2 and 4 million euros, with the percentage of small projects (i.e. those of less than 1 million euros) exceeding 50 percent of the total, although this percentage is on the decline.

The monitoring system, which provides constant verification of a project's progress and a means of identifying any critical issues that may arise, gathers information on the structural characteristics of a project, its timeframes, and its financial plans.
In particular, a project's financial plan includes information on both the actual (past) and estimated (future) spending distribution. The financial plan is broken down by year

for the entire period over which the project is expected to take place. At each monitoring date, the government agencies update the financial plans with the actual numbers as of that date and may also update their forecasts for the subsequent years. Although the financial plans should give insight on future expenditure, this revision can be so relevant that it is, in fact, one of the main reasons for which the UVER forecasting system was developed.

The monitoring system contains both the APQ data as of its signing and the related semi-annual updates, referred to 30 June and 31 December of each year. While the monitoring data is updated semi-annually and is available about three months after the monitoring date, the information regarding the new APQs is entered into the system shortly before the agreement is actually signed and is immediately available.
The APQs with signing data only are not considered when estimating the parameter values, that, instead, are applied to all the APQs in the database to compute the forecasts (see Section 3 below). This means that the parameters can be updated at most twice a year, as a result of the two semi-annual monitoring updates, whereas the forecasts can be integrated with those of the new APQs right after signing, by simply applying to them the most recent parameters. The exclusion of the new APQs from the parameter estimates does not affect the parameter values themselves and makes the most up-to-date forecasts available once data for the new APQs is added to the system.

Table 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) amount to 10,712, for a total of 59bn euros. Table 1 also shows that the spending-to-date for the projects not used to determine the parameters is extremely limited.

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

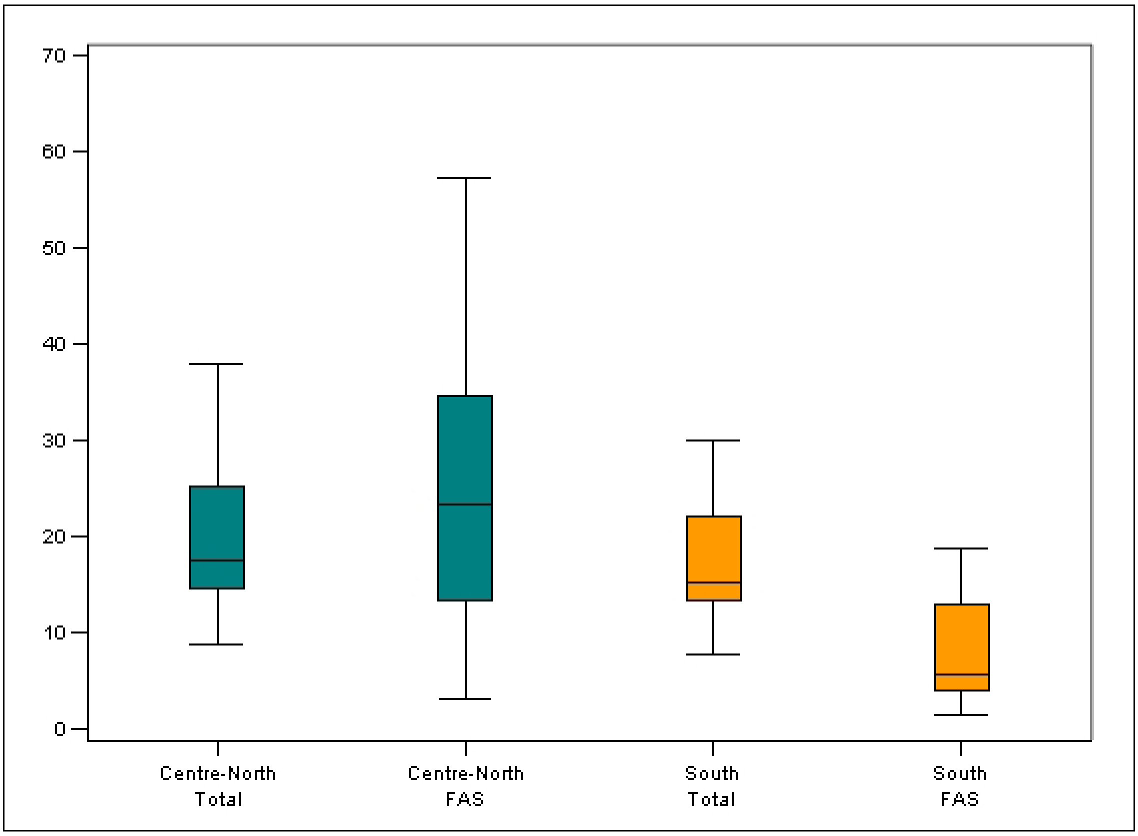
| Category | Number of APQs | Number of projects | Total cost (bn €) | Spending to latest monitoring (bn €) |
|---|---|---|---|---|
| With monitoring data (used) | 267 | 10,712 | 59.0 | 14.2 |
| With signing data (not used) | 155 | 2,376 | 6.8 | 0.1 |
| **Total** | **422** | **13,088** | **65.8** | **14.3** |

For our purposes here, we have used all the information in the database as of 30 December 2005, which includes the latest monitoring data as of 30 June 2005 and all APQs signed in 2005, not subjected to monitoring yet.
The latest monitoring data as of 30 June 2005 are available for 93 percent of the APQs, which account for 91 percent 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 percent of the resources.

According to the update, spending totalled 14.3bn euros, equal to 22 percent of the total value of the projects, worth a total of 65.8bn euros. Spending is on the rise, and, for the period 2000-2004, it increased from just under 0.9bn euros to more than 3.5bn, corresponding to an average annual spending figure of 2.3bn euros (see Figure 1 above). As FAS resources represent the national resources for local development, it is important to consider their share of total spending, totalling 1.2bn euros, equal to 11 percent of the total FAS resources in the programme. The lower spending percentage on FAS resources is explained by a few costly projects that were started in the earliest APQs and were not funded with FAS, so that their contribution only appears in the total expenditure.

The figures vary significantly on a regional scale: Figure 4 below shows the variation in the two macro-areas for total and FAS spending percentages. The so-called underutilised areas, where FAS resources are directed, cover the whole of the 8 southern regions and scattered areas in the Centre-North. The largest amount of "additional" resources is allocated in southern regions: FAS resources are accordingly allocated with an 15-85 ratio in Centre-North and South, while the total amount, for which ordinary resources play a major contribution, appears to have a 45-55 ratio in the same macro-areas.

Figure 4: Regional distribution of spending percentage




The regional values of total spending percentages are concentrated in the 15-25 percent range in both macro-areas, but in the Centre-North there are more extreme top values. They are due to small regions where spending is more rapid. In contrast, FAS spending percentages are higher than total ones in the Centre-North and lower in the South: the more gradual spending rate is typical of the South and is due to the specific features of the projects situated there.

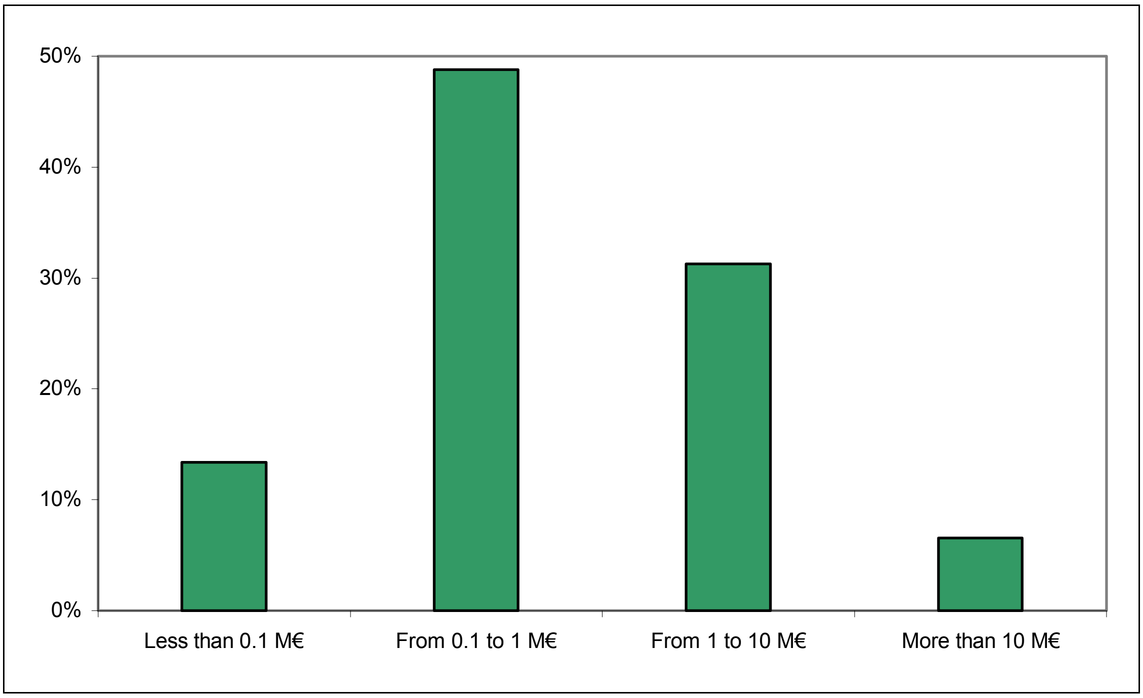
The structural and contextual characteristics of the individual projects, which are used as exogenous variables in the statistical models, are:

- 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 3bn euros;
- Geographic area (North, Central, Southwest, Southeast, Islands): the area of Italy where the project is located;
- Type of project (New construction, Recovery/restoration, Services, Other): the type of construction or 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, estimated as of signing;
- CIPE resolution (No FAS, Pre-2002, Post-2002): indicates whether or not the project is funded by FAS resources and, subsequently, to which set of rules it is subjected; since the 2002 resolution, new rules designed to accelerate spending have been introduced;
- Type of promoting body (Regional agencies, Other territorial agencies or entities, Concessionaries or network and infrastructure management companies, Ministries, Other): the pubic body promoting the project to be added to the APQ;
- Type of implementing body (Regional agencies, Other territorial agencies or entities, Concessionaries or network and infrastructure management companies, Ministries, Other): the public body responsible for implementing the project;
- Design stage as of signing (None indicated, No planning, Feasibility study, Preliminary, Definitive, Executive): the level of technical planning completed and approved prior to signing the APQ;
- Sector (Environment, Charity or social services, Water systems, Culture and recreation, Construction, Energy, Education/Training/R&D, Manufacturing or services, Waste management, Healthcare, Telecommunications, Tourism, Traffic and roadways, Other transport, Other): the category of infrastructure within which the project falls, based on the CPT classification.

Figure 5 below 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 the logarithm of the cost.

Figure 5: Distribution of the number of projects by cost category




It is worth noting that, despite the fact that the number of projects with costs greater than 10 million euros is about a mere 7 percent, these high-value projects account for more than 75 percent of total resources.

Table 2 below shows the distribution of projects based on the various variables of interest.

Table 2: Project distribution by structural and contextual variables

| Variable | Modality | % of projects | % of value |
|---|---|---|---|
| Geographic area | North | 20.2 | 18.6 |
| | Central | 23.7 | 26.7 |
| | Southwest | 17.6 | 15.0 |
| | Southeast | 21.4 | 11.8 |
| | Islands | 17.1 | 27.8 |
| Type of project | New construction | 46.5 | 74.7 |
| | Recovery/restoration | 30.0 | 12.6 |
| | Services | 5.8 | 1.3 |
| | Other | 17.7 | 11.4 |
| 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 |
| | Pre-2002 resolutions | 22.3 | 13.0 |
| | Post-2002 resolutions | 30.8 | 15.2 |
| Type of promoting body | Regional agencies | 68.1 | 42.5 |
| | Other territ. agencies or entities | 13.6 | 5.3 |
| | Contr. or net./infr. mgmt co. | 2.6 | 20.3 |
| | Ministries | 8.4 | 15.7 |
| | Other | 7.3 | 16.2 |
| Type of implementing body | Regional agencies | 10.6 | 11.1 |
| | Other territ. agencies or entities | 53.3 | 14.1 |
| | Contr. 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 | Environment | 16.7 | 3.3 |
| | Charity and social service | 2.1 | 0.4 |
| | Integrated water system | 22.2 | 10.6 |
| | Culture and recreation | 18.9 | 4.6 |
| | Construction | 1.6 | 0.5 |
| | Energy | 3.2 | 1.5 |
| | Education/training/R&D | 3.4 | 1.3 |
| | Manufacturing and services | 3.5 | 6.3 |
| | Waste management | 0.6 | 0.7 |
| | Healthcare | 1.0 | 2.5 |
| | Telecommunications | 3.7 | 2.1 |
| | Tourism | 0.8 | 0.9 |
| | Traffic and roadways | 3.2 | 2.9 |
| | Other transport | 5.4 | 30.0 |
| | Other | 13.9 | 32.4 |

These characteristics of the individual projects make it possible to perform a variety of analyses that are not limited to the categorisations 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 town (special treatment is needed for the projects which span more than a town or province).
This possibility also applies to the results of the forecasting system.

## 3. The forecasting system

In order to calculate the spending forecasts for each project, it is first necessary to set for all projects the start date for the work to be done. This date may be later than the one specified at the time of signing the APQ, due to delays in the design and contract assignment 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.

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;
- an autoregressive model to forecast the spending profile.

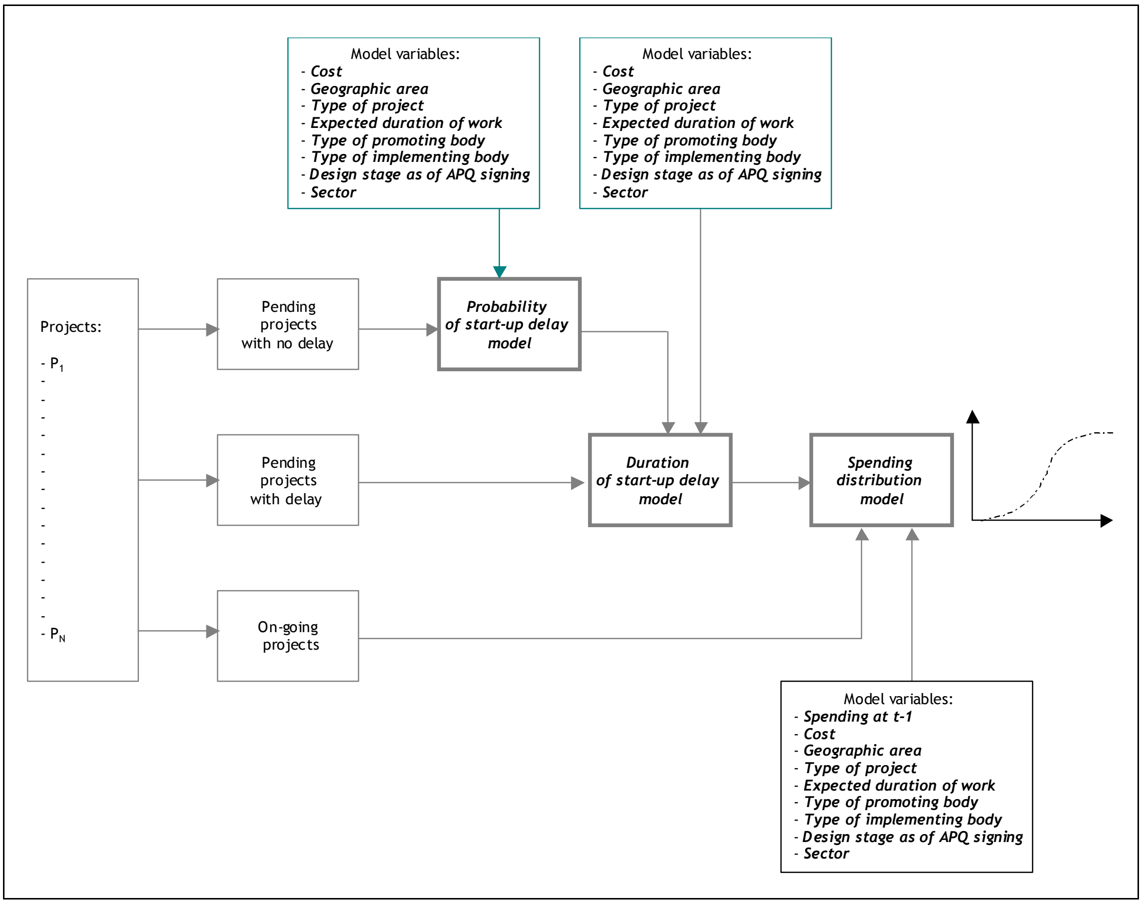
The combination of the first two models provides a forecast of the start date, where the outcome profile of the third model is attached.

The need for a two-step forecast of the start date is driven by the opportunity to exploit all the available data. The variable of interest is the duration of the start-up delay, namely the distance from the start date as of signing of the relative APQ and the actual start date. The duration is defined on the interval $[0,\infty)$ and the available information comes from both actual delays and pending ones, i.e. those of the projects for which all that is known is that the actual start date will be subsequent to the observation date. As the class of models that deal with such information does not take into account null durations, it is necessary to split the forecasting procedure: first we separate the projects with delays from those on schedule, then we apply the duration of delay to the former ones only.

The statistical models that make up the forecasting system involve a set of parameters each, 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 the estimates available in the monitoring system.

Figure 6 below is a diagram of the articulation of the forecasting system into different statistical models.

Figure 6: The structure of the forecasting system




The projects are used in the various models based on whether or not they have been started 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, the combination of the first two models provides a start date for all projects, either actual (for projects already started) or forecast (for pending projects). The third model assigns all projects a spending profile, which begins at the forecast start date in the case of pending projects and from the date of the latest monitoring update and spending level already reached in the case of projects already under way.

Below, the characteristics of the three models will first be presented along with their application to the APQ projects.

### 3.1. Probability of start-up delay model

This model is the first step toward the estimate of a start date for each project. The aim of this model is to separate the projects into two groups, with a start-up delay or on schedule and is trained both on the projects that are already under way (started with a delay or on schedule) and those that are still pending but already delayed. The dependent variable is therefore a binary one and a logistic model is applied, using both the categorical and quantitative features of the projects as exogenous variables.

The model was trained on 9,346 available projects in the APQ database. Of these, 7,090 on-going and pending projects were delayed (76 percent), with 2,256 started as scheduled.
All the exogenous variables (and some first-order interactions between them) are highly significant. The concordant pairs are 97 percent, thus indicating that the logistic model has strong predictive power.

The results of the model are applied to all pending projects that are still on schedule, thereby assigning each project a probability of delay, based on the values observed for the descriptive variables. The projects will be considered as delayed if the forecast probability is greater than 0.5 and vice versa.
Applying the model to the projects that are still on schedule, it turns out that 90 percent are delayed, while only the remaining 10 percent are expected to start as scheduled. For the former ones, and for the other pending projects that are already delayed, the start date is forecast by applying the duration model. For the latter ones the start date is the one indicated as of signing.

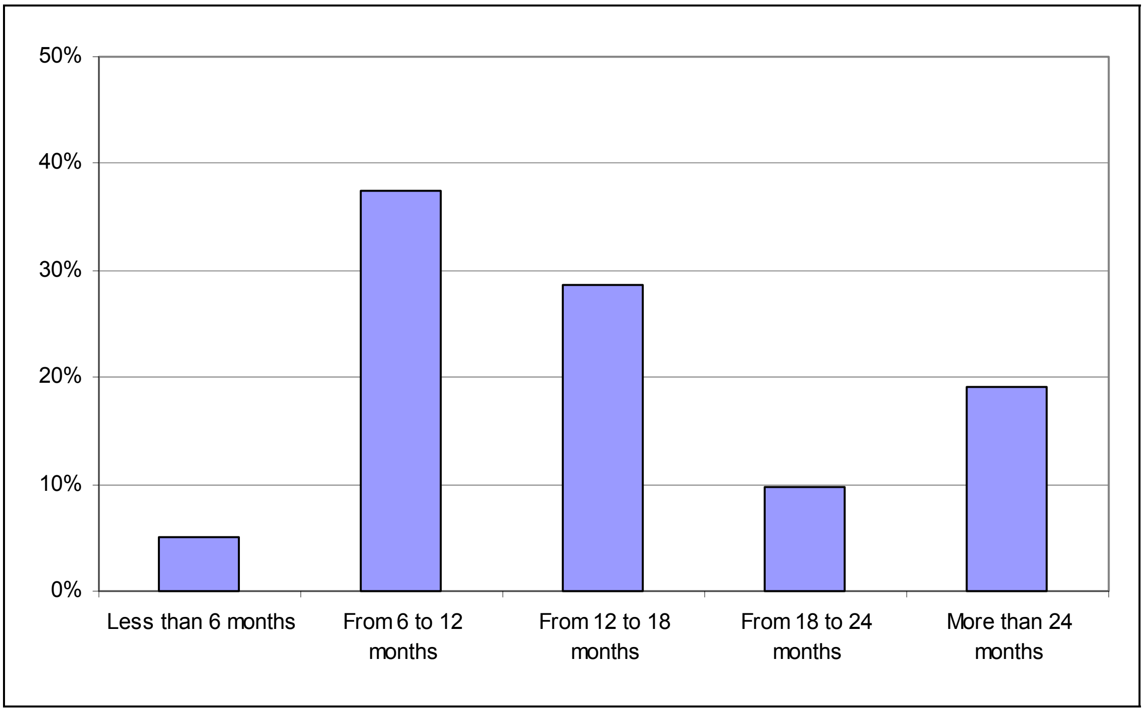
### 3.2. Duration of start-up delay model

This model is the second step toward the estimate of a start date for each project and is applied to delayed projects only. Hazard models make it is possible to use the data of both on-going 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 observation date. The former are referred to as uncensored (or complete), while the latter are known as censored observations.
In the case of the APQs, the duration of the delay is the time passing from the expected start date at the time the agreement was signed to the actual start date. As such, for on-going 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.
In order to forecast the duration of the start-up delay, a parametric hazard model was used, assuming a Weibull distribution for the hazard rate which, in our case, can be interpreted as the probability that a project be started after a given duration of the delay.

The estimated parameters are based on 7,090 projects, both on-going and pending, that were delayed as of the latest available monitoring update.
The distribution of the uncensored delays has a mean of 304 days and a standard deviation of 282 days. As for the duration of censored delays comparable values are obtained, and given that the censored delays continue, by definition, to increase, the average actual delay is also destined to grow.

The goodness of fit of the model is assessed by means of a graphical method, that confirms a satisfactory performance. The results of the model are then applied to all pending 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 less recently signed APQs, the model forecast may not sufficiently represent the actual delays observed. In such cases, it has been decided to maintain the estimated start date as set by the government agencies in the latest monitoring. Figure 7 below represents the distribution of the projects by category of delay.

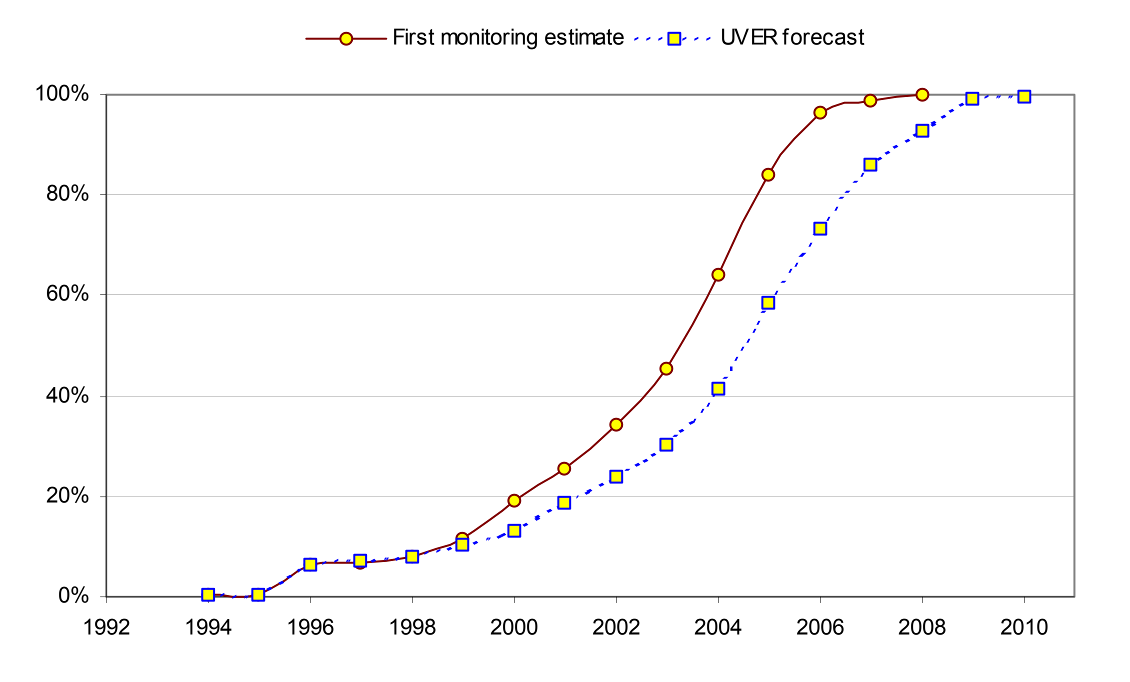
Figure 7: Distribution of the number of projects by forecast delay (pending projects with an estimated probability of delay of greater than 0.5)




The forecast for delayed projects shows that for just over 40 percent of the projects the delayed will be less than 12 months, with nearly 30 percent being between 12 and 18 months and a further 10 percent not exceeding 24 months. However, the forecast for a significant portion, close to 20 percent, is more than 24 months after the originally scheduled start date. The distribution of the delays forecast by the model has an average value of 517 days and a standard deviation of 358 days, which is greater than that of the uncensored delays (see above). In other words, it is expected that, on average, the pending projects will experience greater start-up delays than those that have already begun.

The combination of the estimates for the probability of delay and its duration yield a start-date for each project. Figure 8 below is a comparison of the total value of started projects, according to the estimate as of signing of the relative APQs and according to our forecasting system. The latter curve is equal to the actual values observed until 2004 (the actual data for 2005 are only available for the first semester).

Figure 8: Percentage value of started projects




The forecast shows that the projects will all be started within 2010, two years later than initially expected. Moreover, year 2005 sees the largest increase of started projects: this results in nearly 60 percent of the value of the entire programme being allocated on started projects within 2005.

In terms of FAS resources the acceleration in 2005 is even more evident, as the value of projects started only in 2005 exceeds that of all projects previously started (see Table 3 below).

Table 3: FAS value of started projects, by start-up period

| Region | Value of projects (M€) | | | | Total |
|---|---|---|---|---|---|
| | Started until 2004 | Started in 2005 (forecast) | Started in 2006 (forecast) | Started beyond 2006 (forecast) | |
| ABRUZZO | 98 | 165 | 141 | 78 | 482 |
| BASILICATA | 64 | 184 | 69 | 176 | 492 |
| CALABRIA | 266 | 265 | 122 | 386 | 1,039 |
| CAMPANIA | 575 | 462 | 674 | 507 | 2,217 |
| EMILIA-ROMAGNA | 30 | 15 | 6 | 16 | 67 |
| FRIULI-VENEZIA GIULIA | 9 | 18 | 10 | 18 | 54 |
| LAZIO | 71 | 75 | 63 | 145 | 355 |
| LIGURIA | 72 | 53 | 20 | 18 | 162 |
| LOMBARDIA | 72 | 39 | 69 | 2 | 181 |
| MARCHE | 2 | 16 | 18 | 67 | 103 |
| MOLISE | 20 | 88 | 89 | 33 | 230 |
| P.A. BOLZANO | 12 | 4 | 0 | 5 | 21 |
| P.A. TRENTO | 8 | 0 | 2 | 1 | 11 |
| PIEMONTE | 113 | 138 | 74 | 28 | 352 |
| PUGLIA | 160 | 698 | 274 | 566 | 1,698 |
| SARDEGNA | 261 | 48 | 135 | 570 | 1,015 |
| SICILIA | 310 | 450 | 520 | 851 | 2,132 |
| TOSCANA | 128 | 60 | 29 | 72 | 289 |
| UMBRIA | 29 | 9 | 26 | 66 | 131 |
| VALLE D'AOSTA | 6 | 0 | 1 | 5 | 12 |
| VENETO | 25 | 73 | 63 | 41 | 201 |
| **TOTAL** | **2,331** | **2,858** | **2,404** | **3,652** | **11,245** |

This is due to the "awakening" of Puglia, for which the 2005 value is four times the cumulate of all previous years and to the good performances of Campania and Sicilia. These three regions alone add up to more than 50 percent of all FAS resources. An awakening also is forecast in Molise, although with a less evident effect on the total, due to the small size of the region.

### 3.3. Spending distribution model

The definition of spending adopted within the APQ monitoring system, as the economic value of activities completed regardless of whether payment has actually been made, corresponds exactly to the concept of project implementation shown in Figure 2 above; therefore, in the model used to describe and forecast the path of project implementation, the dependent variable is to be based on the spending to date.
It is also important to specify that each monitoring update provides the entire series of annual spending numbers and, as such, also includes the figures for past years. Therefore, once the latest full update is available, the set of data of actual spending to date is automatically complete.
Half-year data may be recovered from all June monitoring updates, but this has two drawbacks: first, as the previous monitoring updates have had a poor coverage until 2004, the half-year figures are available for too much a limited number of projects; second, it appears that infra-annual spending figures suffer from an excessive seasonality: while financial accounting data used in CPT and progress of work collected in AVLP show a 40-60 half-year seasonal distribution, the APQ data are in the 25-75 range. This suggests a systematic underestimate of half-year spending data by the government bodies: as we are not interested in infra-annual forecasts, we can safely discard infra-annual spending data, thus keeping a yearly time series for each project.

As the short length of the time-series (see Table 4 below) and the need of a forecast for new projects limit traditional individual forecasting methods, the model is estimated with a single regression that makes use of all the available observations for each project at once.

Table 4: Number of years of actual spending for on-going projects

| **Available years of spending** | **Number of projects** | **Total cost (bn €)** | **Spending to latest monitoring (bn €)** |
|---|---|---|---|
| 0 | 1,057 | 2.9 | 0.0 |
| 1 | 2,090 | 6.0 | 1.0 |
| 2 | 1,440 | 6.0 | 2.2 |
| 3 | 813 | 6.6 | 4.2 |
| 4 | 496 | 3.6 | 2.6 |
| 5 | 277 | 4.4 | 2.3 |
| 6+ | 135 | 1.7 | 1.5 |
| **Total** | **6,308** | **31.2** | **13.9** |

The completeness of the annual time-series makes it possible to use a first-order autoregressive model, where the dependent variable is the logit transformation of the actual spending percentage and the exogenous variables, besides the lagged dependent, are the project features, which are all static and need no lagged component. The timescale used in the model is independent of calendar time and it is built as a series of discrete intervals of equal length beginning from the start-up date of work.

Whereas the logit transformation guarantees that the results are bound to the [0,1] interval, the autoregressive component is used to join smoothly the forecasts with the actual spending profile for on-going projects.

The number of available observations has two natural constraints: first, the logit transformation takes on infinite values in the extremes of the spending percentage range 0 and 1; second, the lagged dependent variable in the autoregressive model implies that all projects with only one year of spending would be discarded.
The solution to the first constraint is to define some cut-off values for the spending percentage and discard the points outside the restricted interval. The choice [0.05,0.95] satisfies our needs, but it further reduces the number of available observations.
In fact, the shrinkage of the number of available data points, due to the above causes, is tackled with the generation of artificial data points: the yearly series is expanded into a quarterly series by linear interpolation. The quarterly expansion recaptures part of the information from one-year projects and does not affect the reliability analysis of the estimates, as the model diagnostics are computed on real data only.

The final number of observations used to train the model is 15,549, based on 3,182 on-going projects as of the last monitoring update. The total number of on-going projects is nearly double and amounts to 6,308 projects (see Table 4 above): 1,057 are discarded as they have no spending and 2,069 have spending values falling out of the restricted interval. It is worth noting that, in absence of the quarterly expansion, the number of available projects would drop from 3,182 to 1,099.
The goodness of fit is confirmed by the weighted mean absolute deviation, calculated as follows: first a mean absolute deviation is computed for each project, then the results are averaged, weighting by the project's total cost. The value obtained is 0.05, which indicates that the average deviation between true values and estimates of the expenditure is 5 percentage points.

For all the projects with actual spending data, the model is applied starting from the most recent full year of expenditure (as infra-annual data are discarded), whereas for the pending projects the model is applied to all years from the start-date on, using the default value of 0.01 as starting point for the spending data time-series.

The resulting forecast for the spending distribution in discussed in the next section.

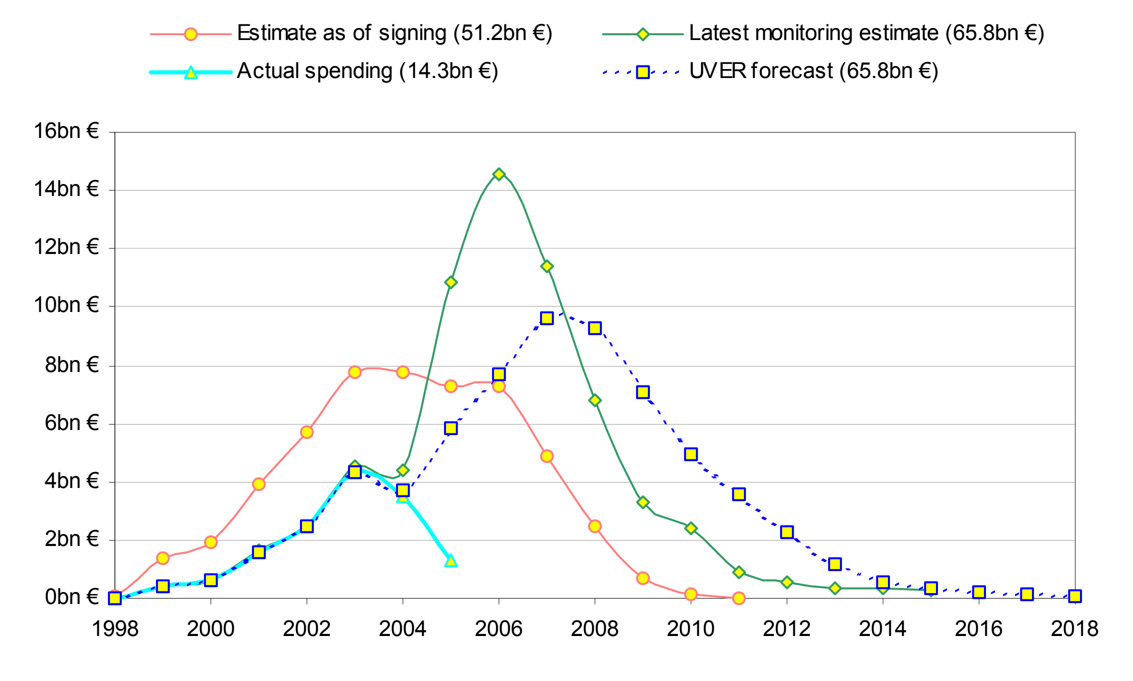
## 4. Forecasts and analysis

The forecast spending distributions are commented before moving to more in-depth analyses, reported in the next paragraph. The parameters of the forecasting system are then applied onto a new set of projects, providing some useful results for the regional agencies responsible for planning. Finally, we extend the use of the forecast as an indicator of potential shortcomings.

### 4.1. Results

The combination of all the models in the system yields a spending distribution for each project. Figure 9 below is a comparison of the spending distribution of all projects, according to the estimate as of signing of the relative APQs, to the most updated estimate and to the forecasting system. Actual spending is also plotted and it is superimposed with the forecasting system data, excluding 2005, for which only partial data are available. It is worth stressing that the forecasting system yields the new spending distributions only on the basis of past actual spending, while not trying to extract a dynamic evolution of the monitoring estimates.

Figure 9: Spending distributions for APQ projects – Total resources




Before any remark on the system forecast, it is possible to observe that the latest monitoring update is visibly shifted from that as of signing: this is due both to the delayed start of the projects and to a more modest spending rate, with the consequence that government bodies have revised their own initial estimates, which were overly optimistic.
Nevertheless it appears to be more concentrated, suggesting expectations for a certain regaining. The integral of the two curves has also increased, meaning that total costs are larger than as of signing: this happens as a result of various causes. On the one hand, projects can either be subjected to cost-increasing factors or have their cost mispecified at an early design stage; this can be considered physiological and accounts for less than 20 percent of the total increase. On the other hand, projects may start as one when the APQ is signed and later split into a few sub-projects, each with a full project status; the splitting is often associated with a cost increase and in fact this is the major cause of the increase, accounting for over 80 percent of the increase.

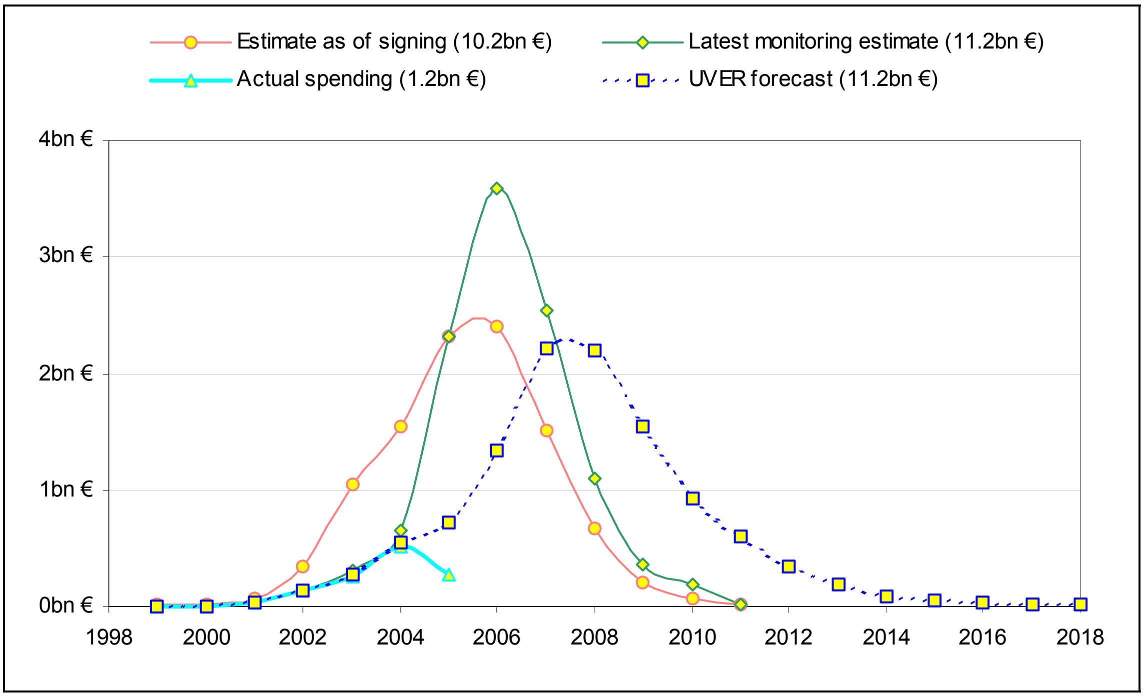
When it comes to the system forecast, we can observe that it features a further shift, implying a persisting optimism in the monitoring data. The spending distribution is more widespread than the latest monitoring data, so the expectations of recovery are only partially fulfilled. The forecast moves the end date of the entire programme from 2015 to 2018 and the peak expenditure value drops from over 14bn euros to less than 10bn euros.
In the short term, the 2005 spending is a forecast itself, because the latest actual spending is updated in June at 1.3bn euros: thanks to the forecasting system it is possible to estimate 5.8bn euros of expenditure in the whole year, which almost halves

the monitoring data; however, the growing trend expected in 2005, after the 2004 adjustment, will continue steadily until 2007.

The results of the forecasting system can also be used as replacement for missing values in the past. In Figure 9 above the 2004 actual spending value does not match the monitoring data: in fact, for a limited number of projects the most recent monitoring dates back to June 2004 or before, so that the forecast can be used in order to have more reliable data in case of an incomplete monitoring.

Figure 10 below is analogous to Figure 9 above, and is referred to FAS resources only: the remarks made on the total are still valid, except for a smaller growth from 2004 to 2005, compensated by an acceleration in 2006 and 2007.

Figure 10: Spending distributions for APQ projects – FAS resources




In general, the shape of a spending distribution can be summarised by its mean and standard deviation, with the meaning of average year of spending and spending concentration.
The shift index between two spending distributions is defined as the difference between the means of the distributions and is a measure, expressed in years, of the average shift of one profile with respect to another. The comparison between the standard deviations gives information on the time-concentration of the distributions.

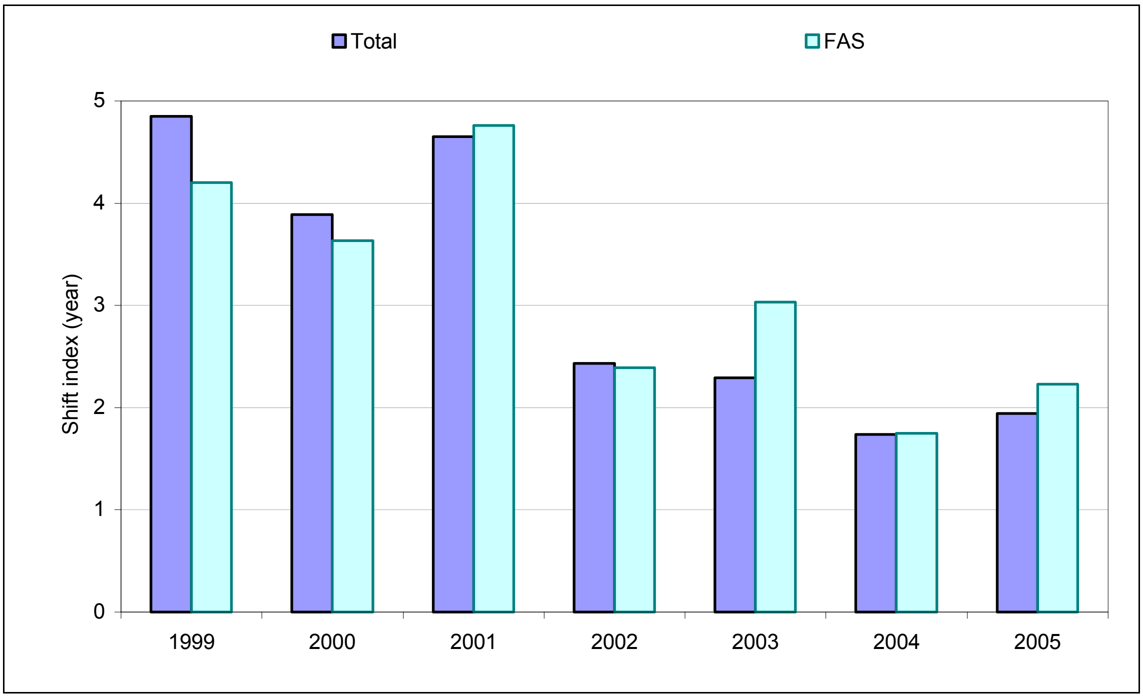
The summary measures of the total and FAS spending distributions are reported in Table 5 below.

Table 5: Mean and standard deviation of the spending distributions

| Distribution | Total | | FAS | |
|---|---|---|---|---|
| | Mean | Standard deviation (years) | Mean | Standard deviation (years) |
| Estimate as of signing | 2005.10 | 2.32 | 2006.35 | 1.69 |
| Latest monitoring estimate | 2007.02 | 2.49 | 2007.12 | 1.47 |
| UVER forecast | 2008.05 | 3.13 | 2008.75 | 2.45 |

As the forecast is based on actual data, if it matched the monitoring data, we could say that the latter are realistic; correspondingly, we can assume that the shift index between the system forecast and a monitoring distribution measures the reliability of the monitoring estimates.
From table 5 above we can easily see that the shift index of the forecast with respect to the distribution as of signing (initial reliability) is 2.95 for total resources and 2.40 for FAS resources. It is most interesting to see how these indices vary over time. Figure 11 below shows the shift index for total and FAS resources between the system forecast and the data as of signing, by year of signing.

Figure 11: Shift index between the system forecast and the data as of signing, by year of signing




The shift index has a clear behaviour that identifies three main periods: the highest values appear until 2001, when the distributions as of signing were the most unreliable; the new regulation introduced in 2002 produced an immediate increase in the reliability, measured by a drop of the index to slightly over 2 years. Another drop occurs in 2004, this time probably due to the proactive efforts of the APQ managing Direction, which also belongs to our Department, towards a better monitoring information quality; 2004 also corresponds to the first delivery of the early forecasting system's results to the regional agencies, but we cannot establish any causal link.

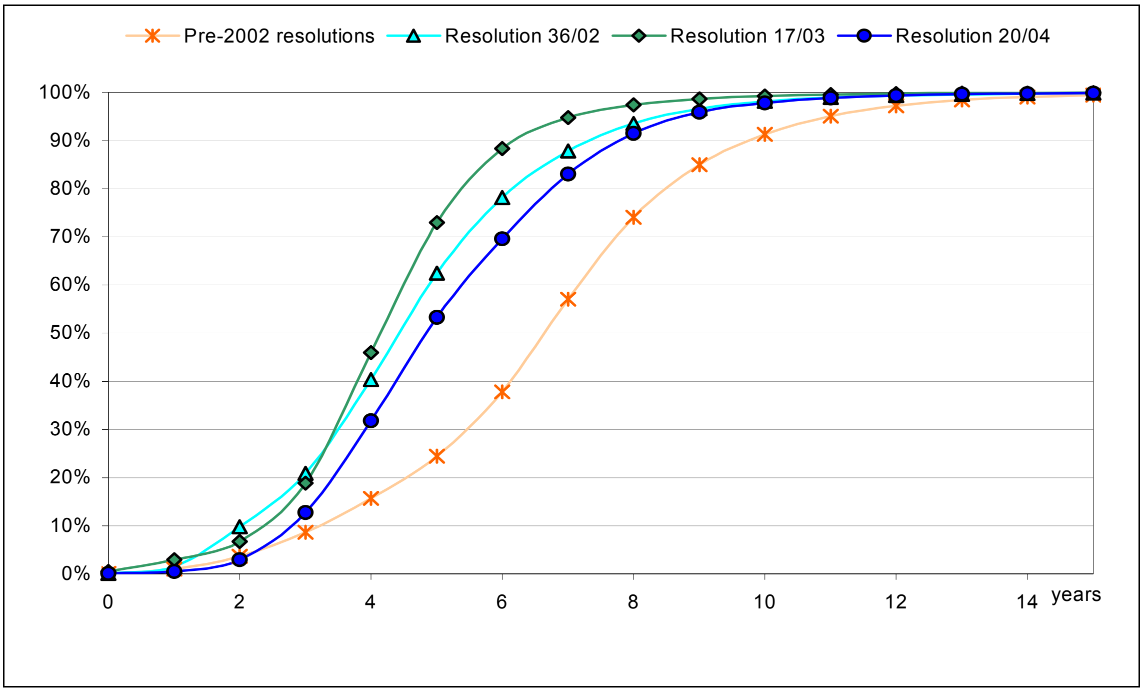
Another interesting analysis is that of the reliability of the most recent data, measured by the shift index between the forecast and the latest monitoring update. Again from Table 5 above, we can see that in this case the shift index on total spending is 1.03 years, whereas on FAS it is 1.63 years: the lower numbers indicate an increased reliability than the initial one, though less pronounced for FAS resources. As the shift index also depends on the percentage of actual spending, the higher FAS value of the shift index with respect to the total is also affected by the lower actual spending (FAS spending is 11 percent versus 22 percent total).

As the shift between two spending distributions is due both to delays in the start date of work and to a more gradual spending rate, it is interesting to measure the relative weights of the two components. In fact, the first component is only definite for pending projects, while for on-going ones it is null. Therefore, for pending projects only the total shift index is 1.62 (for on-going projects the difference between the monitoring and forecast distributions is less severe and their overall shift index is a mere 0.37). The decomposition of the shift index for pending projects yields 0.82 for the start-up component and 0.80 for the spending component: the relative importance of the two components is equivalent. This means that even if the start of work is a turning point in the project's life-cycle, it does not mark the end of its delays, as also the construction stage features an appreciable extension.

The difference of the means also allows a direct comparison between the total and FAS forecast spending distributions: FAS spending is shifted 8 months forward with respect to total spending, but it is more concentrated, as its standard deviation is 22 percent lower than the total's.
The shift of FAS spending is due to the fact that only a small amount of FAS resources has been spent to date: in fact it can be shown that the means of the residual amounts of total and FAS spending are both placed at the end of the first quarter in 2008.

Among the more in-depth analyses that can be done, it is particularly interesting to check if the new regulation introduced in 2002 on FAS resources has had a positive influence onto the actual spending. Figure 12 below shows the system forecasts by year of funding, i.e. CIPE resolution, on a time-scale relative to year of funding.

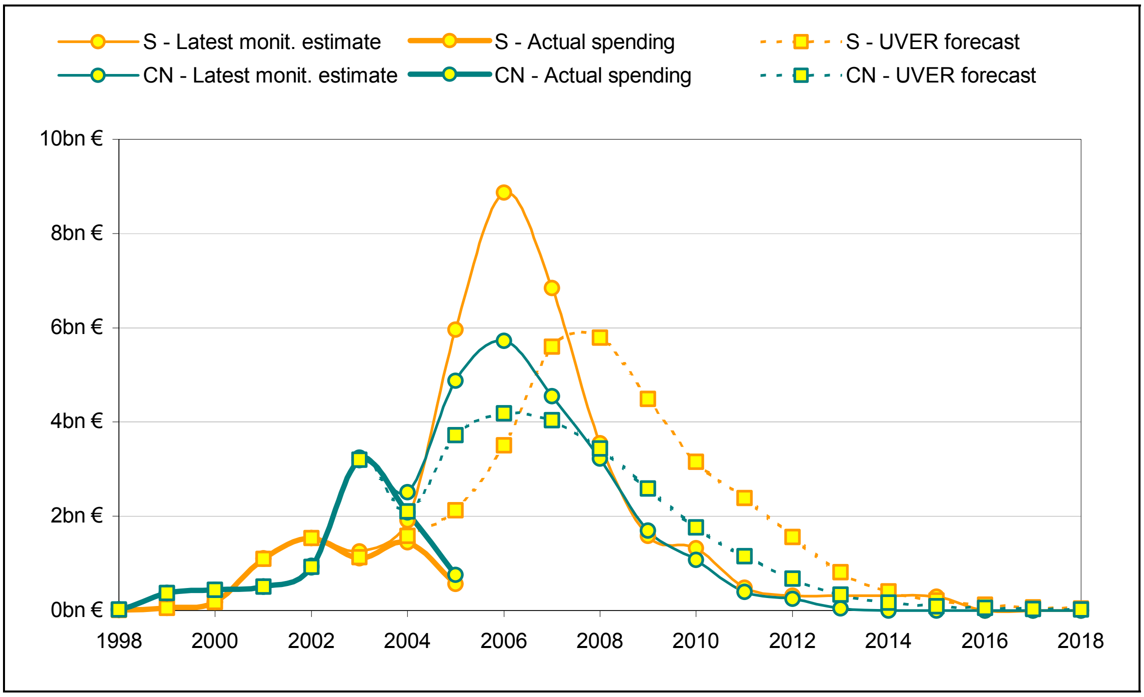
Figure 12: System forecasts for cumulative spending, by CIPE resolution




The funds linked to resolutions dating from 1999 to 2001 are spent considerably more slowly than the more recent ones, which are subjected to the new regulations, thus proving a positive effect on the spending rate: it takes 6-7 years to spend 50 percent of the former funds, whereas the more recent ones reach the same level in 4-5 years. This is also confirmed by a statistically significant difference between the parameters associated to pre-2002 CIPE resolutions and the more recent ones, which in turn have no significant difference among themselves. The apparent deceleration of 2004 funds with respect to 2003 is therefore due to the mixture of projects that can be traced back to them: in fact, 2003 funds have been allocated onto projects that spend faster, as a result of minor size and duration.

Another appealing dimension of analysis is territory. Figure 13 below shows a comparison of the spending distributions in the Centre-North and in the South.

Figure 13: Spending distributions by macro-area

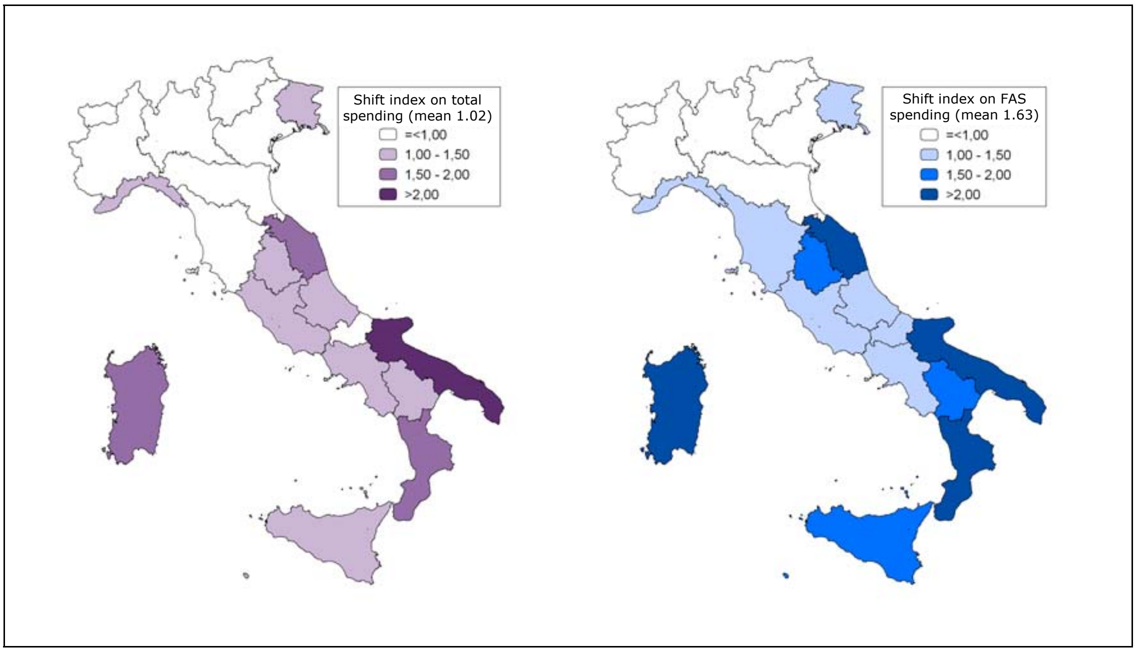



The mean time of spending for the South is shifted 14 months forward with respect to the Centre-North; this is not only due to a slower start in the South, because if we restrict the analysis to residual expenditure then the gap only decreases a little, settling at 9 months, therefore indicating that spending is distributed on a wider time interval in the South, where 55 percent of total resources (and 83 percent of FAS) are located. Again, the difference is due to the mixture of the projects and is not a structural feature of the macro-areas.

In terms of reliability of the monitoring estimates, the South has a much poorer performance with a 1.33 shift index between monitoring and system spending profiles, with respect to 0.66 in the Centre-North. The net difference between the macro-areas is confirmed by the reliability analysis at regional level.

Figure 14 below shows regional values of the shift index between monitoring and system spending distributions of total and FAS resources.

Figure 14: Regional shift index between latest monitoring and system spending distributions of total and FAS resources




Spanning the country from North to South the index grows with few exceptions: in the northern area the estimates of the government bodies are not too far from the system forecasts, while the regions with the worst reliability are Marche, Puglia, Calabria and Sardegna. As these regions account for over one third of FAS resources it is necessary to concentrate specific actions into their territories in order to make their monitoring estimates more reliable.

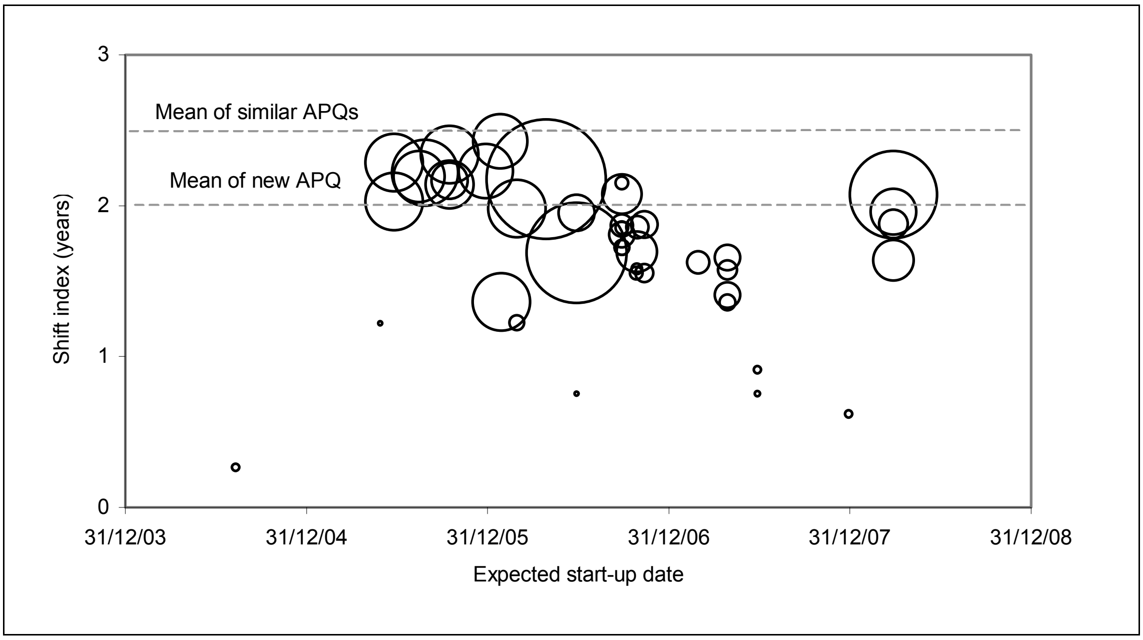
## 4.2. An application to candidate projects

As the system yields forecasts for individual projects, it is possible to apply the estimated parameters to new projects, provided they are supplied with all the relevant information. This process is not free from risks because the system is a statistical tool whose outcome is valid on average and may be less accurate at individual level. Nevertheless it can prove itself useful when it comes to making decisions on candidate projects for new APQs.

This paragaph reports some results of a prototypal analysis carried out on the candidate projects of a new APQ before signing.

A comparison of the pre-signing estimate of the spending distribution and the system forecast yields a shift index equal to 2.0, in line with the mean value of APQs signed in 2005 (see Figure 11 above).
Figure 15 below represents each project as a bubble on a timescale, according to its expected start-up date; the project's shift index in on the y-axis, whereas the size of the bubble represents the project's cost.

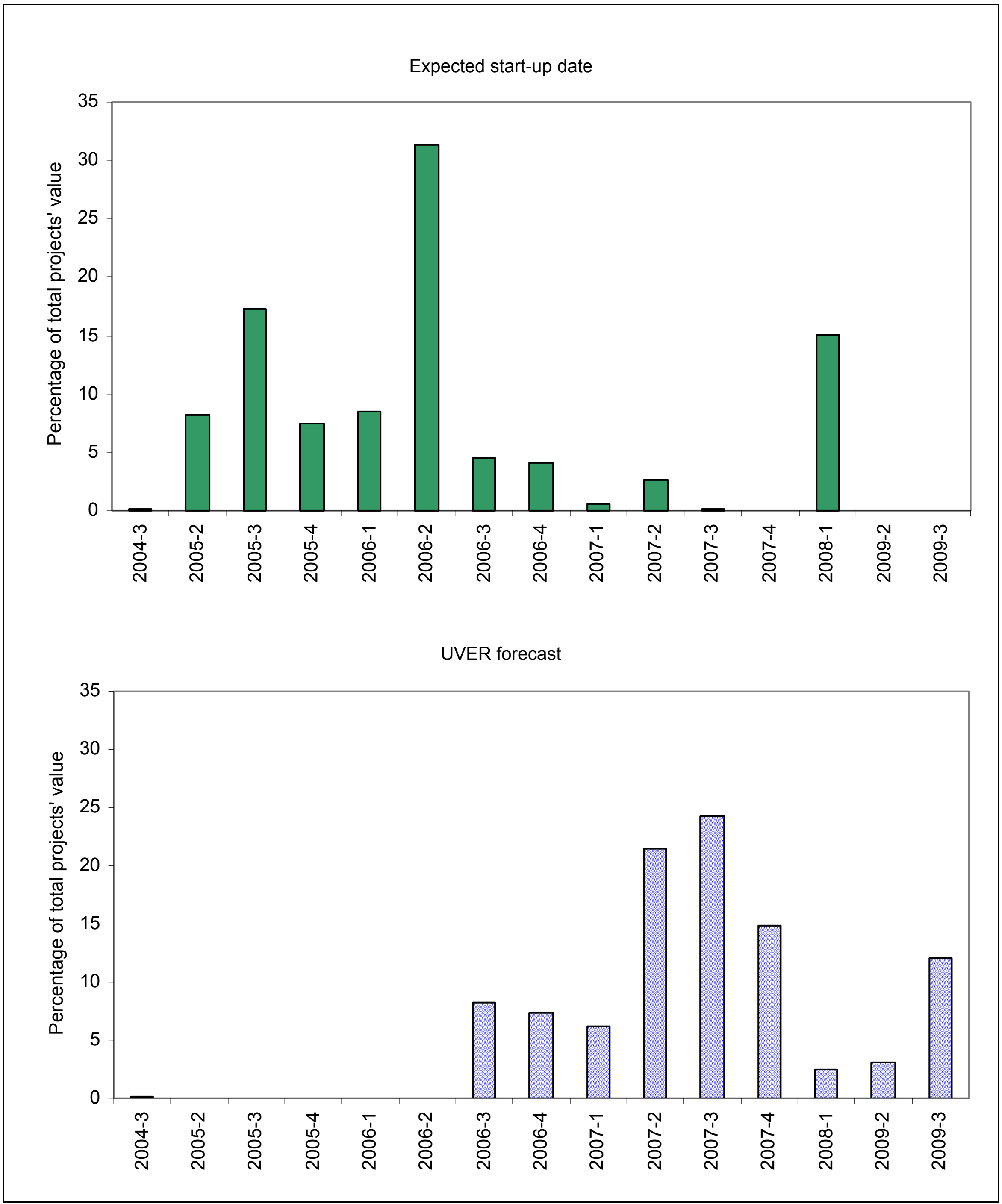
Figure 15: Shift index with respect to expected start-up date for candidate projects




The projects with the larger shift indices are also those expected to start earlier and with greater costs: the spending expected in 2006 finds no correspondence in the virtually null system forecast. The forecasting system thus acts as a forewarning to the regional agencies responsible for APQ planning, as their estimates might start suffering from major delays right after the signing of the APQ.

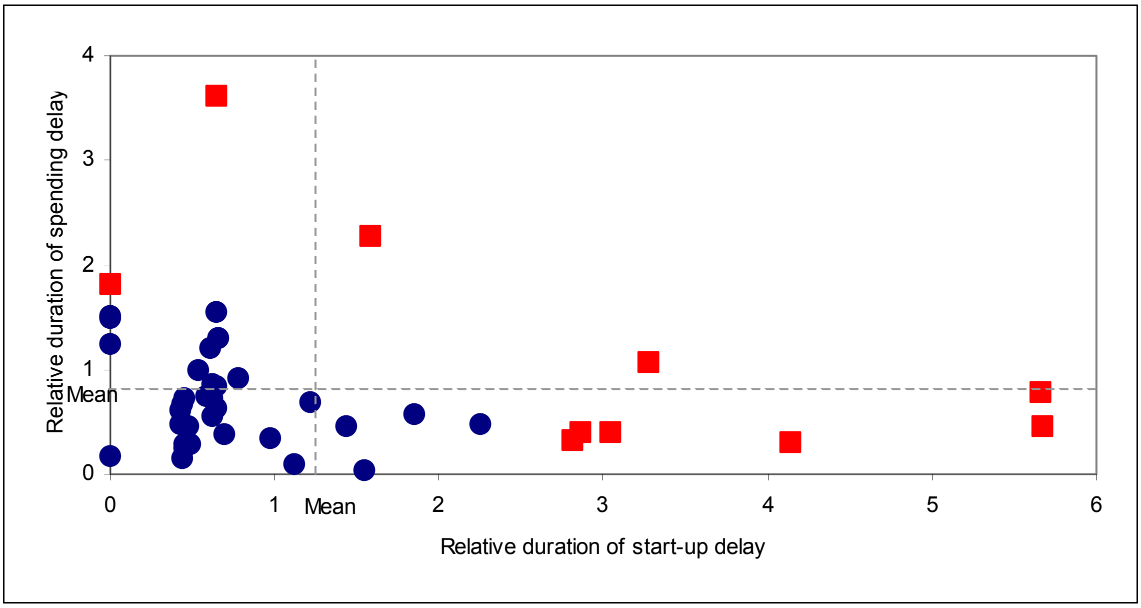
This is also shown in Figure 16 below, where the expected start-up timeline is compared to the corresponding system forecast.

Figure 16: Start-up timelines of the candidate projects




A deeper analysis can be performed considering the two delay components of each project. The chart in Figure 17 below represents the relative durations of start-up and spending delays. The value on the axes represent the ratio between the duration of the delay for each phase and the duration of each phase as expected from monitoring data.

Figure 17: Relative duration of start-up and spending delays for the candidate projects



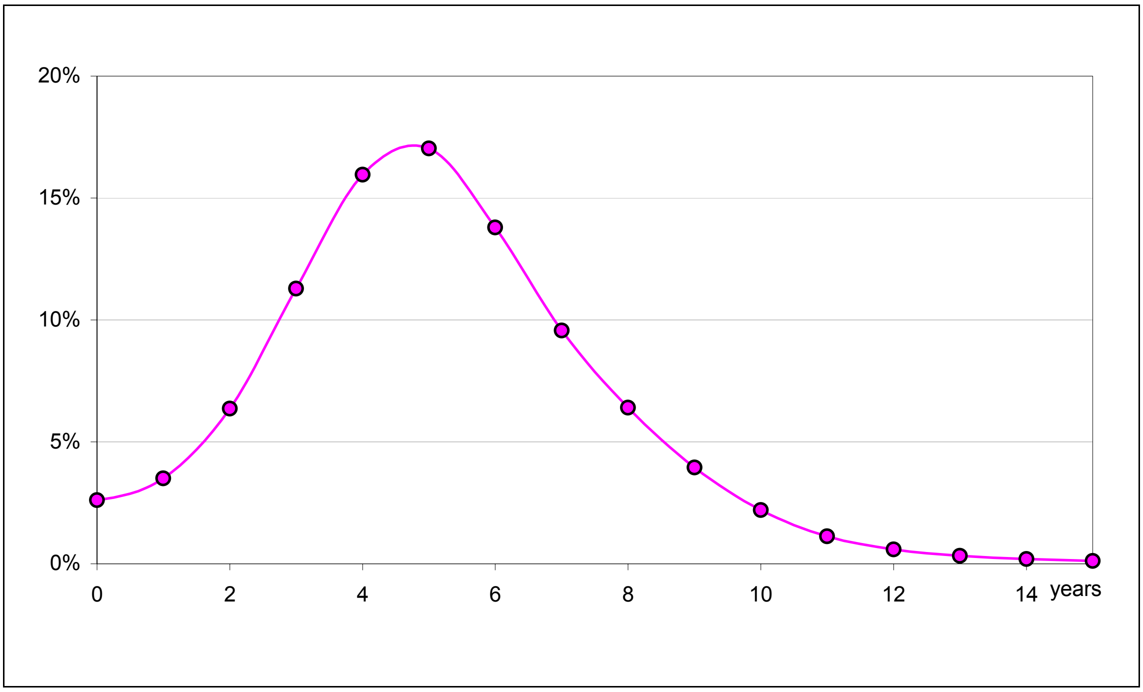

The projects highlighted with red squares are those with the largest positive differences from the mean values of all projects. In particular, the projects are highlighted if either one of their values is greater than twice the average or both its values exceed the average ones.

This kind of analysis allows to pinpoint the projects featuring more potential shortcomings, thus enabling the government bodies to draw particular attention to them. It must be clear, though, that as relative values depend on the estimated duration, they can grow very large also if the latter are very small (which, in turn, can be symptomatic).

## 4.3. Other applications of the forecasting system

The forecasting system can also be used to outline benchmark spending distributions for classes of homogeneous projects: this is especially useful in absence of an adequate set of actual data, as in our case, where the history of projects can at most be traced back to 1999, which may not be enough for analytical purposes as this period does not cover the entire life span of longer projects.
In principle, every combination of parameters yields a particular spending distribution, which is the forecast average distribution applicable to all the projects with the same features. In general, it is more useful to draw benchmarks for broader classes of projects: Figure 18 below shows the average spending distribution of projects in the water system sector with cost greater than 5 million euros. This distribution has the typical bell shape and reaches the highest spending level 4-5 years after the APQ signing and it takes about 12 years for the expenditure to become negligible.

Figure 18: Average spending distribution of projects in the water system sector with cost greater than 5 million euros




In this case, the benchmark is built as the weighted average of the percentage of spending of each project and represents the average behaviour. Other benchmarks can be built as best cases. In fact, the projects used for the benchmark profile can either be from a real set, as in Figure 18 above. In the latter case the forecasting system transforms into a powerful tool for the policymaker as it is possible to build many theoretical scenarios and examine their effects comparatively.

The use of the forecasting system as an indicator of potential shortcomings was also made in 2005, for the selection of APQ projects for on-site verifications. Such verifications are the core activity of another UVER area and is aimed on the one hand at supporting local administrations in the implementation of the projects and on the other at recommending sanctions in case of severe difficulties.
The projects were first filtered on broad criteria, such as cost, type of funding and sector. The filtered projects were then selected according to the results of the forecasting system: the shortlisted projects were those with a shift index larger than the average value of the relative APQ. This principle acknowledges potential shortcomings, proxied by the shift index, as a selection factor for project verification.
In fact, the final report on the verification programme shows that weaknesses have been observed on-site for more than 40 percent of the selected projects. When more updated monitoring data is available for those projects, it will be valuable to check how many of them have a lower-than-average shift index, all of which can be used as a measure of the result of UVER on-site support activities.

## 5. Conclusion

A forecasting system has been developed in order to anticipate the trend in spending data for public investments. The system has been applied to the projects funded with the national additional resources for local development, but its modular structure makes it possible to replicate the estimates for other sets of projects, provided they are supplied with a minimum set of information.

The outcomes of the forecasting system are used for extensive analysis on the factors that influence the expenditure and also as a benchmarking tool for new projects. The system can be also applied to new, or even virtual, projects, thus supporting the government bodies in the project-selection process.

The next challenge to the forecasting system is the definition of a prospective view for the entire CPT investment data. This may be accomplished by means of the information on projects in the call for tender database, under the hypothesis that the CPT figure is in fact generated by the same objects recorded in that database.

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