Using XBRL and Quantrix Modeler to Analyze Financial Statements – Part 1

by

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Abstract

XBRL (eXtensible Business Reporting Language) is a language based on XML for the electronic communication of business and financial data. This paper is intended to: (1) give a brief presentation of the XBRL language and its applicability to financial analysis; (2) define the requirements of a software application supporting financial analysis and planning capable of processing financial data in the XBRL format; (3) appreciate the potential of Quantrix Modeler, a multi-dimensional spreadsheet software, as a platform for implementing XBRL-enabled financial models. The audience for this document is end-users interested in adopting XBRL as a language for preparing, analyzing and communicating financial information.

Summary

1 - Introduction

XBRL (eXtensible Business Reporting Language) is a language for the electronic communication of business and financial data, which is expected to revolutionize business reporting. Based on XML, XBRL provides a framework for defining a shared data dictionary of data items used in financial statements, and reporting templates used for presenting such data. A financial document expressed in XBRL is a collection of XML elements representing individual data items identified by tags referring to financial concepts.

This paper is intended to:

- give a brief presentation of the XBRL language and its applicability to financial analysis;
- define the requirements of a software application supporting financial analysis and planning capable of processing financial data in the XBRL format
- appreciate the potential of Quantrix Modeler, a multi-dimensional spreadsheet software, as a platform for implementing XBRL-enabled financial models.

The audience for this document is end-users interested in adopting XBRL as a language for preparing, analyzing and communicating financial information. XBRL is a complex technology, needing effective tools in order to be exploited in its full potential. I make a case for multi-dimensional spreadsheet being the right tool for the job.

A thorough treatment of the technical aspects of the XBRL standards is beyond the scope of this paper. Basic knowledge by the reader of XML, XBRL and financial analysis is presumed. Readers new to XBRL are pointed to the recent, comprehensive book by Hoffman (see [4]). A more formal treatment is given in XBRL International official documents (see [7-11]). For discussion of specific issues, see the XBRL Australia FAQ in [12]. Italian speaking readers will find a clear introduction to XBRL in our paper by Aste e Panizzolo (see [1]). For additional information please refer to the XBRL web site http://xbrl.org.

I shall refer to the XBRL 2.1 standard. Exposure to the inner workings of the standard is limited to what is relevant for end-users of XBRL data. Most of the examples are based on the ifrs-gp taxonomy, based on the International Financial Reporting Standards issued by the IASB (see [2] for a clear explanation of the ifrs-gp taxonomy).

The research behind this paper has been carried out at the University of Trento within the Smefin research project (see http://smefin.net), financed by the Italian Ministry of University and Research. The Smefin project is aimed at supporting the effective transfer of financial knowledge into actual decision processes by small and medium enterprises (Sme's). Information systems and software solutions making use of XBRL as a language for communicating financial data play a strategic role in pursuing this goal..

This is the first in a series of papers, where a general introduction to the subject is given. Section 2 summarizes the reasons behind XBRL and the main components of the standard that an end-user must understand. In Section 3 a brief survey of software environments for financial analysis and modeling is presented. In this context, the main features of Quantrix Modeler are introduced. Section 4 illustrates some of the approaches to using of XBRL in financial analysis with traditional spreadsheet applications, pointing to their limitations. Section 5 shows how I tried to reproduce the XBRL object model in Quantrix Modeler, with the aid of a

straightforward example[1]. I demonstrate the automatic creation of a report layout taken from the ifrs-gp taxonomy, and its use for a simple financial analysis task, ending with the export of the results in XBRL format. Future developments are sketched in the concluding section.

2 - XBRL and its use in financial analysis

XBRL is being developed by an international non-profit consortium of major companies, organizations and government agencies. It is an open standard, free of license fees. The fundamental concepts of XBRL are summarized hereafter.

2.1 Main benefits of using XBRL

An excerpt from the XBRL web site, presented in the following box provides a comprehensive and clear view of the main advantages of using XBRL.

> *All types of organizations can use XBRL to save costs and improve efficiency in handling business and financial information. Because XBRL is extensible and flexible, it can be adapted to a wide variety of different requirements. All participants in the financial information supply chain can benefit, whether they are preparers, transmitters or users of business data.*
>
> ***Data Collection and Reporting*** *- By using XBRL, companies and other producers of financial data and business reports can automate the processes of data collection. For example, data from different company divisions with different accounting systems can be assembled quickly, cheaply and efficiently if the sources of information have been upgraded to using XBRL. Once data is gathered in XBRL, different types of reports using varying subsets of the data can be produced with minimum effort. A company finance division, for example, could quickly and reliably generate internal management reports, financial statements for publication, tax and other regulatory filings, as well as credit reports for lenders. Not only can data handling be automated, removing time-consuming, error-prone processes, but the data can be checked by software for accuracy. Small businesses can benefit alongside large ones by standardizing and simplifying their assembly and filing of information to the authorities.*
>
> ***Data Consumption and Analysis*** *- Users of data which is received electronically in XBRL can automate its handling, cutting out time-consuming and costly collation and re-entry of information. Software can also immediately validate the data, highlighting errors and gaps which can immediately be addressed. It can also help in analyzing, selecting, and processing the data for re-use. Human effort can switch to higher, more value-added aspects of analysis, review, reporting and decision-making. In this way, investment analysts can save effort, greatly simplify the selection and comparison of data, and deepen their company analysis. Lenders can save costs and speed up their dealings with borrowers. Regulators and government departments can assemble, validate and review data much more efficiently and usefully than they have hitherto been able to do.*

[1] The Quantrix model developed for the example, named `XBRL and Quantrix Modeler-1.model` is available upon request.

Source: http://xbrl.org

The applications that we aim to develop or promote in the Smefin project should provide many of the benefits listed before. The problem is how to implement those functionality in a cost-effective way that is sustainable by a Sme.

2.2 The main components of the XBRL 2.1 specification

The main components of the XBRL specification used in our analysis are the following:

- **XBRL taxonomies**, a set of XML schemata and documents defining the structure of financial information managed by the taxonomy; a taxonomy is composed of the following documents:
  - a *schema* document, containing the dictionary of concepts used in financial reports;
  - a *label linkbase*, containing descriptive labels for accounting concepts in several languages and formats;
  - a *reference linkbase*, containing references to law, regulations, accounting standards or authoritative literature;
  - one or more *presentation linkbases*, defining the layout of reports;
  - one or more *calculation linkbases*, defining the mathematical dependencies among reported items;
  - a *definition linkbase*, defining equivalence and logical relationships between concepts.
- **XBRL instance documents**, which contain the information for specific reports, e.g. financial statements for entity Alfa in year 2004, conformant to a given set of taxonomy documents.

The domain for an XBRL application is defined by means of a set of coordinated taxonomy documents, the *Discoverable Taxonomy Set* (DTS), produced by one or more authorities or entities. The DTS consists of files that are related together. Both taxonomies and instance documents can refer to or import other taxonomies so as to re-use concepts that have been defined elsewhere. A DTS can include user-specific *extensions* to official taxonomies.

2.3 XBRL taxonomies

As explained in [2], an XBRL taxonomy for accounting applications can be conceived as a set of templates representing financial statements and accompanying documents which contains all presentation and disclosure required by a given normative context (defined by business law and/or generally accepted accounting principles) and related common practice. The taxonomy is a collection of concepts and relationships among those concepts. The taxonomy does not define the concepts, which are taken from pre-existing accounting standards. The connection between the taxonomy and the standards is limited to the taxonomy being based on the presentation and disclosure requirements of the standards.

A taxonomy consists of several components. I will not delve into the technical implementation adopted in the XBRL language. XBRL adopts the Xlink standard for describing logical relationships among concepts together with the physical location of data linked together. I will consider a simplified XBRL logical model, clear of the overhead imposed by Xlink constructs, assuming that our application avails of specific tools (processors, parsers, validators and data interfaces) for importing and exporting XBRL taxonomies and documents, taking care of converting between the physical XBRL model and the lightweight logical model I adopt here.

Nonetheless, I will use as far as possible the correct XBRL terminology for defining concepts and their attributes or properties.

2.3.1 The schema document

The schema document is the core of an XBRL taxonomy. It is an XML schema document, stored in a file with an `.xsd` extension, containing the definition of the *concepts* of the taxonomy (serving as a data dictionary). It is integrated by a set of auxiliary information, such as custom *data types* and *roles* used in the taxonomy, used, for example, for enumerating admissible values for a given concept or attribute, (e.g. the set of reports, or label types).

There are two kinds of XBRL concepts:

- *items*, containing single, atomic values; standard XBRL types are monetary, string, decimal, shares, fraction, pure numbers.
- *tuples*, containing a structured set of concepts related to each other; the concepts belonging to a tuple may be items and / or other tuples;

Items are typically used for values reported in main financial statements (e.g. revenues in the Income statement). They belong to closed sets of item types. For a given entity and period an item can occur only once in an instance document representing a set of mandatory reports. Inserting two distinct values for *Revenues* of company Alfa in year 2004 is obviously a redundancy, or an inconsistency, and is illegal in XBRL, unless one defines more than one *context* for the same period (see below, Section 2.4, for a definition of contexts).

The essential information defined in a taxonomy is in the form of *monetary items* corresponding to accounting items listed in the chart of accounts implied by the taxonomy, that is a high level view of the real-life charts of accounts used by software systems compliant with the standard referred by the taxonomy:

- following accounting conventions, items may have an optional `balance` attribute, indicating the section (`debit` or `credit`) where an item of that kind has to be reported when a positive value is provided for it;
- items have also a `period` attribute, which may be `instant` (a single point in time, as appropriate for balance sheet values), `duration` (a time interval between a start date and an end date, used for income, income components, cash flows and changes in balance sheet values) or `forever` (for concepts lacking a time dimension, such as the company's original name).

Legitimate XBRL items other than accounting values may contain textual information, such as the reporting entity name or address, descriptive sections, financial ratios, dates, and so on. Items of type `abstract` play an important role in the definition of a report's layout: they have no value in instance documents, being containers for "constant" literal data, e.g. placeholders used for section titles and similar purposes.

Here is an example of an element definition for an XRBL concept named `RevenueTotalByNature` of type `item` in a taxonomy schema:

```
<element id="ifrs-gp_RevenueTotalByNature"
      name="RevenueTotalByNature"
      type="xbrli:monetaryItemType"
      substitutionGroup="xbrli:item"
      xbrli:periodType="duration"
      xbrli:balance="credit"
      nillable="true" />
```

Tuples are complex XML `sequence` types normally used for information reported in disclosure notes with a form- or record-like structure. As an example, the list of significant shareholdings in subsidiaries can be represented as a table, with one row per subsidiary, containing the following fields: name, country of incorporation, summary financial data. Such table should be defined as a `tuple` concept in the taxonomy schema, with the following syntax:

```
<element id="ifrs-gp_SignificantSubsidiary"
      name="SignificantSubsidiary"
      substitutionGroup="xbrli:tuple"
      nillable="true">
 <complexType>
  <complexContent>
   <restriction base="anyType">
    <sequence minOccurs="0" maxOccurs="1">
      <element ref="ifrs-gp:NameOfSignificantSubsidiary" minOccurs="1" maxOccurs="1" />
      <element ref="ifrs-gp:CountryOfIncorporationOfSignificantSubsidiary" minOccurs="1"
      maxOccurs="1" />
      <element ref="ifrs-gp:PercentageOfOwnershipInterestInSignificantSubsidiary" minOccurs="1"
      maxOccurs="1" />
      <element ref="ifrs-
      gp:PercentageOfVotingPowerInSignificantSubsidiaryIfDifferentFromPercentageOfOwnership"
      minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:SummarisedFinancialInformationOfSubsidiary" minOccurs="0" maxOccurs="1"
      />
      <element ref="ifrs-gp:AmountOfTotalAssetsOfSubsidiary" minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:AmountOfCurrentAssetsOfSubsidiary" minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:AmountOfNonCurrentAssetsOfSubsidiary" minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:AmountOfTotalLiabilitiesOfSubsidiary" minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:AmountOfCurrentLiabilitiesOfSubsidiary" minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:AmountOfNonCurrentLiabilitiesOfSubsidiary" minOccurs="0" maxOccurs="1"
      />
      <element ref="ifrs-gp:AmountOfRevenuesOfSubsidiary" minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:AmountOfNetProfitLossOfSubsidiary" minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-
      gp:ExplanationOfReportingDateOfFinancialStatementsOfSubsidiaryWhenDifferentFromParent"
      minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-
      gp:ReasonForUsingDifferentReportingDateOrPeriodBySubsidiaryWhenDifferentFromParent"
      minOccurs="0" maxOccurs="1" />
      <element ref="ifrs-gp:NatureAndExtentOfSignificantRestrictionsOnTransferOfFundsToParent"
      minOccurs="0" maxOccurs="1" />
    </sequence>
   <attribute name="id" type="ID" use="optional" />
  </restriction>
 </complexContent>
 </complexType>
 </element>
```

In the previous example, concepts forming a `tuple` are referenced as elements in an XML `sequence` where a `ref` attribute points to the `id` of the concept, corresponding to an `item` or `tuple` defined elsewhere in the taxonomy. Such elements contains `minOccurs` and `maxOccurs` attributes. `minOccurs` is 0 for optional items, 1 for required ones. `maxOccurs` is 1 when only one value can be inserted for the item in a tuple instance, `unbounded` when an indefinite number can be included (e.g. values of a financial measure for different reporting periods).

Tuples should not be used for defining the presentation structure of concepts reported in one of the main accounting reports: presentation linkbases (see below) serves that same purpose more appropriately.

An accounting concept should be defined only once in a taxonomy schema, despite the fact that it may be exposed in several reports: for example, the "Profit (Loss) from Operations" item could be defined once and referred twice, in "Income statement by function" and in "Cash flow statement – Indirect method". This principle can be bypassed for convenience reasons, e.g. if one wishes to use presentation reports as a sort of data dictionary, and consequently has to duplicate the items for the same accounting concept exposed in different reports. This practice is discouraged.

It is important to point out that XBRL schemata, and consequently the XBRL instances assuming them, do not contain information about relationships among taxonomy concepts, apart from the structural relationship between tuples and their components (items or tuples). Information about relationships of the various kinds is contained in *linkbases*.

2.3.2 Unique identifiers used in schemata, instances and linkbases

A taxonomy is associated to an universal resource identifier (URI) in order to obtain a global unique identifier. Within a given document referring to the taxonomy, the URI is mapped onto a shorter namespace prefix. In this way, a concept can be uniquely identified by the combination of its prefix and name in a set of related taxonomies (the aforementioned DTS, or discoverable taxonomy set), which may be referred to in a document instance or in taxonomy extensions.

> As an example, the IAS-IFRS taxonomy in the current version has the following URI: `http://xbrl.iasb.org/int/fr/ifrs/gp/2005-05-15`. Such URI is mapped onto the prefix `ifrs-gp`.

As shown in the previous section, for each concept an element in the XBRL schema is defined, identified by means of two XML attributes:

- the `name`, a descriptive text string which must be unique within the taxonomy, usually it is automatically generated from a unique descriptive label of the accounting item (in English for the ifrs-gp taxonomy); the `name` is obtained converting the unique label in camel case format, with spaces and non literal characters removed.

  > As an example the item "Cash restricted or pledged" would expressed with the name `CashRestrictedOrPledged`, while "Profit (loss) from Operations" as `ProfitLossFromOperations`.

- the `id`, another unique identifier that usually is the same as the "name" preceded by a prefix associated with the schema's namespace separated by the underscore "_" character.

  > The *id* corresponding to the *name* `CashRestrictedOrPledged` in a taxonomy mapped onto the `ifrs-gp` prefix becomes `ifrs-gp_CashRestrictedOrPledged`.

For completeness, let's consider the syntax used for referring to concepts defined in an XBRL schema from XBRL document instances and XBRL linkbases (the structure of instances and linkbases is described below).

In a document instance, each concept for which information is reported corresponds to an XML element with name composed by the taxonomy prefix and the taxonomy item `name` attribute, separated by a colon. The same format is used for referencing element names in a `tuple` definition (see below)

> For the previous example we would obtain `<ifrs-gp:CashRestrictedOrPledged/>` as the XML element name.

In linkbases, the unique identifier of a schema concept is defined in elements of type locator (`loc`) by means of the `href` attribute, which is composed prepending the schema file name to the concept's `id`, separated by the "`#`" character, as in html bookmarks.

> If the schema is defined in a file named `ifrs-gp-2005-05-15.xsd`, in a linkbase the `href` attribute containing the reference to the item named `CashRestrictedOrPledged` would become:
>
> `ifrs-gp-2005-05-15.xsd#ifrs-gp_CashRestrictedOrPledged`.

The locator maps the identifier in `href` to a more concise identifier string for the concept used locally to define the relationships between linked concepts and between concepts and resources (the so called *arcs*, which perform functions which are different depending on the linkbase type, as explained below).

Apparently, the coexistence of several formats for expressing the same XBRL concept across the various components of a taxonomy may be confusing. For the sake of simplicity, I will assume that such heterogeneity, together with the physical location of document files, is made transparent to our application, thanks to appropriately configured data interfaces. For our purposes:

- I refer to a namespace prefix in order to uniquely identify a taxonomy or a taxonomy extension; such prefix should be enough for resolving the URI and physical location of the taxonomy files;
- I shall refer to the `id` attribute of schema elements, composed as `[prefix]_[name]`, in order to uniquely identify an XBRL concept to our purposes;

This should be enough in order to process XBRL information conformant to a consistent taxonomy set, which is the typical case in a planning or reporting application.

2.3.3 The label linkbase

A label linkbase provides a caption or label for each concept, in one or more languages. Labels for specific "roles" can be defined in this file by assigning a `labelRole` atttribute to the label. Label roles express different features of a label used at a specific point in a report:

- they can express the format of the label (e.g. standard, terse , verbose);
- they can be differentiated according to the concept's value (e.g. for a `NetProfitLoss` concept, we may define a label "Net Profit" for `labelRole=positiveValue` and "Net Loss" for `labelRole=negativeValue;`
- they can be differentiated following the `context` of the concept value, i.e. the period or nature of the data; so different labels can be defined for roles `periodStartLabel, periodEndLabel, restatedValueLabel.`

Each label linkbase entry includes the following information:

- the reference to the schema concept described by the label;
- the label text in a given language;
- the language code, stored in the `xml:lang` attribute as an ISO 639 two or three letter code;
- optionally, the role of the label, stored in the `xlink:role` attribute.

The following example shows three different `label` elements defined in the ifrs-gp label linkbase for the concept `ConstructionInProgressNet`¸a class of Non Current Assets in the Balance Sheet.

```
<label xlink:type="resource" xlink:role="http://www.xbrl.org/2003/role/periodEndLabel"
xlink:label="ifrs-gp_ConstructionInProgressNet_lbl" xml:lang="en">
Construction in Progress, Net, Ending Balance</label>

<label xlink:type="resource"
xlink:role="http://www.xbrl.org/2003/role/periodStartLabel" xlink:label="ifrs-
gp_ConstructionInProgressNet_lbl" xml:lang="en">
Construction in Progress, Net, Beginning Balance</label>

<label xlink:type="resource" xlink:role="http://www.xbrl.org/2003/role/label"
xlink:label="ifrs-gp_ConstructionInProgressNet_lbl" xml:lang="en">
Construction in Progress, Net</label>
```

The `xlink` syntax of such relations, using elements of type `locator`, `resource` and `labelArc`, is not detailed here.

> In the code excerpt the word "label" is used in three places: (1) <`label`/> is the name of the XML element of type resource; (2) `http://www.xbrl.org/2003/role/label` is the role for the standard label (the last one); (3) the attribute named `label` contains a unique identifier of the containing element in the linkbase, constructed as the concept schema `id` with the suffix `_lbl`. This is a source of confusion for the novice user of XBRL.

Standard labels in a default language are normally used for presenting the content of a taxonomy in tabular format, as a more readable substitute for the concept's *id* attribute.

2.3.4 The reference linkbase

The reference linkbase provides a link from a concept to authoritative literature that defines it, such as a law, an accounting standard or a regulation.

Each reference linkbase entry includes the following information:

- a *locator*, which is a pointer to a given schema concept for which the reference is defined;
- the *reference,* an XML element of complex type composed of sub-elements identifying with precision the accounting rules which apply to the referenced concept;

> For example, in the ifrs-gp taxonomy the following elements are specified:
>
> *Name*: the name of the standards body (e.g. IAS)
>
> *Number*: the number of the relevant standard (e.g. 39 for IAS, Financial instruments)
>
> *Paragraph*: the paragraph number in the relevant standard
>
> *Subparagraph*: the subparagraph number in the relevant standard.
>
> Another structure may be used for different normative sources, e.g. an article and comma in a business law, or a regulation of different nature.

An example of `reference` element is the following.

```
<reference xlink:type="resource"
     xlink:role="http://www.xbrl.org/2003/role/presentationRef"
     xlink:label="ifrs-gp_ConstructionInProgressNet_ref">
      <ref:Name>IAS</ref:Name>
      <ref:Number>16</ref:Number>
      <ref:Paragraph>73</ref:Paragraph>
      <ref:Subparagraph>e</ref:Subparagraph>
    </reference>
```

As in the case of labels, several references with different `xlink:role(s)` can be defined for a given concept.

The reference linkbase can be very useful in combination with on-line electronic versions of normative documents in XML format, which could be accessed from XBRL documents as a context-sensitive help system.

2.3.5 Presentation linkbases and the structure of reports

The layout of reports produced with the taxonomy concepts is defined in presentation linkbases. This taxonomy document is usually the starting point for browsing a taxonomy's content, since it is very similar to the format in which accounting information is presented. Reports may be different by type (Balance sheet, Income Statement, Cash flow statement, Statement of the change in equity, Explanatory Disclosures, Accounting Policies) and, for a given type, by type of entity (General purpose or Financial institution), or by format (e.g. Income statement by function vis-à-vis Income statement by nature). In the ifrs-gp taxonomy, a distinct linkbase is defined for each one of the main reports in order to make the definition of alternative formats more flexible. The choice of the most appropriate format for each type of report is left to the user.

A presentation linkbase document is organized into the following main parts:

- the *listing of extended links* is defined; an extended link is an element with name `presentationLink`, which simply groups XBRL concepts organized in an ordered hierarchical structure matching the logical structure of the report (the order an expert accountant would like to follow), which is usually coincident, or very similar, with its printed format; if a different file is used for each report, there should be one `presentationLink` per `linkbase`, but more than one can be found in more complex reports in order to structure the report in sections[2].
- the structure of each section is configured in a distinct extended link as list of parent-child relationships among XBRL concepts, defined as `presentationArc`(s).
  - The *top level* or *root item* in the report has no parent. It is usually an abstract item containing the report's title.
  - For *other items* the `id` of the parent concept is referred to in the attribute `xlink:from` of the arc, while the `id` of the child item is assigned to the attribute `xlink:to`;
  - the concepts referring to the same parent have an `order` attribute, i.e. an integer value on which they are sorted; in this way a hierarchical structure with an arbitrary number of levels can be defined;
  - the `use` and `priority` attributes are relevant in taxonomy extensions; when `use` is `optional`, the arc may be used (i.e. the child concept may be shown) in the report; if we want to define an alternative format with minor variations, a taxonomy extension can be defined where some child concepts are "switched off" and substituted by others[3]; in order to switch off a child item we must define in the extension an arc for the same pair of `from` and `to` ids, with `use="prohibited"` and `priority` greater than the default value of 0.

[2] The creation of additional `presentationLink's` may also reflect the structure of the corresponding calculation linkbase, where more than one `calculationLink` is needed to define alternative aggregation formulas for the same summary item (see below page 13).

[3] As an example, in the extension an alternative list of items for breaking down the value of a summary item can be defined, that overrides the breakdown of the original taxonomy.

For a child item, a `preferredLabel` attribute may be defined, indicating the type of label (defined in the same terms as the attribute `labelRole` in the label linkbase, see above) to be shown for the reported concept at that point of the report, when it is different from the standard type. In a report, the `preferredLabel` sometimes plays a more important role, for example when is used to indicate the type of value to be placed at that point. In the ifrs-gp taxonomy, this is that case for `periodStartLabel` and `periodEndLabel` roles, as in the following excerpt, regarding the movement analysis for the `ConstructionInProgressNet` item, as reported in the presentation linkbase for explanatory disclosures. For completeness, the complete hierarchy starting from the root item of the report is included.

```
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ExplanatoryDisclosuresPresentation" <!-- root item -->
     xlink:to="ifrs-gp_AssetsDisclosuresPresentation"
     order="1" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_AssetsDisclosuresPresentation"
     xlink:to="ifrs-gp_PropertyPlantAndEquipmentDisclosures"
     order="1" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_PropertyPlantAndEquipmentDisclosures"
     xlink:to="ifrs-gp_MovementsInPropertyPlantAndEquipmentPresentation"
     order="1" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_MovementsInPropertyPlantAndEquipmentPresentation" xlink:to="ifrs-
     gp_MovementsInConstructionInProgress" order="1" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     preferredLabel="http://www.xbrl.org/2003/role/periodStartLabel"
     xlink:from="ifrs-gp_MovementsInConstructionInProgress"
     xlink:to="ifrs-gp_ConstructionInProgressNet"
     order="1" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_MovementsInConstructionInProgress"
     xlink:to="ifrs-gp_ChangesInConstructionInProgressPresentation"
     order="2" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_AdditionsConstructionInProgress"
     order="1" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_AcquisitionsThroughBusinessCombinationsConstructionInProgress"
     order="2" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_DisposalsConstructionInProgress"
     order="3" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-
     gp_TransfersToFromNonCurrentAssetsAndDisposalGroupsHeldForSaleConstructionInProgress"
     order="4" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_DisposalsThroughBusinessDivestitureConstructionInProgress"
     order="5" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_ImpairmentLossRecognisedInIncomeStatementConstructionInProgress"
     order="6" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_ImpairmentReversalRecognisedInIncomeStatementConstructionInProgress"
     order="7" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_ForeignCurrencyExchangeIncreaseDecreaseConstructionInProgress"
     order="8" use="optional"/>
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_OtherIncreaseDecreaseConstructionInProgress"
     order="9" use="optional"/>
```

```
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressPresentation"
     xlink:to="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     order="10" use="optional"/>

<!-- the following element is defined in a distinct extended link (its definition is omitted) -->
<presentationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/parent-child"
     preferredLabel="http://www.xbrl.org/2003/role/periodEndLabel"
     xlink:from="ifrs-gp_MovementsInConstructionInProgress"
     xlink:to="ifrs-gp_ConstructionInProgressNet"
order="3" use="optional"/>
```

The last arc belongs to a distinct extended link in order to avoid an illegal duplicate link definition between the same pair of parent and child items (`MovementsInConstructionInProgress` and `ConstructionInProgressNet`). To be exact, the child items are not identical, since they reference the same concept at the start and at the end of the reporting period, as is made clear by the different preferred label assigned. This case shows the XBRL language stretched to its limits.

The following figure shows a possible representation of the items contained in the previous code snippet in a printed report.

Assets Disclosures (Presentation)
Property, Plant and Equipment Disclosures
Movements in Construction in Progress
Construction in Progress, Net, Beginning Balance
Changes in Construction in Progress (Presentation)
Additions, Construction in Progress
Acquisitions Through Business Combinations, Construction in Progress
Disposals, Construction in Progress
Transfers to (from) Non-Current Assets and Disposal Groups Held for Sale, Construction in Progress
Disposals Through Business Divestiture, Construction in Progress
Impairment Loss Recognised in Income Statement, Construction in Progress
Impairment Reversal Recognised in Income Statement, Construction in Progress
Foreign Currency Exchange Increase (Decrease), Construction in Progress
Other Increase (Decrease), Construction in Progress
Changes in Construction in Progress, Net, Total
Construction in Progress, Net, Ending Balance

Browsing the `presentationArc` elements in the linkbase, we find most of the information needed to reproduce the layout and to identify the data to be reported: the report must show in sequence the concepts referred to in the `xlink:to` attribute of the arcs; the corresponding `xlink:from` attribute defines the nesting level of the child item in the presentation tree hierarchy[4], which can be determined recursively assigning level 0 to root elements, and adding 1 to the parent's nesting level for others. However, the list of `xlink:to` attributes contained in `presentationArc(s)` is not enough for reproducing the complete report: you have to put the root parent element at the beginning of the tree (it does not appear in `xlink:to` references, as is the case for `AssetDisclosures` in the example); you have also to put together items connected to the same parent defined in arcs placed in different extended links (as the ending balance of `ConstructionInProgressNet` in the example above).

2.3.6 Calculation linkbases and the mathematical dependencies among reported items

An accounting report usually includes items which are computed as the algebraic sum of other items. In mandatory financial statements, addition and subtraction are enough to do all the math that is required, so XBRL has defined a parsimonious way to represent such dependencies in a dedicated taxonomy document, the *calculation linkbase.*

[4] The nesting level of reported concepts is not explicitly defined in XBRL linkbases.

The calculation and presentation linkbases have a similar structure: in both cases a set of *reports* is configured, and for each report a linkbase document defines a hierarchical and ordered tree of XBRL concepts. Although not strictly required, it is strongly recommended that calculation and presentation linkbase for a given report have structures mirroring each other.

The main differences between calculation and presentation linkbases are the following:

- calculation linkbases do not include abstract elements, which are not involved in calculations;
- in calculation linkbases, `calculationArc`(s) connect the summed items (referenced by the `xlink:to` attribute) to a parent item (referenced by the `xlink:from` attribute) containing their aggregate value; in presentation linkbases the parent item is usually an abstract item, and both the summed items and their sum are children of that same parent, and the sum follows its components at the same presentation level; as an alternative, a compact layout may be chosen where the summed item is the parent in both linkbases, and is shown before its children;
- relationships between `to` and `from` elements defined in `calculationArc`(s) have in addition to the `order` attribute, a `weight` attribute, that normally takes either 1 or –1 value; it commands the algebraic sign to be applied to child items in the summation that returns their parent, which is a sub-total or total item; summation relationships are nested, and parent items at a given level in the hierarchy can be child items with respect to a higher level item.
- the specification of more than one extended link (named `calculationLink`) is needed whenever different formulas have to be defined for the same aggregate concept;

  As an example, in the consolidated income statement the bottom line, Profit (Loss), may be defined in two ways:

  - as the sum of Profit (Loss) Attributable to Equity Holders of Parent and Profit (Loss) Attributable to Minority Interest;
  - as the difference between Profit (Loss) after Tax from Continuing Operations and Profit (Loss) from Discontinued Operations Net of Tax.

  The two formulas must be implemented as sets of `calculationArc`(s) assigned to two distinct `calculationLink`(s).

With regard to other attributes in the arc (`use`, `priority`) and their settings in taxonomy extensions, the same rules of presentation linkbases apply. Obviously, there is no `preferredLabel` attribute.

Values reported in document instances must verify the following equivalence:

$$\text{value of parent item} = \sum_{j=1}^{n} \text{value of child item}[j] \times \text{weight of child item}[j]$$

where n is the number of child elements contributing to the value of a given parent item.

A calculation linkbase allows validation of summary values reported in a document instance, or even may drive the derivation of calculated values from the aggregation of input values.

In XBRL 2.1, the setting for performing mathematical and logical operations on data is still affected by relevant limitations:

- calculations can be defined for items belonging to the same context (i.e. to the same entity and period) in an instance document (see below); as an example, there is no way to reference a value in a previous or subsequent period, or to define a difference between entities;
- you can only add or subtract values, so it is impossible to define a formula even for a simple accounting ratio using a multiplication or a division (let alone financial or statistical functions).

As an example of such limitations, let's see the `calculationArcs`(s) for the section of explanatory disclosures shown before.

```
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_AdditionsConstructionInProgress"
     order="1" weight="1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_AcquisitionsThroughBusinessCombinationsConstructionInProgress"
     order="2" weight="1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_DisposalsConstructionInProgress"
     order="3" weight="-1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-
     gp_TransfersToFromNonCurrentAssetsAndDisposalGroupsHeldForSaleConstructionInProgress"
     order="4" weight="-1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_DisposalsThroughBusinessDivestitureConstructionInProgress"
     order="5" weight="-1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_ImpairmentLossRecognisedInIncomeStatementConstructionInProgress"
     order="6" weight="-1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_ImpairmentReversalRecognisedInIncomeStatementConstructionInProgress"
     order="7" weight="1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_ForeignCurrencyExchangeIncreaseDecreaseConstructionInProgress"
     order="8" weight="1" use="optional"/>
<calculationArc xlink:type="arc" xlink:arcrole="http://www.xbrl.org/2003/arcrole/summation-item"
     xlink:from="ifrs-gp_ChangesInConstructionInProgressNetTotal"
     xlink:to="ifrs-gp_OtherIncreaseDecreaseConstructionInProgress"
     order="9" weight="1" use="optional"/>
```

There is no formula defining "Construction in Progress, Net, Ending Balance" as the sum of the "Construction in Progress, Net, Beginning Balance" and "Changes in Construction in Progress, Net, Total" because beginning and end balances are items of period type `instant`, whereas changes are of type `duration`. They may not share a common context, and therefore cannot be summed together.

A forthcoming XBRL specification, the *formula linkbase* (see [10]) will allow sophisticated mathematical and logical operations to be carried out on taxonomy concepts along different dimensions, so as to allow the definition of complex financial models and the creation of validation and derivation rules[5].

[5] The XBRL formula language will be dealt with in a forthcoming paper in this series.

The following table lists the report types defined in the ifrs-gp taxonomy, and their corresponding calculation and presentation linkbase files. For each report both a presentation and a calculation linkbase are defined, except for the Code List.

General purpose

Description	Type	Linkbase File
Balance Sheet, Classified	Presentation	ifrs-gp-pre-bs-classified-2005-05-15.xml
	Calculation	ifrs-gp-cal-bs-classified-2005-05-15.xml
Balance Sheet, Order of Liquidity	Presentation	ifrs-gp-pre-bs-liquidity-2005-05-15.xml
	Calculation	ifrs-gp-cal-bs-liquidity-2005-05-15.xml
Balance Sheet, Net Assets	Presentation	ifrs-gp-pre-bs-netAssets-2005-05-15.xml
	Calculation	ifrs-gp-cal-bs-netAssets-2005-05-15.xml
Income Statement, by Function	Presentation	ifrs-gp-pre-is-byFunction-2005-05-15.xml
	Calculation	ifrs-gp-cal-is-byFunction-2005-05-15.xml
Income Statement, by Nature	Presentation	ifrs-gp-pre-is-byNature-2005-05-15.xml
	Calculation	ifrs-gp-cal-is-byNature-2005-05-15.xml
Cash Flow, Direct Method	Presentation	ifrs-gp-pre-cf-direct-2005-05-15.xml
	Calculation	ifrs-gp-cal-cf-direct-2005-05-15.xml
Cash Flow, Indirect Method	Presentation	ifrs-gp-pre-cf-indirect-2005-05-15.xml
	Calculation	ifrs-gp-cal-cf-indirect-2005-05-15.xml
Statement of Changes in Equity, General Purpose	Presentation	ifrs-gp-pre-sce-2005-05-15.xml
	Calculation	ifrs-gp-cal-sce-2005-05-15.xml
Accounting Policies, General Purpose	Presentation	ifrs-gp-pre-policies-2005-05-15.xml
	Calculation	ifrs-gp-cal-policies-2005-05-15.xml
Disclosures, General Purpose	Presentation	ifrs-gp-pre-disclosures-2005-05-15.xml
	Calculation	ifrs-gp-cal-disclosures-2005-05-15.xml
Disclosures, First Time Adoption of IFRS	Presentation	ifrs-gp-pre-firstTime-2005-05-15.xml
	Calculation	ifrs-gp-cal-firstTime-2005-05-15.xml
Classes, General Purpose	Presentation	ifrs-gp-pre-classes-2005-05-15.xml
	Calculation	ifrs-gp-cal-classes-2005-05-15.xml
Other, General Purpose	Presentation	ifrs-gp-pre-other-2005-05-15.xml
	Calculation	ifrs-gp-cal-other-2005-05-15.xml
Code Lists, General Purpose	Presentation	ifrs-gp-pre-codes-2005-05-15.xml

Financial Institutions

Description	Type	Linkbase File
Balance Sheet, Portfolio Basis	Presentation	ifrs-gp-fi-pre-bs-portfolio-2005-05-15.xml

	Calculation	ifrs-gp-fi-cal-bs-portfolio-2005-05-15.xml
Income Statement, Financial Institutions	Presentation	ifrs-gp-fi-pre-is-2005-05-15.xml
	Calculation	ifrs-gp-fi-cal-is-2005-05-15.xml
Cash Flow, Direct Method, Financial Institutions	Presentation	ifrs-gp-fi-pre-cf-direct-2005-05-15.xml
	Calculation	ifrs-gp-fi-cal-cf-direct-2005-05-15.xml
Cash Flow, Indirect Method, Financial Institutions	Presentation	ifrs-gp-fi-pre-cf-indirect-2005-05-15.xml
	Calculation	ifrs-gp-fi-cal-cf-indirect-2005-05-15.xml
Accounting Policies, Financial Institutions	Presentation	ifrs-gp-fi-pre-policies-2005-05-15.xml
Disclosures, Financial Institutions	Presentation	ifrs-gp-fi-pre-disclosures-2005-05-15.xml
	Calculation	ifrs-gp-fi-cal-disclosures-2005-05-15.xml
Classes, Financial Institutions	Presentation	ifrs-gp-fi-pre-classes-2005-05-15.xml
	Calculation	ifrs-gp-fi-cal-classes-2005-05-15.xml

2.3.7 Definition linkbases

For completeness I only mention the definition linkbase, used for describing certain special attributes of reporting facts, such as equivalence between two concepts. Definition linkbases have been seldom used until recently. They are now being re-discovered for defining multi-dimensional data structures in taxonomies and instances. Such features will be considered in a forthcoming paper.

2.4 XBRL document instances

Instance documents, also called ·XBRL Data Documents, contain the data related to specific accounting reports. Instance documents contain one or more sets of context information. A *context* is a complex element type that allows the consistent identification of:

- the reporting organization(s), defined in an `entity` element;
- the date(s) or time interval(s) for which information is being reported; specified in a `period` element;
- details of organizational unit (such as the different divisions that are reporting inside a single organization), defined in a `segment` element, a complex data type with a user-defined structure;
- details of the status of the data with respect to the degree of certainty / objectivity or stage in the planning, budgeting, auditing and reporting process (such as “budget” figures, “forecast” figures and “actual” figures) that are being used, defined in a `scenario` element.

Instance documents must also contain one or more `unit` identifiers that define the units of measure in use: units are typically currencies, identified by three-letter ISO-4217 codes, but can also be physical or derived measures such as tons, earnings per share, or Celsius degrees.

Finally, and most importantly, instance documents contain a set of *facts*. A *fact* is a complex XML element consisting of a concept tag used in a given taxonomy, the data that relate to this concept tag and the attributes that place the information in context.

For each fact entry (i.e. the value of an accounting item for a given context), an XML element must be inserted in the instance document. Since instance data is the central piece of information consumed by XBRL-enabled applications, an example is appropriate here, taken from a fictitious instance document.

First, I define a point-in-time (`instant`) context. The reporting entity is a fictitious company identified as `Sample Company` according to the classification scheme associated to the `http://www.businessregister.org` URI, a fictitious authority. The `id` attribute of such context is assigned as an attribute to facts representing balance sheet item values as of 31st December 2003. The optional scenario element is set to `actual`. The data document only presents data at the company level, so there is no `segment` information.

```
<context id="Current_AsOf">
    <entity>
      <identifier scheme="http://www.businessregister.org">Sample Company</identifier>
    </entity>
    <period>
      <instant>2003-12-31</instant>
    </period>
    <scenario>
      actual
    </scenario>
  </context>
```

In the following example, I define a `context` for a duration time-interval, which may be assigned to income and cash flow items for fiscal year 2003.

```
<context id="Current_ForPeriod">
    <entity>
      <identifier scheme="http://www.businessregister.org">Sample Company</identifier>
    </entity>
    <period>
      <startDate>2003-01-01</startDate>
      <endDate>2003-12-31</endDate>
    </period>
    <scenario>
      actual
    </scenario>
  </context>
```

Monetary values are expressed in euros. So we need a `unit` of measurement "euro", defined with the following syntax:

```
<unit id="U-Euros">
    <measure>iso4217:EUR</measure>
  </unit>
```

The contexts and units defined above are assigned to fact elements. The XML *element name* of each fact is composed of the taxonomy namespace prefix and the concept *name* attribute, as defined in the taxonomy schema, separated by ":". For example, a value of € 540.000 for the item "Property, plant and equipment, net" in the Asset section of the Balance Sheet at year end 2003 is expressed in this way:

```
<ifrs-gp:PropertyPlantEquipmentNet
 contextRef="Current_AsOf"
 unitRef="U-Euros"
 decimals="0">
    540000
</ifrs-gp:PropertyPlantEquipmentNet>
```

A value of Revenues in the "Income Statement by function" report for 2003 of € 1.300.000 is described in this way:

```
<ifrs-gp:RevenueFunction
 contextRef="Current_ForPeriod"
 unitRef="U-Euros"
 decimals="0">
    1300000
</ifrs-gp:RevenueFunction>
```

The value is expressed with "." as decimal separator and without thousands separator. The `decimals` attribute drives the rounding of fact values performed by XBRL parsers. It is an important aspect for a data consuming application that should produce numbers with the desired degree of precision. That point is of capital importance in an accounting application where totals must balance. The reported value for an aggregate item is considered correct if such value equals the sum of its child item values rounded to the number of decimals defined in the `decimal` attribute.

In an instance document, footnotes may be inserted for specific facts. The syntax for specifying footnotes is analogous to the one used in label linkbases. Notes are contained in a footnote linkbase that is embedded in the instance document. Here is an example for the element of type `resource` where the note text is stored.

```
<link:footnote xlink:type="resource"
xlink:role="http://www.xbrl.org/2003/role/footnote"  xlink:label="ifrs-
gp_ConstructionInProgressNet_note" xml:lang="en">
    For 2003, relates to real estate development projects in Southern Italy
</link:footnote>
```

As for labels, the footnote linkbase requires also locator and arc elements, which are not detailed here.

As concept definitions in the taxonomy schema, elements describing facts in instance documents do not follow an order. Order is imposed upon the data when it is processed according to a report structure as defined in the presentation and/or calculation linkbases.

2.5 Use of XBRL taxonomy and data documents in financial analysis

XBRL provides a rich and consistent framework for defining the data model of an application for the analysis of financial statements, implementing standard methodologies such as:

- historical analysis of actual financial statements by means of reclassified reports and financial ratios;
- *ex ante* business and financial planning by means of pro forma statements.

A conformant XBRL taxonomy provides a powerful setup for defining:

- the data dictionary of items consumed by the financial model as input variables;
- the layout and computation of reclassified reports, as far as the math used in them is limited to algebraic sums of elementary items.

When the formula linkbase specification (see [10]) will be released, the whole business logic of the model used for analysis will be manageable in an XBRL taxonomy. Until then, more sophisticated algorithms must be defined in an application specific setting, e.g. with spreadsheet formulas, XPath expressions, XQuery statements or with any sort of computer program. In the following section, I will present an implementation with a multidimensional spreadsheet program, Quantrix Modeler.

XBRL document instances may be used as a format for data fed into the analysis module, or for exporting the data processed in such model to other applications. As an example, we may export a forecasted income statement to accounting software add-ins for planning and budgeting, or a cash flow statement on actual data to be included in a web portal for management reporting.

A powerful feature of XBRL in this setting is the extensibility of both taxonomy and instance data models.

2.5.1 Information contained in financial statements

A state-of-the-art taxonomy, such as the ifrs-gp, already contains most of the data that is elaborated in financial analysis, with a degree of detail that is adequate for sophisticated ratio or cash flow analysis at the company level. The degree of detail may be deepened at will by means of sector- or company-specific extensions to taxonomies. Such extensions should be used for a finer classification of items by economic nature or function. They should not be used for breaking down items along dimensions which reflect time, company organization or scenario hypotheses, for which the use of `context` elements within instances is more appropriate.

2.5.2 Information contained in disclosures

The taxonomy may also define complex data structures used for exploding or explaining the information that is summarized in the main statements. Disclosures that are relevant for financial analysis purposes can be classified in five categories:

- *movement analysis,* exploding the net change in value of items reported in the balance sheet, which are aggregations of accounting transactions grouped by classes;

  > An example of movement analysis has been given above for the item Construction in Progress (see Section 2.3.5).

- *breakdown of values reported in main financial statements*, with the optional addition of extra information explaining the factors behind reported values in order to appreciate company policies and strategies, and risk exposure; this information is obtained from specialized modules of the accounting or ERP systems (e.g. inventory, financial instruments, accounts receivables, depreciable assets, equity investments); this line of analysis exposes the business and financial model behind a company's performance, i.e. its supply chain and key drivers; in this way it provides a link between actual and forecasted amounts, because future values can be computed from driver variables using the same model that is good for analyzing the formation of actual values.

  > A typical example may be a detail of raw material inventories by commodity and age of origination, with evidence of physical quantity, average carrying cost, current market value, another example is the breakdown of labor expenses with respect to the composition of personnel.

- *alternative representation of the value of items,* coming from criteria different form the ones used in the reported figures, e.g. a fair value vis-a-vis a value at amortized cost for a building; these values as well are managed by specialized applications, or are the result of ad hoc evaluations; this kind of information is strictly related to the qualitative disclosures on accounting policies and their changes over time;

- *non monetary quantitative data* provided for informational or statistical purposes, independently from accounting values (e.g. the number of employees, some data on physical volumes of production, etc.);

- *disclosure of accounting policies and other qualitative information* about the reporting firm which may be useful to interpret the accounting figures.

If a company discloses information of the types summarized above, any kind of report or analysis can be produced: cash flow statements (both direct and indirect method), EVA™ reports, liquidation value of assets, economic value of assets, etc.

In our setting, the parts of an XBRL taxonomy that define the structure and content of disclosures have great importance. With appropriate design, they can serve the needs of *ex post* analysis, as well as of *ex ante* planning and forecasting. The crucial design choice is the appropriate degree of detail of disclosures. They must support interfaces on three sides:

- first, the breakdown criteria by economic nature and by business or organizational unit must be compatible with the analytical chart of accounts used by the company in its financial accounting or ERP system, otherwise one could not fill the reclassification schemes with actual figures;
- second, the breakdown of changes in values by movement type must be compatible with the classification of transaction types, and these key types must be usable for selectively grouping the value of homogenous transactions from the accounting system; in this way the analyst can reach a high degree of control over the consistency among income, assets /liability and cash-flow items;
- third, a common business and financial model linking reported values to physical and economic drivers should be reflected both in the data model used for reporting and in the computing model used for planning and forecasting, in this way every report used in the model can be projected forward and backward on the time dimension.

Achieving such consistency is not an easy task. It cannot be imposed as a requirement for a general purpose XBRL taxonomy for external reporting, but it can be pursued in a closed environment (a single firm of a group of homogenous firm sharing an application platform) where the user is in full control of an integrated data warehouse used for financial accounting, cost accounting, management reporting and business performance management.

3 - Software tools for financial analysis and Quantrix Modeler

3.1 Software tools for financial modeling

In the described setting, our case for using Quantrix is made in view of the shortcomings of alternative software solutions for financial modeling. For a more articulated analysis of this issue, please refer to our Smefin internal report (see [3]).

Existing software can be grouped into three main classes:

- enterprise resource planning (ERP) applications, complemented by business intelligence (BI) and reporting applications
- traditional spreadsheets;
- software platforms for business performance management

ERP and BI/reporting applications do not support free form creation and modeling of data. In most cases, their functionality supports budgeting rather than true planning according to changing business dynamics.

Because of the limitations of current accounting and financial systems, financial professionals turn to the traditional **two dimensional spreadsheet** for significant modeling tasks - especially

those involving scenarios. Limitations of spreadsheets make them unsuitable for complex modeling, as demonstrated in [5]. Such limitations include two-dimensional design, formulas written with arbitrary coordinates, logic tied to the initial layout of the data, and, as a consequence, rigidity in the iterative refactoring of the model.

There area also physical constraints affecting spreadsheet models, coming from the maximum allowed number of rows and columns, and from the huge file size, due to the storage of a formula in each calculated cell.

Numerous issues arise from the aforementioned limitations: spreadsheet revision is an error-prone activity, with low and decreasing productivity. Model auditing is a tedious and time consuming task. Author dependence, lack of portability and limitations on business insight complete the picture.

In spite of all these problems, business professionals throughout the world use the basic spreadsheet package to accomplish their modeling tasks because spreadsheets are ubiquitous and there has been no product alternative to get the job done with existing skills and application frameworks.

Beyond spreadsheets, we have the more articulate solutions, which combine and extend the capabilities of the previous categories, i.e. **software platforms for business performance management and strategic finance**. On top of accounting or ERP systems, multinational firms employ additional software components for financial planning and reporting or the so called "business performance management" (BPM), i.e. distributed systems enabling decision makers in every department of the company to participate in the planning process, and monitor the financial performance in real time, fostering immediate reaction to new opportunities and threats coming from the markets or from inside the firm. BPM software is a very complex (and expensive) replacement for spreadsheet models developed in-house. BPM can be conceived as a "super-spreadsheet" software application modeling the value chain of a company, i.e. the processes linking financial results to key economic drivers (demand, input prices, efficiency, product prices, etc.). Such a solution avoids the problem and huge cost of converting and reconciling the data coming from the numerous spreadsheets used in the various departments into a central repository. The BPM solution makes the planning cycle shorter and more accurate, and involves actors with the best knowledge in the timely provision of information that is immediately available to decision makers all over the business. Users of BPM systems interact with a central application which embodies the business model. Information is stored in a central database available as a data warehouse with OLAP functionality. Pioneers in the development and adoption of BPM systems are usually bigger corporations, or firms in the technology sector with very sophisticated IT solutions for managing their production chain in real time. Providers of this kind of software are either specialized vendors (Adaytum, Cartesis, Cognos and Outlooksoft, to name a few), or providers of platforms for OLAP and information retrieval and multidimensional databases (such as Hyperion). The big players in the ERP market are also entering these segment with offerings based upon their platform (e.g. the components for strategic and financial planning by SAP).

The high cost and technological requirements of these solutions makes them unaffordable by our target users, i.e. small and medium sized firms.

3.2 About multi-dimensional spreadsheets and Quantrix Modeler

In 1986 a team at Lotus conceived the idea of a revolutionary spreadsheet, and translated the idea into a software development project. A final version of the application, called Improv, was released in 1991. Lotus Improv was based on three components:

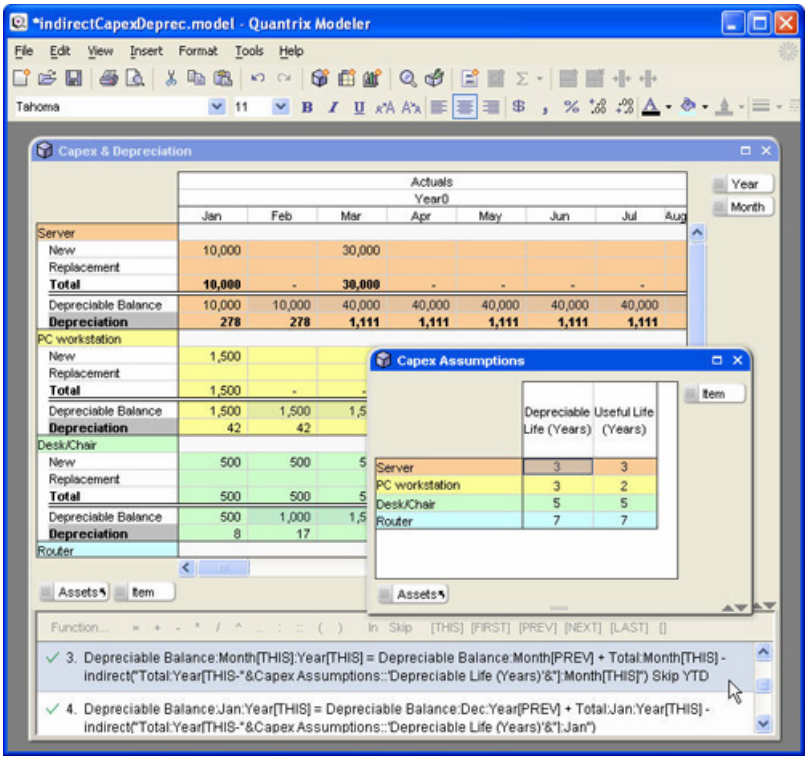
- a multidimensional data model tightly coupled with a computational engine based on formulas expressed in a rich textual language;
- a graphical user interface, originally developed for the NextStep operating system, allowing flexible manipulation of a model's data in tabular and graphical format;
- a macro programming language for automating complex procedures and personalizing the user interface.

In 1993 a Windows version appeared. For reasons that I will not consider here, despite acclaim by users and in the press, the product was subsequently abandoned.

3.2.1 Quantrix Modeler: an end-user's view

Quantrix Modeler is the only commercial software application available today that builds upon Improv's vision on an open Java-based platform, offering a solution targeted to the development of models for financial analysis and business intelligence. Quantrix Modeler combines an innovative architectural approach, based on separation of logic, structure and presentation, with a multidimensional calculation engine to deliver an elegant and powerful modeling tool designed for financial professionals.

The following screenshot gives an idea of Quantrix user interface.



3.2.2 Quantrix multidimensional model

At the heart of Quantrix there is a multidimensional model used for structuring information and defining the computational model. This architectural feature presents some analogy with business intelligence applications supporting OLAP (on-line analytical processing). OLAP applications are usually built on top of a DBMS, which can be a relational system, such as Oracle or SQL server, or a dedicated multidimensional environment, such as Hyperion Essbase. In the first case, data are pre-processed before being queried by the OLAP system, and the same applies to external data sources that can be accessed via specific data links.

In OLAP systems, the data warehouse is represented as a multidimensional matrix of data. In the OLAP jargon, the following concepts apply:

- the matrix, or *hypercube*, contains data to be analyzed, organized in fields called *measures* (e.g. the revenues and costs of a company);
- each data point is qualified by a variable number of key fields; following the matrix metaphor, they are called *dimensions* (e.g. geographical areas, business units, products, periods, customers);
- each dimension may assume several values, which can be organized in *hierarchies*: for example, at the finest level of detail revenues can be recorded by the combination of product, customer, month and province. Each of these dimensions can be organized hierarchically (e.g. month > quarter > year for a time dimension; product > product line > business unit for a business entity dimension; province > region > area > country for a geographical dimension).

Basic query expressions have the form of a function call taking an argument for each of the dimensions used. The generic shape of query results is also a multidimensional matrix, which may collapse to a scalar value, a vector, or a familiar two-dimensional table, depending on the shape and size of the underlying hypercube, and of the parameters, which may be single valued items, or groups of them corresponding to a higher level in a hierarchy.

> The polymorphism of data constructs may be confusing at first, but gives elegance and power to query languages used in these environments.

OLAP query languages are enhanced by strong computational capabilities. Calculated fields (measures) can be added. Various kinds of grouping operators (count, sum, average, etc.) can be applied. A rich set of built-in functions is provided, extensible with user defined functions. Complex procedures can be programmed for repeated execution of data retrieval and manipulation processes.

Such concepts and functionality have a correspondence in Quantrix:

- you can create a *model* containing one or more *matrices*;
- each matrix has one or usually more than one dimensions, called *categories*; a given category may be used only by that matrix, or else shared among two or more matrices; in the second case they are named *linked categories*; in linked categories, the list of items as well is shared among matrices, and modifications to a category's items in a matrix are immediately reflected in the linked ones[6]; linked categories are a powerful tool for cross referencing information among different matrices
- the values that a category can assume at the finest level of detail are called *items*;
- the user can create *groups* of items nested on several levels, corresponding to OLAP hierarchies;
- measures have not a rigid equivalent, usually fields containing "final data" to be analyzed are grouped in a category named *Item*, having "data field" names as item values; a scalar data point correspond to a *cell* in the matrix, uniquely identified by a set of coordinates, i.e.

[6] Please note that matrices with linked categories share the respective list of items, not the data associated to each item. Take a model with two matrices; Alfa company income and Beta company income; they share the *period* and *lineItem* categories, so they contain data for the same combinations of periods and income components but obviously values for a given cell (e.g. Revenues for year 2004) are different.

a set of item values for "dimension" categories and a "data field" item value from the *Item* category;

– for a matrix a set of *formulas* can be defined in order to obtain calculated values for a subset of its cells, defined by the *left side* of the formula; the formula's *right side* can reference data in the same matrix, in other matrices of the same model, or from matrices in external models.

The similarities between an OLAP system and a multidimensional spreadsheet model end when one comes to the user experience. In OLAP systems the user navigates across a pre-existing information base doing data mining and analysis, The structure of the underlying matrix, the data Hypercube, is defined by a system administrator, as well as computed fields and automated procedures. The end-user can change the perspective and level of detail of inquiries, following numerous paths (slicing and dicing, drill-down, design of personalized dash boards, etc.), but has no control over the underlying information base or the business logic applied. In Quantrix data and its structured representation can be modified interactively, as is typical in financial planning where the user changes assumptions and other subjective input data, that is mixed with actual information, imported from external systems. Computations, too, are in control of the end user. The model can be flexibly changed, and the effect of the changes is immediately appreciated.

4 - XBRL and two-dimensional spreadsheets

As can be imagined, spreadsheets have been used as the primary end-user tool for performing analysis of XBRL data. In this section, I will briefly give some hints on the use of the most popular commercial spreadsheet application, Microsoft Excel, for analyzing XBRL data.

4.1 Spreadsheet add-ins for importing and manipulating XBRL data

XBRL data services developed by the US SEC (Edgar On Line), the Deutsche Börse and the Korean Stock exchange[7] use Excel as one of the export formats. Special Excel templates or add-ins are provided as a tools to report or analyze XBRL data.

In 2003 Microsoft announced a set of XBRL tools for the Office Suite, comprising an Excel add-in capable of tagging ranges of data in a spreadsheet in order to produce valid XBRL document instances. Such prototype allowed the definition of formulas in terms of XBRL concepts, addressing the specific problem of analysis of accounting ratios and stock market indicators. As far as I know, a more refined version of this tool is being developed, but its release has not been announced yet.

In 2004 Rivet Software released Dragon Tag, an Excel add-in targeted to end-users of XBRL information. Dragon Tag is capable of reading XBRL taxonomies. The user can also extend imported taxonomies (a relevant feature of this software). It allows the configuration of context elements for an XBRL document instance. On the basis of the concept classification taken from the imported and extended taxonomy set, and of the context coordinates configured in the spreadsheet, the user can tag data in Excel with XBRL metadata, so as to export valid document instances. Another advertised feature of Dragon Tag is the ability to "paint" cell ranges, not only single cells, with taxonomy or context tags, for example assigning a `period` attribute to a column of values in a table. This shared settings are called *hoppers.*

[7] See, respectively, http://www.edgar-online.com, http://xbrl.kosdaq.com and http://xbrl.deutsche-boerse.com.

Other vendors have similar offerings (see the product showcase on http://www.xbrl.org for an updated list).

The experience so far in the use of spreadsheet-based software in the XBRL arena confirms the strength and weaknesses of this popular tool that have been summarized above. The spreadsheet in itself is a clean slate. The bulk of the work needed for specific processing of XBRL taxonomy and instance data is done by add-in modules. There are not relevant synergies between XBRL and native spreadsheet functionality, both in representation and in processing of information. The strength of spreadsheets resides once more in their widespread adoption: one can bring XBRL data into a spreadsheet and then work on it in the familiar way.

4.2 Analyzing imported data in spreadsheets

Once in a spreadsheet model, the XBRL information can be managed in two ways.

The simpler solution consists of tabular reports displaying decoded XBRL data with any desired layout The add-in module has to prepare the "landing area" for *concept* labels, placed in the rows headings, and *context* elements, placed in column headings on one or several levels (by period, entity, segment, scenario); it has then to populate the report skeleton with data, adding formulas for computed cells implementing the logic in the calculation linkbase; other formulas may be added manually by the user. Formula expressions may refer to cell coordinates or else use XBRL concept *names*; in the second case an extra layer of processing is required (presumably the creation of *range names* mapped to concept elements, and the definition of cell formulas based on those names).

Another solution makes use of *pivot tables*. Imported information can be stored in a worksheet as a flat table that is assigned as a data source to a pivot table. Each row of the data source should contain a data point together with key fields of two kinds:

- metadata from the taxonomy, i.e. a flattened subset of data and attributes from the schema and the presentation, calculation and label linkbases, such as concept name, report where it is displayed, descriptive labels, parent concept, calculation weight, etc.;
- metadata from the specific instance (period, entity, segment, scenario).

You can filter the data for a specific report and visualize it in the correct order as a pivot table; following this approach, you preserve the semantic and the structure of XBRL information behind reports. The layout can be flexibly restructured changing the type and the order of context dimensions used for visualization; computed values according to the calculation linkbase can be reproduced adding some calculated columns to the data source and using automatic row or column totals in the resulting table. You can also add formulas for creating calculated fields and calculated items to the pivot table, but this is not an intuitive process. Data visualized in the pivot report can be further elaborated upon in other sections of the spreadsheet model, using the GetPivotData() function, which accepts field names and values as arguments, or pointing and clicking to the pivot report's data manually. Pivot tables can be a good environment for visualizing and doing basic computation on imported XBRL data, if one is satisfied with the formatting options available and can tame their sometimes unexpected behavior.

5 - Managing XBRL in Quantrix

Quantrix distinctive features can be useful in designing a system for consuming and manipulating XBRL documents.

Underlying XBRL there is a multidimensional data model. At present, the best-practice approach to designing XBRL software applications is based upon specialized processors (taxonomy parsers and editors, instance creators, data servers), implementing an object model composed of software classes, written in Java or other programming languages, mapped onto taxonomy and instance elements. There are several implementation of such application platform, both commercial (e.g. Ubmatrix, Fujitsu, Decisionsoft) and open source (e.g. ABRA, XBRLcore, XBRLapi). The line between commercial and free software is blurred, as the major vendors make available no-charge versions (Fujitsu) or adopt a mixed commercial – open source business model (UBmatrix). Specialized XBRL repositories for persisting and sharing XBRL data are the other main component of an XBRL programming platform. Such repositories are built either with native proprietary solutions, provided by the same specialized vendors of XBRL libraries mentioned above, or using database management systems (DBMS). The DBMS of choice for an XBRL project may be a native XML database, ore a familiar relational DBMS (see [6]).

Quantrix multidimensional matrices can offer an alternative solution for both XBRL processing and data management. In Quantrix you maintain a one-to-one, transparent mapping between XBRL concepts and their equivalent in the data consuming application, adding extra functionality for extending the taxonomy and manipulating the instance data thanks to rich computation capabilities offered by formulas, with the additional benefit of hiding the complexity of the underlying XBRL model. I will prove the advantages of using Quantrix by means of an example, based upon a report (Income Statement, by function) from the ifrs-gp taxonomy.

5.1 Configuring the DTS

The user of reports written in the XBRL language works in an environment that is defined by a *Discoverable Taxonomy Set* (DTS). The DTS is a set of taxonomy documents: schemata, linkbases, other documents defining data types and domains (roles). The DTS may include documents from several taxonomies. In a typical case a *base taxonomy*, such as the `ifrs-gp`, forms the backbone, with one or more *extension taxonomies*. The physical organization of document files must be managed by a data import interface, configured via appropriate settings in a Quantrix model[8].

In order to make our environment self contained, I will define for each taxonomy or taxonomy extension a *namespace prefix*, and suppose that each prefix is unique within the DTS, and that it is consistently used across the DTS in order to build unique *id* attributes for a given XBRL concept. These prefixes also correspond to the ones used in document instances in order to identify schema concepts taken from different taxonomies[9].

In order to configure the environment for data interfaces, a matrix named *DTS-taxonomies* is created, containing a category *prefix* used as the unique identifier of taxonomies. For each taxonomy, the string composing the namespace of the taxonomy and the file names of the "dictionary" documents (schema, label and reference linkbases) are inserted as items in an *Item* category. The physical location of corresponding files can also be specified in a *local dir* item.

For file names, an item group named *file* is created, with children *schema*, *label* and *reference*. *file.label* is another item group with as many items as the languages for which labels are

[8] We cannot provide a detailed treatment of import procedures here. Additional information can be requested to the author.

[9] If namespace prefixes for the same taxonomy URI are varied by creators of instance documents, a simple mapping table is needed to change the prefix to the one used in our model, when importing XBRL, and *vice versa*, when exporting.

defined. For languages different from the default (English for the ifrs-gp), the language code is included in the file name of label linkbases. The following figure shows the *DTS-taxonomies* matrix followed by the formulas computing the namespace and file names.

			ifrs-gp
name			IFRS - International Financial Reporting Standards - General Purpose
schema			http://
authority			xbrl.iasb.org
jurisdiction			int
reporting type			fr
actg standard			ifrs
economic sector			gp
qualifier			
date			2005-05-15
namespace			http://xbrl.iasb.org/int/fr/ifrs/gp/2005-05-15
checkPrefix			ifrs-gp
local dir			c:\AAAtestXML
file	schema		ifrs-gp-2005-05-15.xsd
	label	en	ifrs-gp-lab-2005-05-15.xml
		it	ifrs-gp-lab-it-2005-05-15.xml
	reference		ifrs-gp-ref-2005-05-15.xml

1. checkPrefix:'ifrs-gp' = actg standard:'ifrs-gp'&"-"&economic sector:'ifrs-gp' & if(qualifier="","","-"&qualifier)
2. file.schema = @prefix & "-" & text('DTS-Taxonomies'::date,"yyyy-mm-dd") & ".xsd"
3. file.label = @prefix & "-lab-" & if(@Item="en","",@Item & "-") & text('DTS-Taxonomies'::date,"yyyy-mm-dd") & ".xml"
4. namespace = Item.schema&authority&"/"&jurisdiction&"/"&reporting type&"/"&actg standard&"/"&economic sector&if(qualifier="","",qualifier&"/")&"/"&text(date,"yyyy-mm-dd")

The *DTS-taxonomies* matrix

A taxonomy may have an indefinite number of reports, configured in their respective presentation and calculation linkbases. In order to set the list of reports to be imported in our model, a *DTS-Reports* matrix is created. Each report is uniquely identified by a *prefix* category (linked to *DTS-Taxonomies*), which refers to a taxonomy, and a *prog* category (a generic counter). A short *name* is assigned to each report. The file names for presentation and calculation linkbases (*file.presentation* and *file.calculation*) are computed from the taxonomy's prefix and date, the report's *type* (`is` for Income Statement, `bs` for Balance Sheet, and `cf` for Cash Flow Statement) and *qualifier* (a short string indicating its specific format), and the linkbase's type (`pre` for presentation and `cal` for calculation). Here is the result.

	name	type	qualifier	file	
				presentation	calculation
1	BalanceSheetClassfied	bs	classified	ifrs-gp-pre-bs-2005-05-15.xml	ifrs-gp-cal-bs-2005-05-15.xml
2	BalanceSheetLiquidity	bs	liquidity	ifrs-gp-pre-bs-2005-05-15.xml	ifrs-gp-cal-bs-2005-05-15.xml
3	BalanceSheetNetAssets	bs	netAssets	ifrs-gp-pre-bs-2005-05-15.xml	ifrs-gp-cal-bs-2005-05-15.xml
4	IncomeStatementByFunction	is	byFunction	ifrs-gp-pre-is-2005-05-15.xml	ifrs-gp-cal-is-2005-05-15.xml
5	IncomeStatementByNature	is	byNature	ifrs-gp-pre-is-2005-05-15.xml	ifrs-gp-cal-is-2005-05-15.xml
6	CashFlowDirect	cf	direct	ifrs-gp-pre-cf-2005-05-15.xml	ifrs-gp-cal-cf-2005-05-15.xml
7	CashFlowIndirect	cf	indirect	ifrs-gp-pre-cf-2005-05-15.xml	ifrs-gp-cal-cf-2005-05-15.xml

1. file.presentation = @prefix & "-pre-" & type & "-" & text('DTS-Taxonomies'::date,"yyyy-mm-dd") & ".xml"
2. file.calculation = substitute(file.presentation,"pre","cal")

The *DTS-Reports* matrix

5.2 Dictionary matrices

The information needed by our model will be imported from taxonomy files into dedicated Quantrix matrices. One main category `concept` will manage the unique identification of

taxonomy concepts. An XBRL concept is mapped onto an unique identifier composed of its taxonomy's `prefix` (see before) and its `name` attribute separated by "_". The same composite key will be used to identify concept data in matrices created from instance documents (see below, Section 5.5).

We will have[10]:

- a *DTS-Schema* matrix with *prefix* and *concept* as row categories and *Item* as column category with columns *type* (containing basic XBRL types such as *monetary*, *string*, *decimal*, *shares*, or taxonomy specific types, prepended by their namespace), *substitutionGroup* (item or tuple), *period*, *balance*, and *abstract*, a boolean valued 1 if the concept is abstract and 0 otherwise;
- a *DTS-Label* matrix with *prefix*, *concept*, *language* and *labelRole* as categories; in this way, each label can be uniquely identified; *prefix* and *concept* are linked to the corresponding categories in *DTS-Schema*; a *label* value is assigned to each valid combination of the categories, together with an *id* field computed by the import procedure, given by prefix + concept name + labelRole + language code separated by "_", which serves as a convenience primary key for looking up label values to be shown in reports.

The following figure shows a view of the *DTS-Label* matrix:

			label	id
ifrs-gp_ConstructionInProgressNet	label	it	Commesse a Lungo Termine, Nette	ifrs-gp_ConstructionInProgressNet_label_it
		en	Construction in Progress, Net	ifrs-gp_ConstructionInProgressNet_label_en
	periodEndLabel	it	Commesse a Lungo Termine, Nette, Chiusura del Bilancio	ifrs-gp_ConstructionInProgressNet_periodEndLabel_it
		en	Construction in Progress, Net, Ending Balance	ifrs-gp_ConstructionInProgressNet_periodEndLabel_en
	periodStartLabel	it	Commesse a Lungo Termine, Nette, Apertura del Bilancio	ifrs-gp_ConstructionInProgressNet_periodStartLabel_it
		en	Construction in Progress, Net, Beginning Balance	ifrs-gp_ConstructionInProgressNet_periodStartLabel_en
ifrs-gp_ContingenciesDisclosures	label	it	Sopravvenienze, Informativa	ifrs-gp_ContingenciesDisclosures_label_it
		en	Contingencies Disclosures	ifrs-gp_ContingenciesDisclosures_label_en

A *DTS-Reference* matrix can also be created, but it will not be considered because it is not used in our application.

"Dictionary" matrices, and *DTS-label* in particular, make use of numerous categories. Since the ifrs-gp taxonomy is a huge one, with 4111 concepts, this has a cost in terms of larger model size and longer recalculation times. The "hyperdimensionality" of the matrices should not be an issue because taxonomy information is used only in the stage of configuring matrices used for reports. Moreover, Quantrix does a good job in managing sparse matrices, provided that the underlying formulas are few and simple, as is the case for our *DTS* matrices, which have no formulas. At any rate, schema and label dictionaries can subsequently be removed from the model, releasing memory and disk space. On the positive side, with generous use of categories, importing data into unique rows and looking up attribute values for a given concept *id* is much easier.

The process of importing data from the schema and label files into the *DTS* matrices is performed through a QAPI[11] action developed in a Quantrix plugin, making extensive use of the

[10] See above 2.3, page 5 for a brief explanation of taxonomy elements and attributes mentioned here.

functionalities provided by Quantrix Datalink[12]. I have enhanced XML parsing and transformation by means of two open source Java libraries, *dom4j* and *saxon*. Something better could be done if QAPI provided finer control over the native XML import engine in Quantrix[13]. The import procedure is computationally intensive, because it tries to compact information that is dispersed in different parts of schema or linkbase files. As an examples, it browses elements of type `locator` in order to reconstruct the presentation sequence of a report, but most of the needed information is taken from `presentationArc` elements, cross-referenced via xslt and XPath instructions.

The above mentioned XBRL processing engines from major vendors do a much better job than our home made import procedures: they maintain in memory the whole network of schema and linkbase elements, and therefore provide a more powerful and specialized toolkit for parsing taxonomies, navigating around and sorting out what is really needed. Anyway, our import procedure, although not designed for speed and efficiency, gets the job done. It can be easily substituted with one of the XBRL libraries currently available as open source software.

5.3 Report matrices

Importing schema and label dictionaries into Quantrix has been straightforward so far. Configuring the layout and the computational structure of the reports, on the contrary, is not trivial task. A lot more functionality has to be implemented, and complex relationships between taxonomy and instance data must be managed.

A Quantrix matrix representing a report should have at least the following features:

- visualize report items in the correct order and in the right hierarchy;
- expose descriptive labels, for the correct `labelRole`, in a language of choice;
- show values from document instances for different contexts, exploding context dimensions into a readable format (e.g. indicating the reporting period) with various layouts (e.g. current and previous periods side by side, or only current period, or detail by period / scenario, etc.); we shall assign values taken from a document instance to a *valueInput* item,
- compute values for aggregate items from the respective component items, according to the formulas specified in the calculation linkbase; these values are assigned to another item, named *valueCalc*;
- compare *valueInput* and *valueCalc* for any item, and explain the cause of inconsistencies between them, which may arise from a calculation error in the instance or else from the lack of detail in the input data.

Quantrix modeler offers various routes for meeting this list of requisites. I will present what I have learnt from my personal experience, with no presumption of having found an optimal approach.

The first challenge is reproducing the presentation hierarchy of reported XBRL concepts. Two approaches can be followed:

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[11] QAPI is a Java programming interface available to users of the professional version of Quantrix Modeler. With QAPI, users can develop plugins extending the functionalities of the program.

[12] Quantrix Modeler Datalink, available in the professional version of Quantrix Modeler, is a set of procedures for importing data into a Quantrix model's matrix from external data sources such as relational databases (through JDBC), text files, XML files and web services.

[13] Allowing preliminary `xslt` transformation, or the execution of an XQuery statement, would be a welcome addition to Quantrix Datalink's XML module.

- one is giving structure to the items of the *concept* category, by means of a hierarchy of item groups and items corresponding to "leaf" concepts, containing elementary input values;
- the other is maintaining a flat sequence of concepts, without groups, and reflect the hierarchy in the visual aspect of concept labels.

The first approach may seem promising at first, and actually I started from it. It requires a lot of programming: a QAPI action must be written, computing the nesting level of concepts in the hierarchy and creating groups in a bottom-up order, starting from leaf items and ending up with the report's root. This way meets serious shortcomings:

- the tree structure is represented in the leftmost category column, containing items related to the XBRL concepts; you are forced to choose a readable format for item names (not the concept's `id`);
- with the previous solution, you must choose a reporting language, which could be changed only with a Java procedure browsing the item names and changing them to a different language;
- the text or aspect of names in a category column cannot be modified neither with formulas, nor with conditional format settings; it must be set manually or programmatically;
- in theory, formulas from the computation linkbase can be assigned to summary items inserted for each item group; those formulas might have a simple structure of the sort `[group].valueCalc = sum(summary([group].valueInput*[group].weight))` in practice, this is awkward, if not unfeasible, because you have to manage the sign of the `weight` attribute of child items in a nested structure; higher level sums do not maintain the sign of leaf items, but you have to consider the `weight` assigned to the intermediate level sum;

  > As an example, Profit is defined as (Revenues × 1 + Expenses × -1), but each item summing up to Expenses has a positive weight, and their weighted sum is positive, so the weight of detailed items must be reversed in order to computed Profit directly from their values. It is not easy to manage a nested product of weights with changing sign in a summary item.

- using summary items, you insert something that has not necessarily an equivalent in the presentation linkbase; the position of the total must be chosen (before or after the child items?) and you have also to decide about the display of the group name (yes or no? is it a placeholder for an abstract XBRL item?); such choices must be hard coded in the Java action;
- when the XBRL formula specification will be released, weighted sums will no longer be the only way for defining the computational structure of a report; it is unreasonable to limit what you do in Quantrix because you cannot do it in XBRL now (but you will be able in the future).

For these reasons, I have decided to follow an alternative route. After a lot of trial-and-error, I convinced myself that a solution should meet the following principles:

- the matrix for a given report should self-contain, or easily access in a dedicated helper matrix, all the taxonomy information needed to present, compute and audit its data content;
- the matrix dimensions (and its size) should be kept as few as possible;
- readable Quantrix formulas should be created by the import procedure from the calculation linkbases's dependency trees.

What I obtained on this grounding is a report design with the following features. The main dimension of the report is a category called *concept_label*, whose items are unique ids for concepts reported; *concept_label* is a string normally composed of *prefix*, concept *name* separated by "_", as in the *concept* category of *DTS* matrices; only for items linked to special label roles, such label role value (e.g. `periodStartLabel` or `restatedLabel`) is appended, again separated by "_".

5.4 Representing layout and calculations of a report in the *taxo* matrix

I decided to keep all the taxonomy information used for displaying the report and validating the instance data in a dedicated *taxo* matrix. The *concept-label* category provides the main dimension for a report matrix. *Taxo* matrices have also a category named *Item* that contains the following metadata items taken from the taxonomy:

- *prefix*, the taxonomy prefix for the concept;
- *concept,* the concept's XBRL `name`;
- *presRole* and *calcRole*, respectively the names of the `presentationLink` and of the `calculationLink` containing the concept;
- *presFrom* and *calcFrom,* respectively the `id` of the parent concept, which corresponds to the attribute `xlink:from` in the presentation and calculation arcs used in the respective linkbases; for root elements a fictitious id value `[prefix]_root` is assigned by the import routine;
- *presOrder,* the position in the sequence of children of the same parent (the `order` attribute in a presentation arc);
- *labelRole*, the label type used at this point in the report;
- *presLevel*, the level in the presentation tree hierarchy, which assumes value 1 for root concepts and increases for children up to the deepest nesting level; unlike previous columns, this one is computed in Quantrix using a recursive formula[14];
- *orderCode*, a computed item that returns a long integer used for sorting the report's rows in the correct presentation order[15]; an alternative is to sort the rows in the import procedure and omit this item, which entails computing *presLevel* as well; the current solution may be better if one intends to change the report structure in Quantrix, as is done in a taxonomy extension;
- a *labels* group named after the language's code, containing one item per managed language; in our example we have two items *labels.en* and *labels.it*; their values are looked up in the *DTS-Label* matrix with a formula[16];

---

[14] The formula is:

```
presLevel = if(presFrom="","",if(presFrom=prefix &
      "_root",1,select(presLevel:concept_label,@concept_label,presFrom)+1))
```

[15] The formula for *orderCode* is the following:

```
orderCode = if(presLevel="","",if(presOrder=0, countif(presOrder:concept_label[FIRST] ..
   presOrder:concept_label[THIS],0)*10^((max(presLevel:concept_label)-
   1)*2),select(orderCode:concept_label,@concept_label,presFrom)+presOrder*10^((max(pres
   Level:concept_label)-presLevel)*2)))
```

The complexity of the formula arises from the need to manage more than one root element per report, which is never the case in the report layouts considered here.

[16] The formula is:

More columns may be added to include all the schema attributes for each concept (e.g. *balance*, *periodType*), so as to make the report matrix completely self-contained.

Here is a view of the hidden "metadata" part of the *taxo* matrix for the report *Income Statement, by Function*.

	prefix	presFrom	calcFrom	presOrder	labelRole	presLevel	orderCode	labels	
								en	it
ifrs-gp_IncomeStatementPresentation	ifrs-gp	ifrs-gp_root		0	label	1	100000000	Income Ste	Conto E cor
ifrs-gp_ProfitLossFromOperationsPresentation	ifrs-gp	ifrs-gp_IncomeStatementPresentation		1	label	2	101000000	Profit (Loss	Corrispettiv
ifrs-gp_GrossProfitByFunctionPresentation	ifrs-gp	ifrs-gp_ProfitLossFromOperationsPresentation		1	label	3	101010000	Gross Profi	Utile Lordo
ifrs-gp_RevenueTotalByFunction	ifrs-gp	ifrs-gp_GrossProfitByFunctionPresentation	ifrs-gp_GrossProfitByFunction	1	label	4	101010100	Revenue, T	Ricavi, Tot
ifrs-gp_CostOfSalesByFunction	ifrs-gp	ifrs-gp_GrossProfitByFunctionPresentation	ifrs-gp_GrossProfitByFunction	2	label	4	101010200	Cost of Sal	Costo del V
ifrs-gp_GrossProfitByFunction	ifrs-gp	ifrs-gp_GrossProfitByFunctionPresentation	ifrs-gp_ProfitLossFromOperations	3	label	4	101010300	Gross Profi	Utile Lordo
ifrs-gp_OtherOperatingIncomeByFunctionPresentation	ifrs-gp	ifrs-gp_ProfitLossFromOperationsPresentation		2	label	3	101020000	Other Oper	Altri Prover

The columns actually displayed in the report are the following:

- *label*, a computed item[17] taking the label text for the current language selected in the *Settings* matrix, and prepending to it a number of spaces equal to *presLevel* × 2; the column has a conditional format, assigned by the import procedure, depending on *presLevel*;
- *valueInput*, a container of instance values for an appropriate `context`; the assignment formula is presented below;
- *valueCalc*, a group of computed items taking *valueInput* by default, and overridden by formulas defined in the calculation linkbase in the case of aggregate items; *valueCalc* has as many items as the number of *calculationLink(s)* used in the report (multiple calculation links allow more than one definition per aggregate item, see above, page 13); formulas for *valueCalc* are composed by the import procedure; a readable Quantrix formula seemed to me a much better alternative than a nested tree showing attributes of `calculationArc(s)`. A declaration `In valueCalc.[calculationLink name],` is prepended to the formula in order to make it more compact. Children items are referenced via their *concept_label* item values, which normally are the same as their XBRL `id(s)`.

```
labels = select('DTS-Label'::Item.label,'DTS-Label'::id,
      concept & "_" &labelRole & "_" & @Item)
```

[17] The formula is:

```
label = if(concept="","",rept("  ",presLevel) & indirect(Settings::lang))
```

The following figure shows the columns *label, valueInput* and *valueCalc* of *Income Statement, by Function* (note the presence of two items in the *valueCalc* group, one for the main calculation linkbase (*IncomeStatementByFunction*) and the other for a second, ancillary calculation linkbase (*other*):

	label	valueInput	valueCalc	
			IncomeStatementByFunction	Other
ifrs-gp_IncomeStatementPresentation	Income Statement (Presentation)			
ifrs-gp_ProfitLossFromOperationsPresentation	Profit (Loss) from Operations (Presentation)			
ifrs-gp_GrossProfitByFunctionPresentation	*Gross Profit [by function] (Presentation)*			
ifrs-gp_RevenueTotalByFunction	Revenue, Total [by function]	1.300.000	1.300.000	1.300.000
ifrs-gp_CostOfSalesByFunction	Cost of Sales [by function]	500.000	500.000	500.000
ifrs-gp_GrossProfitByFunction	Gross Profit [by function]	800.000	800.000	800.000
ifrs-gp_OtherOperatingIncomeByFunctionPresentation	*Other Operating Income [by function] (Presentation)*			
ifrs-gp_InterestIncomeByFunction	Interest Income [by function]			
ifrs-gp_DividendIncomeByFunction	Dividend Income [by function]			
ifrs-gp_GainOnForeignCurrencyExchangeFromBorrowingsRelatingT	Gain on Foreign Currency Exchange from Borrowings Relating to Interest Costs			
ifrs-gp_GainOnRedemptionAndExtinguishmentOfDebt	Gain on Redemption and Extinguishment of Debt			
ifrs-gp_MiscellaneousOtherOperatingIncomeByFunction	Miscellaneous Other Operating Income [by function]			
ifrs-gp_OtherOperatingIncomeTotalByFunction	Other Operating Income, Total [by function]	21.000	-	21.000
ifrs-gp_OperatingExpensesByFunctionPresentation	*Operating Expenses [by function] (Presentation)*			
ifrs-gp_MarketingAndDistributionCostsByFunction	Marketing and Distribution Costs [by function]	90.000	-	90.000
ifrs-gp_MarketingCostsByFunction	Marketing Costs [by function]			
ifrs-gp_DistributionCostsByFunction	Distribution Costs [by function]			
ifrs-gp_ResearchAndDevelopment	Research and Development			
ifrs-gp_AdministrativeExpensesByFunction	Administrative Expenses [by function]	50.000	50.000	50.000
ifrs-gp_RestructuringCosts	Restructuring Costs			
ifrs-gp_MiscellaneousOtherOperatingExpensesByFunction	Miscellaneous Other Operating Expenses [by function]	31.000	31.000	31.000
ifrs-gp_OperatingExpensesTotalByFunction	Operating Expenses, Total [by function]	171.000	81.000	171.000
ifrs-gp_ProfitLossFromOperations	*Profit (Loss) from Operations*	650.000	719.000	650.000
ifrs-gp_ProfitLossBeforeTaxPresentation	Profit (Loss) Before Tax (Presentation)			
ifrs-gp_GainLossOnFinancialInstrumentsDesignatedAsCashFlowHe	*Gain (Loss) on Financial Instruments Designated as Cash Flow Hedges*			
ifrs-gp_GainLossOnDerecognitionOfAvailableForSaleFinancialAsset	*Gain (Loss) on Derecognition of Available-for-Sale Financial Assets*			
ifrs-gp_GainLossOnDerecognitionOfNonCurrentAssetsNotHeldForSa	*Gain (Loss) on Derecognition of Non-Current Assets Not Held for Sale, Total*			
ifrs-gp_FinanceCostsForNonFinancialActivities	*Finance Costs [for Non-Financial Activities]*	9.000	9.000	9.000
ifrs-gp_IncomeLossFromInvestments	*Income (Loss) from Investments*			
ifrs-gp_NegativeGoodwillImmediatelyRecognised	*Negative Goodwill Immediately Recognised*			
ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments	*Share of Profit (Loss) from Equity-Accounted Investments*	20.000	20.000	20.000
ifrs-gp_ShareOfProfitLossFromEquityAccountedAssociates	Share of Profit (Loss) from Equity-Accounted Associates			
ifrs-gp_ShareOfProfitLossFromEquityAccountedJointVentures	Share of Profit (Loss) from Equity-Accounted Joint Ventures	20.000	20.000	20.000
ifrs-gp_OtherNonOperatingIncome	*Other Non-Operating Income*			
ifrs-gp_OtherNonOperatingExpenses	*Other Non-Operating Expenses*			
ifrs-gp_ProfitLossBeforeTax	*Profit (Loss) Before Tax*	661.000	730.000	661.000
ifrs-gp_ProfitLossAfterTaxFromContinuingOperationsPresentation	Profit (Loss) After Tax from Continuing Operations (Presentation)			
ifrs-gp_IncomeTaxExpenseIncome	*Income Tax Expense (Income)*	107.000	107.000	107.000
ifrs-gp_ProfitLossAfterTaxFromContinuingOperations	*Profit (Loss) After Tax from Continuing Operations*	554.000	623.000	554.000
ifrs-gp_ProfitLossPresentation	Profit (Loss) (Presentation)			
ifrs-gp_ProfitLossFromDiscontinuedOperationsNetOfTax	*Profit (Loss) from Discontinued Operations, Net of Tax*			
ifrs-gp_ProfitLoss	*Profit (Loss)*	554.000	623.000	554.000
ifrs-gp_ProfitLossAttributableToEquityHoldersOfParentAndMinorityIn	Profit (Loss) Attributable to Equity Holders of Parent and Minority Intere			
ifrs-gp_ProfitLossAttributableToEquityHoldersOfParent	*Profit (Loss) Attributable to Equity Holders of Parent*	553.400	553.400	553.400
ifrs-gp_ProfitLossAttributableToMinorityInterest	*Profit (Loss) Attributable to Minority Interest*	600	600	600
ifrs-gp_EarningsPerSharePresentation	Earnings Per Share (Presentation)			
ifrs-gp_BasicEarningsLossPerShare	*Basic Earnings (Loss) Per Share*		-	
ifrs-gp_BasicEarningsLossPerShareFromDiscontinuedOperations	Basic Earnings (Loss) Per Share from Discontinued Operations			
ifrs-gp_BasicEarningsLossPerShareFromContinuingOperations	Basic Earnings (Loss) Per Share from Continuing Operations			
ifrs-gp_DilutedEarningsLossPerShare	*Diluted Earnings (Loss) Per Share*		-	
ifrs-gp_DilutedEarningsLossPerShareFromDiscontinuedOperations	Diluted Earnings (Loss) Per Share from Discontinued Operations			
ifrs-gp_DilutedEarningsLossPerShareFromContinuingOperations	Diluted Earnings (Loss) Per Share from Continuing Operations			

The report can be rendered in another supported language by changing the *lang* value in the *Settings* matrix. Here is a portion of the Italian version:

	label	valueInput	valueCalc	
			IncomeStatementByFunction	Other
ifrs-gp_GrossProfitByFunctionPresentation	*Utile Lordo [per funzione] (Presentazione)*			
ifrs-gp_RevenueTotalByFunction	Ricavi, Totale [per funzione]	1.300.000	1.300.000	1.300.000
ifrs-gp_CostOfSalesByFunction	Costo del Venduto [per funzione]	500.000	500.000	500.000
ifrs-gp_GrossProfitByFunction	Utile Lordo [per funzione]	800.000	800.000	800.000

Behind the scenes, the following formulas, automatically composed by our taxonomy import procedure, are ready to be computed:

1. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_ProfitLoss' = 'ifrs-gp_ProfitLossAfterTaxFromContinuingOperations' - 'ifrs-gp_ProfitLossFromDiscontinuedOperationsNetOfTax'
2. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_DilutedEarningsLossPerShare' = 'ifrs-gp_DilutedEarningsLossPerShareFromDiscontinuedOperations' + 'ifrs-gp_DilutedEarningsLossPerShareFromContinuingOperations'
3. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_ProfitLossFromOperations' = 'ifrs-gp_GrossProfitByFunction' + 'ifrs-gp_OtherOperatingIncomeTotalByFunction' - 'ifrs-gp_OperatingExpensesTotalByFunction'
4. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_OperatingExpensesTotalByFunction' = 'ifrs-gp_MarketingAndDistributionCostsByFunction' + 'ifrs-gp_ResearchAndDevelopment' + 'ifrs-gp_AdministrativeExpensesByFunction' + 'ifrs-gp_RestructuringCosts' + 'ifrs-gp_MiscellaneousOtherOperatingExpensesByFunction'
5. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_MarketingAndDistributionCostsByFunction' = 'ifrs-gp_MarketingCostsByFunction' + 'ifrs-gp_DistributionCostsByFunction'
6. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_ProfitLossBeforeTax' = 'ifrs-gp_ProfitLossFromOperations' + 'ifrs-gp_GainLossOnFinancialInstrumentsDesignatedAsCashFlowHedges' + 'ifrs-gp_GainLossOnDerecognitionOfAvailableForSaleFinancialAssets' + 'ifrs-gp_GainLossOnDerecognitionOfNonCurrentAssetsNotHeldForSaleTotal' - 'ifrs-gp_FinanceCostsForNonFinancialActivities' + 'ifrs-gp_IncomeLossFromInvestments' + 'ifrs-gp_NegativeGoodwillImmediatelyRecognised' + 'ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments' + 'ifrs-gp_OtherNonOperatingIncome' - 'ifrs-gp_OtherNonOperatingExpenses'
7. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_OtherOperatingIncomeTotalByFunction' = 'ifrs-gp_InterestIncomeByFunction' + 'ifrs-gp_DividendIncomeByFunction' + 'ifrs-gp_GainOnForeignCurrencyExchangeFromBorrowingsRelatingToInterestCosts' + 'ifrs-gp_GainOnRedemptionAndExtinguishmentOfDebt' + 'ifrs-gp_MiscellaneousOtherOperatingIncomeByFunction'
8. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_GrossProfitByFunction' = 'ifrs-gp_RevenueTotalByFunction' - 'ifrs-gp_CostOfSalesByFunction'
9. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_BasicEarningsLossPerShare' = 'ifrs-gp_BasicEarningsLossPerShareFromDiscontinuedOperations' + 'ifrs-gp_BasicEarningsLossPerShareFromContinuingOperations'
10. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments' = 'ifrs-gp_ShareOfProfitLossFromEquityAccountedAssociates' + 'ifrs-gp_ShareOfProfitLossFromEquityAccountedJointVentures'
11. In valueCalc.'IncomeStatementByFunction', 'ifrs-gp_ProfitLossAfterTaxFromContinuingOperations' = 'ifrs-gp_ProfitLossBeforeTax' - 'ifrs-gp_IncomeTaxExpenseIncome'
12. In valueCalc.Other, 'ifrs-gp_ProfitLoss' = 'ifrs-gp_ProfitLossAttributableToEquityHoldersOfParent' + 'ifrs-gp_ProfitLossAttributableToMinorityInterest'

In the formatted report displayed above, some values are displayed. They are taken from a sample document instance and fed into the *valueInput* column by means of a formula (see below, section 5.5, for details). All the values shown in *valueInput* are from a single instance context, named `CurrentForPeriod`, of type *period*.

The *valueCalc* column echoes by default *valueInput* thanks to a general formula *valueCalc* = *valueInput*, except for the concepts having a mathematical definition in the calculation linkbase. Such definitions are translated into matrix formulas "eclipsing" the general one.

In the displayed data, there are some inconsistencies between inputs and calculated values: sometimes, as for *Gross profit [by function]* in the 7th row, *valueCalc* is equal to *valueInput*; elsewhere, as in the case of *Other operating income, Total [by function]* in the 14th row, *valueCalc*, computed from a formula, is zero-valued, whereas *valueInput*, coming from the instance, has a non-zero value. The problem lies in the incompleteness of instance data: the items that sum up to *Other operating income, Total [by function]*, which are not disclosed in detail in the given instance, have empty values summing up to zero. We will solve this problem adding some conditional expressions to the formulas. Before showing how to do that, let's analyze the information contained in the instance in order to find a way to display data for more than one context along several dimensions.

5.5 Document instance information

Data contained in XBRL instances are more dynamic than a taxonomy's metadata. The crucial issue is the enumeration of *contexts* and the "explosion" of their dimensions (*period*, *entity*, *segment*, and *scenario*), which are defined in the instance and cannot be known in advance. Moreover, *segment* and *scenario* elements may have an arbitrarily complex structure. I will not deal with this case here, and assume that *segment* and *scenario* are either undefined or take a simple value (a string identifier).

Our example uses the `SampleCompany.xml` instance file, which has been made available on the IASB web site. In order to import instance document files, I have programmed another QAPI action in Java. Such procedure parses the instance document and creates three matrices:

- *Instance-Contexts,* a flat representation of contexts used in the instance;
- *Instance-Units,* a list of units of measure used in the instance;
- *Instance-Facts*, each one containing data for a combination of concept, context and unit.

Instance-Contexts has a main category named *context*, having items corresponding to the names of contexts used in the instance. For each context the following properties are defined, as items in the usual *Item* category:

- child elements and attributes of `context` elements, namely *entity*, *entityScheme, segment* and *scenario*;
- *periodStartDate*, *periodEndDate* and *isInstant*, used for capturing `period` information; when period is of type `instant` *isInstant* has value 1, and *periodStartDate* equals *periodEndDate*, whereas periods of type `duration` have *isInstant* = 0, and *periodStartDate* < *periodEndDate;*
- *contextValue*, a convenience column replicating the *context* item name.

Hereafter we have the *Instance-Contexts* matrix created by our import procedure applied to the sample instance:

	entity	entityScheme	segment	scenario	periodStartDate	periodEndDate	isInstant	contextValue
Current_AsOf	SAMP	http://www.sampleCompany.com	noSegment	noScenario	2004-12-31	2004-12-31	1	Current_AsOf
Current_ForPeriod	SAMP	http://www.sampleCompany.com	noSegment	noScenario	2004-01-01	2004-12-31	0	Current_ForPeriod
Prior_AsOf	SAMP	http://www.sampleCompany.com	noSegment	noScenario	2003-12-31	2003-12-31	1	Prior_AsOf
Prior_ForPeriod	SAMP	http://www.sampleCompany.com	noSegment	noScenario	2003-01-01	2003-12-31	0	Prior_ForPeriod
PriorPrior_AsOf	SAMP	http://www.sampleCompany.com	noSegment	noScenario	2002-12-31	2002-12-31	1	PriorPrior_AsOf
Current_Shares	SAMP	http://www.sampleCompany.com	noSegment	noScenario	2004-01-01	2004-12-31	0	Current_Shares
Prior_Shares	SAMP	http://www.sampleCompany.com	noSegment	noScenario	2003-01-01	2003-12-31	0	Prior_Shares

As can be seen, *segment* and *scenario* take default values *noSegment* and *noScenario* respectively, since they are undefined in the sample instance.

Instance-Units has a very simple structure, with a main *unit* category and an *Item* category with only one item *measure* (complex measures are not used):

	measure
U-Euros	ISO4217:EUR
nonMonetary	

A fictitious *nonMonetary* unit has been added manually in order to filter facts not relevant for our analysis.

Once the domain of contexts is configured, importing data is straightforward. One has to create an *Instance-Facts* matrix with the following structure:

- a main category *concept*; this category may be linked to the corresponding category in *DTS-Schema* matrix, but I did not link it for two reasons, first to avoid redundancy (the instance may contain a small subset of a very long list of concepts), and second because we would lose the physical order of concepts in the instance document;
- two categories *context*, and *unit*, linked to the corresponding categories created before in *Instance-Contexts* and *Instance-Units* matrices;
- the usual category *Item* with items *value* and *decimals*, used for storing instance fact values.

By creating linked categories, we are able to exploit Quantrix multi-dimensional engine for filtering, displaying and referencing facts related to different contexts and units. However, we shall see that context references have to be “exploded” and elaborated in order to extract the dimension that are meaningful to show in a report or a financial analysis document.

The information contained in the fact elements of the document instance is easily imported in this structure with the QAPI action. Here is a portion of the resulting matrix with fact values:

		value	decimals
ifrs-gp_PropertyPlantAndEquipmentNet	Current_AsOf	540.000	0
	Prior_AsOf	400.000	0
	PriorPrior_AsOf	300.000	0
ifrs-gp_AdditionsPropertyPlantAndEquipmentNet	Current_ForPeriod	200.000	0
	Prior_ForPeriod	100.000	0
ifrs-gp_DisposalsPropertyPlantAndEquipmentNet	Current_ForPeriod	50.000	0
	Prior_ForPeriod	0	0
ifrs-gp_DepreciationExpensePropertyPlantAndEquipmentNet	Current_ForPeriod	10.000	0
	Prior_ForPeriod	10.000	0
ifrs-gp_ChangesInPropertyPlantAndEquipmentNetTotal	Current_ForPeriod	140.000	0
	Prior_ForPeriod	100.000	0
ifrs-gp_LandNet	Current_AsOf	100.000	0
	Prior_AsOf	100.000	0
	PriorPrior_AsOf	100.000	0
ifrs-gp_BuildingsNet	Current_AsOf	350.000	0
	Prior_AsOf	205.000	0
	PriorPrior_AsOf	150.000	0

This matrix is the source of values displayed in the report shown above (see section 5.4). For simplicity, values are assigned to *valueInput* by means of Quantrix `indirect()` function with the following formula, taking as argument a string composed of the item names which define the dimensions of the appropriate cell in the *Instance-Facts* matrix (references to *scenario* and *unit* are hard-coded into the formula for simplicity):

```
valueInput=clearerror( indirect( "'Instance-Facts'::'U-
Euros':Current_ForPeriod:value:'" & @concept_label &"'"))
```

As an alternative, we could use Quantrix `select()` function.

5.6 Normalizing and extending *context* information

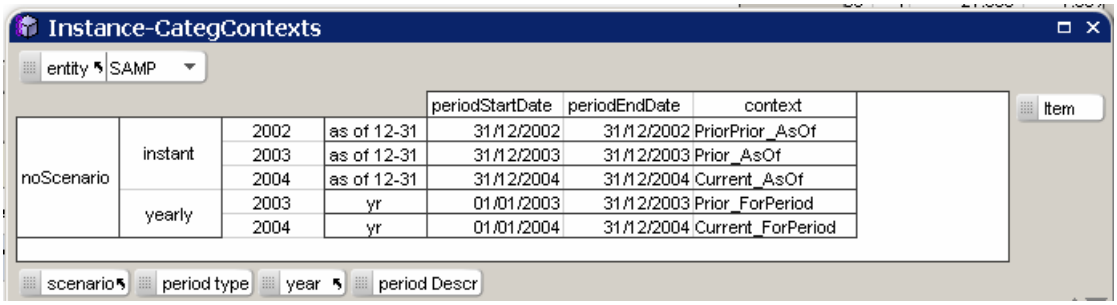
In a financial report, one would like to see values displayed by relevant dimensions, such as period, entity, scenario. In Quantrix Modeler a financial analyst can easily design the structure of multidimensional reporting templates, and reshape it by simply dragging and dropping category tiles. In this section I show how this can be done for the reports created from an XBRL taxonomy.

Reporting dimensions other than financial concepts must be extracted from instance contexts. Contexts are opaque elements. They just provide a unique identifier for a set of dimensions. For a typical annual report, you must have at least two contexts for each accounting period, one for duration data and the other for instant data. You cannot guess from a context's properties the relationships with other contexts: for a duration context you cannot identify the instant context for the same fiscal year, or the context for preceding or following periods, or even the context for the same period but having a different scenario.

In order to make this information transparent to the model, I have created an *Instance-CategContexts* matrix, a multi-dimensional re-mapping of the *Instance-Context* matrix. In order to gain insight into the relationships among contexts, I added to *Instance-Context* three calculated items:

- *period type*, which may assume the values instant, monthly, quarterly, yearly, irregular (for details see the enclosed sample model);
- *year*, i.e. the year containing the instant date or the end date of the period;
- *period Descr*, an ancillary string item to be added to *year* in order to specify the context's period with clarity.

The *Instance-CategContexts* matrix is obtained with a Quantrix *Datalink* procedure, using *Instance-Context* as the data source. In this way we transform some of the properties of contexts into Quantrix categories. Here is a view of the resulting *Instance-CategContexts* matrix:



				periodStartDate	periodEndDate	context
noScenario	instant	2002	as of 12-31	31/12/2002	31/12/2002	PriorPrior_AsOf
		2003	as of 12-31	31/12/2003	31/12/2003	Prior_AsOf
		2004	as of 12-31	31/12/2004	31/12/2004	Current_AsOf
	yearly	2003	yr	01/01/2003	31/12/2003	Prior_ForPeriod
		2004	yr	01/01/2004	31/12/2004	Current_ForPeriod

Some of the categories in *Instance-CategContexts* are for convenience and can be removed in order to avoid the multiplication of cells in the matrix.

Thanks to the reshaping of contexts, we gained knowledge about context properties. We know which context belongs to a given entity (there is only one, named *SAMP*, in the sample instance). We can match the instant and yearly context referring to the same year. We have control over the time sequence of contexts of a given period type. Now we are ready to design a realistic report layout and fill it with instance data.

5.7 Showing a report in the *data* matrix

We will now put together the hierarchy of financial concepts from the *taxo* matrix and the *context* dimensions extracted from the sample instance. This is done for a given report in a *data* matrix , a close sibling of *taxo*, containing the following categories:

- *concept_label*, linked to *taxo* in order to have easy access to the report's metadata;
- *entity, unit, scenario* and *year*, linked to *Instance-CategContexts*;
- *Item*, containing input and calculated values (*valueInput* and *valueCalc*) and other convenience variables.

Fact values from the sample instance are assigned to *valueInput* with a formula that first resolves the context name in *Instance-CategContexts* thanks to the categories linked to such matrix[18], and than refers to a cell in *Instance-Facts* through the *indirect()* function, as was done in *taxo*:

```
valueInput = clearerror(indirect("'Instance-Facts'::'"& 'IncomeStatementByFunction
taxo'::concept & "':'" & 'Instance-CategContexts'::yearly:yr:context & "':'" & @unit
&"':value"))
```

data improves over the computational capabilities of *taxo*. In *taxo,* you could compute values for a single context, with no control over the presence or consistency of input values. In *data*, I have added a boolean variable to the *Item* category, called *hasUndisclosedChildren*. This variable, calculated for every concept, takes value 1 (*true*) whenever all of the "calculation children" have empty values. The formula is lengthy and intricate (see the sample model for details) and should be substituted by a more efficient QAPI function.

[18] In the formula I have restricted the lookup of contexts to the ones having period type = *yearly* and period Descr = *yr*, as is appropriate for a report displaying the income statement in an annual report.

When a calculated concept has a value of *hasUndisclosedChildren*=1, its *valueCalc* is taken directly from the corresponding *valueInput*, by-passing the aggregation formula. Here is an example for the concept *OperatingExpensesTotalByFunction*:

```
In valueCalc, 'ifrs-gp_OperatingExpensesTotalByFunction' =
if('ifrs-gp_OperatingExpensesTotalByFunction':hasUndisclosedChildren;
'ifrs-gp_OperatingExpensesTotalByFunction':valueInput;
'ifrs-gp_MarketingAndDistributionCostsByFunction' + 'ifrs-gp_ResearchAndDevelopment'
+ 'ifrs-gp_AdministrativeExpensesByFunction' + 'ifrs-gp_RestructuringCosts' +
'ifrs-gp_MiscellaneousOtherOperatingExpensesByFunction')
```

Thanks to this conditional expression, one can spot wrong calculations by simply comparing *valueInput* and *valueCalc*.

Another refinement in *data* is the elimination of multiple *valueCalc* items that were needed in *taxo* when multiple alternative formulas were defined for the same concept in different calculation links: in such cases a new *concept_label* item is created by appending the secondary extended link name (e.g. *other*) to the item's name.

Here is the resulting *data* matrix, with empty rows hidden.

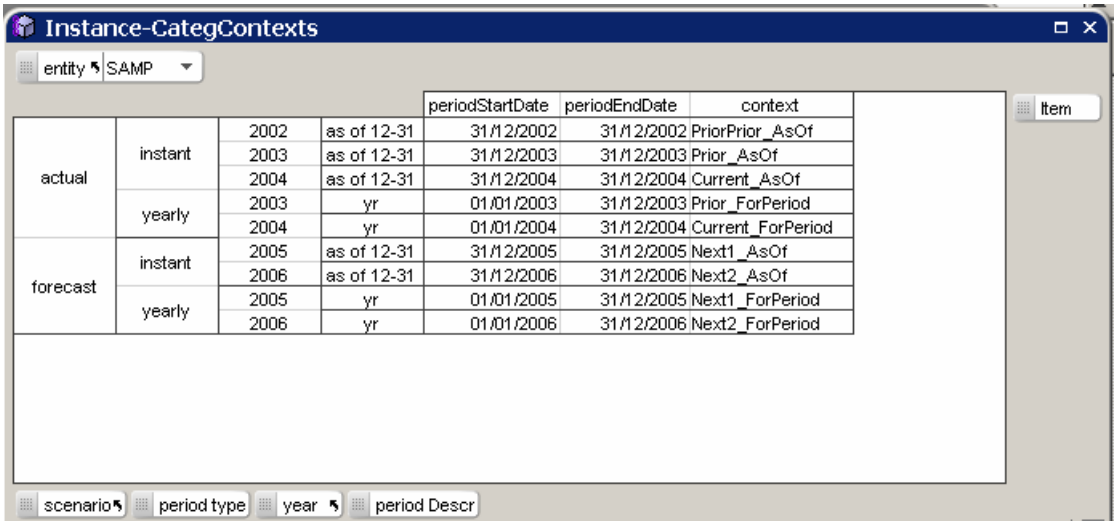
	2003			2004		
	valueInput	hasUndisclosedChildren	valueCalc	valueInput	hasUndisclosedChildren	valueCalc
ifrs-gp_RevenueTotalByFunction	**1.200.000**		**1.200.000**	**1.300.000**		**1.300.000**
ifrs-gp_CostOfSalesByFunction	550.000		550.000	500.000		500.000
ifrs-gp_GrossProfitByFunction	**650.000**		**650.000**	**800.000**		**800.000**
ifrs-gp_OtherOperatingIncomeTotalByFunction	**18.000**	**1**	**18.000**	**21.000**	**1**	**21.000**
ifrs-gp_MarketingAndDistributionCostsByFunction	80.000	1	80.000	90.000	1	90.000
ifrs-gp_AdministrativeExpensesByFunction	49.000		49.000	50.000		50.000
ifrs-gp_MiscellaneousOtherOperatingExpensesByFunction	32.000		32.000	31.000		31.000
ifrs-gp_OperatingExpensesTotalByFunction	**161.000**		**161.000**	**171.000**		**171.000**
ifrs-gp_ProfitLossFromOperations	**507.000**		**507.000**	**650.000**		**650.000**
ifrs-gp_FinanceCostsForNonFinancialActivities	8.000		8.000	9.000		9.000
ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments	18.000		18.000	20.000		20.000
ifrs-gp_ShareOfProfitLossFromEquityAccountedJointVentures	18.000		18.000	20.000		20.000
ifrs-gp_ProfitLossBeforeTax	**517.000**		**517.000**	**661.000**		**661.000**
ifrs-gp_IncomeTaxExpenseIncome	95.000		95.000	107.000		107.000
ifrs-gp_ProfitLossAfterTaxFromContinuingOperations	**422.000**		**422.000**	**554.000**		**554.000**
ifrs-gp_ProfitLoss	**422.000**		**422.000**	**554.000**		**554.000**
ifrs-gp_ProfitLossAttributableToEquityHoldersOfParent	421.600		421.600	553.400		553.400
ifrs-gp_ProfitLossAttributableToMinorityInterest	400		400	600		600
ifrs-gp_ProfitLoss_Other			**422.000**			**554.000**

In the *data* matrix, there is a problem with the display of labels. In the *taxo* matrix, labels were displayed in a column item, belonging to the same category as *valueInput* and *valueCalc* (the *Item* category). The hierarchy was rendered by means of cell formats, made conditional on the nesting level of each row. In *data* we have a multiplication of dimensions related to context properties. If we add a *label* item to the *Item* category, it will be repeated for each combination of *entity*, *unit*, *scenario* and *year*. One can collapse repeated *label* columns in order to hide them, but anyway the output doesn't look good. Labels are shown under the *year* item in the first year. Changing the arrangement of categories can require manual resetting of hide / show options.

For this and other reasons, the "flat list" approach adopted in the examples shown in this paper is not fully satisfactory: while it makes easier building a report's layout automatically from a presentation linkbase, on the other side it makes unavailable the key features of Quantrix for giving structure and readability to matrices. The *data* matrix would be more usable and better looking if the *concept_label* category contained a hierarchical tree of labels, instead of a flat sequence of identifier strings. Creating such structured view while importing a given XBRL taxonomy isn't straightforward. Such an approach is easier to follow when you design the taxonomy in Quantrix, having control over the names of XBRL concepts and their mapping to XBRL labels. In our Smefin project, we have followed the "structured tree" approach in the design of the Italian XBRL taxonomy, with good results. I will elaborate on this experience in a forthcoming paper. For now, we will pretend to be satisfied with the flat list approach.

5.8 Adding a forecast scenario

Let's assume that the sample instance contains actual financial data. We can develop a very simple pro-forma income statement where forecast values are computed from actual ones under given assumptions for the two years following the last reporting period (fiscal year 2004). In order to keep actual values distinct from forecasts, I have created a new *scenario* named *forecast*. For clarity, I have also changed the name of the default scenario created by the import procedure from *noScenario* to *actual*. I have made these changes in the *Instance-CategContexts* matrix. In order to show the newly created contexts, we must disable the *Hide Empty Rows/Columns* option in the *View* menu. I have also added two new items to the *year* category, for years 2005 and 2006. At this point, we must fill the cells for the new instant contexts in the columns *periodStartDate*, *periodEndDate* and *context*. Instant contexts are named *Next1_AsOf* and *Next2_AsOf*. We do something similar for period contexts, which are named *Next1_ForPeriod* and *Next2_ForPeriod*. After turning the *Hide Empty Rows/Columns* option on, we get the following view:



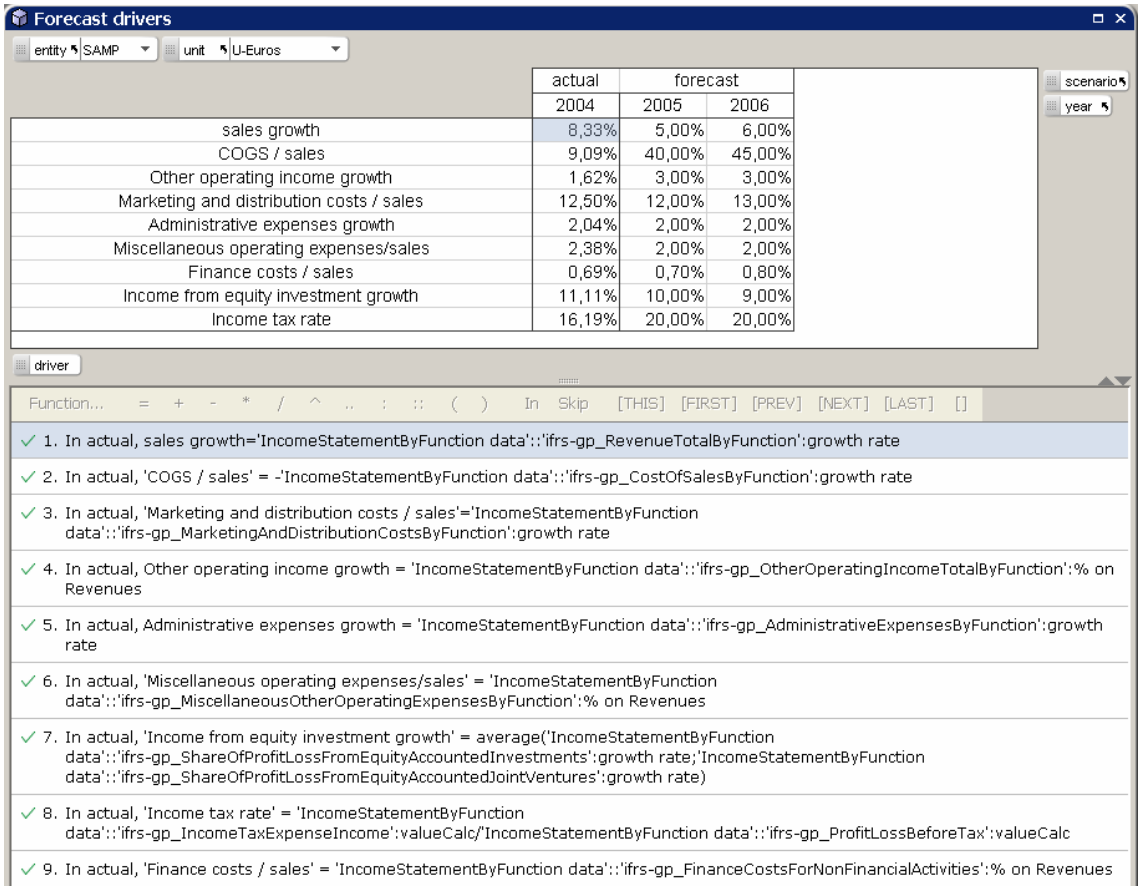
				periodStartDate	periodEndDate	context
actual	instant	2002	as of 12-31	31/12/2002	31/12/2002	PriorPrior_AsOf
		2003	as of 12-31	31/12/2003	31/12/2003	Prior_AsOf
		2004	as of 12-31	31/12/2004	31/12/2004	Current_AsOf
	yearly	2003	yr	01/01/2003	31/12/2003	Prior_ForPeriod
		2004	yr	01/01/2004	31/12/2004	Current_ForPeriod
forecast	instant	2005	as of 12-31	31/12/2005	31/12/2005	Next1_AsOf
		2006	as of 12-31	31/12/2006	31/12/2006	Next2_AsOf
	yearly	2005	yr	01/01/2005	31/12/2005	Next1_ForPeriod
		2006	yr	01/01/2006	31/12/2006	Next2_ForPeriod

For a budgeting model, we would have defined *actual* scenarios also for years 2005 and 2006, so as to perform analysis of variance as times passes and forecast periods become actual. Here we want to perform a simple financial planning exercise, and consequently *actual* is used only for past periods, whereas *forecast* is assigned only to current and future periods.

Changes to *year* and *scenario* categories are immediately reflected in the *data* matrix, where such categories are linked.

I have created a *Forecast drivers* matrix where assumptions can be set by the user. The main driver is the sales growth rate. Other drivers are growth rates of other items, incidence ratios of expenses on revenues, and the income tax rate. This matrix has *entity*, *unit*, *scenario* and *year* categories linked to *Instance-CategContexts* and *data* matrices. In the *forecast* scenario, drivers are set as input values. In the *actual* scenario, they are computed as ratios on historical values. For convenience, I have added two calculated columns in the *data* matrix, containing the percentage change over the previous period and the incidence on Revenues.

The following screenshot shows the structure and the formulas of the *Forecast drivers* matrix.

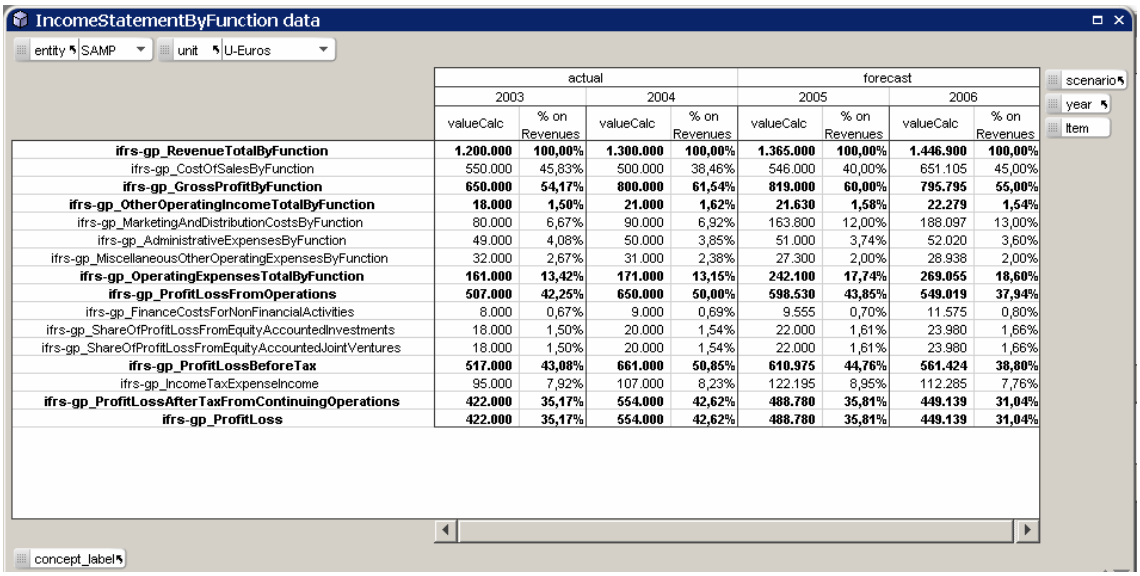


	actual	forecast	
	2004	2005	2006
sales growth	8,33%	5,00%	6,00%
COGS / sales	9,09%	40,00%	45,00%
Other operating income growth	1,62%	3,00%	3,00%
Marketing and distribution costs / sales	12,50%	12,00%	13,00%
Administrative expenses growth	2,04%	2,00%	2,00%
Miscellaneous operating expenses/sales	2,38%	2,00%	2,00%
Finance costs / sales	0,69%	0,70%	0,80%
Income from equity investment growth	11,11%	10,00%	9,00%
Income tax rate	16,19%	20,00%	20,00%

In *forecast* scenarios, input values that in *actual* scenarios were obtained from the XBRL instance, are substituted by values computed according to a financial model. Formulas for forecasted values are straightforward. The *valueInput* column is computed with the following expressions, which depend on *Forecast drivers*:

1. In forecast, 'ifrs-gp_RevenueTotalByFunction':valueInput =if(value(@year)>Settings::last actual;if(value(@year)=Settings::last actual+1;'ifrs-gp_RevenueTotalByFunction':actual:valueCalc:year[PREV];'ifrs-gp_RevenueTotalByFunction':valueCalc:year[PREV])*(1+Forecast drivers::Sales growth);"")*//FROM HERE: FORMULAS FOR DETERMINING INPUT VALUES DEPENDING ON EXOGENOUS DRIVER ASSUMPTIONS OR ON OTHER DRIVER VARIABLES*
2. In forecast, 'ifrs-gp_CostOfSalesByFunction':valueInput='ifrs-gp_RevenueTotalByFunction':valueInput*Forecast drivers::'COGS / sales'
3. In forecast, 'ifrs-gp_OtherOperatingIncomeTotalByFunction':valueInput =if(value(@year)>Settings::last actual;if(value(@year)=Settings::last actual+1;'ifrs-gp_OtherOperatingIncomeTotalByFunction':actual:valueInput:year[PREV];'ifrs-gp_OtherOperatingIncomeTotalByFunction':valueInput:year[PREV])*(1+Forecast drivers::Other operating income growth);"")
4. In forecast, 'ifrs-gp_AdministrativeExpensesByFunction':valueInput =if(value(@year)>Settings::last actual;if(value(@year)=Settings::last actual+1;'ifrs-gp_AdministrativeExpensesByFunction':actual:valueInput:year[PREV];'ifrs-gp_AdministrativeExpensesByFunction':valueInput:year[PREV])*(1+Forecast drivers::Administrative expenses growth);"")
5. In forecast, 'ifrs-gp_MiscellaneousOtherOperatingExpensesByFunction':valueInput='ifrs-gp_RevenueTotalByFunction':valueInput*Forecast drivers::'Miscellaneous operating expenses/sales'
6. In forecast,'ifrs-gp_MarketingAndDistributionCostsByFunction':valueInput='ifrs-gp_RevenueTotalByFunction':valueInput*Forecast drivers::'Marketing and distribution costs / sales'
7. In forecast,'ifrs-gp_FinanceCostsForNonFinancialActivities':valueInput='ifrs-gp_RevenueTotalByFunction':valueInput*Forecast drivers::'Finance costs / sales'
8. In forecast, 'ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments':valueInput =if(value(@year)>Settings::last actual;if(value(@year)=Settings::last actual+1;'ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments':actual:valueInput:year[PREV];'ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments':valueInput:year[PREV])*(1+Forecast drivers::'Income from equity investment growth');"")
9. In forecast, 'ifrs-gp_ShareOfProfitLossFromEquityAccountedJointVentures':valueInput =if(value(@year)>Settings::last actual;if(value(@year)=Settings::last actual+1;'ifrs-gp_ShareOfProfitLossFromEquityAccountedJointVentures':actual:valueInput:year[PREV];'ifrs-gp_ShareOfProfitLossFromEquityAccountedJointVentures':valueInput:year[PREV])*(1+Forecast drivers::'Income from equity investment growth');"")

In *forecast* scenarios, formulas for calculated values need not being redefined: they are the same formulas, derived from the calculation linkbase, that were good for *actual* values. Here is an example of a report showing actual and reported values, both as euro values and as a percentage of revenues:



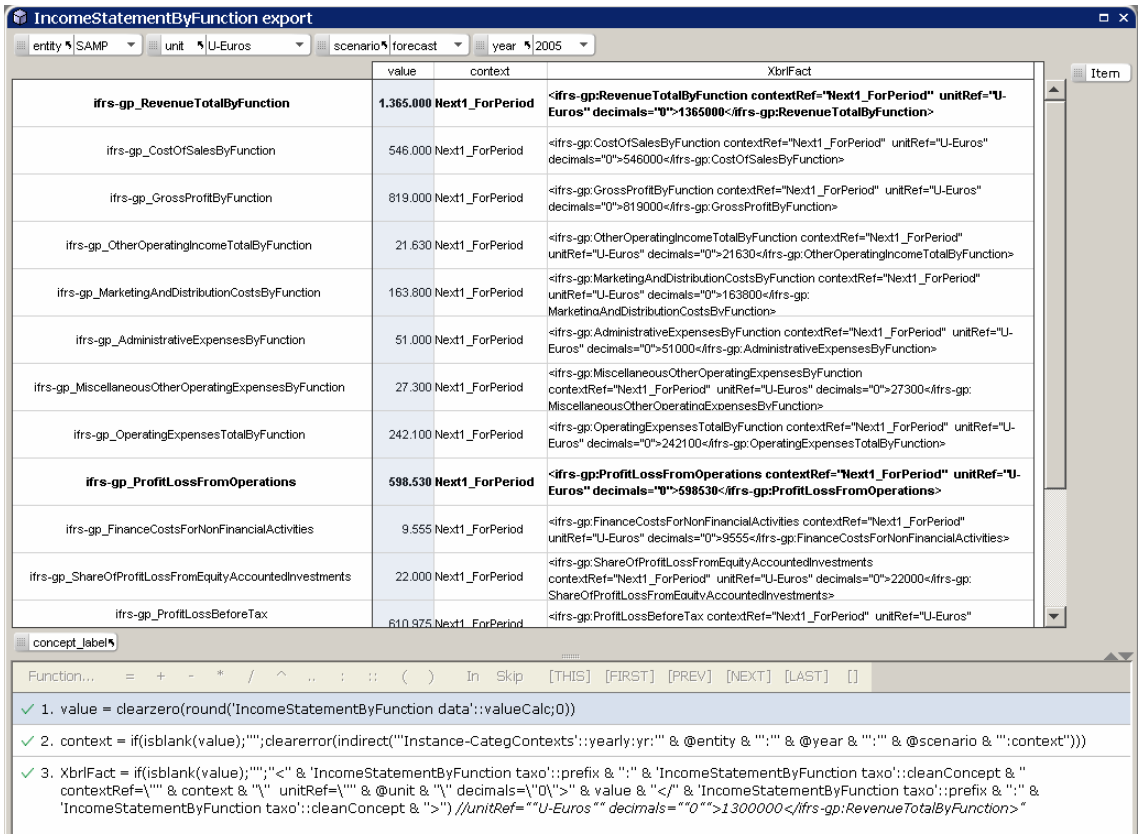
	actual				forecast			
	2003		2004		2005		2006	
	valueCalc	% on Revenues	valueCalc	% on Revenues	valueCalc	% on Revenues	valueCalc	% on Revenues
ifrs-gp_RevenueTotalByFunction	**1.200.000**	**100,00%**	**1.300.000**	**100,00%**	**1.365.000**	**100,00%**	**1.446.900**	**100,00%**
ifrs-gp_CostOfSalesByFunction	550.000	45,83%	500.000	38,46%	546.000	40,00%	651.105	45,00%
ifrs-gp_GrossProfitByFunction	**650.000**	**54,17%**	**800.000**	**61,54%**	**819.000**	**60,00%**	**795.795**	**55,00%**
ifrs-gp_OtherOperatingIncomeTotalByFunction	**18.000**	**1,50%**	**21.000**	**1,62%**	**21.630**	**1,58%**	**22.279**	**1,54%**
ifrs-gp_MarketingAndDistributionCostsByFunction	80.000	6,67%	90.000	6,92%	163.800	12,00%	188.097	13,00%
ifrs-gp_AdministrativeExpensesByFunction	49.000	4,08%	50.000	3,85%	51.000	3,74%	52.020	3,60%
ifrs-gp_MiscellaneousOtherOperatingExpensesByFunction	32.000	2,67%	31.000	2,38%	27.300	2,00%	28.938	2,00%
ifrs-gp_OperatingExpensesTotalByFunction	**161.000**	**13,42%**	**171.000**	**13,15%**	**242.100**	**17,74%**	**269.055**	**18,60%**
ifrs-gp_ProfitLossFromOperations	**507.000**	**42,25%**	**650.000**	**50,00%**	**598.530**	**43,85%**	**549.019**	**37,94%**
ifrs-gp_FinanceCostsForNonFinancialActivities	8.000	0,67%	9.000	0,69%	9.555	0,70%	11.575	0,80%
ifrs-gp_ShareOfProfitLossFromEquityAccountedInvestments	18.000	1,50%	20.000	1,54%	22.000	1,61%	23.980	1,66%
ifrs-gp_ShareOfProfitLossFromEquityAccountedJointVentures	18.000	1,50%	20.000	1,54%	22.000	1,61%	23.980	1,66%
ifrs-gp_ProfitLossBeforeTax	**517.000**	**43,08%**	**661.000**	**50,85%**	**610.975**	**44,76%**	**561.424**	**38,80%**
ifrs-gp_IncomeTaxExpenseIncome	95.000	7,92%	107.000	8,23%	122.195	8,95%	112.285	7,76%
ifrs-gp_ProfitLossAfterTaxFromContinuingOperations	**422.000**	**35,17%**	**554.000**	**42,62%**	**488.780**	**35,81%**	**449.139**	**31,04%**
ifrs-gp_ProfitLoss	**422.000**	**35,17%**	**554.000**	**42,62%**	**488.780**	**35,81%**	**449.139**	**31,04%**

Formulas make use of XBRL concept names, and are consequently understandable, and reasonably concise. A matrix containing financial ratios could be easily created, provided that the values required by the ratios are contained in some *data* matrix. If new periods or scenarios, or even companies and currency units, are added to the model, formulas need no modification, and the report layout adjusts with little user intervention. Here the multidimensional structure of Quantrix Modeler shows its strength. Think of the hard work that would be otherwise required in a traditional spreadsheet: making room for new columns and sheets, revising the formulas, checking for errors, adjusting layouts and printing options, etc.

5.9 Exporting a new version of the document instance with forecasts

Now that we have prepared an extended financial statement, let's export our forecasts, together with actual values, in a new XBRL instance document. We have already defined the contexts for forecasts. It's very easy to compose the XML for the facts reported in the *data* matrix. To show how easy it is, I have created an *export* matrix, using three plain formulas for assembling the instance fact elements from information contained in the *taxo* and *data* matrices. The following figure is an excerpt from the *export* matrix.

The root *xbrl* element of the instance, as well as *context* and *unit* elements, can be easily put together from information already in the model. A QAPI procedure could perform the whole process efficiently.



6 - Conclusions and directions for future research

The model used for preparing the example presented in this paper is a proof of concept of the capabilities of Quantrix as an environment for analyzing and producing financial data in XBRL. We have shown how the multidimensional data model and calculation engine at the heart of Quantrix can be successfully adapted to the XBRL object model. Reports defined in a taxonomy can be translated almost automatically in Quantrix matrices, preserving their layout and calculations. Financial analysts can expand on standard XBRL reports adding ratio analysis and forecasting, simply using XBRL-aware Quantrix formulas. New data created in Quantrix models can be easily expressed in XBRL, and made available to other applications.

In the simple exercise presented before, I have used only native Quantrix functionalities, without any custom extension to functions used in computations. Using the QAPI Java programming interface, I have extended the Quantrix Datalink module by adding some procedures for importing XBRL taxonomy and instance documents. The prototype shown is a starting point, but has the potential to evolve into a production system. There is great room for improvements in terms of efficiency, compliance with XBRL rules, and reduction of memory consumption. As an example, we could substitute our home made methods for document processing with specialized XBRL Java libraries, or offload the document processing duty to an external database server, which could provide a simplified view of XBRL constructs.

The results obtained are very promising for another key consideration: Quantrix has the potential to front run the development of innovative features in the XBRL standard. The modeling of dimensions in the structure of reports and in instance contexts and the formula linkbase specification are two key developments of the XBRL standards, currently under way. Those same functionalities can be easily implemented in Quantrix now. Quantrix can become a precious tool for designing and testing innovative features, and make them available to end

users. Most of the work on new features of XBRL assumes a computing platform based on server-based applications and XML query languages such as XPath or XQuery. Quantrix would be an ideal complement to the toolset, being a client-oriented environment targeted to a more interactive use.

As has been said in the introduction, this is the first in a series of papers. In a second forthcoming paper, more complex issues will be analyzed, and specifically the new XBRL specification for dimensions and its use in reports with a bi-dimensional table structure (e.g. the Statement of changes in equity and movement analyses in explanatory notes). Subsequent papers will tackle advanced issues, such as the implementation of the XBRL formula language, and the integration of Quantrix with XBRL data repositories.

There is a lot of work to be done. With time, this work will be hopefully shared among a growing user community, from both the Quantrix and XBRL worlds.

7 - References

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