Pentaho Business Analytics: a Business Intelligence Open Source Alternative

Diana TÂRNĂVEANU
West University of Timişoara, Faculty of Economics and Business Administration,
Timi oara, ROMANIA
diana.tarnaveanu@feaa.uvt.ro

Most organizations strive to obtain fast, interactive and insightful analytics in order to fundament the most effective and profitable decisions. They need to incorporate huge amounts of data in order to run analysis based on queries and reports with collaborative capabilities. The large variety of Business Intelligence solutions on the market makes it very difficult for organizations to select one and evaluate the impact of the selected solution to the organization. The need of a strategy to help organization chose the best solution for investment emerges. In the past, Business Intelligence (BI) market was dominated by closed source and commercial tools, but in the last years open source solutions developed everywhere. An Open Source Business Intelligence solution can be an option due to time-sensitive, sprawling requirements and tightening budgets. This paper presents a practical solution implemented in a suite of Open Source Business Intelligence products called Pentaho Business Analytics, which provides data integration, OLAP services, reporting, dashboarding, data mining and ETL capabilities. The study conducted in this paper suggests that the open source phenomenon could become a valid alternative to commercial platforms within the BI context.
Keywords: *business intelligence (BI), decision-making, data analysis, data warehouses*

1 Introduction

Romania strives to meet the demands of knowledge-based economy, such as: flexibility, globalization, horizontal/ vertical integration, innovative enterprises, organizational learning and customer-led strategy [1]. Business Intelligence (BI) is a concept often used in Romania for the last 10 years [2]. It is not a new trend anymore, but it became a must during the last decade, being considered as a basic tool used by the modern management [3].

Having as a main goal productivity and profitability, BI systems track down trends, problems and factors as soon as they act, outlining the key performance indicators (KPI) [4]. KPIs assess or measure certain aspects of the business operations (at operational level) and business strategies (at strategic level) that may otherwise be difficult to assign a quantitative value to [5]. The four main perspectives (Finance, Internal Business Processes, Education and Growth, Customers) provide relevant feedback for the managers' initiatives [6].

Data analysis proved to be of a valuable importance in many sectors (such as banking, federal government, education performance management or executive scorecards for healthcare professionals); aggregating data across many dimensions being helpful for insight analysis [7], [8].

BI systems ensure obtaining of useful, correct and in-time information, usually taken from disparate data sources. They close the gap between the huge amount of data available to the decision factor, and the report analysis presented in a suggestive way that should support the decision making process [3].

BI offers sophisticate information analysis and information discovery technologies such as Data Warehouse, On-line Analytical Processing (OLAP), Data Mining, etc. BI

solutions arrived to the third generation BI, providing access to information, advanced graphical and web-based OLAP, information mining tools and prepackaged applications that exploit the power of those tools [9]. A BI system has four major components: a data warehouse (with its data source), business analytics (a collection of tools for manipulating, mining and analyzing the data from the warehouse), business performance management (for monitoring and analyzing performance) and a user interface (connecting to the system via a browser) [10].

A data warehouse is the core component of a BI infrastructure. The dimensional model of a data warehouse consists in numeric measures, dimensions and fact tables. Related measures are collected into fact tables. The measures can be looked upon in different ways, those ways being called dimensions. A dimension is a particular area of interest such as time, geographic position, category and so on [9].

An OLAP instrument is a combination of analytical processing procedures and graphic presentations [10]. OLAP uses the word cube to describe what in the relational world would be the integration of the fact table with dimension tables [9]. It generally includes a calculation engine for adding complex analytical logic to the cube, and a query language. Because the standard relational query language (SQL) is not well suited to work with cubes, Multidimensional Expression (MDX), an OLAP-specific query language, has been developed.

Data mining is a technology that uses complex algorithms for data analyzing and discovering valuable information for the decision maker [10]. The emphasis is on data's quality to be valid, previously unknown, comprehensible and actionable.

When designing the data scheme of the warehouse, the following types of schemes may be used: star, snowflake or constellation [11].

Some of the most important factors that should be taken into account when successfully introducing a BI solution are: the BI solution should be business-oriented, rather than technology-oriented, act towards reaching the goals of the organization; a truthful partnership between management and informatics within the organization should be realized and the entire organization should be evaluated as a whole [12].

The need of a strategy for adopting a BI solution is a result of the following issues: high investment costs; the need of buying a BI solution suited for the needs of the organization; understanding the goal of implementation; the focus should be on incomes and results; it should monitor BI processes and provide feedback in order to refine and revise business strategy [12].

This paper presents a practical solution implemented in a suite of open source Business Intelligence products called Pentaho Business Analytics, providing data integration, OLAP services, reporting, dashboarding, data mining and ETL capabilities.

2 Pentaho BI – Analytics for everyone

Analytics is all about gaining insights from the data for better decision making [13]. A competitor on the growing market of BI solutions, Pentaho BI is an ongoing effort by the Open Source (OS) community to provide organizations with best-in-class solutions for their enterprise BI needs. It encompasses the following major application areas: reporting, analysis, dashboards and data mining [2].

Pentaho Business Analytics (BA) enables business users to intuitively access, explore and analyze all data, enabling them to make information-driven decisions that positively impact the performance of their organizations.

The collection of analysis components in Pentaho Business Analytics enables visualizations of data trends by creating static reports from an analysis data source, traversing an analysis cube, showing how

data points compare by using charts, and monitoring the status of certain trends and thresholds with dashboards.

The process starts by using any client tools, consolidating data from disparate sources into one canonical source and optimizing it for the metrics wanted to be analyzed; creating an analysis schema to describe the data; iteratively improve that schema so that it meets the users' needs; and create aggregation tables for frequently computed views [14]. The architecture of an Open Source BI solution is depicted in Figure 1 [15].

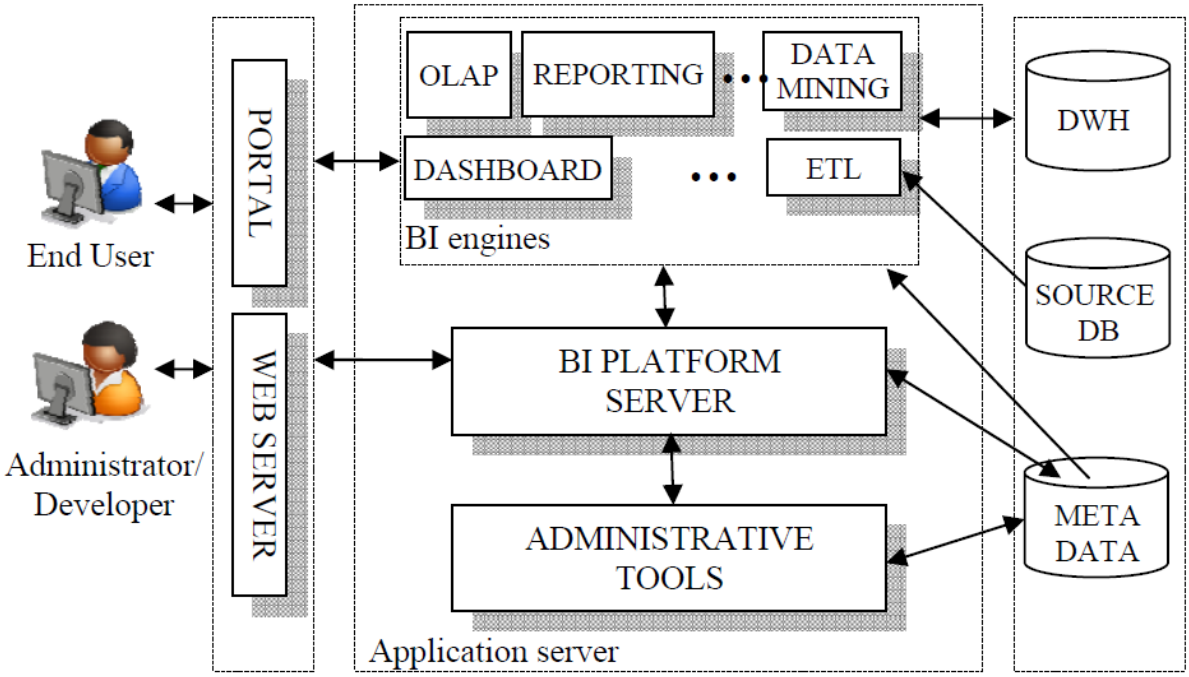


Figure 1. Architecture for BI OS Platforms

Pentaho Analysis is built on the Mondrian relational online analytical processing (**ROLAP**) engine. Relational OLAP (ROLAP) supports relational database management systems (RDBMS) products through the use of metadata layer, avoiding the requirement to create a static multidimensional data structure [9]. ROLAP relies on a multidimensional data model that, when queried, returns a dataset that resembles a grid. The rows and columns that describe and bring meaning to the data in that grid are **dimensions**, and the hard numerical values in each cell are the **measures** or **facts**. In Pentaho Analyzer, dimensions are shown in yellow and measures are in blue [14]. ROLAP requires a properly prepared data source in the form of a star or snowflake schema that defines a logical multi-dimensional database and maps it to a physical database model. Once the data structure is in place, a descriptive layer should be designed for it, in the form of a Mondrian schema, which consists of one or more cubes, hierarchies, and members. Mondrian schemas are XML models that have cube-like structures which use fact and dimension tables found in a relational database. A Mondrian schema is created using Schema Workbench or generated by the Data Source Wizard, (either through a manually-entered SQL query, an auto-query written against one fact table, multiple database tables joined to a fact table, or a CSV file).

In this paper, **BA Server Enterprise Edition (version 4.5)** was used, in order to develop an analysis made for the main indicators in the Research-Development activity by sector of performance and type of ownership. BA Server Enterprise Edition

includes two graphical user interfaces: User Console and Enterprise.

The **Pentaho User Console**, includes:

1. *Interactive Reporting* for quick and easy data-driven reports;
2. *Pentaho Analyzer* for ROLAP-based reports and charts;
3. *Pentaho Dashboard Designer* for informative overviews of key performance indicators (KPI).

Pentaho Enterprise Console gives system administrators, IT managers, CIOs, and database administrators control over most aspects of BA Server configuration, management, and security [14].

1. **Pentaho Interactive Reporting** provides a Web-based, drag-and-drop interface that allows adding elements to the report layout quickly and easily. Available features include: font selection, column resizing, column sorting, ability to rename column headers, copy and past functionality, unlimited undo and redo functionality, ability to output reports as HTML, PDF, CSV, or Excel files and ability to display reports in a dashboard. The data source for an Interactive Report is based on a metadata model. Queries are generated based on the metadata selection [14].

2. **Pentaho Analyzer** is an interactive analysis tool that provides a rich **Web-based, drag-and-drop user** interface, which makes it easy to create reports based on exploration of the data. Pentaho Analyzer reports can be displayed in a dashboard. Pentaho Analyzer reports allow exploring data dynamically and drilling down into the data to discover previously hidden details. It presents data multi-dimensionally and allows selecting dimensions and measures. It is used to drill, slice, dice, pivot, filter, chart data and create calculated fields.

3. In order to create a dashboard in **Dashboard Designer**, a layout template, theme, and the content should be selected. In addition to displaying content generated from action sequences, Interactive Reporting, and Analyzer, Dashboard Designer can also include: **Charts**: simple bar, line, area, pie, and dial charts created with Chart Designer; **Data Tables**: tabular data and **URLs**: Web sites. Dashboard Designer has dynamic filter controls, which enables end-users to change a dashboard's details by selecting different values from a drop-down list, and to control the content in one dashboard panel by changing the options in another (content linking). Using different combinations and controls, BI Dashboards provide a view of the features of the business monitoring environment [1].

3 Developing an Open Source BI solution

Today's BI architecture typically consists of a data warehouse (or one or more data marts), which consolidates data from several operational databases, and serves a variety of front-end querying, reporting, and analytic tools.

3.1 Establishing the future measures

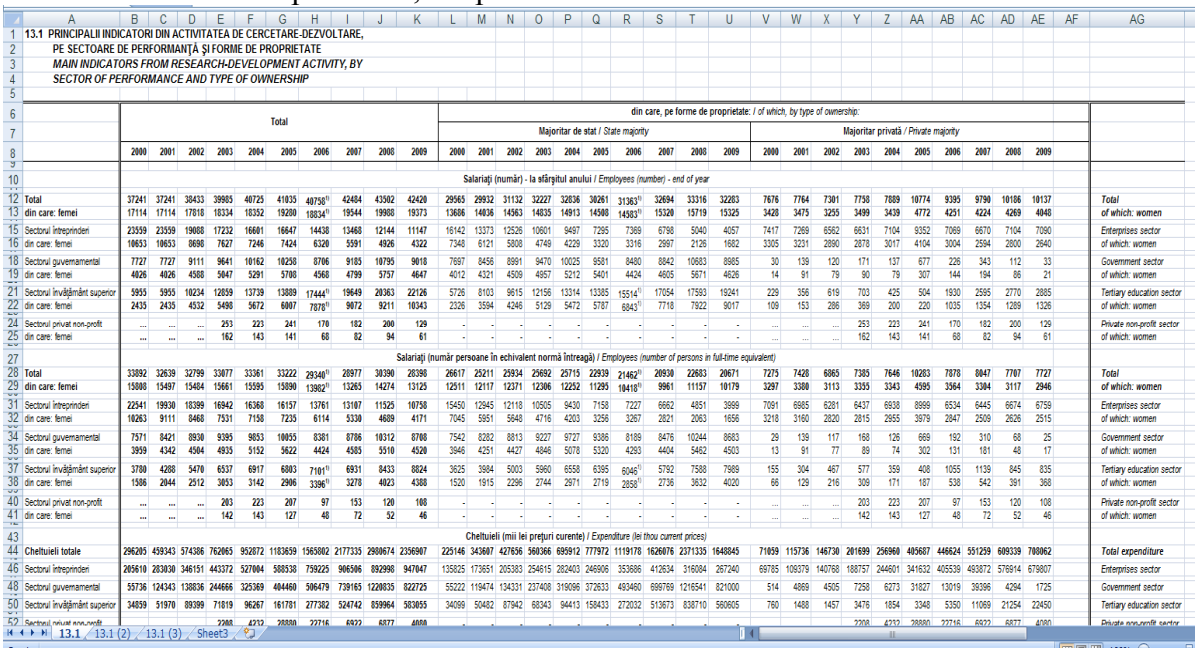
The indicators considered for the analysis were the ones provided by [16] – Research-Development activity by sectors of performance and type of ownership – Figure 2. In table presented below, related to the following fields: ownership type (state majority, private majority), years (2000-2009), gender (men, women), sector of performance (enterprises sector, government sector, tertiary education sector and private non-profit sector); the values for the following indicators are given: employees (number) end of year, employees number of persons in full-time equivalent, total expenditure, current expenditure and capital expenditure (investments) lei thou current prices.

The analysis was made based on these measures:

- *M1* – employees number at the end of the year and employees – number of persons in full time equivalent, with regards to the sector of performance and ownership type;
- *M2* – employees number at the end of the year and employees – number of

persons in full time equivalent, with regards to the sector of performance;

- *M3* – employees number at the end of the year and employees – number of persons in full time equivalent, with regards to the ownership type, sectors of performance and gender;
- *M4* – total expenditure, capital expenditure (investments) and current expenditure (lei thou current prices) with regards to ownership type and sectors of performance;
- *M5* – total expenditure (lei thou current prices) with regards to sectors of performance and years.


13.1 PRINCIPALII INDICATORI DIN ACTIVITATEA DE CERCETARE-DEZVOLTARE, PE SECTOARE DE PERFORMANŢĂ ŞI FORME DE PROPRIETATE
MAIN INDICATORS FROM RESEARCH-DEVELOPMENT ACTIVITY, BY SECTOR OF PERFORMANCE AND TYPE OF OWNERSHIP

	Total										din care, pe forme de proprietate: / *of which, by type of ownership:*																					
											Majoritar de stat / *State majority*										Majoritar privată / *Private majority*										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Salariaţi (număr) - la sfârşitul anului / *Employees (number) - end of year*																															
Total	37241	37241	38433	39965	40725	41035	40758[1)]	42484	43502	42420	29565	29932	31132	32227	32836	30261	31363[1)]	32694	33316	32283	7676	7764	7301	7758	7889	10774	9395	9790	10186	10137	*Total*
din care: femei	17114	17114	17818	18334	18352	19280	18834[1)]	19544	19988	19373	13686	14036	14563	14835	14913	14598	14583[1)]	15320	15719	15325	3428	3475	3255	3499	3439	4772	4251	4224	4269	4048	*of which: women*
Sectorul întreprinderi	23559	23559	19088	17232	16601	16647	14438	13468	12144	11147	16142	13373	12526	10601	9497	7295	7369	6798	5040	4057	7417	7269	6562	6631	7104	9352	7069	6670	7104	7090	*Enterprises sector*
din care: femei	10653	10653	8698	7627	7246	7424	6320	5591	4926	4322	7348	6121	5808	4749	4229	3320	3316	2697	2126	1682	3305	3231	2890	2878	3017	4104	3004	2594	2800	2640	*of which: women*
Sectorul guvernamental	7727	7727	9111	9641	10162	10258	8706	9185	10795	9018	7697	8456	8991	9470	10025	9581	8480	8642	10683	8985	30	139	120	171	137	677	226	343	112	33	*Government sector*
din care: femei	4026	4026	4588	5047	5291	5708	4568	4799	5757	4647	4012	4321	4509	4957	5212	5401	4424	4605	5671	4626	14	91	79	90	79	307	144	194	86	21	*of which: women*
Sectorul învăţământ superior	5955	5955	10234	12659	13739	13889	17444[1)]	19649	20363	22126	5726	8103	9615	12156	13314	13385	15514[1)]	17054	17593	19241	229	356	619	703	425	504	1930	2595	2770	2885	*Tertiary education sector*
din care: femei	2435	2435	4532	5498	5672	6007	7878[1)]	9072	9211	10343	2326	3594	4246	5129	5472	5787	6843[1)]	7718	7922	9017	109	153	286	369	200	220	1035	1354	1289	1326	*of which: women*
Sectorul privat non-profit	...	...	...	253	223	241	170	182	200	129	-	-	-	-	-	-	-	-	-	-	...	...	...	253	223	241	170	182	200	129	*Private non-profit sector*
din care: femei	...	...	...	162	143	141	68	82	94	61	-	-	-	-	-	-	-	-	-	-	...	...	...	162	143	141	68	82	94	61	*of which: women*
Salariaţi (număr persoane în echivalent normă întreagă) / *Employees (number of persons in full-time equivalent)*																															
Total	33892	32639	32799	33077	33361	33222	29340[1)]	28977	30390	28398	26617	25211	25934	25692	25715	22939	21462[1)]	20930	22683	20671	7275	7428	6865	7385	7646	10283	7878	8047	7707	7727	*Total*
din care: femei	15886	15497	15484	15661	15595	15890	13982[1)]	13265	14274	13125	12511	12117	12371	12306	12252	11299	10418[1)]	9961	11157	10179	3297	3380	3113	3355	3343	4595	3564	3304	3117	2946	*of which: women*
Sectorul întreprinderi	22541	19930	18399	16942	16368	16157	13761	13107	11525	10758	15450	12945	12118	10505	9430	7158	7227	6662	4851	3999	7091	6985	6281	6437	6938	8999	6534	6445	6674	6759	*Enterprises sector*
din care: femei	10263	9111	8468	7531	7158	7235	6114	5330	4689	4171	7045	5951	5648	4716	4203	3256	3267	2821	2063	1656	3218	3160	2820	2815	2955	3979	2847	2509	2626	2515	*of which: women*
Sectorul guvernamental	7571	8421	8930	9395	9853	10055	8381	8786	10312	8768	7542	8282	8813	9227	9727	9386	8189	8476	10244	8683	29	139	117	168	126	669	192	310	68	25	*Government sector*
din care: femei	3959	4342	4584	4935	5152	5622	4424	4585	5510	4520	3946	4251	4427	4846	5078	5320	4293	4404	5462	4503	13	91	77	89	74	302	131	181	48	17	*of which: women*
Sectorul învăţământ superior	3780	4288	5470	6537	6917	6983	7101[1)]	6931	8433	8824	3625	3984	5003	5960	6558	6395	6046[1)]	5792	7588	7986	155	304	467	577	359	408	1055	1139	845	835	*Tertiary education sector*
din care: femei	1586	2044	2512	3053	3142	2906	3396[1)]	3278	4023	4388	1520	1915	2296	2744	2971	2719	2858[1)]	2736	3832	4020	66	129	216	309	171	187	538	542	391	368	*of which: women*
Sectorul privat non-profit	...	...	...	203	223	207	97	153	120	108	-	-	-	-	-	-	-	-	-	-	...	...	...	203	223	207	97	153	120	108	*Private non-profit sector*
din care: femei	...	...	...	142	143	127	48	72	52	46	-	-	-	-	-	-	-	-	-	-	...	...	...	142	143	127	48	72	52	46	*of which: women*
Cheltuieli (mii lei preţuri curente) / *Expenditure (lei thou current prices)*																															
Cheltuieli totale	296205	459343	574386	762065	952872	1183659	1565802	2177335	2909674	2356907	225146	343687	427656	560366	695912	777972	1119178	1626076	2371335	1648845	71059	115736	146730	201699	256960	405687	446624	551259	609339	708062	*Total expenditure*
Sectorul întreprinderi	205610	283030	346151	443372	527004	588538	759225	906506	892998	947047	135825	173651	205383	254615	282403	246906	353686	412634	316084	257240	69785	109379	140768	188757	244601	341632	405539	493872	576914	679807	*Enterprises sector*
Sectorul guvernamental	55736	124343	138836	244666	325369	404460	506479	739165	1220835	822725	55222	119474	134331	237408	319096	372633	493460	699769	1216541	821000	514	4869	4505	7258	6273	31827	13019	39396	4294	1725	*Government sector*
Sectorul învăţământ superior	34859	51970	89399	71819	96267	161781	277382	524742	859964	583655	34099	50482	87942	68343	94413	158433	272032	513673	838710	560605	760	1488	1457	3476	1854	3348	5350	11089	21254	22450	*Tertiary education sector*
Sectorul privat non-profit				2398	4213	28890	22716	6922	6877	4080											2208	4232	28880	22716	6922	6877	4080				*Private non-profit sector*

Figure 2. Main indicators for Research-Development Activity

3.2 Analyzing data sources

The data base was created using Microsoft Access 2007, proposing the following data scheme – Figure 3.

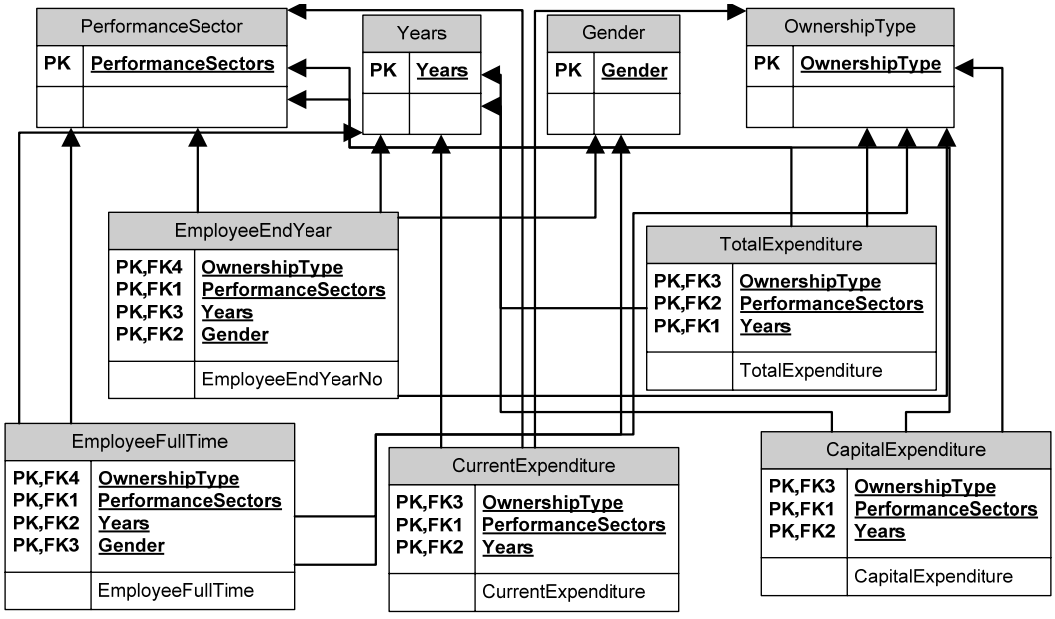


Figure 3. Research Development Database

3.3 Implementation aspects

With regards to the business requirements and as a result of a complex data analysis, the data model will ground the logical design of the data warehouse [2].

Facts and dimensions, building a multidimensional approach (Figure 4) will be established. The constellation data schema was used. For each measure defined before, a fact table was created: M1 – EmployeeOPY, M2 – EmployeePY, M3 – Employee OPG, M4 – Expenditure OPY and M5 – Expenditure PY.

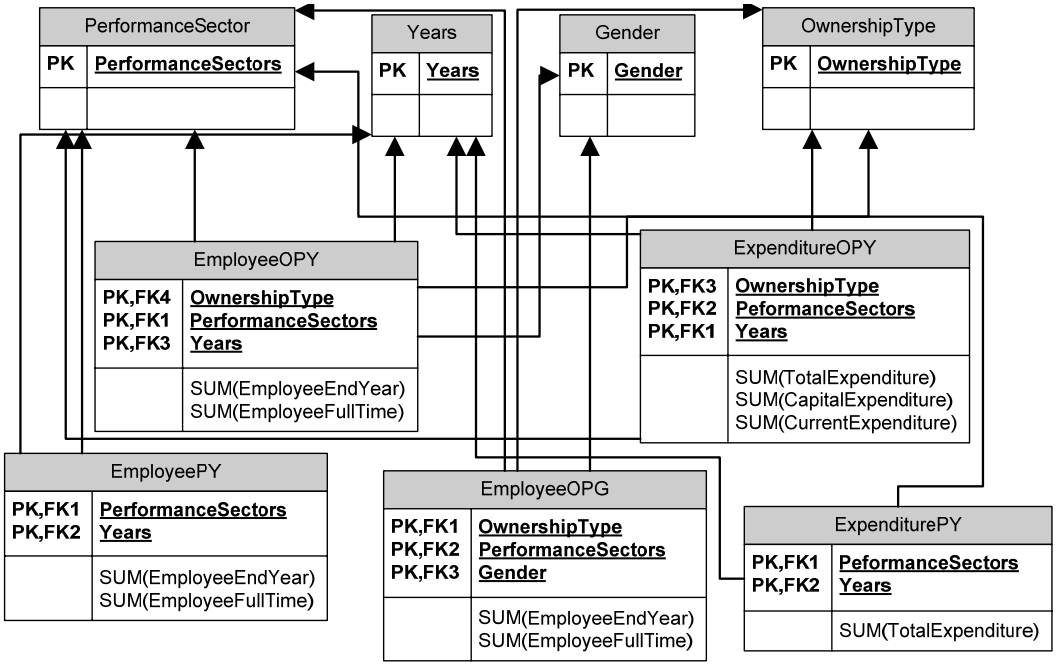


Figure 4. The data warehouse model

The data source was loaded into the BI system by importing it as a csv file.

Corrections had to be made to the default proposal, so the data source scheme suits the analysis needs – Figure 5.

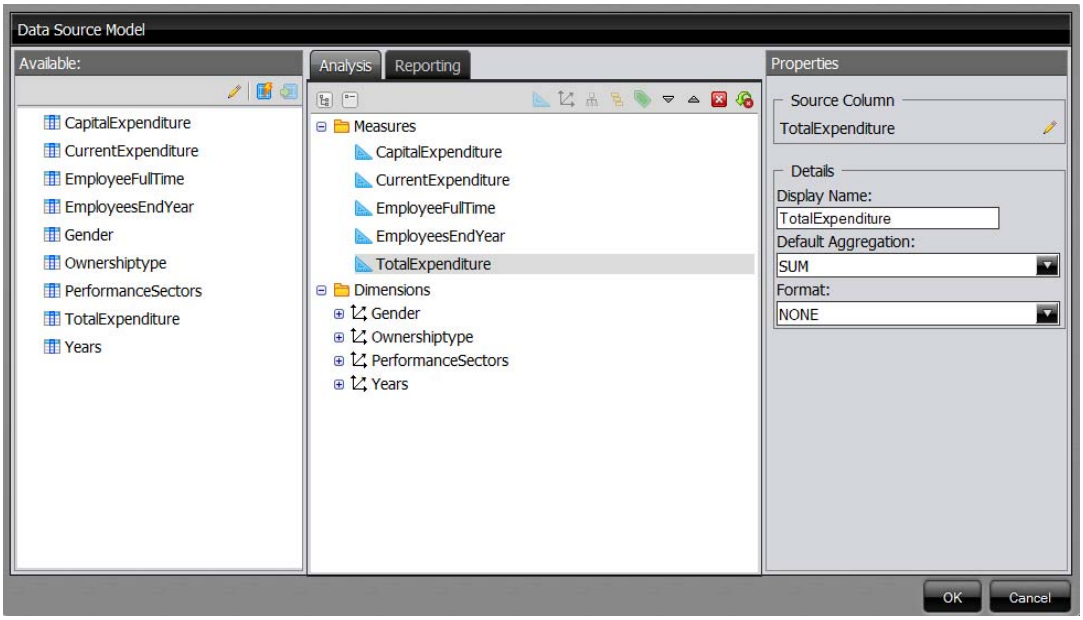


Figure 5. The Data Source Model

Using the Analysis functionality from the Pentaho User Console in order to display in a more intuitive way the first measure (M1) established at the beginning, EmployeeOPY fact table was used – Figure 6.

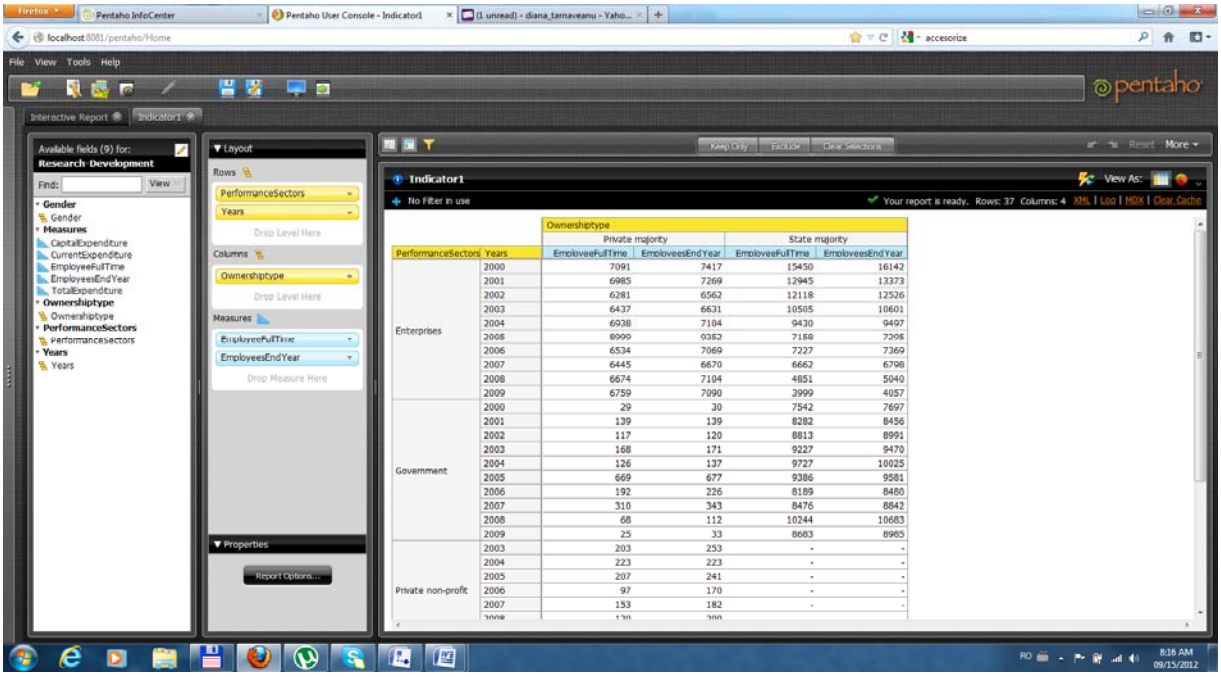


Figure 6. Measure M1

Using the same Analysis functionality, a chart was created in order to display employee's number at the end of the year and employees – number of persons in full time equivalent, with regards to the sector of performance and years – Figure 7. Facts table EmployeePY was used,

In the chart on the OX axis the aggregated values of employees at the end of the year and employees – nmber of persons in full time equivalent are displayed, and on OY axis, the years are displayed. The legend displays different colors for each combination column-measure.

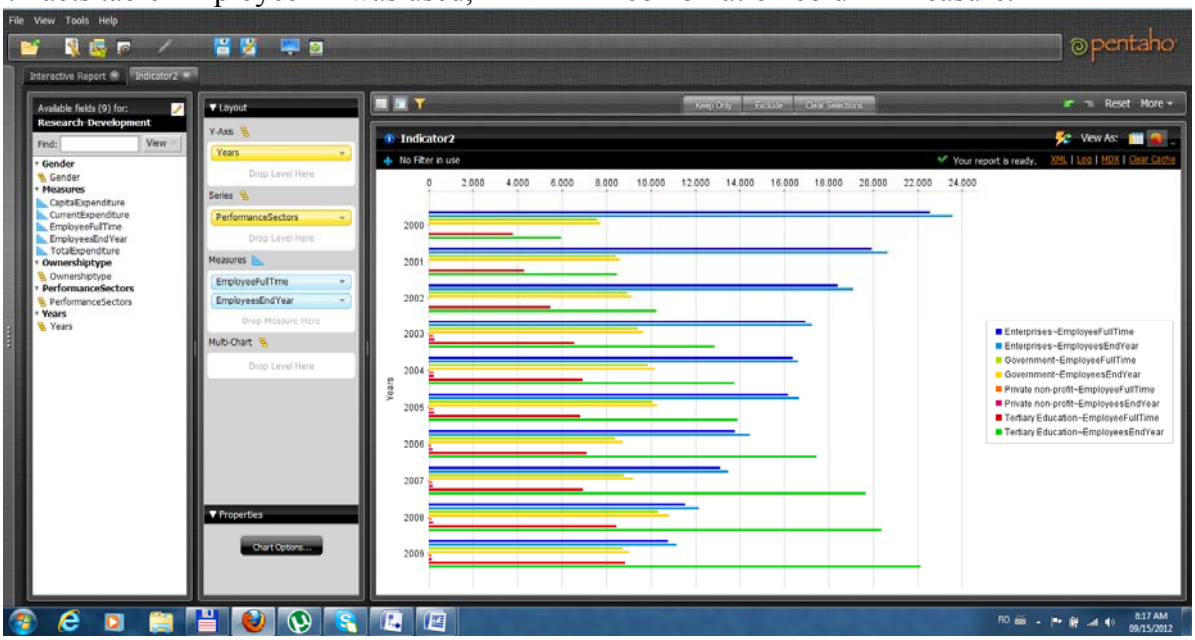


Figure 7. Measure M2

The Report functionality was used in order to create a report that displays employees number at the end of the year and employees – number of persons in full time equivalent, with regards to the ownership type, sectors of performance and gender – Figure 8. Facts table EmployeeOPG was used, considering ownership type as a group, performance sectors and gender – as columns and employees at the end of the year and employees number of persons in full time equivalent as measure. A filter was applier, so that only year 2009 is displayed.

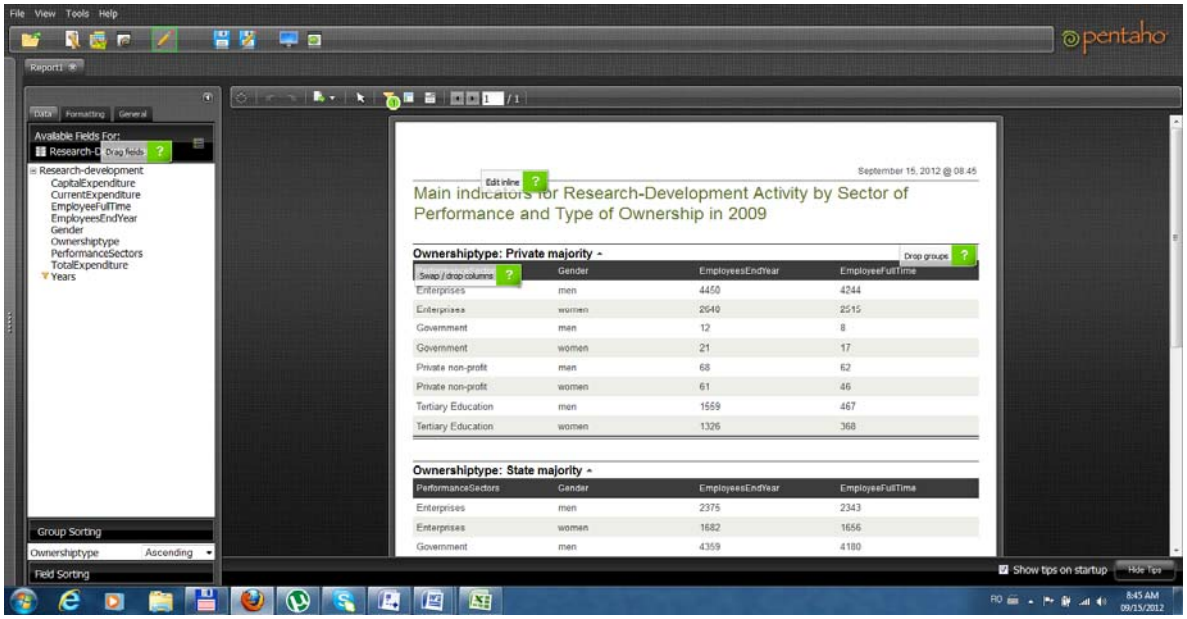


Figure 8. Measure M3

Dashboards increase the analytical power of the visualization by allowing multiple perspectives on the dataset in the same location. Several content types are available: Charts, Data Tables, URLs, and Files created before using the Analysis or Report features.

A template with 4 visualizations was chosen. When creating a dashboard, the Data Table content type allows a tabular representation of a database query in a dashboard. It also allows the manipulation of the data, directly from the dashboard. The first box, from up left corner, corresponds to the measure M4, ExpenditureOPY fact table being used. The result can be seen in Figure 9.

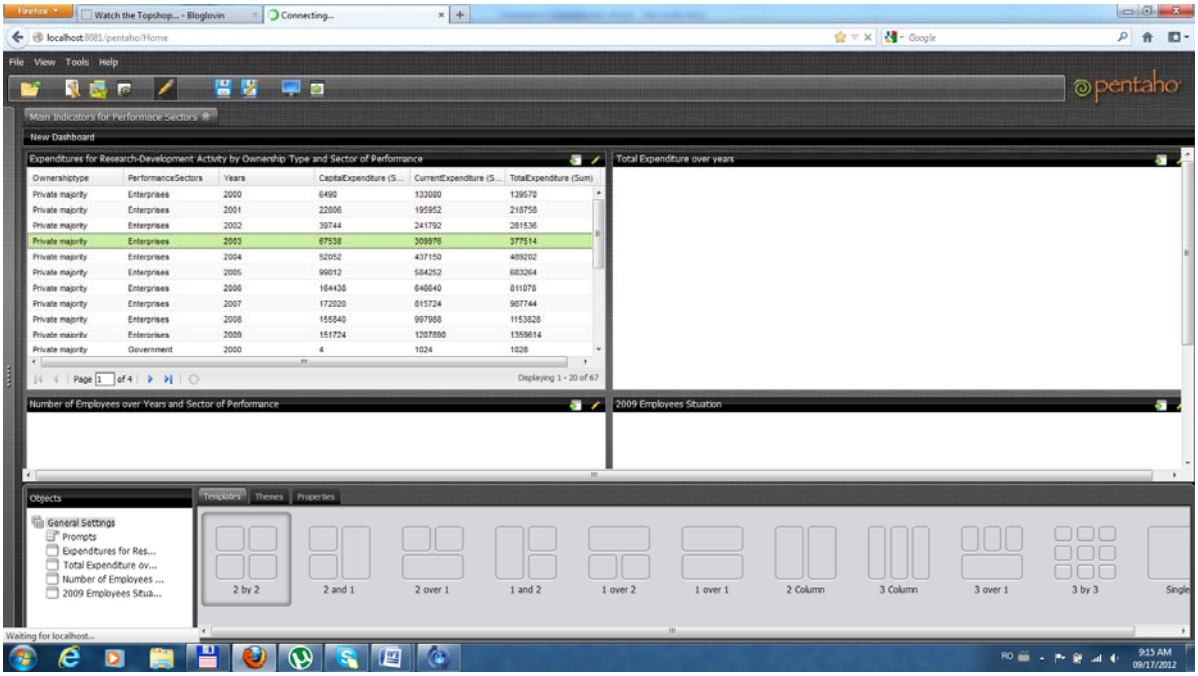


Figure 9. The data table for M4

For the top right-hand side – a chart-type visualization was chosen, in order to display measure M5, using ExpenditurePY fact table.

The Chart Designer allows creating bar, pie, line, dial, and area charts that can be added to a dashboard. When building a chart, a data source has to be selected, then a query built on that data source. The selected columns for the query were performance sectors and years, and for the aggregation function, SUM, applied to the field total expenditure. Performance sectors dimension was chosen as a series column, years as a category columns and total expenditure dimension as values column. Total expenditure (lei thou current prices) is displayed, with regards to sectors of performance and years – Figure 10.

Figure 10. Measure M5

The previous analysis (the chart) and report are displayed on the two remaining boxes from the lower part of the dashboard – Figure 11.

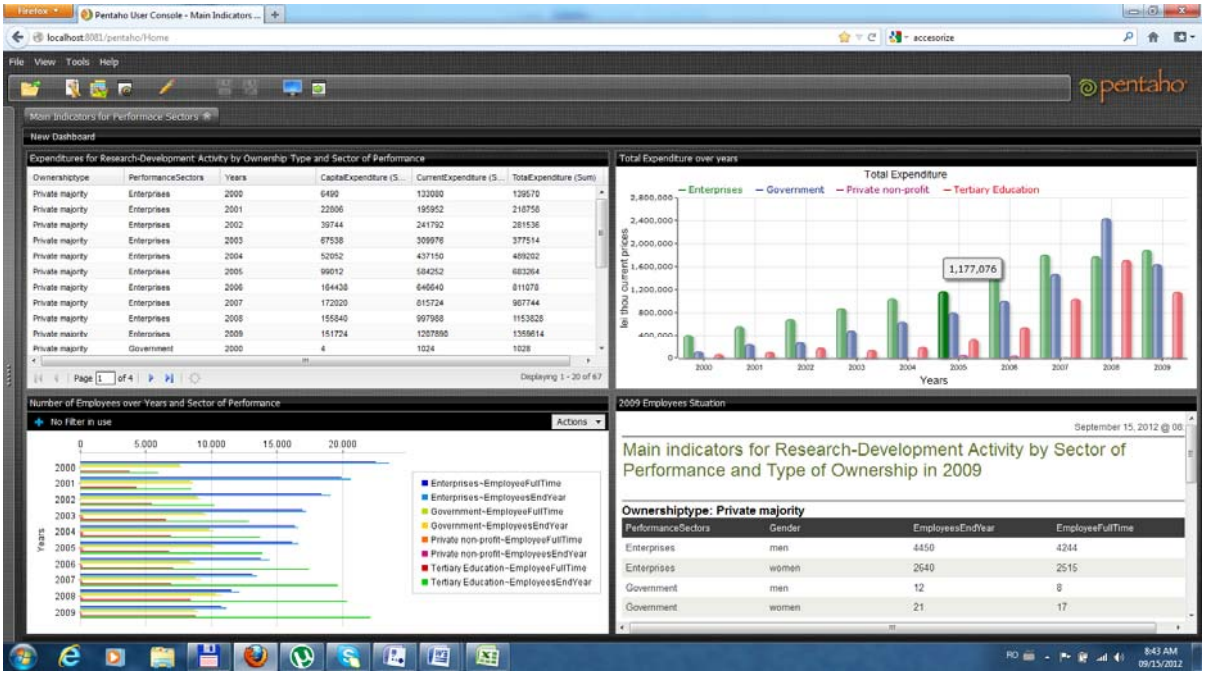


Figure 11. Dashboard displaying M2, M3, M4 and M5

We obtain a complete analysis of the main indicators for Research-Development activity by sectors of performance and type of ownership, much more intuitive and insightful that the original data table – Figure 4.

4 Conclusions

Because of the vast variety of BI solutions on the market, each organization must decide which solution contribute more effectively to achieving the goals of the organization, evaluating the costs/benefits [12].

It is estimated that today more than 60% of companies and governments worldwide use some form of open source software, either as a known resource or as a resource embedded in other applications, many of which are vendor supplied.

Open source solutions are now becoming serious alternatives to proprietary software with ever increasing open source projects providing a wide variety of tools for data warehousing and full BI suites.

Pentaho Business Analytics allows IT to rapidly develop and deploy a secure, scalable, flexible and easy to manage business analytics platform [14].

Open Source BI Platforms provide a sufficient level of reliability even though they are not so sophisticated as commercial ones, especially in small and medium-size enterprises where the quantity of data and the workload are not critical points [15].

Because of the evolution of information and communication technology, organizations strive to operate as intelligent organizations. It is necessary to develop an agile Business Intelligence solution with the help of modern technologies such as Service Oriented Architecture, Business Process Management, Business Rules, Cloud Computing and Master Data Management [1].

References

[1] M. Mircea, B. Ghilic-Micu, M. Stoica, "An Agile Architecture Framework that Leverages the Strengths of Business Intelligence, Decision Management and Service Orientation", Business Intelligence - Solution for Business Development, ISBN: 978-953-51-0019-5, InTech, Available from: http://www.intechopen.com/books/business-intelligence-solution-for-business-development/an-agile-architecture-framework-that-leverages-the-strengths-of-business-intelligence-decision-manag

[2] D. Târnăveanu, M. Muntean, "Free Business Intelligence – An Easy and Reliable Alternative", *Mathematical Models & Methods in Applied Sciences*, WSEAS Press, pp. 158-164, ISBN 978-1-61804-098-5, available at SSRN: http://ssrn.com/abstract=2143945

[3] A.R. Bologa, R. Bologa, "Business Intelligence using Software Agents", *Database Systems Journal,* vol.II, no.4/2011, available at http://dbjournal.ro/archive/6/4_Bologa.pdf

[4] M. Muntean, D. Târnăveanu, A. Paul, "BI Approach for Business Performance", *Proceedings of the 5th WSEAS International Conference on Economy and Management Transformation (Volume II)*, Timişoara, 2010, pp. 792-797, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1732190

[5] M. Muntean, "Business Intelligence Approaches", Published in: *Mathematical Models & Methods in Applied Sciences*, Vol. I, WSEAS Press, (10. June 2012): pp. 192-196

[6] M. Muntean, L.G. Cabau, "Business Intelligence Approach In A Business Performance Context", Online at http://mpra.ub.uni-muenchen.de/29914/, MPRA Paper No. 29914, posted 28. March 2011 / 19:42

[7] M.C. Voicu, "Algorithms used to obtain aggregated value sets from relational databases", *9th WSEAS Int. Conf. on MATHEMATICS & COMPUTERS IN BUSINESS AND ECONOMICS (MCBE '08)*, Bucharest, 2008, pp.209-221, available at http://www.wseas.us/e-library/conferences/2008/bucharest/mcbe/34mcbe.pdf

[8] M. Voicu, G. Mircea, "Constructing and Exploiting Hypercubes in order to Obtain Aggregated Values", *WSEAS Transactions on Information Science and Applications*, Issue 10, Volume 3, October 2006, pp. 2008-2015

[9] M. Muntean., C. Brândaş, "Business Intelligence Support Systems and Infrastructures", *Economy Informatics*, 2007, No. 7, pp. 100-104, 2007, available at SSRN: http://ssrn.com/abstract=1082465

[10] A. Butuza, I. Hauer, C. Muntean, A. Popa, "Increasing the Business Performance using Business Intelligence", *Analele Universităţii "Eftimie Murgu"* Reşiţa, anul XVIII, nr.3, 2011, pp. 67-72, available at http://anale-ing.uem.ro/2011/C9.pdf

[11] M. Mircea, A.I. Andreescu, "Agile Development for Service Oriented Business Intelligence Solutions", *Database Systems Journal,* vol.II, no.1/2011, available at http://dbjournal.ro/archive/3/5_Mircea_Andreescu.pdf

[12] B. Ghilic-Micu, M. Mircea, M. Stoica, "The Audit of Business Intelligence Solutions", *Informatica Economică* vol. 14, no. 1/2010, available at http://revistaie.ase.ro/content/53/07%20Ghilic,%20Mircea,%20Stoica.pdf

[13] G. Gligor, S. Teodoru, "Oracle Exalytics for Speed-f-thought Analytics ", *Database Systems Journal,* vol.II, no.4/2011, available at http://dbjournal.ro/archive/6/1_Gligor_Teodoru.pdf

[14] http://www.pentaho.com/

[15] M. Golfarelli, "Open Source BI Platforms: a Functional and Architectural Comparison", Proceeding DaWaK '09 Proceedings of the 11th International Conference on Data Warehousing and Knowledge Discovery, pages 287 - 297, available at http://bias.csr.unibo.it/golfarelli/papers/DAWAK09%20-%20Golfarelli.pdf

[16] http://www.insse.ro/cms/files/Anuar%20statistic/13/13%20Stiinta,%20tehnologie%20si%20inovare_ro.pdf

Diana TÂRNĂVEANU has graduated the Faculty of Mathematics from the West University of Timişoara in 1995. She holds a PhD diploma in Management from 2008. Currently she is lecturer of Economic Informatics within the Department of Business Information Systems at Faculty of Economics and Business Administration from the West University of Timişoara. She is teaching advances in database management systems, business intelligence and decision support systems. She is the author of more than 10 books and over 35 journal articles in the field of Knowledge Management, Decision Support Systems, Collaborative Systems and Business Intelligence.