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Finding the Essence in Geographic Statistics – Promoting Informed Decision Making *

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Abstract

Official statistics have great potential to generate knowledge and serve as basis for decisions taken by many actors in society; however, the potential is grossly under-utilised because many people do not know about statistics, do not care about them and do not understand them.

This paper highlights an innovative tool for exploring geographic statistics, which has been developed by the University of Linköping, Sweden. The paper demonstrates how the tool has been implemented in Denmark as a powerful enabler to different categories of users of statistics, who wish to understand the geographic dimension of societal phenomena and find the facts hidden in the data. The scope of the tool spans from leading edge regional researchers, through local and regional planners and news media, to the general public, e.g. citizens who want to understand what goes on in their community. Consequently, the tool allows for many different ways of presenting itself and the data, and it is applied to many different levels of geographical detail.

It will be demonstrated how Statistics eXplorer can be used by an advanced user to explore geographic statistics, uncover hidden structures and relationships in the statistics; how an analyst can present her findings and stories to a broad audience; and how users "from the outside" can insert their own data in the tool, investigate new theories and communicate them to colleagues.

Keywords: Statistics, visualisation, knowledge, dynamic maps

1 THE PROBLEM: WHY ARE STATISTICS UNDER-UTILISED?

Official statistics from national and international sources are an immensely rich and potentially important source of information. Statisticians working in official

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statistics are committed to promote informed decision making in all aspects of life. Many decisions in legislation, government administration and planning, research and education, as well as problem-solving and decision making in the citizens' planning of their own lives, should be based on empirical evidence. Official statistics are well suited to support such decisions, often in combination with other types of information from other sources. Indeed the real value of statistics depends on whether or not they influence decisions in some way – especially in generating decisions leading to desired results rather than the opposite. Official statistics are generally high quality information, built on fundamental principles and using scientific methods. We know that official statistics are often used as an important background for decisions, especially in public planning and policy making and, maybe to a lesser extent, in private market planning and monitoring. Official statistics are much less recognised and used than they ought to be, considering the valuable information they could offer. Many public policy makers and business decision makers don't know about the official statistics and turn to other sources or decide without sufficient evidence base, and among the informed public they are even less used or known.

Thus the potential is vastly under-utilised. There may be several explanations to this. Do people know about existing statistics? – Not sufficiently. Can they find them? – Not as easily as statisticians tend to think. And if they eventually get to them, do they actually understand them in such a way that they can use them in their decisions? These are issues that are dealt with in quality frameworks in many statistical organisations under headings like "Accessibility" and "Interpretability". Statistical organisations are working to improve in these respects. This paper shall concentrate on how to make geographic statistics understandable and useable to larger audiences.

Statistics have an unfortunate image of being boring – even though some of us know that they are in fact fascinating and exciting. But it is a historical fact that the representations of statistics in different media do not necessarily lend themselves easily to being absorbed by non-experts. This, in turn, makes people less prone to go and look for statistics.

2 THE QUALITY OF OFFICIAL STATISTICS

Organisations providing official statistics have a long and strong tradition for search for excellent quality. A basic principle has been using sound scientific methodology. In 1994 the United Nations published the Fundamental Principles of Official Statistics, UN (1994), and most countries and international organisations subscribe to these principles and monitor their adherence to them, which reinforces transparency and quality.

In order to ensure a high standard, many of the organisations producing official statistics have adopted quality frameworks during the past decade. These frameworks first define the concept of quality, usually in a very broad sense. The basic concept is fitness for use, i.e. to which degree the information produced meets the needs of different users and desired uses. The basic concept is then broken down in a small number of dimensions. For example, the OECD views quality in terms of seven dimensions: relevance; accuracy; credibility; timeliness; accessibility; interpretability; and coherence. Most organisations use very similar dimensions. The frameworks aim to make sure that the processes of production lead to high quality results. The quality framework will comprise guidelines for the production processes that will lead to excellent quality along these dimensions.

3 OFFICIAL STATISTICS: A LIGHTHOUSE IN THE INFORMATION JUNGLE?

Official statistics are statistics published by government agencies or other public bodies such as international organisations. They provide quantitative or qualitative information on all major areas of citizens' lives, such as economic and social development, living conditions, health, education, and the environment. Official statistics can be found on web sites of national statistical agencies such as Statistics Denmark (www.statbank.dk) and international organisations such as the OECD (www.oecd.org/statsportal).

Producers of official statistics hold no monopoly regarding the kind of information on society in which they specialise. There are many other data providers who make competing information, among them social science researchers, private market research institutes, ministries and banks.

Much of this information can be reached on the Internet, producing what is often called information overload. There is a lot of data out there, but it is difficult to find the good plants among the weeds. Therefore it should be the ambition of official statistics to be one source with a high reputation, to which people should turn when in need of good information. A first precondition to obtaining a status as a lighthouse in the information jungle is that the data are actually of excellent quality, but as explained above it is not enough to have good data, the official statistics must also perform well on credibility, accessibility and interpretability.

Recent research highlights some of the problems in these respects. The European Commission published a Eurobarometer survey in 2008 entitled “Europeans’ Knowledge of Economic Indicators” . This study confirms the limited knowledge of economic indicators that one would expect, but it also shows that trust in official statistics is not high everywhere. There are large differences between the EU countries: Trust is high in the Netherlands where 77% tend to trust the Official Statistics of the country, and in Denmark (73%), while trust is low

in France and UK (35% and 33%, respectively). Interestingly, to the question whether people believe that statistical information play an important role in business, public and political decision making, people in Denmark (with 89%) and the Netherlands (77%) are again the most convinced that this is the fact, while the French (67%) and the British (65%) also have quite high numbers, meaning that people think that the statistics they don't trust are nevertheless utilized. Here the nations that have the lowest number of believers are the Eastern European countries, with Bulgaria (42%) as the lowest.

4 MAKING GEOGRAPHIC STATISTICS UNDERSTANDABLE

Starting in 2009, Statistics Denmark has undertaken to improve the communication of geographic statistics to the public and to paying customers, using mapping tools.

The data that we want to present in a better way are mainly statistical data with geographical references at various levels of detail. Thus, they may be aggregated at different geographical levels:

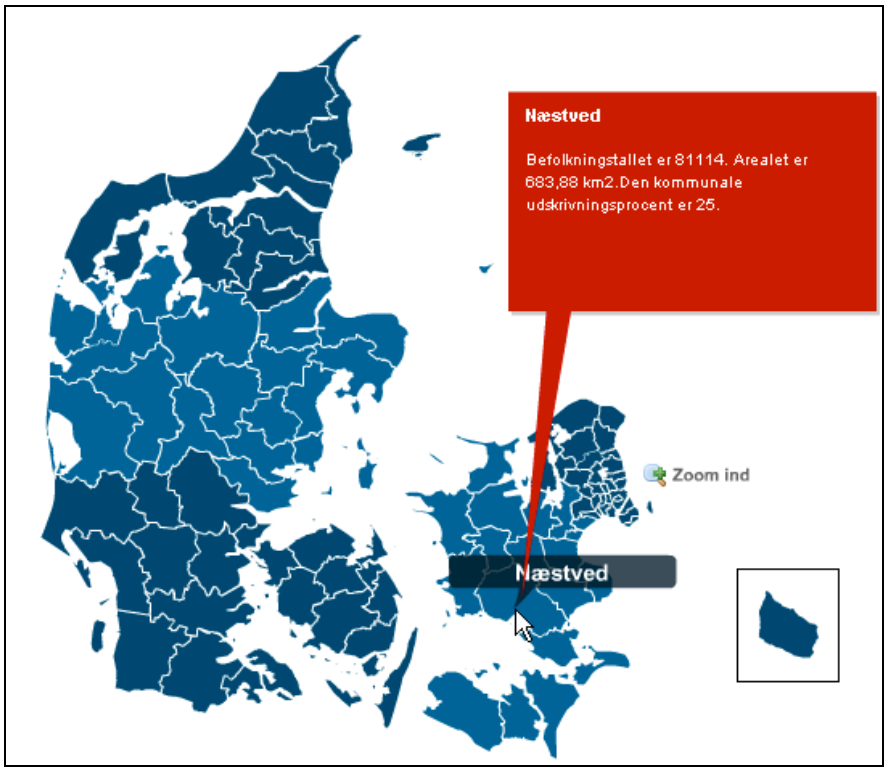
- well established administrative divisions of Denmark, which are usually shown in statistical publications (municipalities, regions)
- more fine-grained administrative or statistical divisions that are not included in freely accessible statistics, or only included to a limited extent (zip codes, parishes, cities)
- grids with different granularity
- specific areas defined by customers
- countries (in international comparisons).

In addition, we have micro data on individuals, referring to points or distances between points (driving distance or linear distance). The geographic references may relate to residence addresses (for individuals and households), work addresses (for individuals), location addresses (for business entities, properties, buildings, dwellings) and surfaces, polygons (for land). In this paper, I shall not dwell on the organization of production and use of this information. In addition to the statistical data with geo-references, we may wish to include reference maps showing boundaries, towns, rivers, topography etc, which makes it easier to recognize where you are in the world. Google is an increasingly used provider of such maps on the Internet, and it is appealing to reuse their maps for visualisation.

5 YESTERDAY'S MAPPING

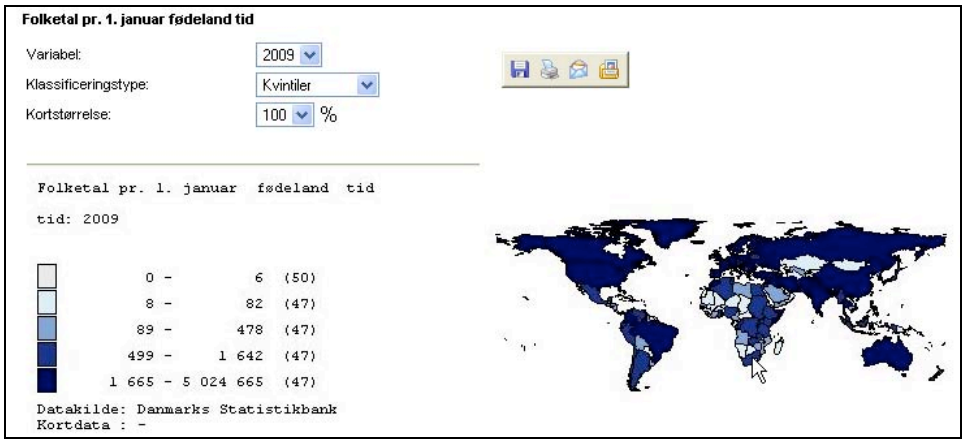
Until recently, Statistics Denmark's web site contained only few maps or pictures; content was almost exclusively data and text. You could see a municipality map with 3 indicators in the "Municipalities on Map" http://www.dst.dk/Statistik/kit.aspx but the map only shows only them as associated data, there is no signature or colour highlighting the differences (see Figure 1).

Figure 1: Municipality map



In StatBank.dk is possible to display the data selected on a map using the PX-Map tool. It is possible to see maps for all municipal statistics and e.g. population broken down by country of birth (see Figure 2), but the map is not interactive, you can not see data, or field name by mouse-over, not zoom or pan, not switch to other indicators.

Figure 2: PX-Map generated from Statbank.dk



Our statistical publications have not been encumbered by too many maps either, even if you can spot an odd municipality map here and there, e.g. in the yearbook. The maps are usually area maps with boundaries from the National Survey and Cadastre. These maps are now freely usable for non-commercial purposes. Until recently, we had no examples of use of Google Maps, which are used by most other information agents across the web.

Along with the National Survey and Cadastre, Statistics Denmark has developed a grid of Denmark with different mesh sizes down to 100 * 100 m; it is used by several of our customers, who typically resell information to other customers, but it is not yet used in our dissemination of statistics. In connection with the establishment of a coming paid databank service, it has been proposed to use visualization of grid data to for instance night population (occupied household addresses).

The GIS tool used until now for most of our communication is PX-Map (developed by Statistics Norway as part of the PC-Axis family, see Statistics Norway (2006). Other GIS tools used in Statistics Denmark are X-Point, ArcView / ArcGIS and Fleet View. X-Point is used only for external customers. Its strong point is that it is fast and easy to visualize data on small areas such as parishes, postal codes, grid cells and grid clusters. ArcView / ArcGIS is a professional GIS tool for specialists and is the program that is used in-house to construct the map illustrations for our publications and “real” GIS analysis, including the preparation of the annual delimitation of towns, annual commuting distance statistics and parts of environment, and commissioned work for customers (e.g. catchment area analysis. Fleet View is a special program exclusively used for distance

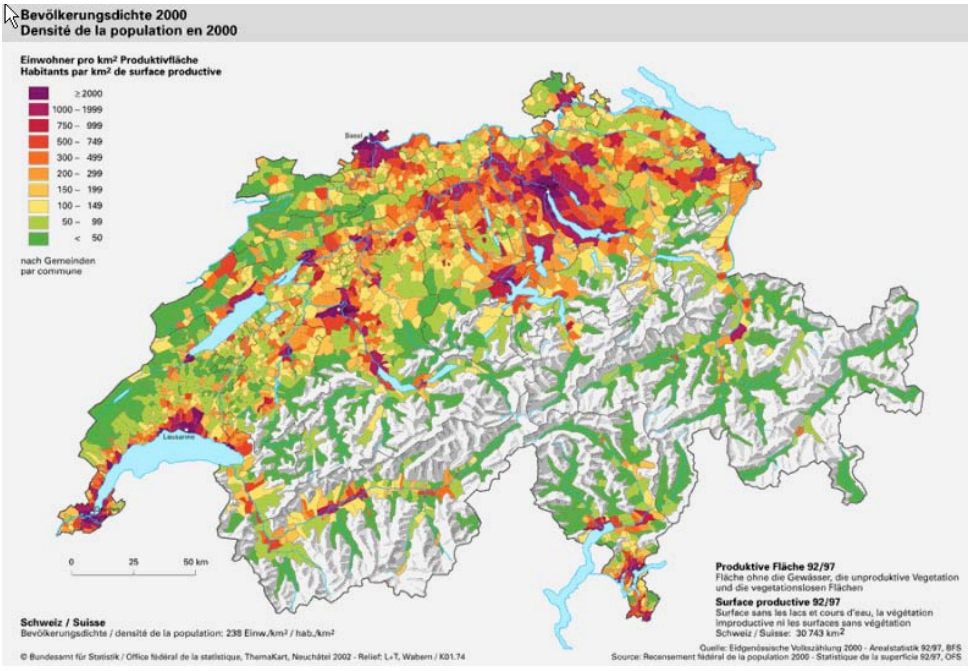
calculations, e.g. showing the number of citizens living within 20 minutes driving distance from a planned location of an institution.

For visualization of the statistics, we started experiments in 2009 with the interactive tool Statistics eXplorer. This tool is developed at Linköping University by the NCVA research team led by Professor Mikael Jern. NCVA is interested in working with us to further development and improvement. The open version of the product is free. It is becoming more and more recognised by the statistical offices of several countries and international organizations.

6 GOOD PRACTICES FROM ELSEWHERE

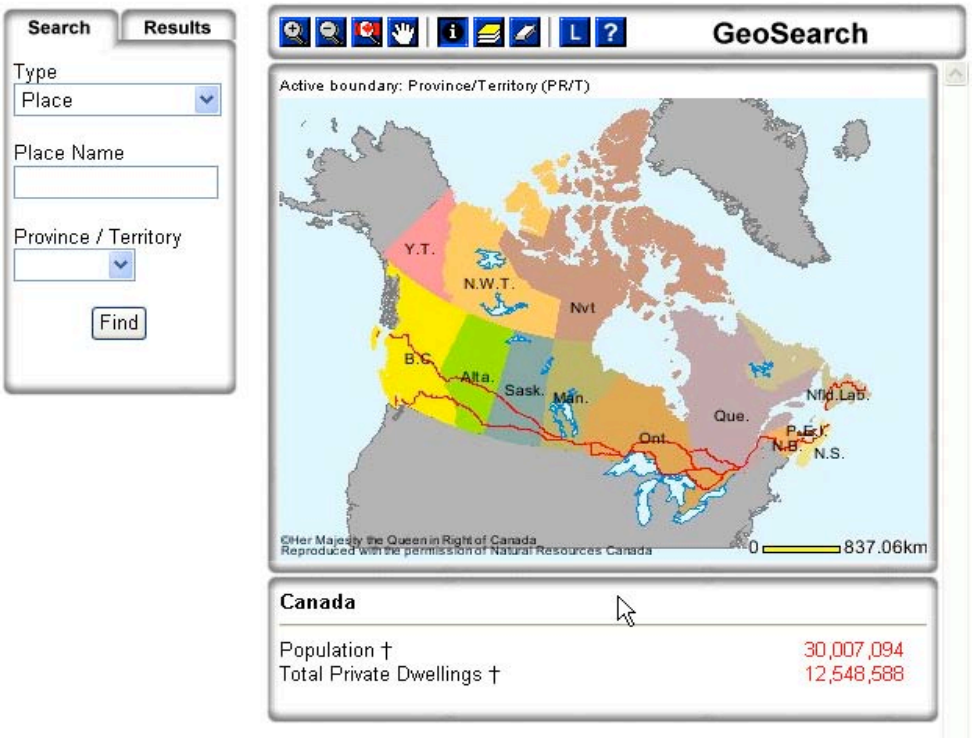
Before concentrating on Statistics eXplorer, Statistics Denmark has made a survey of statistics web sites to see if there is anything we can steal or be inspired by. We found some beautiful PDF maps without interactivity, e.g. from Switzerland:

Figure 3: Beautiful Swiss map



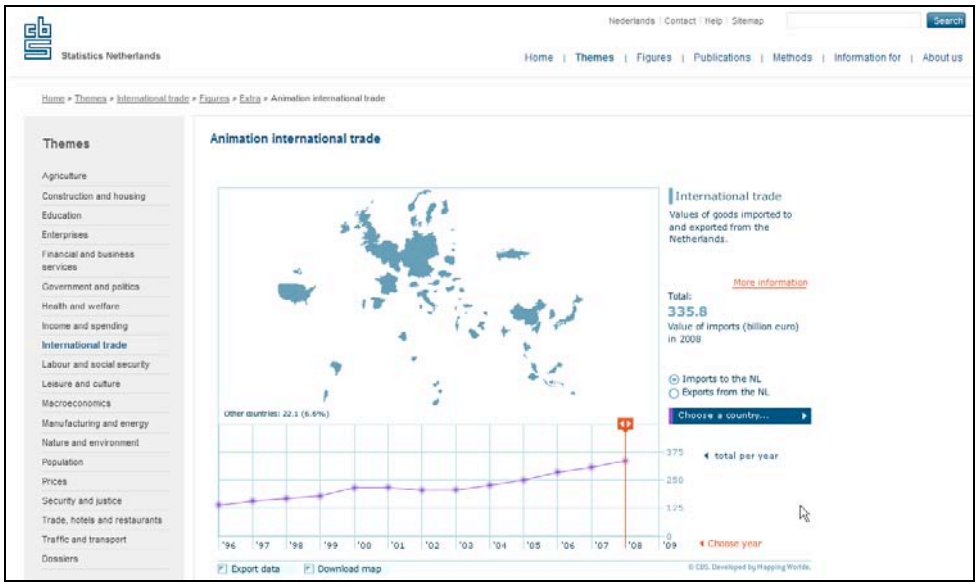
We also found maps with some interactivity. Statistics Canada has a nice site where you can find census data on the map, down to census-district level:

Figure 4: Canadian census map



Statistics Netherlands has an SVG map attached to its StatLine database in approximately the same way as Statistics Denmark, i.e. when you have selected data, you can display them in a map; unfortunately we could not figure out how it worked, so it is probably not worth imitating. In addition, CBS has a dynamic map for foreign trade, where dynamics allow to re-scale the size of regions or countries proportional to the amount of import or export to individual countries http://www.cbs.nl/en-GB/menu/themas/internationale-handel/cijfers/extra/2008-animatie.htm , which seems like more fun than useful:

Figure 5: Country sizes proportional to indicator



CBS has also developed another interesting tool that has been presented around the world, based on Google Earth. Unfortunately it can not be seen on computers at Statistics Denmark and probably many other places because it requires the installation of Google Earth and an SVG viewer; the latter is not mainstream and can not be expected to be found on everyone's computers, unlike Flash.

The Office for National Statistics (ONS) of the UK has launched a fine interactive, dynamic map with statistics on aging: http://www.statistics.gov.uk/ageingintheuk/agemap.html . There is also an interesting interactive map of commuting in London Region: http://neighbourhood.statistics.gov.uk/HTMLDocs/images/index.html . It gives a fascinating picture of commuting out of each individual geographical sector, but does not seem to show the data. The explanation seems to be that it would be too heavy with all the data.

Slovenia's statistical agency has launched a very good statistical atlas with interactive maps, http://www.stat.si/eng/iatlas.asp# . A fairly large number of indicators can be selected, and the maps are simple and understandable. There are time series but not animation. As the Atlas is launched directly on the home page on the Office's web site, it is very easy to find.

7 REQUIREMENTS FOR A TOOL

The literature on geovisual analytics (GeoAnalytics) identify many benefits that can be obtained from visualisation tools (e.g. Andrienko et al (2006), Dykes et al (2005)).

Statistics Denmark wishes to allow its users to reap many of these benefits while consuming its geographic statistics. The organisation has therefore been looking for a well functioning web tool that can visualise domain-related statistical data and thereby satisfy a wide range of demands from the regular, free dissemination of statistics as well as from paid services for customers. In addition, Statistics Denmark would like to have a tool that can be used for micro data related to points and distances; such a tool will be most useful for internal purposes, since individual micro data cannot be given to users outside Statistics Denmark. It is important that we do not use more tools than necessary because it would make it difficult to ensure competence in the organisation and contribute to confusion among users.

In 2008-2009 the OECD launched the OECD eXplorer with regional data and the Factbook data, see for instance http://stats.oecd.org/OECDregionalstatistics/ . It is highly interactive with opportunity for interaction between different maps and graphs. This tool immediately displayed many of the features Statistics Denmark saw as important for the users. Therefore the list of requirements takes departure from what was already there, and which additional features are seen as important.

7.1 Requirements list for a tool for domain-related statistics

The domain-related tool must basically have all the good qualities that Statistics eXplorer already displays, including:

- stable and proven technology (Statistics eXplorer has been running in production from OECD, Statistics Sweden, ISTAT and Eurostat for a year, so errors and inappropriate units have been cleaned)
- web based,
- based on Flash and Adobe Flex, which is state of the art
- high performance, so you do not have to wait long while the data load
- highly interactive,
- mouse-over for different metadata
- excellent colour choices, based on university research in visualization
- dynamic map interacting with other dynamic graphs included in the tool
- time animation, i.e. opportunity to see the movements over time in the listed indicators as a kind of movie

- modular design, so you can easily adjust the display to easily make new data and maps,
- ability to overlay several types of maps so you can have both area boundaries with statistics and background maps from e.g. Google with certain topographic objects ,
- storytelling: choosing the maps and other presentations (with or without time animation), that we want to show the user with a narrative of what they reveal
- allow users themselves to insert their own data and stories
- multilingual, so you can switch between multiple languages (Danish and English, but perhaps also e.g. Swedish for the Oresund database, which covers a cross-national region in Denmark and Sweden)
- easy to customise using an installation wizard.

These features are described in more detail elsewhere, e.g. in Jern et al (2009). In addition to these needs, which were already fulfilled, we had the following wish-list:

- data should be presented in different ways, some of which are quite simple (e.g. only a map, or a map with a story) while others may be more complex and allow the user a deeper analysis
- must be able to show not only the annual time series, but also monthly and quarterly
- be able to read and display data and metadata represented in SDMX-ML (generic message); the purpose is to ensure that data can be uploaded dynamically from a general and complete format
- must be able to communicate dynamically with Statistics Denmark's data warehouse StatBank (www.statbank.dk) so that you ask for data using a query with a human interface à la PC-AXIS to StatBank and then view the results in Statistics eXplorer maps, etc.
- should be able to show data in a grid (e.g. 100 * 100 m) with a facility for aggregation on the fly
- maps and other graphs can be exported directly from the application in standard formats (PDF, JPEG, etc.) in high quality without using print screen so that they can be used directly as standard images in web sites, reports and publications
- it would be interesting to have an easy opportunity to present images and text as video, either as a simple web recording of animation in the tool or as a real film with a talk.

7.2 Use Cases

Here are some typical situations of certain kinds of users whom we want to support:

1. A school student who must write a social studies assignment on regional differences in youth unemployment (described in more detail, including suggestions about solutions to the problem)
2. A journalist who wants to write an article on the socially troubled residential areas of Denmark, e.g. Vestegnen and Aarhus.
3. An economist who, as a private citizen, wants to get acquainted with the geographical distribution of poverty or wealth
4. A regional researcher who wants to explore the links between economic growth, household income and commuting patterns.
5. A municipal school administration, who wants to get an overview of differences in school coverage or in the distribution of students' social background of local school districts.
6. A municipal school administration, who wants to simulate a model of alternative school districts to illustrate the impact on coverage, etc.
7. A marketing manager in a retail company who wants to find out what the customer potential for a store is in different trade areas . The manager can define the trade area of the shop, based on its location (typically given in the form of an address). The trade area will typically be measured either as a distance as the crow flies or driving distance or time from the hypothetical store address. Data for the trade area is aggregated and presented to the marketing manager.
8. An advertising manager who is planning an advertising campaign and therefore needs to know the distribution of a potential target population (e.g. car ownership, differentiated by age of the car).
9. An author of a publication or thematic web site of Statistics Denmark, who wants to make good maps and for this purpose needs to try out different options for selecting and putting together the data, etc.

7.3 Some practical applications - examples

On October 13, 2009 Statistics Denmark published a press release “The elderly occupy the islands” (http://www.dst.dk/OmDS/BagTal/Arkiv/2009-10-13-De-aeldre-indtager-oeerne.aspx). This article shows the publicly available figures for the proportion of people aged 65 + years by municipality now and in the future, according to the official population forecast. Wouldn’t it be nice to show these figures in a dynamic map with time animation and integrate this into the article on Web site, instead of referring to the StatBank, where the reader has to manage menus and select data, and then manipulate them in Excel to come up with something similar? It would be interesting to put this together with employment

rates, number of old pr. employed, the share of women in productive ages (it is mentioned in the article that women leave the rural areas before the men), data on the number of schoolchildren?

Confidence index for Copenhagen (Report of the City of Copenhagen in August 2009 http://www.kk.dk/Nyheder/2009/August/Tryghedsindeks_Kbh_kortlaegger_tryghed.aspx) highlights an index summarising which areas of the city are harassed by high crime rates, in which areas the citizens express confidence, and where people fear becoming victimised; the web site also features a simple but excellent interactive map. But wouldn't it be much better if, in addition to showing confidence index, the site could also show index for example only violence and threats crimes? Or seek out neighbourhoods with a security pattern as measured by several variables (e.g, particularly high violence but low rate of notification to the police from victims), looking at correlations between crime rates, reporting rates and other socio-economic data for the districts? This might interest the Copenhagen municipality and the police who have purchased the survey in Statistics Denmark?

7.4 User orientation

To ensure that users would come forward and contribute to a good implementation of visualization of the transfer and sale, Statistics Denmark established a small user group consisting of users having profiles similar to some of the use cases described above. The group met in early 2010 and was been invited to test and evaluate solutions based on Statistics eXplorer. The feedback was very positive, as most user categories found that services along these lines would greatly help them understand and use the geographic information. They also gave useful input regarding aspects of the presentation, some asking for additional features, others for simplifications. This confirms the expectation that we must have different levels of service for different segments of users – which is possible to manage with Statistics eXplorer. The producer of Statistics eXplorer, NCVA, has shown great interest in these messages and has proved willingness to act on them.

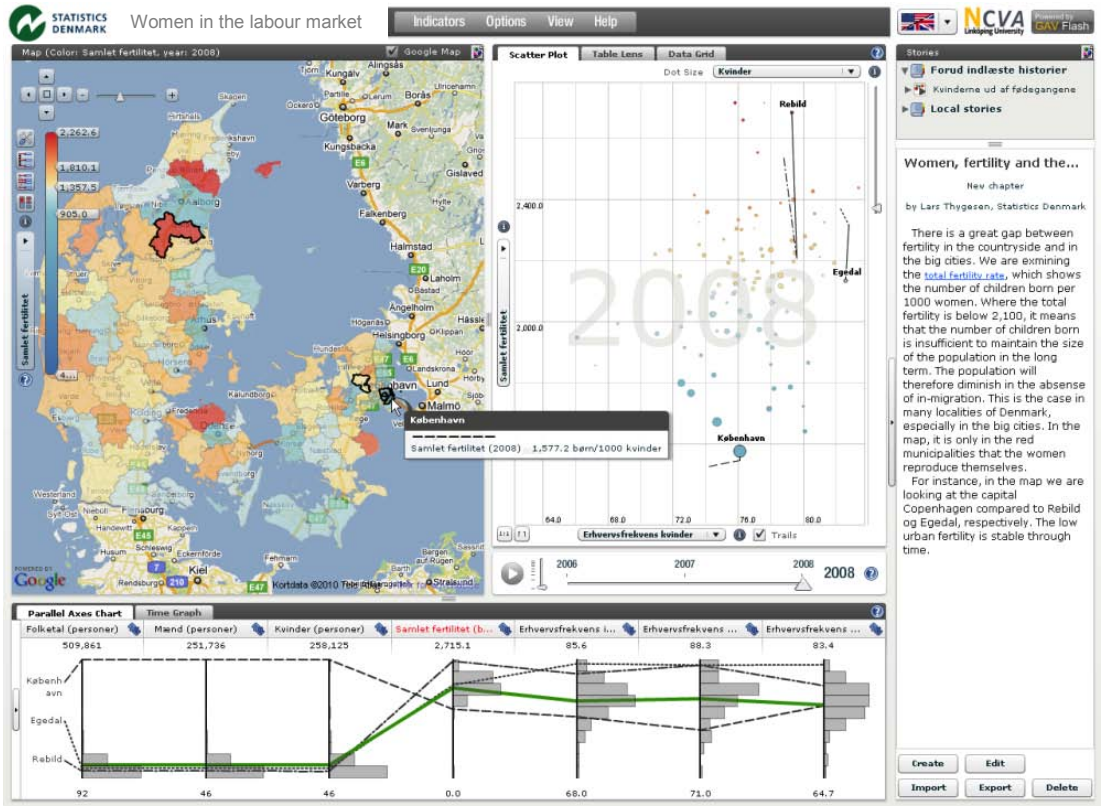
8 KEY FEATURES OF EXPLORER

This paper will not give a technical description of what Statistics eXplorer has to offer; for such a description, se for instance Jern (2009). Instead we will briefly explain some of the features that greatly help turning statistics into knowledge, seen from a user perspective.

8.1 Open eXplorer components

With the Statistics eXplorer tool, we can easily present statistics by municipalities, counties, parishes or other geographical division into interactive maps and other graphics, which help users to see and understand the structures and relationships in the statistics. Statistics eXplorer can uncover messages hidden in the statistics and generate knowledge to the reader. Statistics Denmark uses Statistics eXplorer to present statistics on its own web site and to assists clients who need such a tool to show their statistics, so they create knowledge. For example, in a presentation like Figure 6, a user familiar with the country will immediately discover the fact that fertility is low in metropolitan areas as compared to rural districts. Using the dynamic feature included in the tool, you will be able to see how fertility develops over time, correlated with economic activity rate among women.

Figure 6: Example of Statistics eXplorer with story



Explorer is designed with different options for viewing, so it can be used aiming for expert users who want to analyze and go in depth with data; another view aims for an ordinary citizen needing an easy overview of the geography of a statistic, e.g. ageing of the population.

Explorer is centred around dynamic maps that interact with other dynamic graphs included in the tool. It offers time animation, i.e. opportunity to see the movement over time in the selected indicators as a kind of movie. An important part is "story-telling", allowing Statistics Denmark or another user to select the maps and other presentations (with or without time animation) to show the user along with a story of what they show; that way the reader can receive and understand the story. A user can easily put his own data in and compose a new story.

The standard view on Statistics eXplorer is shown in Fig. 6 above. In addition to the dynamic map, with mouse-over showing data, you can choose from the following views: Scatter-plot, Table Lens, Data Grid (i.e. a table), Parallel Axes Chart and Time Graph. All views are fully synchronised and can be shown with time animation.

8.2 Story-telling

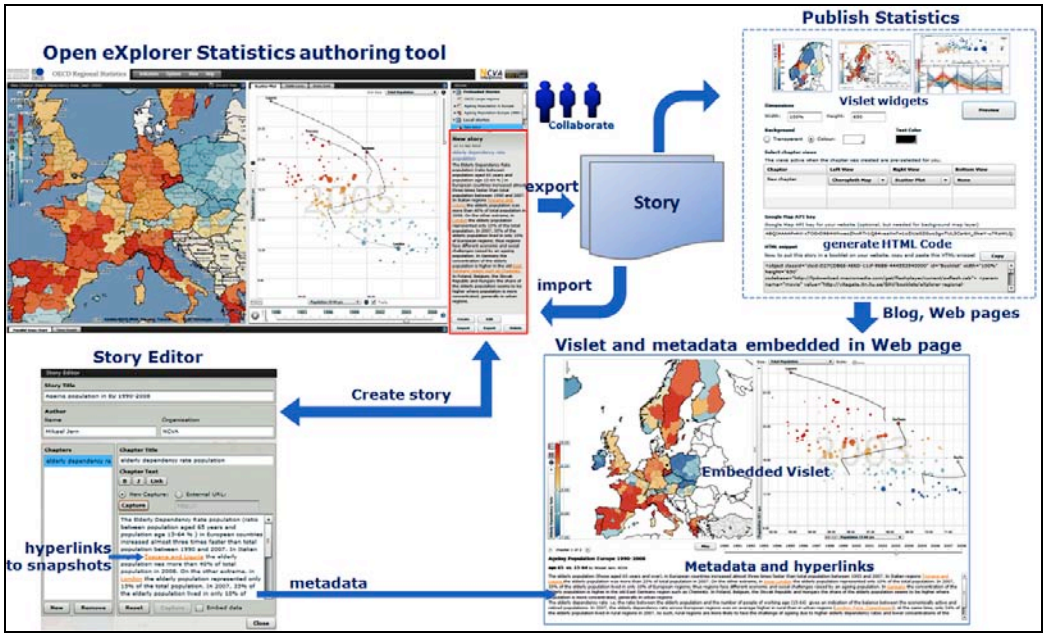
It is obvious that if the user is to devote interest to statistics, gain knowledge, and use the information for decisions, the statistics must clearly convey a message. In organisations specialising in analysing data, finding the most important messages is a core activity and expertise. Decision makers (of all kinds) need to find such important stories and use them, but it is not so easy to find those stories. Therefore they may have to engage statistical experts and analysts in order to discover the messages in the first place. Ideally, tools should be able to help users here.

During the past few years, there has been a trend towards presenting the data in dynamic tools, which have been selected and preset by analytical experts in such a way that they illustrate stories – developments, structures, correlations – that the organisation finds particularly important to show to users; these stories can be accompanied by a written or narrated text directly connected to the initial presentation of the data. The idea is illustrated in Fig. 7.

8.3 Vislets

A recently added subsystem of Statistics eXplorer (called vislet) allows you to choose the components you want (e.g. only a map) and "embed them into" a web site. Here it is also possible to have links in the story, which then activates the animation of maps and graphs. This can also be seen in Fig. 7 below.

Figure 7: Creating stories and vislets



9 LIES AND STATISTICS

All progress entails risks. And here we are looking at giving powerful new tools for everyone to use. You don't have to be an expert of statistics or of GIS. The monopoly of information also dwindles when we give free access to large amounts of geographic information.

If users do not find the stories they are looking for, they will try to find their own stories, combining data in different ways. This entails the risk of finding false stories, combining statistics that do not make sense. This kind of use of statistics is as old as statistics themselves and has given rise to many well-known proverbs about lies and statistics.

It is well known that statistics can be deceptive, and that the messages that seem to emerge from data can be misleading. With new powerful tools that allow virtually anyone to present the data in a very compelling and intuitive way, it can be argued that the risk of making and communicating erroneous conclusions is greater than ever. Should this lead to abandoning the efforts to make powerful tools? We don't believe so, and with a historic parallel we don't believe either that Gutenberg's invention of the printing press was a bad thing, although many silly things have been published since then.

The sources of mistakes are many, as is shown in numerous textbooks on statistical inference and manuals on how to make good graphs. This includes the choice of indicators to present together; ignorance of the characteristics of the data being presented, e.g. on quality dimensions; calculating ratios between indicators that do not relate to each other; failure to distinguish between indicators with different levels of measurement, e.g. treating ordinal data as if they were measured on a ratio scale; choice of scales for graphs in such a way that it distorts the facts; and overly simplistic analysis ignoring factors that are not shown in the graph (latent variables) but influencing the development of the statistics observed.

It is obviously a task for tools to try to minimise the risk of such fake stories being generated, and constructors of tools must think hard about how this can be promoted; the tools must make it easy to do sensible things but hard to do stupid things. Intelligence should be imbedded in the tools. However, the only way to completely avoid the risk of making false conclusion and consequently bad decisions is to publish no data, which is no solution to promote informed decision making.

Just as it is important to certify good and official data, it is important to distinguish, in the communication of statistics, between certified stories produced by experts with a proved sound knowledge and understanding of the information, and stories coming from more uncertain sources, even though they may be using the same data.

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