

GeBIZ: Singapore and the Suppliers that make her tick

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Abstract—Singapore is recognized worldwide for its efficient and clean public service. Ranked 6th in the world in a corruption perceptions index by Transparency International, the incidence of public sector corruption here remains one of the lowest in the world. Efforts to maintain openness and transparency in all government activities can be witnessed throughout the established systems and processes. GeBIZ is Singapore's public eProcurement portal for suppliers to bid on tenders published by various agencies and ministries. While public agencies enjoy the economies of scale which come with the electronic purchase of goods and services, suppliers have broader access to government tenders and quotations.

GeBIZ encourages greater transparency together with fair and open market competition as all procurement operations are published online. Using network analysis and other visualization techniques, we will explore the relationships between suppliers and the agencies with which they trade. Are there unknown biases in the tendering process which favors certain suppliers over others? Are there strong relationships between certain ministries and suppliers for specific types of projects? Are some suppliers providing such high value services to the government as to pose a concentration risk? These are some of the questions we intend to answer.

Index Terms—GeBIZ, Procurement, Business Intelligence, Network Graphs, visNetwork, tidygraph, R Shiny.

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1 MOTIVATION FOR THE APPLICATION

The large volumes of transactions available on the GeBIZ portal present both an opportunity and a challenge in terms of understanding transactional history and interrelationships between suppliers and agencies. Currently there is no meaningful tool which can help us understand purchasing patterns for government procurement.

From the perspective of the suppliers, there is no means to analyse purchasing patterns of the government agencies with which they trade or to be able to forecast these needs. Presently, the process of researching similar historically successful tenders in order to offer a competitive quotation price is a laborious one.

From an overall government standpoint, no tool exists which can provide a high-level overview of trading relationships and the possibility of bias when it comes to awarding tenders. Furthermore, it is equally challenging to identify suppliers which provide reliable services and can be granted higher priority for future tenders.

Considering these current constraints, we are motivated to create a dynamic and interactive dashboard which can provide ministries, agencies and suppliers with a holistic view on the procurement contracts made thus far.

2 REVIEW AND CRITIQUE OF PAST WORK

GeBIZ was initially implemented in 2000 as a single portal for suppliers and government agencies to transact via the tendering process. The development of Business Intelligence (BI) in GeBIZ started in early 2006.

GeBIZ BI initiatives can be broadly divided into two areas. The first area entails the development of GeBIZ InSIGHT which is a tool developed internally that leverages Artificial Intelligence (AI) to deliver a set of BI tools, that enable individual procurement users to research historical buys to gain market insights for Intelligent Procurement.

The second portion covers the development of GeBIZ Management Console (GMC). GMC enables macro-level portfolio management and performance management in the public sector.

Some key capabilities of GMC include:

- Providing overall spend visibility of government procurement
- Demanding forecasting and identification of potential areas for Demand Aggregation (DA) across the public sector
- Facilitating the establishment of customised procurement Key Performance Indicators (KPI) for individual agencies and the entire government. [2]

However, access to this management console is a paid service which is only granted to Singapore Public Officers for approved agencies. In an effort to democratize access to insights available from this dataset, it is key to develop an open access tool for visualisation.

Team GeViz [3] has worked on an application for visualising the same dataset. This application includes a Treemap, Network Diagram, Sankey Diagram and a Word cloud. This application makes it difficult to see seasonality trends due to the format in which the data is presented. It is only possible to view one year at a time instead of multiple years which would allow us to understand trends over time.

Furthermore, the application also does not allow for understanding of relative weightage of budget allocated to different ministries as there is not visualisation to provide an overview of this. All the visualisations only display one ministry at a time.

The Team GeBiz [4] application is another one which has attempted to visualise the same dataset. As part of their project, a Treemap, Sankey Diagram, Calendar Plot and Network diagram has been displayed.

A major drawback of the network diagram presented is that it is not sized by transaction value. Thus, though the diagram helps users understand the relationships between ministries, agencies and suppliers, it does not attribute a weightage to this relationship in terms of transaction value. As a result, users are unable to distinguish between the strength of multiple suppliers with a single agency.

The topic modelling techniques discussed by this group are outside the scope of our existing project.

3 DESIGN FRAMEWORK

The overview of our data preparation approach can be seen in the following figure.

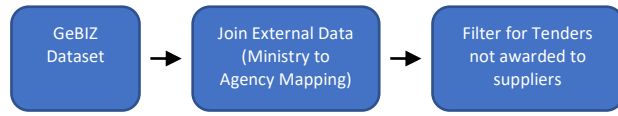


Figure 1. Data Preparation Approach

Prior data preparation will be carried out in order to furnish the dataset with ministry information in addition to the agency information already available. In addition, those tenders which were not awarded to any suppliers will be removed from the dataset as we are only interested in successful tenders.

Subsequently, the visualisations discussed in the following sections will be created.

3.1 Timeseries Chart

To visualize the trend of procurement amount and compare ministries, Dygraph package is used to create timeseries plots of all ministers. Dygraph is a R library inherited from the dygraphs JavaScript library.

This package requires timeseries data instead of normal dataframe, so we need to spread the data, convert the date column to timeseries format using the package of “xts”, and fill NAs with 0 and aggregate the amount by date. Dygraph library can chart single timeseries plot, so to facilitate the comparison of ministries, htmltools package is used to combine the timeseries plots and display all of them at a time.

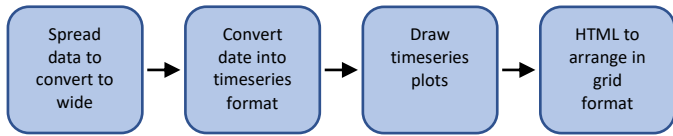


Figure 2. Timeseries Chart Data Preparation

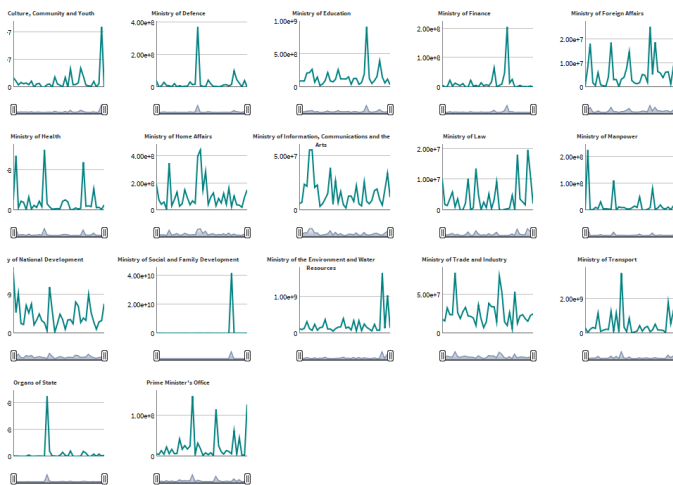


Figure 3. Timeseries Chart

We use digraph for its interactivity. By hovering the mouse over each dot on the lines, we are able to know the amount of procurement at each point of time. And all the plots are linked, so when we either select regions of the graphs or slide the sliders under graphs, we are able to zoom into a particular time period for all the graphs.

3.2 Treemap

After comparing ministries from a time perspective, we wanted to compare the total amount and number of tenders among ministries and agencies, therefore, d3treeR is introduced to chart hierarchy treemap. D3treeR is an advanced R package that makes the traditional treemap interactive with the use of JavaScript.

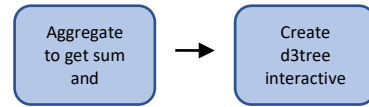


Figure 4. Treemap Data Preparation

For the treemap, the dashboard provides users the option to select years and parameter for size – sort by either total amount or number of tenders.

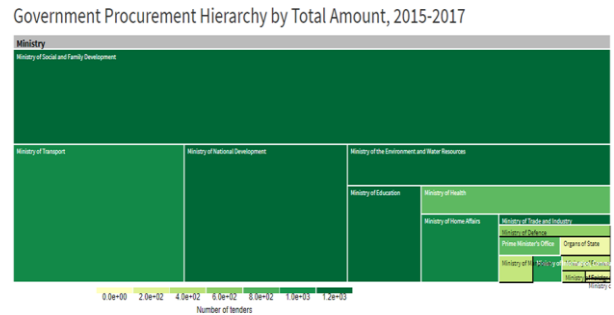


Figure 5. Treemap (sort by total amount)

When the users chose to sort by total amount, the size of grids represents the total amount and the colour represents the number of tenders.

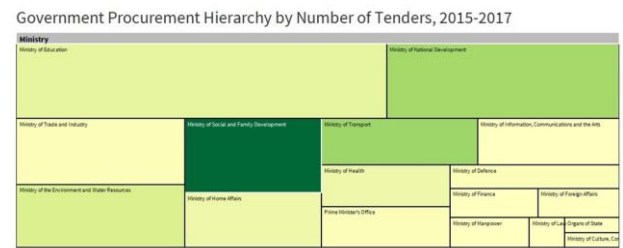


Figure 6. Treemap (sort by number of tenders)

When the users chose to sort by the number of tenders, the size of the grid represents the number of tenders and the colour represents the total amount.

There are two layers of the treemap. The first one is the comparison of ministries based on the user’s selection. Clicking any grid will navigate to the second layer which displays the comparison among agencies of the selected ministry.

To make full use of the treemap, we also use it as an interface to link with the histogram.

By clicking any grid, a histogram of the selected agency will also be shown. And users are provided an option to remove outliers that are not within box plot range. So users can have a whole picture

of the amount range and dig deeper to the distribution of the most common amount.

Tender Amount Distribution of Building and Construction Authority

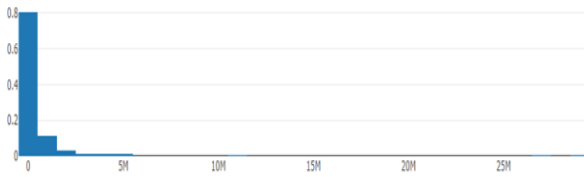


Figure 7. Distribution of tenders' amount

Overall, the combination of the treemap and histogram can not only compare ministries and agencies from a high level but provide details of agencies.

3.3 Network Graph

We used network visualization to showcase relationship and connection landscape for selected ministry and time range. Data subsetting based on filtration criteria is an essential step as network provides explanation value only for limited quantity of nodes. Interactive network was build using vizNetwork library, which allows to benefit from zooming layout, selection of nodes, highlight links and provide tooltips. Additionally, we build static network to show relations of the selected node - for example find if the supplier of interest had tenders awarded from multiple agencies, and what was the dollar amount obtained.

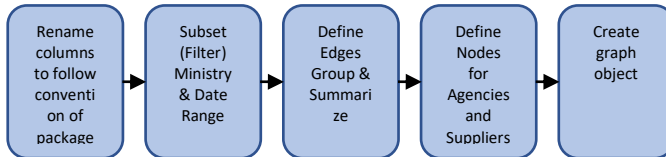


Figure 8. Network Graph Data Preparation

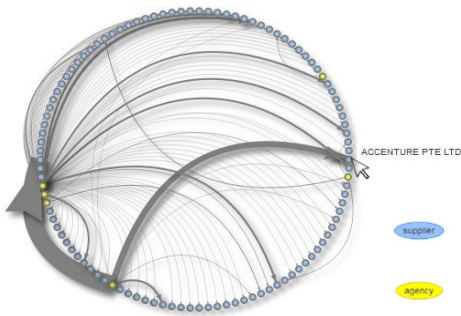


Figure 9. Network Graph

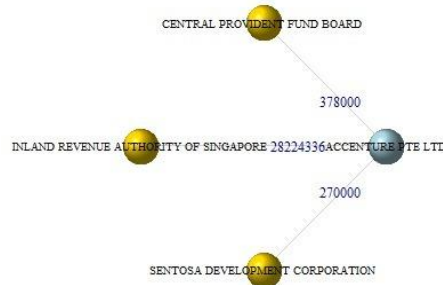


Figure 10. Selected Supplier Relationship with multiple Agencies

3.4 Facet Graph

When we explore the dataset, we find that some tenders have more than one suppliers, so we wondered whether there were some suppliers that were more awarded than others for same tenders. To compare the awarded number of suppliers and show all tenders with more than one suppliers, we use a facet scatter plot.

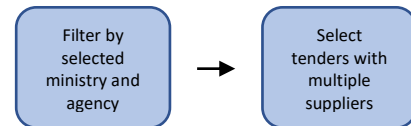


Figure 11. Facet Graph Data Preparation

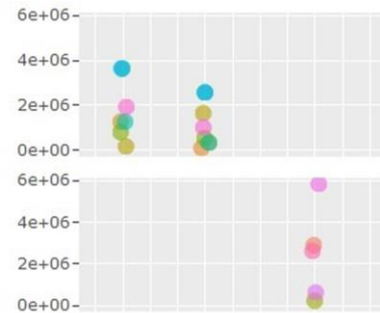


Figure 12. Facet Graph

The above figure shows the result after selecting the ministry and the agency from the sidebar. Each facet stands for a tender that has more than one suppliers, and the scatters stand for the suppliers with the colors represent different suppliers.

From this facet graph, we are able to know that some agencies can have more than 50 tenders that have more than one supplier. And we can also know that some suppliers tend to be more awarded for same tenders.

3.5 Scatterplot & Boxplot

From the facet and network graph, we can find that some suppliers are favourable that they won more tenders than others. Therefore, we are using a box plot to compare suppliers.

The box plot provides users top N suppliers sorted by the number of tenders. And users are provided an option of "Exclude zero" used to exclude tenders that did not award suppliers when sort the suppliers by number of tenders and select the top N suppliers.

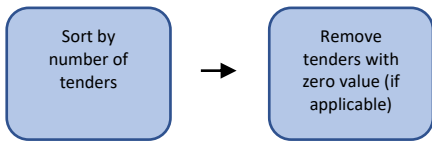


Figure 11. Scatterplot & Boxplot Data Preparation

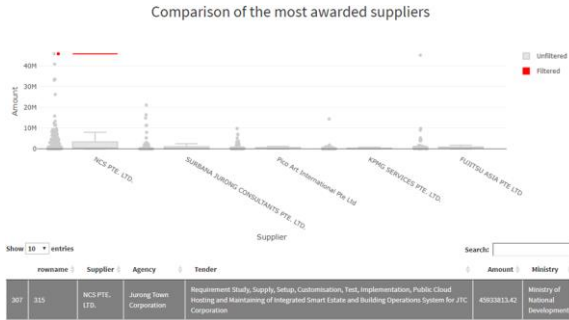


Figure 12. Scatterplot & Boxplot

The scatters next to the box plots displays the tenders' details and they can also be used to select tenders and highlight the corresponding records in the data table, allowing users to get a better understanding of the selected tenders.

4 DEMONSTRATION & DISCUSSION

Ministry of Trade and Industry Exploration

Using Ministry of Trade and Industry (MTI) as a case study, we will explore the R Shiny application developed to gain insights on the procurement data. We will understand the relationship between suppliers and the agencies that fall under MTI.

4.1 Macro View

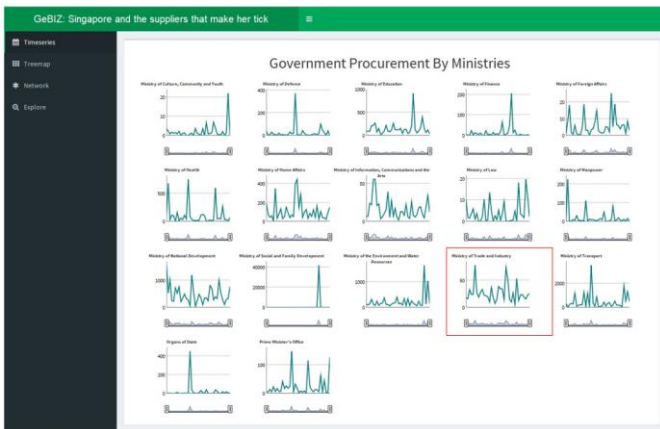


Figure 13. MTI Timeseries

The timeseries chart above shows the expenditure for MTI over the 3 years covered by the dataset. The dollar amounts are displayed in million dollars. We can see that the majority of tenders for this ministry are below \$50 mil. The largest tender award occurred in Jun 2015 for \$78.8 mil. There does not seem to be any seasonality pattern for expenditure for this ministry.

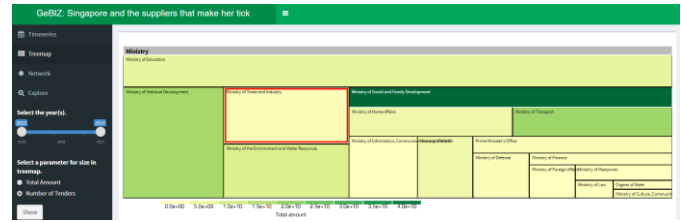


Figure 14. Ministry Treemap (by number of tenders)

The treemap view shows us that MTI is the 3rd largest in terms of number of tenders as shown by the size of the box above. We can also see that the total value of tenders for MTI is relatively much smaller than other ministries as indicated by the paleness of the green colour filling the box.

4.2 Drilldown

Government Procurement Hierarchy by Number of Tenders, 2015-2017



Figure 15. MTI Treemap (by number of tenders)

Further drilling down into the ministry shows us the composition of the agencies that comprise this ministry. We can see that Agency for Science, Technology and Research (A*STAR) makes up almost half of all the tenders for MTI.

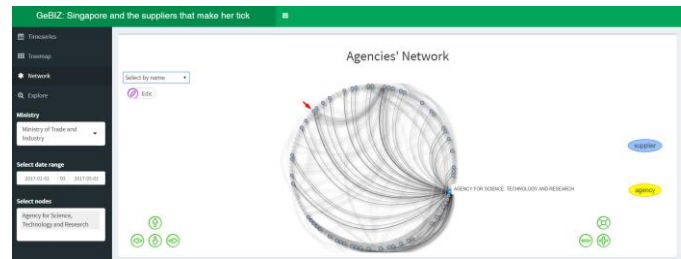


Figure 16. MTI Network Graph

The network graph for MTI shows us that A*STAR has relationships with many suppliers. The thickness of the edges connecting suppliers and agencies indicates the value of the tenders connecting the 2 parties. As indicated by the red arrow on the top left the highest value supplier for A*STAR is NCS Pte Ltd.

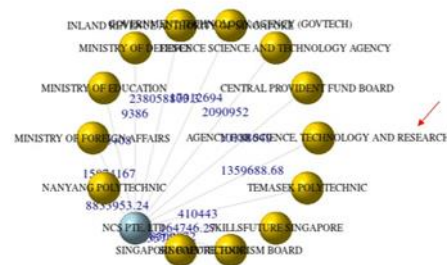


Figure 17. NCS Relationship with Agencies

The network diagram above shows us that this supplier, NCS Pte Ltd, has relationships with various other agencies and that A*Star is only one of the related customers for them.

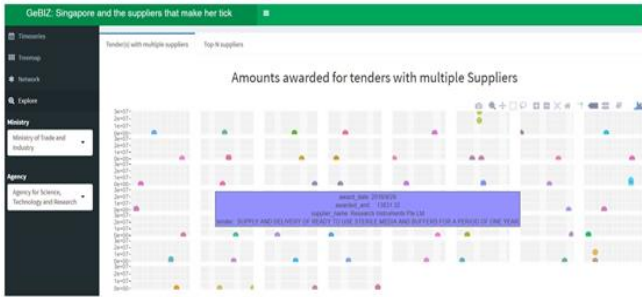


Figure 18. A*STAR Tenders with Multiple Suppliers

The facet graph shows us that A*STAR has numerous tenders which are awarded to multiple suppliers. Hovering over the marks in this visualisation allows the user to understand what tenders were awarded to various suppliers and how the amount was split between suppliers.

5 FUTURE WORK

Within the dataset, one of the variables is a free text field which has a long text description of the tender being awarded. Some examples of the types of tenders being awarded are: Provision of Consultancy services, Provision of Food & Beverage for Events and Provision of Recruitment Services. As a future expansion of our project, it is possible to categorise the types of tenders awarded into various category types for deeper analysis.

The timeseries chart as it exists now within our application has varying scale for each Ministry displayed. This is a conscious choice as the value of tenders awarded by different ministries can vary by a large order of magnitude. A future improvement could be to allow for a standardised scale in order to better reflect the differences between ministries, however this would come at the cost of comprehension of variability for ministries with smaller budgets.

A further expansion of this visualisation would be to allow for selection of a specified quarter for comparison year on year. This would be enhanced by allowing for simultaneous selection of same time point across all ministries.

Improve performance of dashboard to reduce the time taken to display and update visualizations would help improve the user experience.

ACKNOWLEDGMENTS

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