Creating a Repository of Economic Models For Research and Education

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Submitted by:
Nicholas Fajardo
Mitchell Farren
Synella Gonzales
Mark Karpukhin
Artemii Maksimenko
Yaofeng Wang

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Submitted to:

Project Advisor
Svetlana Nikitina

Project Sponsor
The Financial University under the Government of the Russian Federation

On-Site Liaison
Professor Anton Losev
Department of Data Analysis, Decision-Making Theory and Financial Technology

Abstract

The Financial University under the Government of the Russian Federation has expressed interest in developing an educational tool to help students and researchers access economic models. To reach this goal, we conducted extensive research on a variety of models, administered a survey to see potential interest in an economic repository and its components, coded results into a repository, and developed a Wiki to foster educational applications of a repository. As a result, we compiled a version of a repository which could serve as a framework for future development of educational and research applications.

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Authorship

Section	Primary Author	Editor(s)
Executive Summary	Nicholas Fajardo	All
Introduction	Yaofeng Wang	Synella Gonzales
Background	Synella Gonzales	Nicholas Fajardo, Mitchell Farren, Yaofeng Wang
Methodology	Nicholas Fajardo	Mitchell Farren, Synella Gonzales, Yaofeng Wang,
Results and Discussion	Synella Gonzales	Nicholas Fajardo, Mitchell Farren, Yaofeng Wang
Conclusion and Recommendations	Mitchell Farren	Nicholas Fajardo, Synella Gonzales, Yaofeng Wang
References	Yaofeng Wang	Synella Gonzales
Appendix A - Sponsor Description	Nicholas Fajardo	Mitchell Farren, Synella Gonzales, Yaofeng Wang,
Appendix B - Interview Protocol	Nicholas Fajardo, Mitchell Farren, Synella Gonzales, Yaofeng Wang	All
Appendix C - Dashboard Questionnaire	Nicholas Fajardo, Mitchell Farren, Synella Gonzales, Mark Karpukhin, Artemii Maksimenko, Yaofeng Wang	All
Appendix D - Model Descriptions	Nicholas Fajardo, Mitchell Farren, Synella Gonzales, Mark Karpukhin, Artemii Maksimenko, Yaofeng Wang	All

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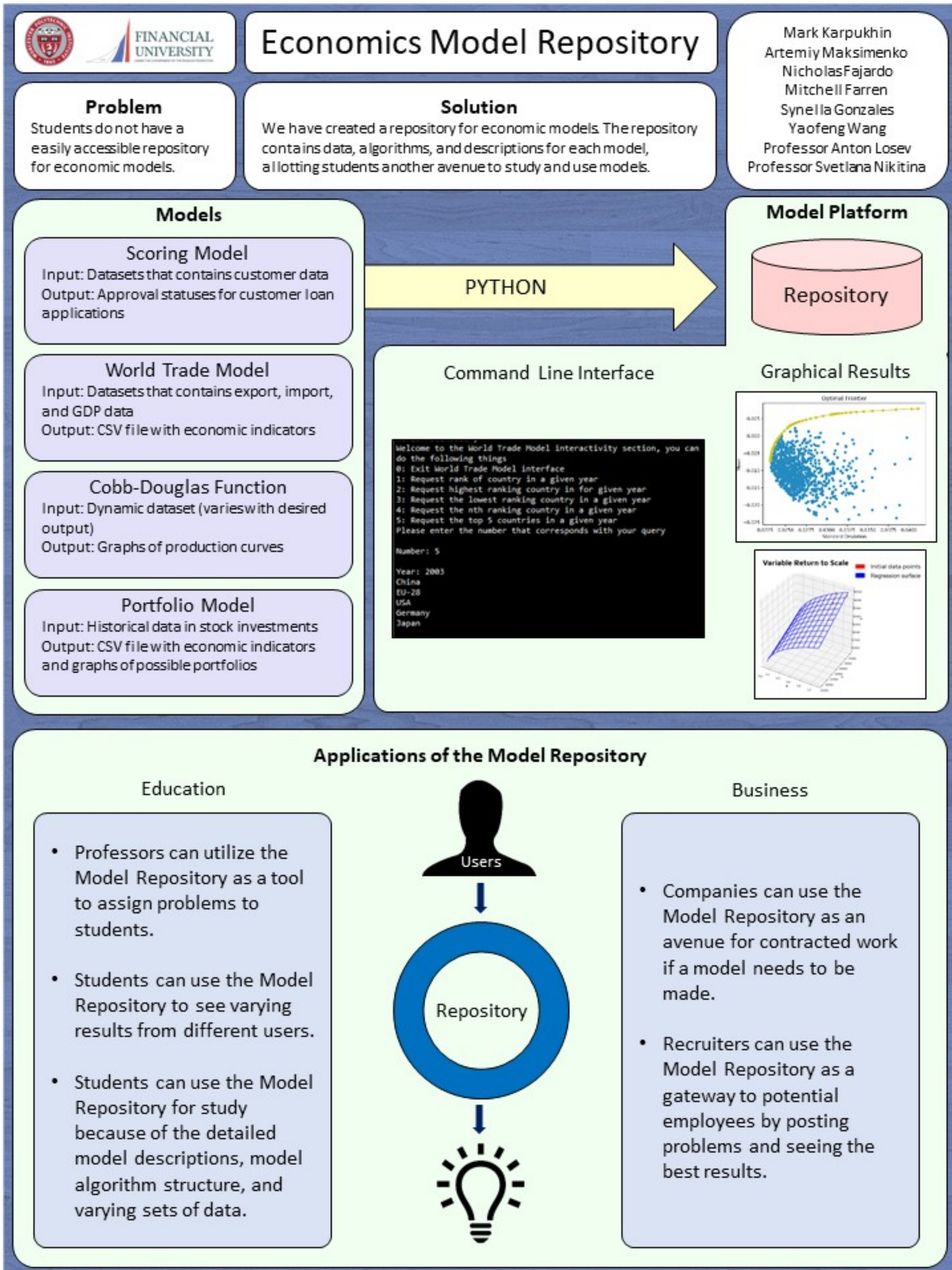
Executive Summary



1. Frontiers in Russian Economics Studies

According to research done by the Center for Economic and Financial Research (a Moscow-based independent think tank), enhancing human capital through education reform is one of the keys to unlocking the potential of the Russian economy. The Organization for Economic Co-Operation and Development (OECD) has even coined a term called "*knowledge-based economy*" based off of the idea that knowledge and technology foster more economic growth and expansion (OECD, 1996). Building a knowledge and understanding of economics requires huge amount of research in various formats -- from electronic resources to conventional texts or research papers (Acton, 2013). In the past, researchers, students, and professors had to analyze economic data by manually applying economic models to anticipate issues and problems that can arise in the economy (Morey, 2016). The economists must perform research to find the applicable economic model for the situation they are analyzing, and then convert the model into some sort of program (or even code it themselves if a program does not yet exist) in order to handle bigger data sets. This process is extremely tedious and, if done manually, virtually impossible to apply to large data sets.

Previous attempts at making economic models readily available for researchers, professors, governments, and students alike have been mostly implemented using manual classical methods. Those methods can be defined as textbooks, research papers, articles, and lectures. However, as society has become more digitized, there are now online tutorials and forums that foster discussion on economics. These attempts are widespread and uncentralized, and to utilize these tools as a learning module would require some sort of organization and data storage. There is no central repository for this *specific* kind of information. A library or online database may have various texts on economic models, but simple access to the models themselves still requires sifting through various sources, which consumes research time.

There are also many different software and programming languages that allow economists to perform the same research and Big Data analysis. The main caveat with these software and programming languages is that the software is typically unavailable outside of corporate or university settings, and programming languages can take up to months to master. When the main point of research is to perform data analysis, coding the models becomes a necessary evil. Simply put, there is currently no easy way to cut out this "middle man" of economic modeling.

Our project with the Financial University under the Government of the Russian Federation (Financial University) aimed to address this concern and forge this frontier. The Financial University is seeking to find its place in the digitized world that this analysis and research is moving towards. Its emphasis on economic education underscores that there needs to be a university-wide digital platform to unify a vast network of professors, researchers, and students, and facilitate expedited analysis of trends and behaviors in the Russian economy. This will allow researchers to create better economic strategies that will foster a broader understanding of the economy to allow for future improvements and corrections. Furthermore, the future of this platform will allow the Financial University to see where students' main areas of interest among economic research topics lies, and scope out top-performing students for potential scholarships, grants or job opportunities. The goal of this project was to create the tool to assist with economic research and education.

To achieve our goal, we set out to complete three main objectives:

1. Identify major economic models that cover a wide range of economic fields;
2. Program the models such that students and researchers can input their own data and manipulate the models for analysis;
3. Create a framework for an interactive website that implements the modeling system this project seeks to facilitate.

Through this implementation, users will be able to maximize their research productivity and minimize the amount of time spent on mundane, repetitive tasks associated with inputting compiled economic data into economic models. In the next chapter, we will review some background information on the current state of the Russian economy to further clarify the significance of this project. We will also uncover the past and current tools economists use to perform their research, and pave the way for the final platform we aim to create.

2. Economic Models: Scope, Significance, and Applications

In this chapter we will provide a brief background to the past and current status of the Russian economy and summarize current economic trends. We will then explain why the Russian economy is in need of better economic analysis for educational and research purposes. This will provide a rationale for why our sponsor, the Financial University, has requested this research to be done. This will be followed by examples and explanations of repositories and tools for economic analysis, both past and present.

The Russian economy's unique path and need for better modeling

Russia's economic progress has been notably slower than most countries experiencing a transition of power (Berglöf et al., 2003), and its path has been in many ways unique and difficult to predict. After the fall of the Soviet Union in 1991, Russia struggled to regain its footing and was forced to begin its rebuilding during a period of economic recession.

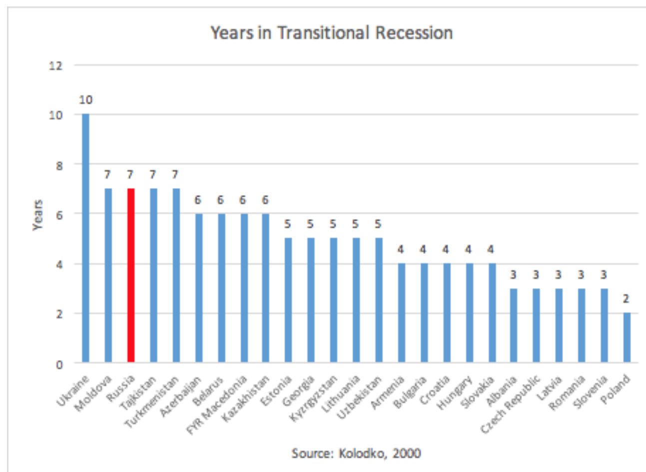


Figure 1: Time spent by Eastern European countries in a transitional recession after the fall of the Soviet Union (in years).

While this is not transition countries, Russia's recession lasted much longer and was worse than other transitioning economies (Kolodko, 2000). In Figure 1, it is clear that Russia spent more time in a recession than most other countries experiencing a transition of power. Furthermore, another indicator of Russia's economic performance can be seen with its low Gross Domestic Product (GDP). By convention GDP is typically used to determine the health of an economy (Berglöf et al., 2003).

Figure 2 below displays the instability of Russia’s GDP. As a country sitting on approximately 30% of the planet’s natural resources, the Russian economy should be outperforming most countries due to this geographic advantage (Korabik, 1997). However, because Russia’s GDP relies so heavily on oil prices, the economy remains extremely sensitive to the changing value of oil.

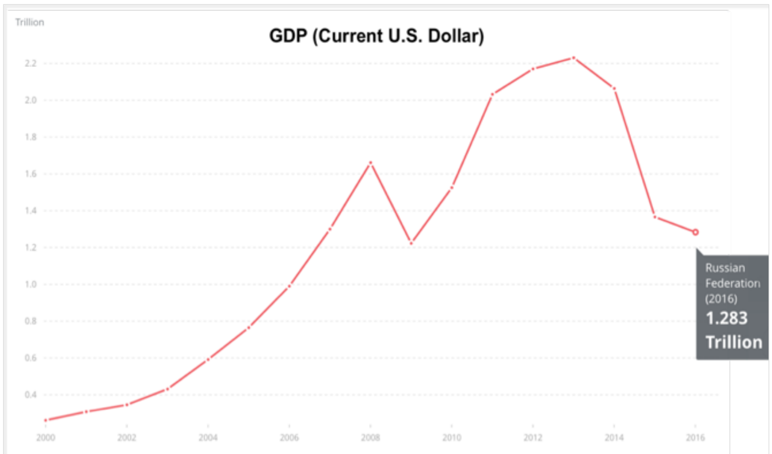


Figure 2: Russia's current Gross Domestic Product (GDP)

The Russian economy has seen slight improvement towards 2016, albeit at a strikingly low rate. Historically low oil prices and international sanctions have prevented the economy from making a strong recovery. According to data collected by Bloomberg, the GDP declined 0.225% in 2016, since it pulled out of the recession in 2016 (Andrianova, 2017). This can be seen below in Figure 3.

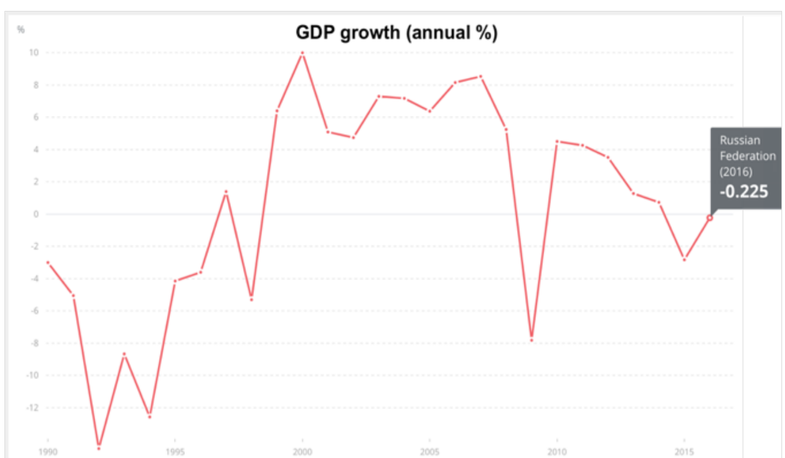


Figure 3: Russia's current GDP growth.

This slow growth is cause for concern, especially if the price of oil continues to drop below a sustainable value. Due to the nature of the Russian economy, there needs to be more analysis and research done in order to understand the mechanics of the economy and build new techniques to improve growth and sustain prosperity.

How does education and research support economic growth?

William Walstad, the Director of the National Center for Research in Economic Education, stated that "nations benefit from having an economically literate population because it improves the public's ability to comprehend and evaluate critical issues" (Walstad, 1998). In summary, increased economic literacy has the potential to improve economic performance because it enables citizens to make smarter decisions regarding investments. By understanding how the economy works, a citizen can make educated decisions, which leads to an increased return on investments. Furthermore, the more research that is done on the Russian economy, the more possible solutions and preventative methods can be created to mitigate economic crisis situations. For example, if the price of oil suddenly drops, an informed citizen would be able to understand that the Russian GDP would be negatively affected as a result, and would manage his or her assets accordingly.

What are the current methods of economic study?

Economists currently use direct research and hard coding to conduct economic analyses (Pavlov, 4 April, 2017). Economists manually search through economic literature, notes, journals, and/or online sources in order to find the applicable models and formulas. Then they have to manually hard code said models and formulas into the program of their choice. Economists waste valuable time performing this research as they are trying to solve a problem or analyze some economic phenomenon. For higher-level economic models, there is a plethora of factors that require someone proficient in a programming language or proprietary software to fully capture. Economists are faced with a decision: either learn how to do it themselves, which takes a significant amount of time, or contract an external developer to tackle the technical aspects of the model.

What are economic models?

Economic models are one of the best ways to learn about economic behavior. Simply put, they are theoretical constructs used to explain current behavior and predict future behavior of economic systems (Morey, 2016; Mankiw, 2001). They are essential to economic theory. They allow you to understand how and why specific economic behavior or phenomena occur (Samuelson and Nordhouse, 1998). These models can take many shapes -- from basic graphs to complex equations. They are created by calculating the relationship between variables in a system -- as well as taking into account the past and present behavior of the system under varying circumstances -- to create a theoretical generalization about how the system behaves.

Through the use of economic models, economists gain insight into the inner workings of a system. They allow the user to peel back hidden layers and grasp the more fine-tuned details that may not be explicitly visible, and pave the way for a more well-rounded knowledge of the system. The more knowledge one has of a system, the more room there is for understanding how to improve it. On a larger scale, one can use economic models to study actual economies of entire countries. They can determine how valuable a resource may be, or to analyze risk factors of political moves. This allows one to estimate the outcome of potential decisions without the risk of actually making them. In doing so, one can see the collateral effects of a decision, maximizing the conservation of time, money, and even lives.

Why are models important?

To emphasize the importance and impact of economic modeling, let us look at an example of a study done by researchers at the University of Southern California's Keck School of Medicine and Truven Health Analytics in Cambridge, Massachusetts (Johnson, 2015). An economic model was created to determine the benefits of co-testing for cervical cancer and human papillomavirus (HPV). The model concluded that by combining the two tests, doctors would be able to detect up to *150,000 additional cases* of cervical cancer, *prevent 100,000 deaths*, and *save $4.4 billion* over a 40-year time period.

Economic models vary from case to case, but their applications may also be useful in other scenarios. In a study done by Gibbard and Varian (1978), the researchers concluded that the amount of variance among economic models can be very small, and it is difficult to distinguish between the different types of models. This is due to the fact that economic models can represent many phenomena and situations, with very small variation among them. This makes it difficult for economists to find the model most applicable to the problem at hand. The Financial University is looking for a way to organize and store important economic models in a centralized location -- a repository -- to expedite time spent researching for its students and for other economic researchers. By doing so, the students and researchers of the Financial University will be able to get straight to their research, rather than wasting time searching and coding the models they need to perform their analysis.

How will these models be accessed by university staff and students?

A repository is a centralized location in which data are stored and from which they can be accessed (Oberkamf and Roy, 2010). Therefore, the models should be housed in a single repository to create a "one-stop-shop" for economists to use to carry out their research. The goal of a repository is to cut down the time wasted on trivial steps, such as coding, in order to allow economists to gain the information they need quickly.

With a repository of economic models, economists could efficiently search through the different models to find the one most applicable to solve the problem. Previously, Gibbard and Varian (1978) categorized economic models they studied in a research paper depending on the type of calculation performed. This allowed the reader to fully understand how a certain type of model within a specific category can be applied to real-world situations. The same results could be achieved by implementing a repository of fully functioning economic models that are ready for use. For example, if economists were looking for an economic model for portfolio optimization, they could simply search for optimization models and easily locate the desired one.

The value of a repository of economic models can be better understood by studying a previous implementation. In 2012, a study was done by the University of Warwick in which they analyzed business models and business cases appropriate to supply chain data (Cave, 2012). They stored this data in a repository, which allowed stakeholders to access the information easily, and assisted them in designing suitable business models to enhance the value of their existing relationships. For example, if a stakeholder wanted to create a cost-benefit analysis of purchasing a new machine designed to maximize production while minimizing time, they could simply go into this database and search for the business model for this situation. Then, they could input their company's data and statistics to see how beneficial this business move could be in the long run. Figure 4 below provides a visualization of the mechanics of such a repository.

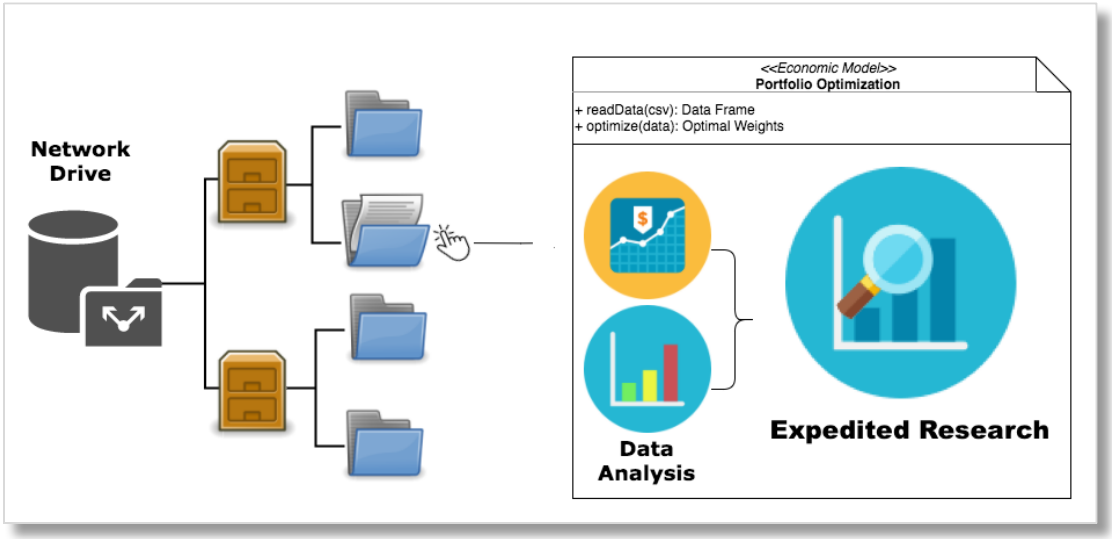


Figure 4: Mechanics of a repository

What are current methods used to study and analyze economic models?

There are several tools economists in Russia can currently utilize to interact with these economic models. Software like MatLab, Maple, and Stata or programming languages like R, Python, and C/C++ can all be used to code economic models using variables that the user can change according to data they need to analyze (Dr. Oleg Pavlov, personal communication, April 19, 2017). There are even tutorials online on how to use these software programs and programming languages to code economic models (Sargent and Stachurski, 2014). However, while these tools are all extremely useful and applicable to studying economic models, they are not the tools of an economist, but rather of a computer scientist. The issue is that one must be proficient in using these tools in order to apply them to economic modeling and analysis. A researcher must go through some sort of "middle-man" before performing their analysis using these tools. In more complex cases, a researcher may need to even hire a professional software engineer (sometimes even a team of engineers), or maybe attend a class on how to use certain software. Economists would prefer to not deal with this type of work, but to do so they will need others to help them to be able to focus simply on applying economic models using data that they or others have collected to analyze the economic trends and make predictions.

In the next chapter, we will explain the methods we will apply to carry out our research in order to achieve our goal of creating a platform for Financial University students to have easy access to economic models to enhance their education and foster their growth in the field.

3. Methodology: Program Fabrication

The scope of this project was to create a system that would act as a repository for economic models. After consultation with our on-site liaison Professor Anton Losev, we determined what was feasible to accomplish within our time here. We assessed our goals in relation to the timeframe we were given to achieve the creation of the platform, and concluded that we would tackle only several essential aspects of the overall task to be able to deliver quality work.

These are our objectives:

1. Identify major economic models that cover a wide range of economic fields;
2. Program the models such that students and researchers can input their own data and manipulate the models for analysis;
3. Create a framework for an interactive website that implements the educational modeling system this project seeks to facilitate.

By doing so, we hope to provide the Financial University with a tool to allow for easier access to economic data and facilitate research on the Russian economy. This tool can be further adapted for use in the business/consulting field.

Economic Model Research

After we assessed our goals, we concluded that there should be four starting models: World Trade, Cobb-Douglas, Loan Scoring, and Portfolio Optimization models. These models, proposed by our sponsor, exemplify the diversity of analysis methods there are in the real world. By ensuring this diversity exists in the repository, students who use the repository will be more well-rounded when problem solving. The models cover the main aspects of economic modeling: optimization, scoring, ranking, and data assessment. Additionally, each model has three main components that are essential to the educational value of this repository: input data, model algorithm, and model description.

The first task we tackled was data collection. We decided that the data for each model should come from public sources. This was determined because public data is the most accessible source for the target users of this system, who are students and researchers. While discussing this with our sponsor, we learned that users can easily pull data from a website called Kaggle. This website is essentially a hub for Big Data -- it hosts competitions on data analysis and provides free downloads of large data sets as Comma Separated Value files, or '.csv' files, which is the standard file type for inputs in this repository. Furthermore, the data sets are often extremely specialized. You can find anything from movie lists, stock exchange history, and even trending YouTube videos. This allows users to apply the models to any topic they may have interest in.

Next, we had to actually code the economic models. In terms of the algorithm construction, we determined that the easiest language to use was Python. This was determined for a variety of reasons. Python follows a strict pact of "There should be one-- and preferably only one-- obvious way to do it." (Peters, 2004). We felt that this aspect of Python is essential for collaboration with our Russian teammates, who were familiar with this programming language. Python also has the largest third party selection for data science packages. This will greatly improve the performance of the algorithms, as these third party packages are extremely powerful and will ensure efficient and accurate results while cutting down on programming time. Competition for Python is not evident for data science. In fact, only the R programming language is comparable to Python for statistical and data analysis usage. We chose Python over R since the latter language cannot be easily integrated into a website's framework, while Python can. Due to its widespread international use -- there is an abundance of frameworks specifically designed for web development.

The last main component of our platform is the description Wiki. This is the documentation that users can use as guidelines for the software and models that we design. They explain the significance of the data, the algorithm structure, the output structure and explanation as to what a user can do with the results of the algorithm. To gain an understanding of the models ourselves, we had to conduct extensive research on the models to understand the parameters, calculations and expected results. This research was then put into text alongside the corresponding code so that users can see the connection between the data manipulation and the model algorithm. To further enhance the educational value, we ensured that the code contained many visualizations and graphical representations of the data manipulation to provide for a more well-rounded user experience. This component is essential to the educational aspect of the repository – by reading the model descriptions, users can actually gain an understanding of how the model works before using the algorithms to apply to their own data for analysis.

Programming the models

To begin the coding process for each model, we first had to determine the input and output parameters, as well as the description of what the model will actually compute. This will shed light on the educational value of studying the model, as seen in Table 1 below.

Table 1: Model inputs, outputs, succinct descriptions and research sources

Model	Input	Output	Description	Source
World Trade	Trade and GDP Datasets	CSV file with ranked countries & command line query interface	Model shows what inputs need to be altered for a desired output. This also graphically shows the relationship between parameters	Mikic and Gilbert (2009)
Cobb-Douglas	Dynamic dataset	Graphic representation of relationships	Model shows what inputs need to be altered for a desired output. This also graphically shows the relationship between parameters	Stewart (2008)
Portfolio Optimization	CSV file of stock portfolio returns	Optimized weights for each asset for maximum return	Model shows the relationship between investments.	Sharpe, Alexander and Bailey (1999)
Scoring	Credit history dataset	Binary predictions of whether customers should receive a loan.	Model allows the user to gain a better understanding of machine learning techniques.	Gadil (2016)

A more robust explanation of the inner workings of each model can be seen in Appendix D.

Organizing and storing the models

We stored the models in a network database where all the algorithms for the various models would be accessible. We organized the selected economic models into folders corresponding to their practical use. For example, producing calculations or performing data analysis. Within those folders, they will be subdivided into the categories in which they operate -- for example, optimization or ranking parameters within large data sets. By doing so, we expedite the economist's research and allow them to get straight to the analysis.

Front-end framework

The front-end of this project would ideally be accessible to a large audience. Since the main idea of this platform is to provide a tool for research and education limiting the accessibility of the platform would essentially negate the impact we hope to achieve. This in itself limits the development process of the deliverable to specific methods. The first is to make an executable package for Windows based systems. However, his limits the audience since this would not be compatible for Macintosh computers. The second avenue would be to make a web-based tool. This would be the ideal solution since web-based tools are accessible from all modern devices, and can shift the balance of the processing from the user client to the server.

We can now determine the structure of the website based on the requirements for the system as a whole. The two possibilities that can be explored in this timeframe is either making a local website that the financial university will host, or making a page that would be hosted by the Financial University fitted with descriptions, Python code, and algorithms.

The first option that could be explored would allow any user (whether it be student, teacher, or company) to run code without downloading any files locally. This would alleviate the processing requirements on the client end of the system, and make it accessible from any device that can connect to the university or any other hosting location. Access through the university will require students and teachers to log in with their university credentials to access the platform. To broaden the platform's outreach, it could be hosted on a public website. This would allow people without credentials to access the platform. The second option is to have a front end structure that has a detailed description of the model, how it works, how to run it, and what data can be fed into it. This page would also entail the data, code, and necessary third party packages. This possibility comes with the assumption that the user has previous knowledge or guidance available about running the program locally.

Since we honed our focus to developing the models correctly, we decided to use the second option for the front end since it is less time consuming. The first option could still be achievable in the future, and would allow the users to have an environment that would encapsulate the process of developing a model, testing a model, and sharing a model with employers or teachers.

Survey Development

All of our objectives lie within the understanding that this tool will become an integral part of economics education. To defend our assumption, we sent out a survey, through a tool called Microsoft Forms, in order to gather results rapidly in an organized fashion. Since we wanted the survey to be fast, easy, and accessible, we fabricated seven questions that touch on background, appeal of the tool, and ways the tool should be used. Figure 5 shows the list of questions, along with the sections that correspond to its significance.

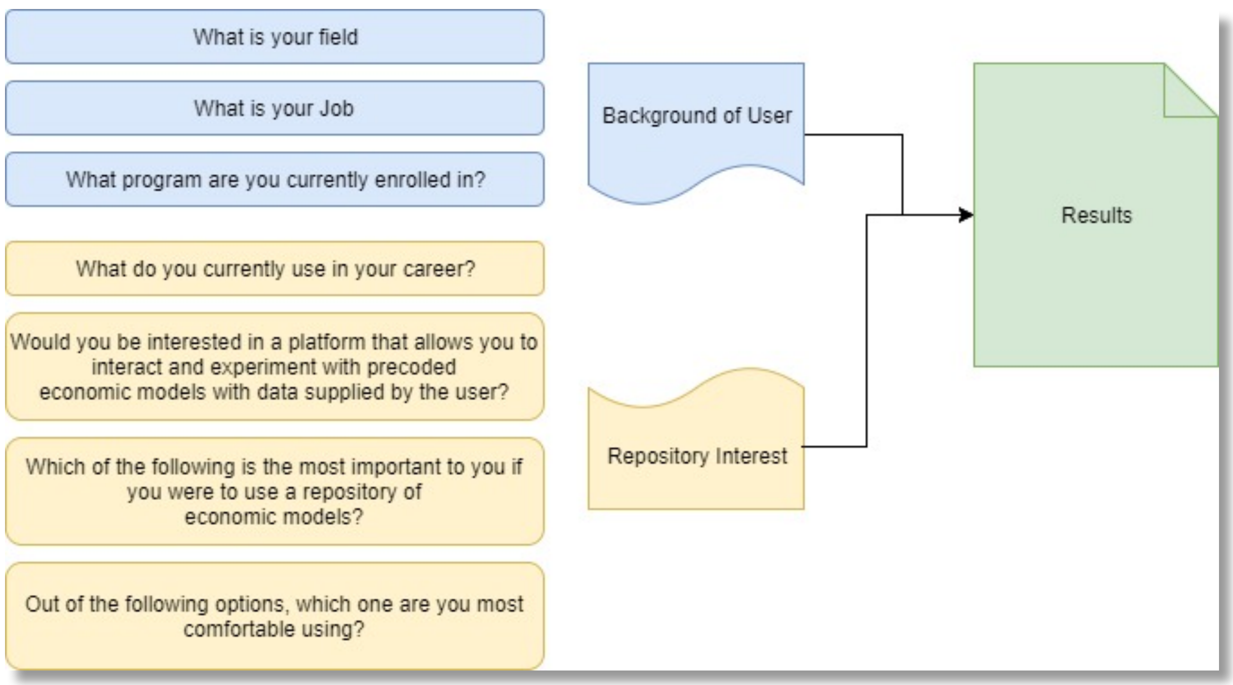


Figure 5: Survey questions

Third Party Tools and Packages

To accomplish our goals of creating efficient and accurate programs for each model, we needed to use four specific third party tools. These tools are packages that are designed to easily parse, manipulate, and analyze Big Data, and are explained in Table 2 below. These packages are extremely powerful and allow us to perform high-level calculations on large data sets.

Table 2: List of Third Party tools and packages

Package/Tool Name	Application	Description
Pandas	Big Data analysis in Python	Allows data to be easily manipulated
NumPy	Big Data analysis in Python	Allows mathematical operations to be easily run
Spyder	Python IDE	Streamlines programming process by catching bugs quicker
CvxOpt	Data optimization in Python	Allows convex optimization application straightforward

As previously mentioned, all aspects of this project use open source resources in order to achieve the goals set out. These third party packages streamlined the processes we needed to use to achieve our technical goals. This comes with the requirement that the end user would also have to download these packages with the code attached to each model. We will be bundling the code with the third party packages in order to make the process for the user to use the algorithms easier. It is important to note that we are **not** violating any trademarks, copyrights, or patents since everything is open source.

In terms of collaboration, we used diverse of tools to share code, work on documents together, communicate, send out surveys, and track our progress. Table 3 explains each tool's significance.

Table 3: List of Collaboration Tools

Package/Tool Name	Application	Description
GitHub	Version Control	Allowed the team to effectively share code
Google Drive	Document Storage and Fabrication	Allowed the team to work on document and presentations simultaneously.
Telegram	Communication	Enabled the team to effectively communicate over laptops and mobile devices
Trello	Organization	Allowed the team to effectively track progress, set tasks, and stay on top of deadlines

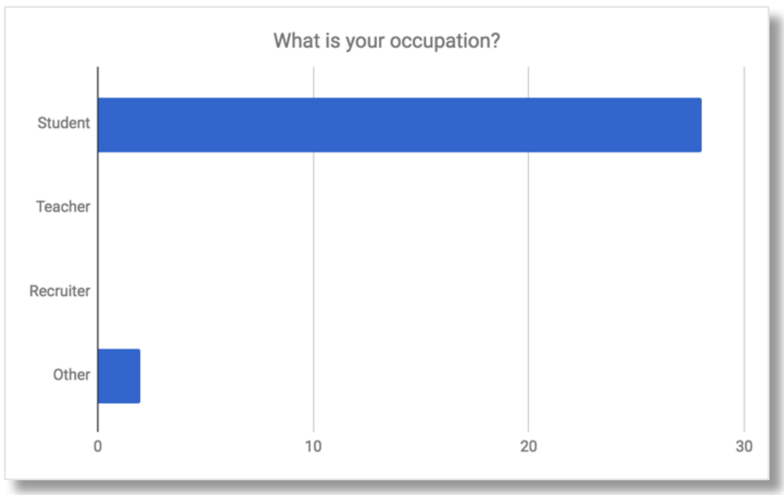
The goal set by our sponsor was extremely challenging, but with these methods we were able to foster easy collaboration between us and the Financial University students to complete our objectives. In the next chapter, we will discuss the results of our project and our goals for its future.

4. Results and Discussion

The result of our project was the development of the Financial University's Wiki for economic models. The website is located on the Financial University's website. After completing our objectives, we created a framework that sets the foundation for a platform that has the potential to become a vital research and analysis tool not only for the Financial University, but for economists and economic students across the globe. Our project utilized our strengths in data analysis and manipulation. This introduces a Financial University-specific way for researchers and students who are specialized in areas other than data science to leverage their expertise with Big Data, and produce a previously labor intensive result very quickly.

Survey Results

The results of our survey (shown below) paralleled our development of the platform.



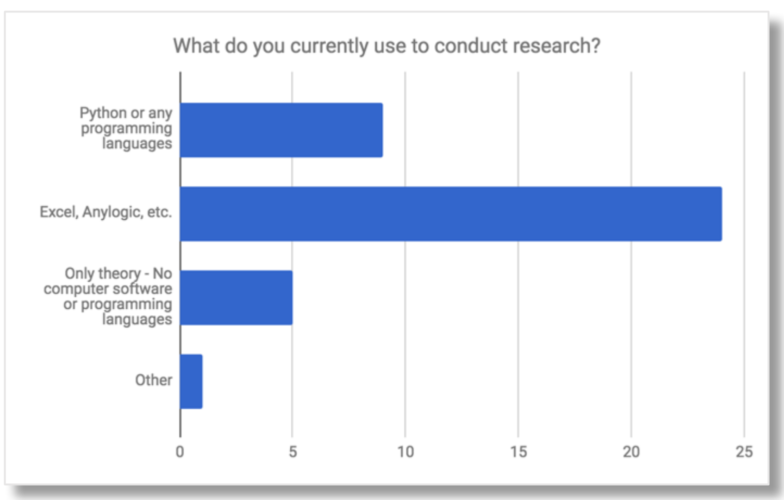


Figure 6: Survey results – gauging the audience

It is important to note that we did not receive any responses from Financial University faculty. Because of this, we can not tell if our platform will be of use as a teaching tool for professors to use in the classroom. We decided that we would move forward under the assumption that our 30 respondents will become our target audience, as we needed to begin developing our platform. That being said, we catered our platform for a more personal (outside of the classroom) educational use. As our implementation is modular, this tool can be further developed to become a teaching tool for professors to use, if needed.

Our respondents were mostly undergraduate students of the Financial University, whose main research is conducted through current software like Microsoft Excel and AnyLogic. However, the majority of these students state that they would like a more interactive educational software. In Figure 7 below, it is clear that a significant portion of the students surveyed would like model descriptions of the models to understand the technical equations and high-level theory behind them.

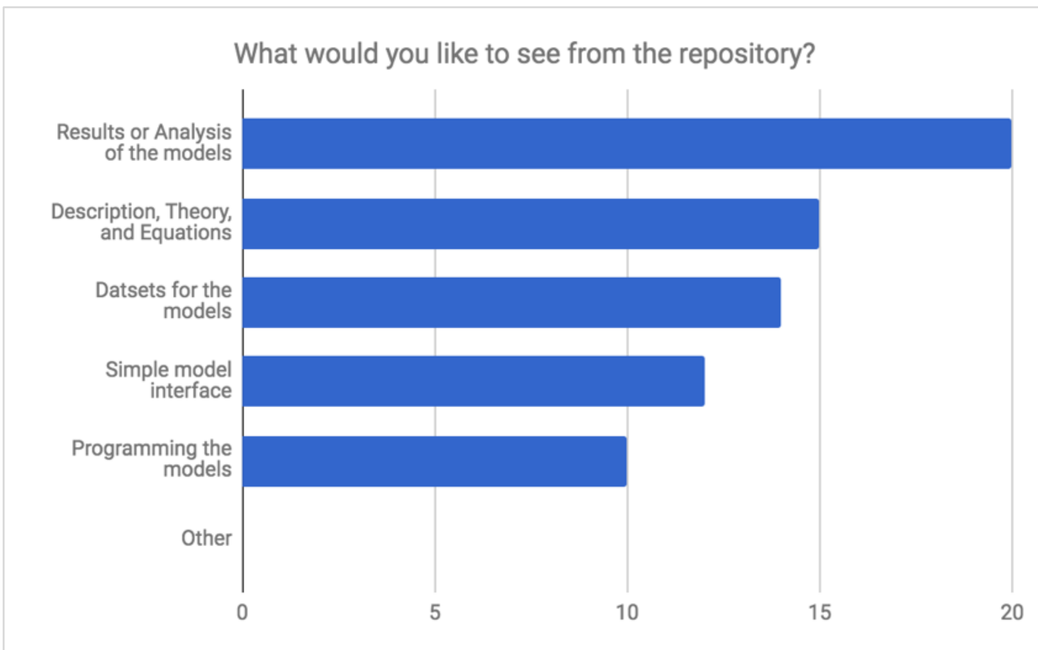


Figure 7: Survey results – deciding what to include in the repository

These results supported the format of the Wiki and gave us a better understanding of our potential audience. By collecting this data, we were able to develop the platform with the desired modules and models for end-users.

Creating the framework

With our survey results in mind, we customized our platform to our target demographic - Financial University undergraduate students. We decided that with our time constraints, creating a simple "Wiki" page of the model descriptions and linking downloadable code of the models (shown below in Figure 8) would be the easiest implementation we could successfully implement.

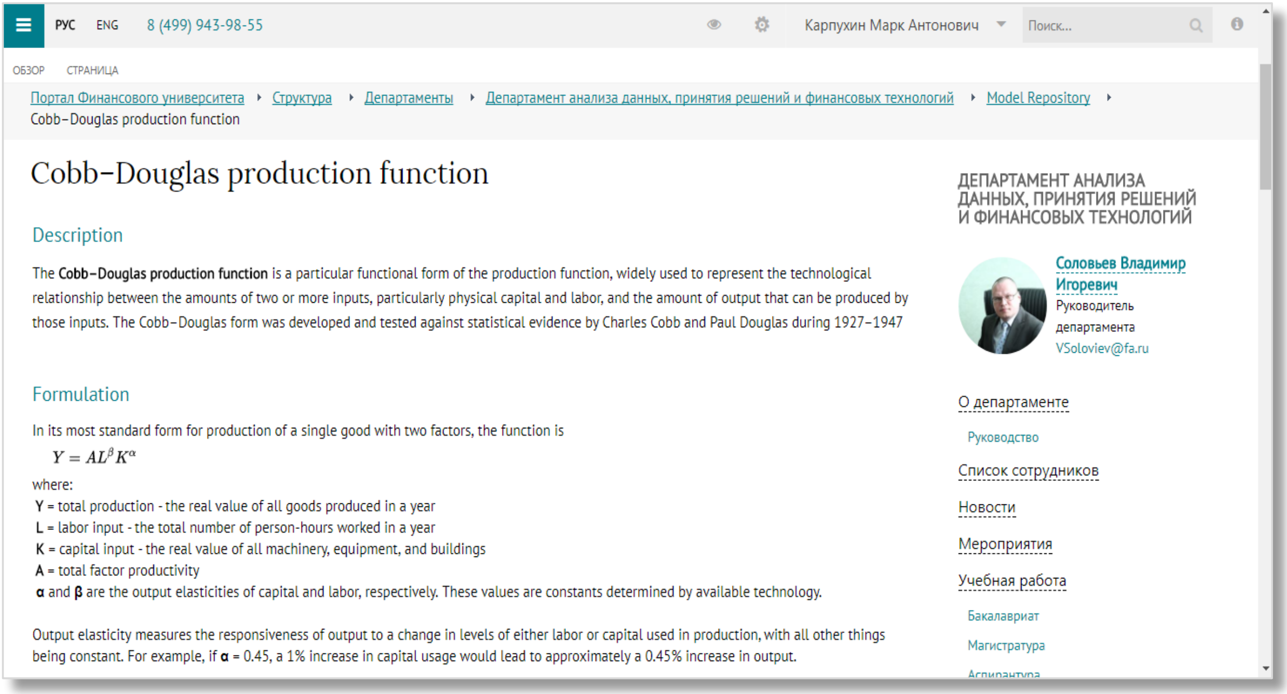


Figure 8: Current implementation of the Wiki

This Wiki page is on the Financial University's website so it is easily accessible to students. The Wiki page includes a thorough description of the model, the formulas needed for manual calculation, and the download links for the files holding the model algorithms. This allows students to gain an understanding of the theory behind the models (through the descriptions), and analyze the logic of the models (through the heavily documented algorithms). Furthermore, as the students can download the algorithms for their own use, they are able to input and view results on their own data.

The modular framework of the Wiki also allows for future development of this project through a web-based interface. Not only does the framework make our code easier to implement in the future, it also provides a template for adding new models. This template will offer the ability to seamlessly integrate more models in consistent form, providing a scalability factor to our project. However, the development of any web application is bound to have limitations.

Study Limitations

The first two weeks of our time at the Financial University was essentially spent discussing with our sponsor, and our Russian teammates, what the end-goal of our project was. The idea of the repository had been set in stone since the beginning of this project, but we had to determine how to shape the final platform and Wiki. We also had to discuss what was feasible to complete in the remaining weeks. Only after we successfully identified these two goals, we could begin our work.

Furthermore, as we are a team of computer science, robotics engineering, and industrial engineering majors, our knowledge of economics and economic models was extremely limited. For all the economic models, we had to spend weeks performing research with our Russian counterparts in order to ensure that our algorithms were accurate, and that each step was heavily documented to ensure the educational value of the repository remained intact.

5. Conclusion and Recommendations

Through the development and implementation of our economic model repository, we believe that both economics students and researchers alike will be able to experience the significant simplification of the data science aspect of economics research. We have found that the included models will aide a wide range of problems that students and researchers face. While there are alternatives to our platform, such as the R programming language and proprietary software suites, they require the user to become proficient in either a programming language or a commercial piece of software, which can be difficult to learn from scratch.

By creating code to manipulate large amounts of specific data to obtain clearly defined results, we have armed economists and students with a powerful tool that can take their research to the next level. The data we collected through our survey helped us devise the optimal way to deliver this platform to the clients that will have access to it. Additionally, the work we have done has been performed with future development of the platform in mind. Future developments will need to include the addition of other models, the development of a practical front-end dashboard, and the ability to input third-party datasets that can interact with the models. By lowering the barrier to entry for students and researchers to use Big Data through comprehensive model descriptions and functions, our goal is to bolster financial literacy and promote economic research and education.

Recommendations

After we researched, programmed, and implemented our repository, we anticipate and encourage the following future developments and improvements for both the end users of our platform as well as for software developers.

For users:

- We recommend reading the documentation (developed by us) provided with the models. While learning the actual code defeats the purpose of our project, having a general idea of what is going on will help with the optimal utilization of the models.

For developers:

- Back-testing on real market data is recommended, as some models were only tested on our own collected data.
- When adding additional models, we recommend to create separate files for each model, and utilize pre-existing data manipulation packages, such as pandas, NumPy, and sklearn, that we incorporated into our models. This will not only make many complicated data management tasks easier, but also allow for models to share robust, proven code, minimizing the need for repetitive code.
- When dealing with large quantities of data, the amount of time it takes to actually run the program can be substantial. Keep the time it takes to calculate the results in mind when incorporating new features or models. If the calculations are done on a centralized server and the results are delivered through a web app or other medium, running calculations for multiple users may bog down performance and make the

platform unusable. This can be rectified by developing back-end, load management code.

- While using the Python console is better than editing the code yourself, a more user-friendly user interface would further broaden the user base of this platform as well as make the utilization of such a platform less intimidating to a new user. This would also minimize the user error by providing limited value inputs.
- If the code is centralized to one server and accessed through a web app, we recommend the user input be sanitized. This will prevent malicious code from being introduced into the model code, preventing intentional or unintentional corruption of the files. In the case of models that use such methods as machine learning, the code needs to learn from multiple iterations what is good, and if the code was reset to its initial state after every iteration, this new learning would be lost.

During the next steps of the project, we recommend that the focus be on integrating the repository into a centralized server that can be accessed through a web app. This is the next large portion of the final platform, and because of this, it needs a significant investment of time and resources to complete. The addition of more models to the Wiki, while not being easy, can be accomplished incrementally now that the platform structure is set up.

To summarize, we recommend the next step in development of this project should be to focus on developing a web app that allows users to not be dependent on having to download any code or dataset, but rather interact with a user interface that allows similar data input and output. This repository was created with the intention of alleviating the extra effort students and researchers must put in when performing economics research and analysis. We hope future development of this repository leads to the Financial University gaining a unique and specific tool to help boost their students work. By doing so, we hope that our platform achieves our overall goal of providing users with a tool to track and analyze the Russian economy to gain a better understanding of it.

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Appendices

Appendix A: Sponsor Information

The Financial University under the Government of the Russian Federation, opened on March 2nd, 1919, is one of the top 15 Russian universities (Expert Russian Ratings Agency, 2016). The Financial University is state-funded and hosts thirty eight subdivisions that all lend themselves towards the success of their students -- mainly in economic fields. The motto of the Financial University is “We value the past. We built the future.” (Financial University). They pride themselves on the advanced learning technologies and state of the art programs that help mold high-performing, expert graduates.

Initially starting with an enrollment of around 2,000 students, the Financial University has grown to more than 20 times that size. Over the span of its 10 campuses and 25 university branches located throughout the country, the school has an enrollment of around 50,000 students as of 2016 (Financial University). Higher education opportunities range from Bachelor Degree programs to PhD programs. Under the 21 scientific schools, students can choose to study within the fields of economics, finance and lending, management, law, political science, applied mathematics, computer science, and more. Additionally, the Financial University also offers a range of research opportunities. The university aims its efforts towards the “development of new projects” and “evolving creative thinking of the teaching staff” to assemble high-level research teams in order to further development of knowledge about the economy, finance, security, and corporate government/business strategy development.

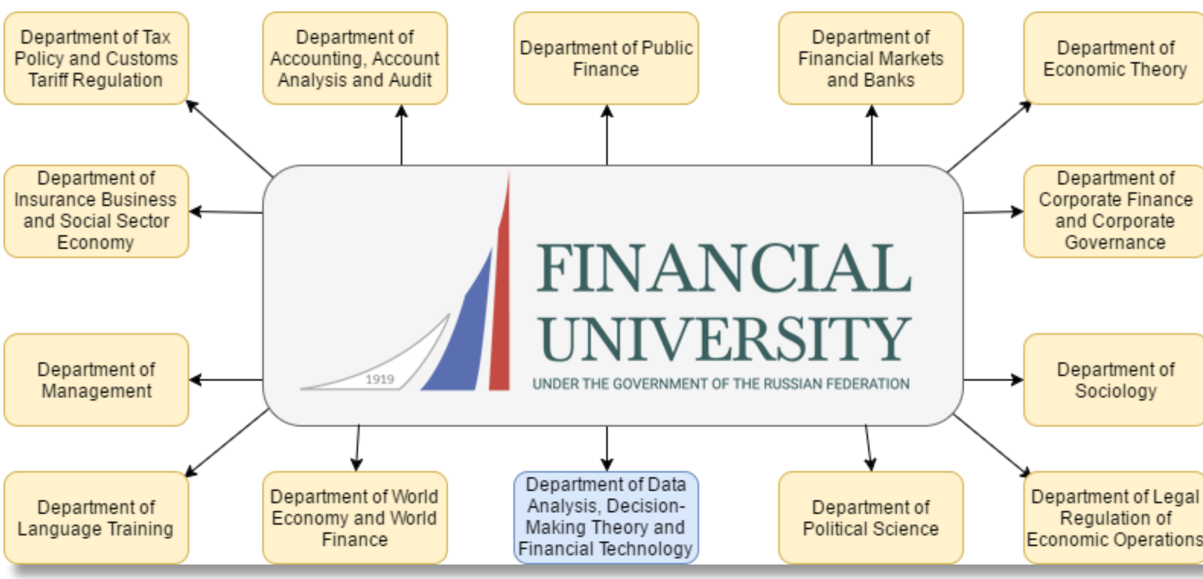

Figure 9: Financial University Department Structure

International collaboration is another skill the Financial University fosters in its students; the faculty at the university teach their students how to initiate and promote dialogue between different countries and cultures by offering a range of exchange programs. By doing so, they hope to shape well-rounded and open-minded individuals, who can then use the communication and cooperation skills gained from working in multicultural environments and apply them to the professional world.

This project specifically has ties to the Department of Data Analysis, Decision Making Theory and Financial Technology, which is one of the 14 main economic departments in the university. This division specifically deals with the decisions in business that use data analytics, forecasting, and other Business Intelligence tools. The branch leader and department heads, Dr. Vladimir Solovyev, Dr. Irina Denezhkina, and Dr. Vadim Feklin, all have experience in business, mathematics, and information technology. The on-site liaison for this IQP, Professor Anton Losev, is an assistant professor within this division.

Appendix B: Interview Protocol

Before the day of the actual interview:

- Email/contact the interviewee if we have permission to use their name, title, and quotes from the interview in our project proposal. Furthermore, we will ask if we have consent to use an audio recorder during the interview to ensure we can quote as accurately as possible.
  - If we do not have clearance to use an audio recorder, one of our team members will be taking notes during the interview. These notes will be sent to the interviewee after the interview so they are fully aware of the points of information gathered, and to allow them to confirm or deny any direct quotes.

At the actual interview:

- Introduce team members and project/project goals.
- Thank the interviewee for taking the time to meet with us.
- Clarify: Can we use this information as a citation in our documentation? We will cite the date and time of this interview, as well as the your name and title. We may also use direct quotes, as we will be using an audio recorder for this interview to ensure we do not misquote anything said to us, or misinterpret any information.
  - If the answer is yes, tell the interviewee that we will contact them before we release any documentation and ask if the content written with regards to their interview is an accurate reflection of their intentions/opinions.
- Ask questions[1]

Data Science/Computer Science Related Interviewee

1. Have you had any projects that have had to implement the creation of an analytics dashboard/visual interface from a repository?
   i. If so, please elaborate on the processes that the project(s) underwent, the challenges that the specific project(s) encountered, and anything else imperative that you might feel is useful to us.
   ii. If you had to choose which steps of the process were the most important, which steps would you choose and why?
2. What time frames do these projects usually take?
   i. If they vary, what trends do you see in regards to the quality of the project versus the time spent on it?
3. What setbacks, if any, have your projects usually encountered, and are there ways to preemptively counter them?
4. What experience have you had with Economics? Do you have any familiarity with economic modeling? If so, please explain what economic modeling you are familiar with.
5. What dashboards have you seen that look the best for Big Data (or specifically economic data)? Please explain their most important features.
6. What would you say are the Pros and Cons of using a web based dashboard versus an executable package pre installed on a PC?
7. Do you know of any resources that you think would help us out? If so, what are they?

[1] Not all questions will be asked. Depending on the expertise/experience of the person and time, questions may be omitted during the interview as the relevance of the interviewee varies and as time becomes a limiting factor.

Economy Modeling related Interviewee

1. How useful would you foresee an accessible repository of economic models?
2. What economic models would you see useful to put into this repository?
3. Would the implementation of such a repository be useful in teaching/research environments? Why?
4. Have you ever worked with a team to create a repository or application like the one we are being asked to develop?
    i. If so, can you elaborate on that process?
5. What are the current alternatives to creating economic projections/forecasts other than using software?
6. What metrics/algorithms/methods have you found helpful for creating accurate economic projections/forecasts?
7. What type of visual aids do you find the easiest to understand when using computer software?
8. As Computer Science majors, we do not have a strong background in economics. Can you direct us to any resources (papers, journals, books, etc.) that may help us develop a basic understanding of economic modeling and forecasting?

Wrap Up Questions (applies to all interviewees)

1. Have you had any language barrier issues in any projects you have participated/supervised in?
    i. If so, what were the tactics used to get around any communication issues?
2. Do you have any advice that you feel would apply to our project?

Technical Questions

1. Reiterate: can we use this information as a citation in our documentation? We will cite the date and time of this interview, as well as the interviewee's name and title.
    i. If the answer is yes, tell the interviewee that we will contact them before we release any documentation and ask if the content written with regards to their interview is an accurate reflection of their intentions/opinions.
2. Would you like to be notified about our progress?
    i. **If allowed by sponsor to share research*: We are developing a website that will document our journey in Moscow with and without relation to this project. If you wish to be notified, we can add your email to the list when there is updates to the website.
    ii. **If not allowed by sponsor to share research*: We can share our finished project proposal at the conclusion of the term. Afterwards, our sponsor wishes to keep our research private.

- ➢ Thank the interviewee again for taking the time to meet with us, and exchange contact information so we can continue correspondence if necessary and send them the interview notes if needed.

Appendix C: Dashboard Questionnaire

- **General Questions:**
  - Age
  - Field/background
  - Are you an interactive/hands-on learner? Or do you prefer to learn through textbooks or papers?
  - Would you be interested in a platform that allows you to interact and experiment with pre-coded economic models?
  - Would you be interested in a platform in which problems are posted, and users are able to submit their own solutions using the economic models? This platform will allow employers and professors to see student's work capabilities, and would potentially lead to scholarship grants and even job offers.
- **Technical Questions:**
  - Are you comfortable using the command line to interact with code?
  - Would you prefer a colorful and complete dashboard with visualizations? Or a simple input/output of calculations?

Appendix D: Model Descriptions

World Trade Model

The World Trade Model evaluates indicators for countries over a specified time period, and outputs a file that gives detailed analysis on each possible country possible. The world trade model takes in two datasets as an input. The data that is analyzed was gathered from two main sources, UN Comtrade and World Bank Open Data.

The algorithm itself uses the data mentioned above, and then computes indicators for each country included in the data. Keep in mind that the two datasets have a different amount of countries, so we only use common countries between them. Each country has the following indicators: All of the indicators are compiled into a csv file.

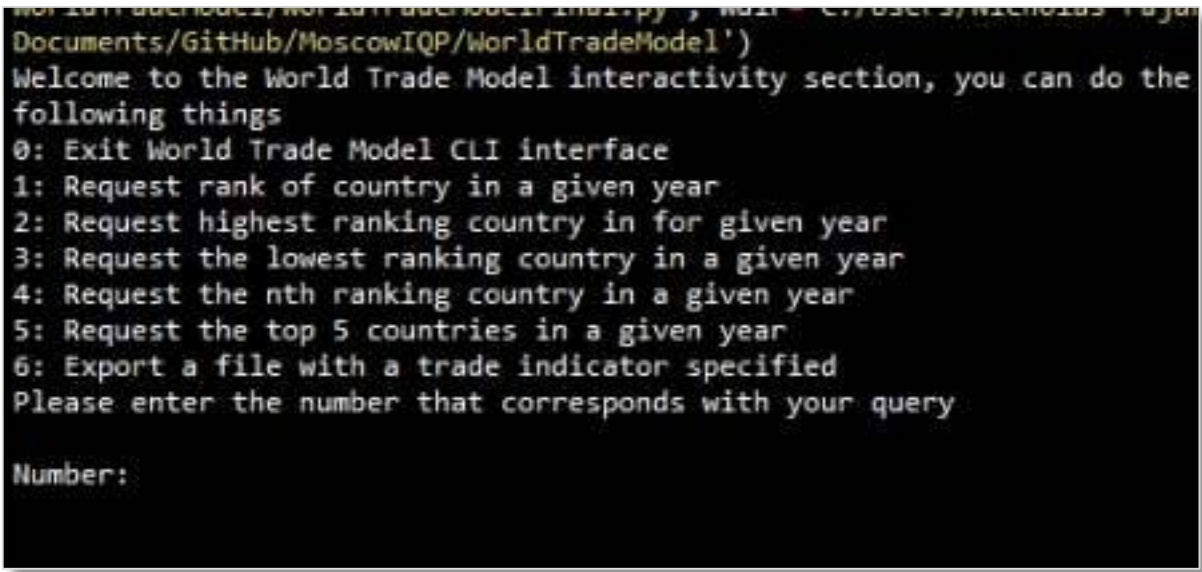

Figure 10: CLI Interface for World Trade Model

The CLI (command line interface) takes in a desired number, and then calls certain functions depending on the query. These functions use a Data Frame constructed from the data, and then calculates the ranks to return to the user.

```python
def calculateRank(country, year):
    temporaryIndexDF = indexDF.sort_values(str(year), ascending=False, na_position='last')
    rank = 0
    for row in range(len(temporaryIndexDF)):
        rank = row
        if temporaryIndexDF.iloc[row, 0] == country:
            break
    return rank

def getHighestRankingCountry(year):
    temporaryIndexDF = indexDF.sort_values(str(year), ascending=False, na_position='last')
    return temporaryIndexDF.iloc[0, 0]

def getLowestRankingCountry(year):
    temporaryIndexDF = indexDF.sort_values(str(year), ascending=True, na_position='last')
    return temporaryIndexDF.iloc[0, 0]

def getSpecificRankedCountry(rank, year):
    temporaryIndexDF = indexDF.sort_values(str(year), ascending=False, na_position='last')
    return temporaryIndexDF.iloc[(rank-1), 0]

def getTopFiveCountries(year):
    temporaryIndexDF = indexDF.sort_values(str(year), ascending=False, na_position='last')
    countryList = {}
    for row in range(len(temporaryIndexDF)):
        if row > 4:
            break
        countryList[row] = temporaryIndexDF.iloc[row, 0]
    return countryList
```

Figure 11: Called functions corresponding to possible queries

These functions will return the desired results, and the CLI will display the correct data, and then remain on standby to receive further queries.

```
Documents/GitHub/MoscowIQP/WorldTradeModel')
Welcome to the World Trade Model interactivity section, you can do the
following things
0: Exit World Trade Model CLI interface
1: Request rank of country in a given year
2: Request highest ranking country in for given year
3: Request the lowest ranking country in a given year
4: Request the nth ranking country in a given year
5: Request the top 5 countries in a given year
6: Export a file with a trade indicator specified
Please enter the number that corresponds with your query

Number: 5

Year: 2003
China
EU-28
USA
Germany
Japan
```

Figure 12: Query for top 5 countries in 2003, according to Trade Index

Once a user is done with the CLI, they can enter 0 to terminate the code, and a local copy of the index calculations will be saved in the same directory as the python code. This file is called indexData (ordered), and has the countries listed top down according to their rank through the years overall.

Table 4: Snippet of Output CSV for World Trade Model

Country	2000	2001	2002	2003
China	0.03506	0.038745	0.044938	0.051997
EU-28	0.109885	0.115268	0.118873	0.119441
USA	0.109784	0.106438	0.095677	0.085858
Germany	0.077324	0.083203	0.085019	0.088815
Japan	0.067429	0.058729	0.057516	0.056005
Rep. of Korea	0.024236	0.021904	0.022423	0.022997

Cobb-Douglas Production Function Model

The Cobb–Douglas model is a production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs. This model was chosen because it is the most versatile model to represent what a company would need to do in order to significantly affect their profits, marketing strategies for certain products, or other services they seek to analyze The input data of the model can be seen in Table 5 below.

Table 5: The input data for the Cobb-Douglas Production Function Model

GDP (Russian Federation) (in 2008 prices, bil. rub.)											
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
24799,9	**26062,5**	**27312,3**	**29304,9**	**31407,8**	**33410,5**	**36134,6**	**39218,7**	**41276,8**	**38048,6**	**39762,2**	**41457,8**

Employed persons (Russian Federation) (thous. ppl.)											
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
65070,4	**65122,9**	**66658,9**	**66339,4**	**67318,6**	**68339,0**	**69168,7**	**70770,3**	**71003,1**	**69410,5**	**69933,7**	**70856,6**

Investments in fixed assets (Russian Federation) (bil. rub.)											
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1165,2	**1504,7**	**1762,4**	**2186,3**	**2865,0**	**3611,1**	**4730,0**	**6716,2**	**8781,6**	**7976,0**	**9152,0**	**11035,6**

With this data, you can calculate the regression model (Figure 13 below).

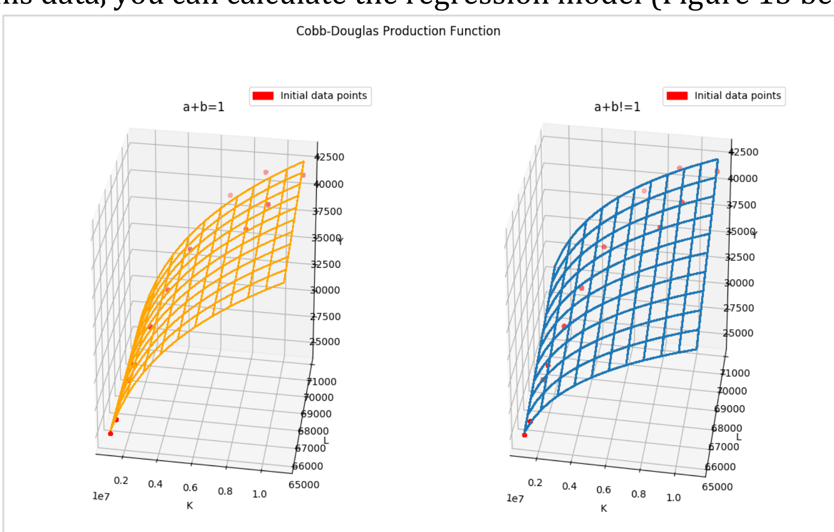

Figure 13: Regression results on a 3D surface

Portfolio Model

The portfolio model takes a dataset of portfolios as an input and generates the optimal weights for each asset that produce the most profitable portfolio (based on historical return over risk).

Table 6: Input Dataset of Assets' Return Values

ASSET	RETURN VALUE					
Gazprom	0.0114	-0.0037	-0.0335	0.0164	-0.0168	…
Aeroflot	-0.0311	-0.0073	-0.0368	0.0229	0.0329	…
Sberbank	0.0090	-0.0206	-0.0601	0.0075	-0.0023	…
Nornickel	0.0183	-0.0105	-0.0434	-0.0055	0.0071	…
Mechel	0.0024	-0.0007	-0.0421	0.0022	0.0017	…

This model first takes in a .csv file (example above in Table 6) consisting of return values of five different assets base on different observation times. The user is then prompted to choose between two calculation methods – Markowitz Optimization and Tangency Portfolio Optimization. The calculations for these two optimization methods can be seen in Figure 14 below.

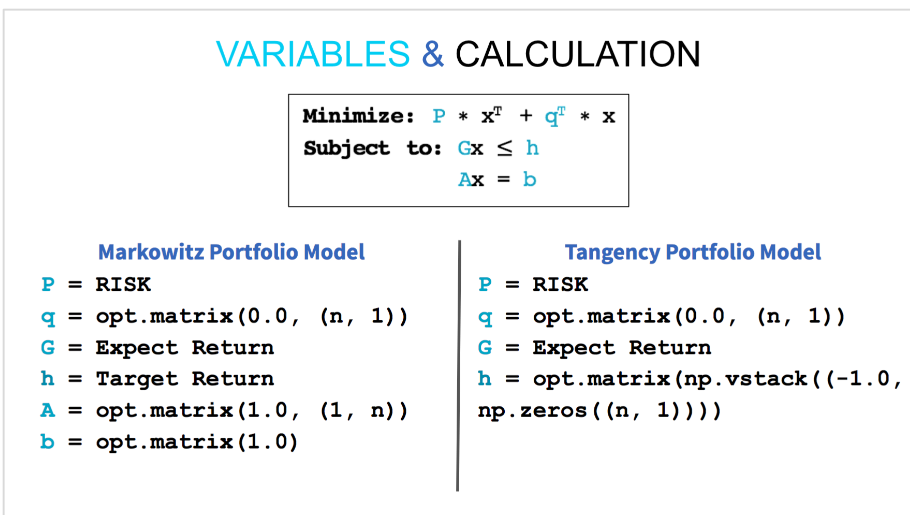

Figure 14: Formulas for optimization calculations

The model then assigns each asset a random weight and calculates the mean and risk (which is determined by the standard deviation. For all normal randomized portfolio, they have similar mean and standard deviation distribution, as a result they have the same efficient frontier (a line of highest return for each risk). In Figure 15, the yellow line shows the efficient frontier of large random portfolios; because the example dataset only consists of five assets and ten observations for each asset, the scatter plot only have a small part overlapping the efficient frontier.

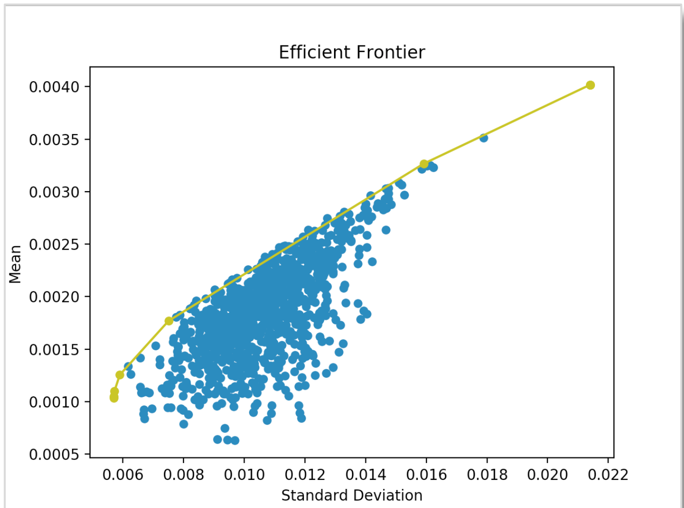

Figure 15: Efficient frontier of randomly generated portfolios

The final result of the model is to get the most optimal weight that can generate the most return and least risk. These optimized portfolios are represented by the yellow points on the scatter plot. The optimization tool this model uses is Convex Optimization (CvxOpt). This can be seen below in Figure 16.

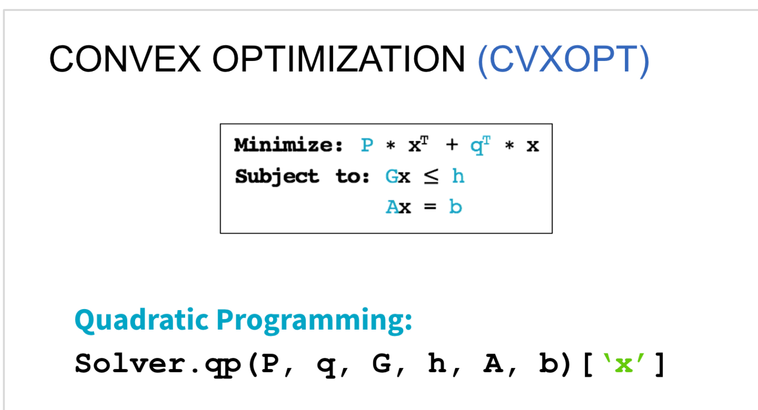

Figure 16: Format for CvxOpt Python function

Finally, this function is called in the main function (Figure 17) to produce the optimal weights (Figure 18).

THE MAIN FUNCTION

```python
def Markowitz_portfolio(returns):
    ...
    weight = solvers.qp(P, q, G, h, A, b)['x']
    ...
    return weight
```

```python
def Tangency_portfolio(returns):
    ...
    weight = solvers.qp(P, q, G, h)['x']
    ...
    return weight
```

Figure 17: Main function of Portfolio Optimization

Markowitz Portfolio Model

```
Gazprom:   0.070264
Aeroflot:  0.357837
Sberbank:  0.162885
Nornickel: 0.266887
Mechel:    0.142125
```

Tangency Portfolio Model

```
Gazprom:   0.000000
Aeroflot:  0.586451
Sberbank:  0.242607
Nornickel: 0.000000
Mechel:    0.170940
```

Figure 18: Final output of optimized weights

Scoring Model

The scoring model in general needs data that can give the most details on a customer. This can include details like age, credit score, current loans, and assets. This data will be used in an algorithm that will decide if the customer is valid for a requested loan through a machine learning process. This machine learning process will use training data to tune the machine correctly. This will in turn make a algorithm that can decide the loan approval status based off of historical data, and current data.

The specific machine learning process we will be using is called Random Forest. This algorithm uses multiple decision trees in order to come up with a verdict for a decision.

After the model is trained from test data, it returns the variables from the data and how much of an impact they have on determining whether or not a potential customer would pay back their loan. This is called variable importance, and the results from the initial training data set can be seen in Figure 19.

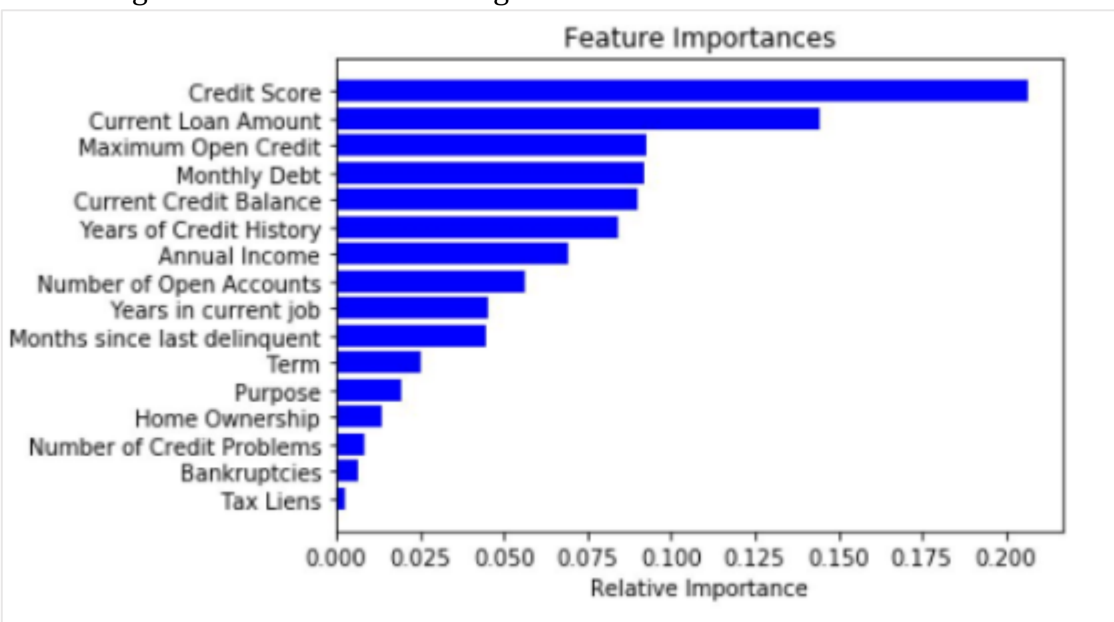

Figure 19: Graph of variable importance

This model, through the use of a user interface, can take in data of a potential loan customer and determine with around 77.7% accuracy whether or not they will pay off their loan. This model is designed to help banks make more educated decisions on who they should give a loan to.