Analytical Approaches to Macroeconomic Forecasting: A Study of Profits through Machine Learning and Deep Learning

A Major Qualifying Project submitted to the faculty of

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Bachelor of Science in Economic Science

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Abstract

With a basis on the analytical framework of Levy and Kalecki's Corporate Profits Equations, this research uses Machine Learning and Deep Learning approaches to provide a reliable forecast for aggregate corporate profits in the United States economy. The principal tool used to deliver this forecasting method was the RapidMiner Software. The data source for the variables in the regression equation was the Federal Reserve Bank of St. Louis. The independent variable was aggregate profits for the following quarter and the dependent variables were Investment, Dividend, Household Saving, Net Government Saving, ROW Saving and the Statistical Discrepancy. Making use of these predictions and relying on economic theory, this paper explores the repercussions of assumptions made since the early beginnings of Marxism, through the Cambridge Controversies, until today, regarding the relationships between the working class and the elite.

Acknowledgments

We would like to thank Professor Michael Radzicki of the Worcester Polytechnic Institute Department of Economics for serving as an advisor and mentor to the development of this project.

We would also like to thank the FED for facilitating data on the U.S. Economy to all general public through their website, thank you for helping us do research.

Without the support and expertise of these people, the success of the project would not have been possible.

Dedication

Jahshanti Allen:

Hollis, Queens, NY This is for you.

Kristy Giacoman:

To my parents, Karime Favela and Omar Giacoman for their dedicated partnership for success in my life;

To my sister, Karol Giacoman for being a source of inspiration and motivation to my drive;

To the proud citizens of my country located in the United States, that came looking for better opportunities;

This research is dedicated to you.

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1.0 Introduction

The goal of every business is to make profits, and desirably, to increase those profits year to year. In order to run a successful business, the owner or owners may find it rather useful to know the profits that the company expects to make in a particular period somewhere in the future. If one was to make predictions regarding the profits of their own business, one would have to define assumptions, study the market, project costs, and ultimately hope for the best, all while keeping a considerable margin to maintain the forecast conservative enough to stay accurate in different scenarios. These predictions are commonly done in every industry, through revenue and expense forecasting, conducted by the CFOs of the bigger companies and by the accountants of the smaller ones.

Venturing through the task of defining the scope of this project, the team fumbled through several avenues. Recognizing the ability that machine-learning technology has to make predictions of variables that impact the economy, on initial thought, the team considered predicting GDP. After studying the GDP NOW model and the Fair GDP Model, Gross Domestic Product forecasting seemed interesting, and predicting its value monthly and/or quarterly was the initial plan. However, since it had already been done before and had widely accepted methods for its prediction, the team decided on another alternative..

Despite the monthly efforts of businesses to predict their earnings, and the widely known efforts of scholars to develop complex multi-sector models to predict GDP or GNP, little effort has been made to make predictions of profits in the aggregate economy. Especially since the first attempt, which dates back decades, when Finkel et. al (1971) used a multiple linear regression

technique to develop and test a model to explain and predict the profit margin at the macro level. They chose to use their own set of variables to make the predictions including utilization of capacity, unit labor costs, a GNP deflator and a trade surplus. For the regression equation of this research, the variables used are those advised by Jerome Levy and Michal Kalecki in their profit equation. Rationale is discussed later in this paper.

Now, why is it even remotely relevant to predict corporate profits on the aggregate? On initial thought, one may be able to draw relationships between economic collapses, debt, and employment in the United States and aggregate profits. Likewise, profits can also point us in the direction of the worker-capitalist relationship in this nation. Finkel et. al (1971) highlights that the importance of making accurate forecasts of aggregate corporate profits should be obvious. Even more so since future aggregate corporate profits are critically important to financial analysts who make market judgements. At the same time, they are also significant as a measure of growth of the economy. This is because in combination with the retention rate, they determine aggregate business savings and hence the potential capital formation ability of the economy (Finkel et. al.,1971).

Most economic modeling and learning is formed on the basis of economic theory. To diverge from this method, the research done for this paper relies on data prediction based on Machine Learning. Firms want predictions so that they can anticipate when to slow down production, employment, and when to do the opposite. This project produces aggregate profit predictions in the United States economy and shows how it affects macroeconomic issues in the country, its firms, and its citizens.

There is and always will be a duel between workers and capitalists in this nation and by using the profit equation by Kalecki and Levy, and our findings from great economic debates such as “The Cambridge Controversies”, we can make sense of the capitalist-worker relationship and predict what it will look like in the future. Data Science and Artificial Intelligence give us predictions without the need for a theoretical backbone, with “raw” science and math. This research provides those predictions, and only then analyzes their social impact based on economic theory.

2.0 Background

2.1 Capitalists and Laborers

It is important to take a step back, and start by the big picture overview. For this it is imperative to start by defining who are the capitalists and the laborers and what are their roles in the economy. Capitalists are the owners of capital, they own the means of production. The means of production can be anything that is used to transform raw materials into goods or services. This could be a building, a factory, machinery, transportation vehicles, money, stocks and so on. Laborers presumably do not own capital, they are the ones hired by the capitalists to use the means of production that the capitalists own and produce goods and services with them. In simple terms, the capitalists own the machines and organize production while the laborers physically produce the goods and provide the services to the customers.

Capital and labor, amongst other things such as technology and raw materials, are inputs to the production process, where the outputs are goods and services. These goods and services are then sold into the market and capitalists and laborers are retributed from these sales. Capitalists are retributed with profits for facilitating the means of production. These profits are commonly seen as the interest charged for the utilization of the capital. Laborers are retributed in wages for physically producing the goods or providing the services through their work. These profits and wages conform to the economic pie. The analogy of a pie refers to the total amount of money that comes from selling the goods and providing the services to the market. The pie is the

revenue being divided between capitalists and laborers according to how much of it each should get depending on their contributions to making the pie in the first place.

2.2 Economic Schools of Thought

Karl Marx is the father of Marxist Communism. His goal was to fix capitalism.His perspective on capitalism was that it was an "outmoded economic system that exploited workers" (Independence Hall Association, n.d.). He also believed that the poor would eventually rise against the rich, once they finally grew tired of the constant oppression. The fundamental communist principle was to stop private ownership. Private ownership encouraged greed and motivated people to knock out the competition, Marx believed. By ending greed and having the government provide stability Marx hoped to see disparity lessen (Independence Hall Association, n.d.).

Capitalism, on the other hand, promotes the private sector and economic freedom (Independence Hall Association, n.d.). Capitalists make decisions about products, pricing, and wages. Marxists believe these to be ingredients for exploitation and greed to grow. However, Capitalism is supposed to be put in balance by Adam Smith's "invisible hand". This ideology suggests that "Supply and Demand" always find the best price in a market (Independence Hall Association, n.d.). The ideology also supports that firms that cannot compete naturally disappear and new firms are naturally born, as we see with competition and species within the Universe. The Invisible Hand can then be compared to a process of natural selection but for the market. To a Marxist, a firm making profit is awful, since they assume the capitalists are exploiting the

workers and promoting greed. To a capitalist, profit is a sign of success in a competitive market place where being an owner is the ultimate risk.

2.3 Cambridge Capital Controversies

Now that the two key players have been defined, we transition into the story where they are the main characters. In every classic story, there is a protagonist and an antagonist; the good guys and the bad guys. However, for this story, the plot really revolves around if there is an antagonist at all. As mentioned before, there is a set amount of revenue that is distributed between the capitalists and workers. The plot of this story revolves around if the way in which the pie is distributed is fair. The question lies on if the capitalists really deserve to keep the profits and if the wages that the laborers receive for their work are a fair enough compensation.

The setting of this story starts in the 20th century. A debate between Cambridge, United States versus Cambridge, England. More specifically, it was a debate between the Massachusetts Institute of Technology (MIT), located in the United States, and Cambridge University, located in England. A debate about if capitalists and laborers are compensated fairly according to the value of their marginal product. MIT argued that the way the economic pie was divided was fair for both parties involved, since capitalists were contributing their capital to the production of the goods. They argued that without their capital, laborers would not be able to produce goods or provide services just by themselves. On the other hand, Cambridge University believed the capitalist economy was exploiting laborers and not compensating them fairly for their work. According to them, the laborers' work produces value, while the machines (capital) by themselves, do not.

The core of this debate touched on the fundamental premises of the theories of value, distribution, and growth, each of which is dependent on an aggregate production function (International Encyclopedia of the Social Sciences, 2019). The inputs of this function are the factors of production of the capitalists and the laborers and the outputs are the rate of profit (or interest) and the wage rate. The ratio of compensation is based on marginal inputs from the capitalists and laborers. Therefore, input of more capital and labor would provide for profit and more money for wages. This brought more attention to the possibility of labor exploitation as it became unclear if investment is what truly made revenue or if it was the work of the laborers that do not see that reflection in their wages.

2.4 Harrod-Domar Model

Before going into the back and forth of these very renowned academics, it is important to provide some background on the Harrod-Domar model. This model is the genesis of modern growth theory. The Harrod-Domar model is a model of the trend and the cycle and it provided a whole new perspective regarding economic growth, however, it had its problems.

Harrod assumed his model under fixed proportions where there was no way of substituting capital for labor without shocking the model. The model, though theoretically sound, was mathematically unstable. This was because if any of the key parameters were to diverge from the center, this would lead to growing unemployment or prolonged inflation (Solow, 1956). Solow (1956) referred to the Harrod-Domar model as unstable by saying that in the long run, the economic system was “at best balanced on a knife-edge equilibrium growth”.

2.5 Economists on Capital

After setting up the big picture, it is important to bring up some names of the characters that fueled this debate about the value of capital. As mentioned before, there were two sides, those supporting the perspectives of MIT and those supporting the ideologies of Cambridge University surrounding this issue. Refer below to an overview of the characters that will be discussed throughout this paper.

MIT	Cambridge University
Robert M. Solow	Jerome Levy
Paul A. Samuelson	Michal Kalecki
Franco Modigliani	Nicholas Kaldor
	Luigi Pasinetti
	Piero Sraffa
	Anwar Shaikh

Figure 1. Economists Involved in the Cambridge Controversies

2.5.1 Robert M. Solow

In the United States we see a strong influence of the Cobb-Douglas production function in modern days at the university level. This all began in the 1920s when the economist Paul Douglas was interested in aggregate level input and output (Border, n.d.). This was after 1909-1918, a decade where the National Bureau of Economic Research (NBER) determined labor output to be 74% to wage paid (Border, n.d.). Douglas partnered with Mathematician Charles Cobb to create a production function to make sense of the NBER's release. The

Cobb-Douglas production function is the most widely used, though in theory, what is important is that the production function follows the Inada conditions.

Japanese academic Kenichi Inada (1963), provided specific properties of the production function that have been crucial in the study of economic growth. These mathematical restrictions were fundamental to neoclassical and endogenous growth theory and led to the analysis of different approaches of production theory (Fare et al., 2002). In short, they talk about two properties of capital and labor, being essential and limitational.

Solow wanted to create a stable version of Harrod's model. He wanted a model where market forces provided corrective action and stabilized the system when shocked. Under this premise, Robert M. Solow created the neoclassical growth model for long term growth which accepted all the assumptions of the Harrod-Domar model except that of fixed proportions (Solow, 1956). The model assumed that if let's say, the price of labor started to go up because demand was tight, the capitalists would be able to substitute machines for laborers. In other words, when minimum wages raised, capitalists would stop hiring people (maybe fire some) and get machines instead. Solow used the Cobb-Douglas production function because it is a production function that allows for the continuous substitution between the mix of capital and labor as markets move. This means that one can get the same amount of output through different mixes of capital and labor. This is called an isoquant and it is illustrated below.

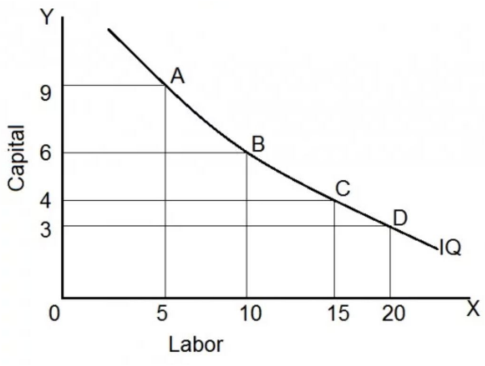

Figure 2. Illustration of an Isoquant

$$Y = A K^{1/4} L^{3/4}$$

Now that the purpose of Solow's model has been explained, we would like to provide the derivation of the Cobb-Douglas Production Function. Above is the original equation, which has two variables to simplify and be able to model in three dimensions. This equation was derived from first assuming that the formula Y = F(K, L) governs the relationship between output Y , capital K, and labor L (Border, n.d.). The function is assumed to be continuously differentiable. They then defined the following variables:

p = output price level, w = wage rate, r = capital rent rate

They then let K∗ (r, w, p) and L ∗ (r, w, p) maximize profit,

pF(K, L) − rK − wL

The interior maximum first order are

$$pF_K(K^*, L^*) = r \quad (1)$$

$$pF_L(K^*, L^*) = w \quad (2)$$

(1) represents the partial derivative with respect to K while (2) is with respect to L. They then used their understanding from the NBER's 74% of output paid to labor to be a constant α (Border, n.d.). This leaves us with

$$(1-\alpha)pF(K^*, L^*) = rK^* \quad (3)$$

$$\alpha pF(K^*, L^*) = wL^* \quad (4)$$

We divide (1) by (3) and divide (2) by (4) and take the integral of both. This leaves us with the results below.

$$\ln F(K, L) = \alpha \ln L + h(K) + c',$$

$$\ln F(K, L) = (1-\alpha) \ln K + g(L) + c,$$

When we combine the two we get the results below.

$$\ln F(K, L) = (1-\alpha) \ln K + \alpha \ln L + C$$

This leaves us with the Cobb-Douglas Production Function (Border, n.d.).

$$F(K, L) = AK^{1-\alpha}L^{\alpha}.$$

2.5.2 Jerome Levy and Michal Kalecki

The profit equation used for this research was derived by Jerome Levy and Michal Kalecki, independently, and generations apart (The Jerome Levy Forecasting Center, n.d.). The first one was Jerome Levy who based his early years trying to solve the problem of unemployment and studying the sources of profits. By deriving the profits equation, Levy was unknowingly creating an entire accounting system for the national economy years before the development of national income and GDP (The Jerome Levy Forecasting Center, n.d.). After Jerome Levy, his son Leon and grandson David, were also prominent economists that continued his studies on profits.

Michal Kalecki was a Polish, self-taught economist who started his career by writing about his version of the theory of effective demand (Lopez et al., 2010). Because he was eastern european, he learned Marxian Economics and, naturally, gravitated towards the split between capital and labor. His mathematical models preceded Keynes and Kalecki and they are at the same level attributed to have started "a new phase in the history of economic ideas and policymaking" (Lopez et al., 2010). Kalecki influenced Cambridge University to think about the shares of the economic pie, which are wages and profit. Through his papers and lectures, he sparked the interests of the economists at Cambridge University to look deeper into how fair were the laborers being compensated for their work by the capitalists.

Profits are usually defined as the gain of selling minus the cost of buying, producing or operating something. However, when we talk about the aggregate profits, we define them through the Levy-Kalecki equation. The implications of this equation can provide guidance in

identifying risks to the macroeconomy and capital markets. The variables for the Levy-Kalecki equation are Net Investment, Household Saving, Rest of the World (ROW) Saving, Government Saving, Dividends, and Statistical Discrepancy. In order to explain the Levy-Kalecki equation, one must understand that hoarding means to accumulate already existing wealth and investing means to create new wealth that didn't previously exist. This paper used a prior study done in 2013 that broke down the equation as you will see below (Philosophical Economics, 2013).

Investment = Saving of the whole economy

Now, the economy is commonly divided into sectors: Households, Corporations, Government, and the Rest of the World (ROW). This makes the equation be:

Investment = Household Saving + Corporate Saving + Government Saving + ROW Saving

At the same time, Corporate Saving can be furtherly explained

Corporate Saving = Corporate Profit - Dividends

By substituting and rearranging the equations, we get the Levy-Kalecki equation for aggregate profits:

Aggregate Profits = Net Investment - Household Saving - Foreign Saving - Government Saving + Dividends

This equation tells us where profits originate, and it is true by definition, however, there are several papers such as "The Corporate Profit Equation Derived, Explained, Tested: 1929-2013" that provide an empirical confirmation (Philosophical Economics, 2013). This

equation also states that if dividends are held constant, then any increase in saving that in the non-corporate sectors that is not offset by an increase in investment will require the corporate sector to save less. An increase in the private sector's wealth equals and increase in the public sector's debt. Lastly, economic growth and financial assets are linked to a growth in private sector borrowing and private sector debt. Profits can indicate the financial well-being of the nation and can even indicate social impacts on its citizens.

2.5.3 Nicholas Kaldor, Pierro Sraffa and Luigi L. Pasinetti

Nicholas Kaldor was hungarian, however, the entirety of his professional career had England as its setting. He started his studies in London School of Economics and became a professor there before moving to Cambridge University (Thirlwall, 2019). Luigi Pasinetti was italian and he completed his undergraduate degree in Università Cattolica Milano and a PhD in King's College, at Cambridge University, besides also attending Harvard University and Oxford University later in his career (Institute for New Economic Thinking, n.d.). Kaldor and Sraffa were Pasinetti's mentors and they all became three of the foremost post-Keynesian economists by defending growth and distribution theory in strong opposition to neoclassical theory (Thirlwall, 2019). Pasinetti's Lectures on the Theory of Production (1977) was to further expand on the concepts introduced by Sraffa and Leontieff and to show that "the theory of production can be reconstructed within the boundaries of a non-marginalist approach" (Meacci, 1998).

Samuelson said about Sraffa that he was a great economist and that he remembered Sraffa with "warm admiration", saying that "he wrote too little, which is our loss" (Kurz, 2000). Little is known about italian economist Pierro Sraffa, this being mainly attributed to his

socioeconomic standing; implying he did not have the financial need to publish papers because he was very well off. Sraffa had two main accomplishments in the field of economics. He was the biographer of David Ricardo, and author of the book, The Production of Commodities by Means of Commodities. Sraffa dedicated also his career to show in a different way that Profit is not a function of the marginal product of capital and that the productivity of capital doesn't determine profits.

The marginal products of the equation indicate that the more work a laborer puts in, the more that worker will see in wages. It also shows that capitalists benefit from the capital that they put in. Through this function, it is easy to suggest Capitalism as a just and fair system. However, Cambridge University in England challenged the Cobb-Douglas equation. Their critique pointed out that the function is not dynamic. Luigi Pasinetti and Nicholas Kaldor are the authors of the dynamic approach. And, as shown below in a System Dynamics major feedback loop, the Vensim software allows you to alter inputs to get a dynamic look of output and better visualize what happens, based on feedback loops.

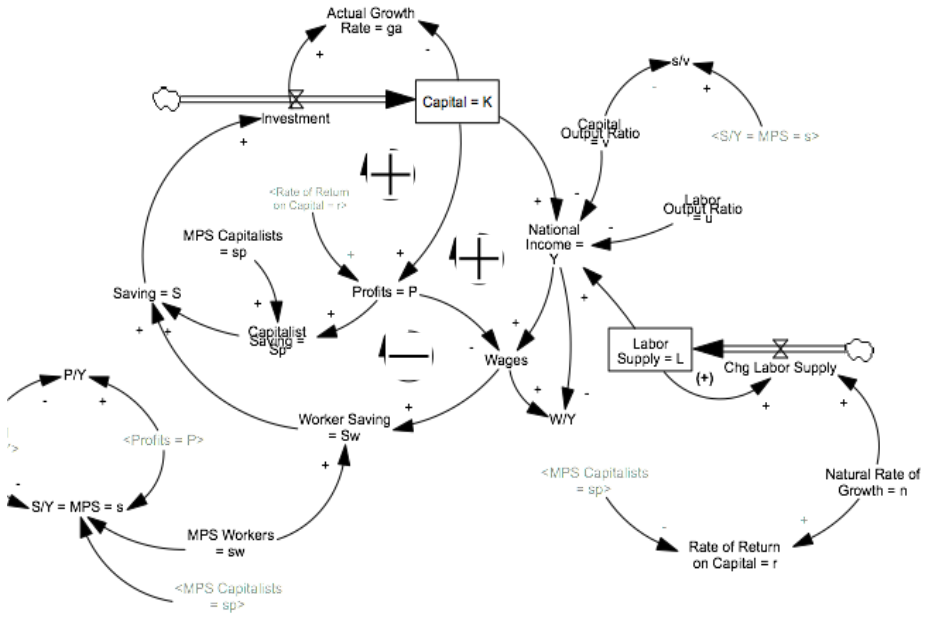

Figure 3. System Dynamics Representation of Profits Equation

Kaldor believed profit would be independent of that of workers' savings in the long run. The model shows the same ideology in that it divides society into capitalists and workers. When income per individual and population grow, we see savings grow for workers. He links profits with capitalists and wages with workers. He also assumes that all profits are saved unless they are spent to earn more (invested), and all wages are consumed. Pasinetti then used the same framework with a few modifications to strengthen the model. He added and acknowledged a golden age, and showed that workers spend what they earn and that capitalists earn what they spend.

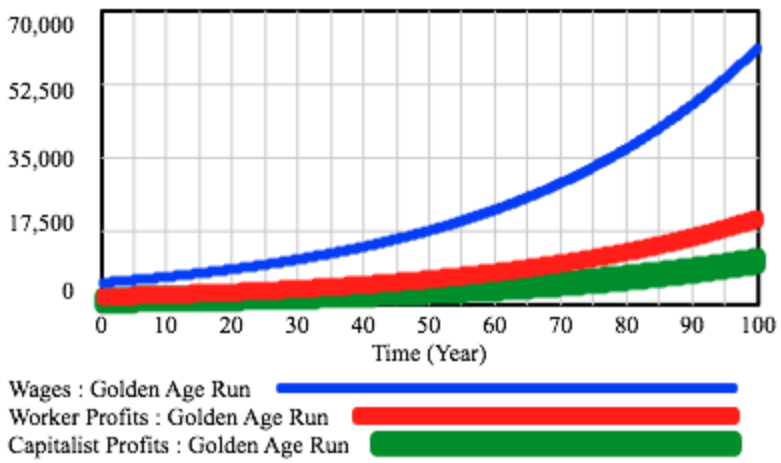

Figure 4. Pasinetti Model - Golden Age, Wages, and Profits

The Golden Age implies greater profits for all. We see wages increase, and profits for both workers and capitalists. It makes sense that workers profits increased faster than capitalists profits. In this era, there was more output, meaning more production and more workers. This allowed capitalists to profit more, but this enabled them to have more mouths to feed. Higher wages often mean people want to have more kids. A greater population to employ is more expensive for the capitalists.

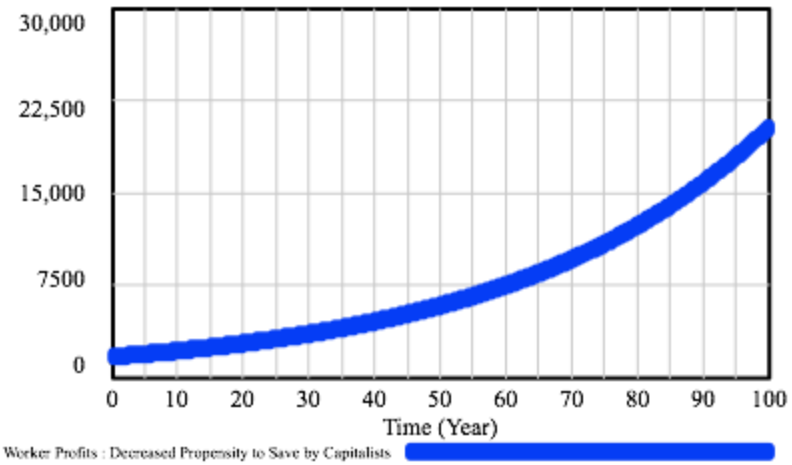

Figure 5. Pasinetti Model - Capitalists Get What They Spend.

As mentioned before, the more capitalists spend, the more they can gain in profit. However, workers cannot spend more to earn more, rather they have to spend what they earn to live. This era showed capitalists spending more. Decreasing propensity makes cheap currency and business more attractive for capitalists, which seems to benefit the workers with greater profits shown.

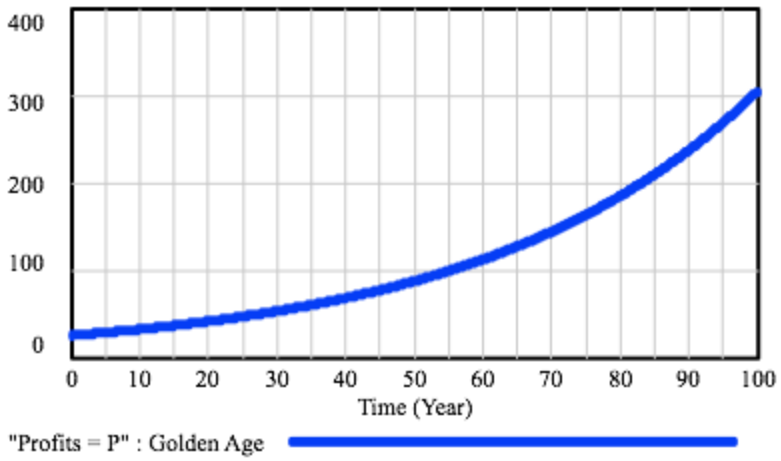

Figure 6. Kaldor Model - Capitalists Get What They Spend

Kaldor's model follows the same rules as the model above in an increase of National Income, workers and capitalists profits, and wages. These models help strengthen one another and without them, the investigation of a whole series of structural dynamic relationships would have been impossible to do (Meacci, 1998).

2.5.4 Paul A. Samuelson and Franco Modigliani

Paul A. Samuelson was an American economist that has been recognized as the person "who made the most distinguished contribution to the main body of economic thought and knowledge" (The Nobel Prize, n.d.). He served as an advisor to both John F. Kennedy and

Lyndon B. Johnson, and devoted his time to theoretical methods and analysis of economics as "the last generalist among increasingly specialized economists" (The Nobel Prize, n.d.).

Franco Modigliani, born Italian, received the Nobel Prize on Economics as well as Paul Samuelson while affiliated to MIT. Modigliani was mainly famous for his theories surrounding savings and for his publications with Miller. Nonetheless, his participation on the cambridge controversies alongside Samuelson did not go unnoticed, as they propose a theorem that aimed to complete Pasinetti's.

The Pasinetti Theorem states that the equilibrium rate of profits is equal to the natural rate of growth divided by the capitalists' propensity to save and it is independent of the workers' propensity to save (1). However, there was an issue with this formulation. When the workers' propensity to save is higher than or equal to the capitalists' propensity to save weighted by the profits share, Pasinetti's relation does not apply and the relation (2) below applies instead(Baranzini, 1975).

$$\frac{P}{K} = \frac{n}{s_c}, \quad \text{Pasinetti's Theorem} \tag{1}$$

and

$$\frac{Y'}{K} = \frac{n}{s_w}, \quad \text{Meade and Samuelson–Modigliani's Dual Theorem, for } s_w \geqslant s_c(P/K).K/Y' = (K/Y')n. \tag{2}$$

For this reason Samuelson and Modigliani presented an extension of this economic model commonly called the Anti-Pasinetti Theorem. They said that there was a paradox beyond the range to what the Pasinetti Theorem is bound to. Samuelson and Modigliani then developed a

neoclassical production function capable of smooth factor substitution and with the case of perfectly competitive markets (Samuelson et al., 1966).

2.5.5 Anwar Shaikh

Anwar Shaikh is a Pakistani American economist from Columbia University that, under the request of economist Joan Robinson, he decided to research the empirical support for the production functions that MIT had been using. Under his first publication is the Journal of economic research (1974), Sheikh argued that argued that "the apparent strength of fitted production functions was a statistical artifact generated by the fact that labor, capital, wage rates, and profit rates are tied together through the accounting identity that the value of output must equal the sum of wages and profits" (Shaikh, 2016). Anwar Shaik said that he could prove the production function arguments to be a tautology, meaning that they were true because they were defined to be true. He is famous for writing a paper in the humbug production function, where he showed how anyone could take the word humbug and fit data to the Cobb-Douglas production function so that it would spell it out. He picked the word humbug because of Ebenezer Scrooge, a character from Charles Dickens's "A Christmas Carol", who is known for being a mean capitalist. This paper was ferociously attacked in print and Shaikh was denied the opportunity to respond to the criticism (Shaikh, 2016).

2.6 Data Science and Artificial Intelligence

The approach used by this research to make predictions regarding aggregate profits is data science. Data science and Artificial Intelligence (AI) are innovative and proven to be the key motor that drives the direction of financial institutions' strategies today. Data science is

using science and mathematics formulas to make sense of data. In this project, however, the team decided to make predictions of aggregate profits of the United States economy on a quarterly basis. For this, the team used artificial intelligence, which is the way computers, machines, and robots, get an answer and make sense of this with "intelligence" as a human does. The team used the RapidMiner software to predict profit in two different ways: Machine Learning and Deep Learning.

Machine Learning is a subset of AI, whereas Deep Learning is a subset of Machine Learning. Machine Learning is a form of artificial intelligence that can find answers to make predictions based on outside influence" (Granville, n.d.). Outside influence meaning a programmer must give it a certain direction and must tell it what to look for. Deep Learning is a subset of Machine Learning and, on the other hand, does not need outside direction. The algorithms must be given what to look for, and must also explain how to look for it (Granville, n.d.). In the case of this project, we asked to forecast profit while telling the algorithm to find a pattern using four quarters of data points at a time.

Deep Learning uses neural nets to make forecasts based on information from the data. Each circle or neuron is given a numerical value from 0 to 1 to give it a weight to show how it impacts the model. Several of these neurons are then compared to one another with the model's input layer to its hidden layer, which affects the output layer (see image below) (Data Driven Investor, 2019).

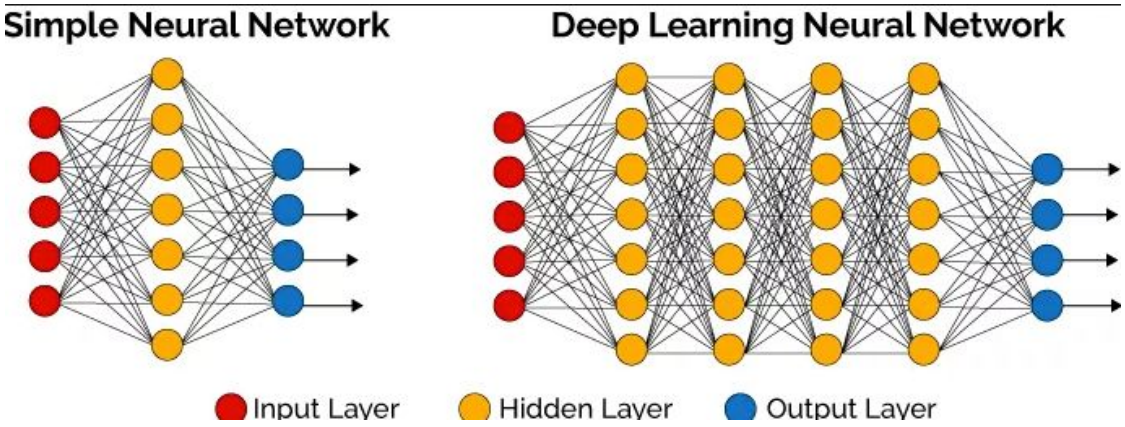

Figure 7. Neural Networks.

Machine Learning is more common in different industries since it is simpler to explain while Deep Learning may get you a better answer with an explanation that is harder to follow and can be more difficult to trust.

3.0 Methodology

3.1 Benchmark

The purpose of this research is to predict aggregate profits for the US economy on a quarterly basis and four quarters ahead. To acquire data regarding the variables of the Levy-Kalecki equation, the source was the Federal Reserve Bank of St. Louis (FED). The FED presents publicly available information on Investment, Dividend, Household Saving, Net Government Saving, ROW Saving and the Statistical Discrepancy from the years 1947 to 2018 quarter by quarter. While researching different forecasting methods, we came across a perspective that studied yield and maturity.

Recessions are caused, among other things, by a loss of business and lack of consumer confidence. As confidence declines, so does demand. Kornai (1994) al describes this as a shift from a supply-constrained economy to a demand-constrained economy or "from a seller's market towards a buyer's market. To a certain extent this can be controlled by monetary fiscal policy. Under this definition, making predictions for a year, or four quarters ahead, could allow researchers to examine economical factors such as possible recessions. Estella et al. (1996) provides a framework showing the way in which predictions can affect how the economy will go, which also affects firms, workers, and society as a whole. Their research showed that "the smaller the interest rate spread between long and short-term interest rates, the greater the probability of a recession four quarters ahead".

This project uses the predictions of aggregate profits to dig deeper in the Levy-Kalecki studies of the past. Both Levy and Kalecki had communist economic thinking. Predictions from this project will provide insight on how workers are being treated in the US. From communist theory we know there is a belief that the more profits a capitalist makes, the more the workers are mistreated. This is the case especially if the workers do not see extra benefit from the increased profits.

3.1.1 Data Collection

The approach of this research for predicting profits was based on the Levy-Kalecki Corporate Profit Equation. The figure below shows the variables used as well as the expected signs. It also provides information as to where to find the data on the United States Bureau of Economic Analysis (BEA) website.

Term	Reference
(+) Investment	NIPA Table 5.1 (Line 21 - Line 13)
(+) Dividends	NIPA Table 1.12 (Line 16)
(-) Household Saving	NIPA Table 5.1 (Line 8)
(-) Government Saving	NIPA Table 5.1 (Line 10)
(-) ROW Saving	NIPA Table 4.1 (Negative Line 29)
(-) Statistical Discrepancy	NIPA Table 5.1 (Line 42)
(=) Corporate Profits	NIPA Table 1.12 (Line 15)

Figure 8. Variables of the Levy-Kalecki Equation

When navigating the BEA website one may notice that the data only went up to 2013. However, the St. Louis Federal Reserve Economic Data (FRED) System provided information for the same variables on a quarterly basis. Data for each of the six variables had been updated to

the most recent quarter, and such data is the one used for the predictions of our model. Each of the data points had the BEA as their source, though it was found on the St. Louis FRED website.

After downloading the publicly available data and putting it on a spreadsheet, the team normalized the data. Normalizing data eliminates the units of measurement and unifies the data in such a way that it is comparable across variables to feed into the regression. This makes it easier to compare how the data truly affects Aggregate Profits and the effect they have on each other.

3.1.2 Software Utilization

The software used for this research is RapidMiner. This software is filled with operators. These operators come with pre-coded functions that make the software extremely user friendly for individuals without a computer science background. Our first step was to get the St. Louis Fed data into RapidMiner. We decided to feed RapidMiner one Excel Spreadsheet with each of the variables titling each column and the data falling below the title chronologically. Through RapidMiner, the team generated profits for each quarter with the Generate Attribute Operator by feeding it the normalized data.

3.1.3 Assumptions

We assume that the next four quarters will be a time of steady profit growth. The most recent political reforms, especially the ones regarding corporate taxes, promote economic growth. It is important to note that growth that is too extreme can lead to a harsh downfall. Assuming companies understand this as well, we assume that slow and steady profit growth will

be the way in which American economy behaves throughout the following year, in order to prevent a harsh period of decline.

But there is more to profits than just that. Profits are roughly the same as earnings, and earnings usually dictate how equity and bond markets will operate. Profits also explain the relationship between capitalists and workers, and our assumption here is that workers are not going to be treated fairly. Workers should be compensated for growth, Levy-Kalecki believed. We assume that the workers will not get rewarded as they should if profits grow as steadily as we believe they will. This assumption is based on the fact that they haven't been rewarded before.

3.2 Forecast

The team used the normalized data to forecast in two ways. We used the windowing Operator in which we predicted four quarters ahead for every quarter in the past as well as quarterly profits for the following year. The second method we used was the Auto Model. This method gave predictions only one quarter ahead. This forecast model was a regression model. Though we have forecasts from it, our primary use of Auto Model was to show how each attribute impacted profit and if the impact was positive or negative.

The team then proceeded into forecasting with Windowing. The outside influencer provided a window size of four, step size of one, horizon attribute selected was profit, and lastly a horizon size of four. From there we received a profit forecasted four quarters ahead for every quarter we had in our data set. The Windowing Operator is simple but a little more complex than the other operators we used before. The window size is what is being captured for the machine learning system to predict what is next. Since we are predicting four quarters ahead, we decided

to capture four data points at a time. The step size is how many data points the window should move down after a forecast. We decided to do a step size of one, meaning the window is moving down one quarter at a time. Using one quarter at a time makes predictions more accurate. The horizon attribute is what the operator focuses on in the window size, which in this case is profits. Lastly, the horizon size is how many quarters ahead one wants to predict. We decided to forecast four quarters ahead because we believe that is a useful timeframe and we are more likely to be accurate than if we try to predict more quarters ahead. Given that the machine uses prior quarters to make predictions, if we were to predict further ahead, previous predictions would be part of the input data.. The machine uses the data in the window size to find patterns and makes predictions and then moves forward with the step size to continue this process.

The Auto-Model forecast is self explanatory. The steps are to first load the normalized data, then select the task, then prepare target and select inputs, then model types, and finally look at and analyze the results. The data loaded was the excel sheet that included the profit attribute. This method provides an array of results such as performance review, predictions, decision tree etc. All of which are further explained in the following chapter.

4.0 Results

4.1 Predictions and Validation

By using Machine Learning and Deep Learning operators provided by the RapidMiner Software this research found some impressive results. The windowing operator demonstrated the capabilities of Machine Learning. As we explained earlier, our goal was to predict Aggregate Profits a year in advance on a quarterly basis. The chart below shows how predictions moved over time.

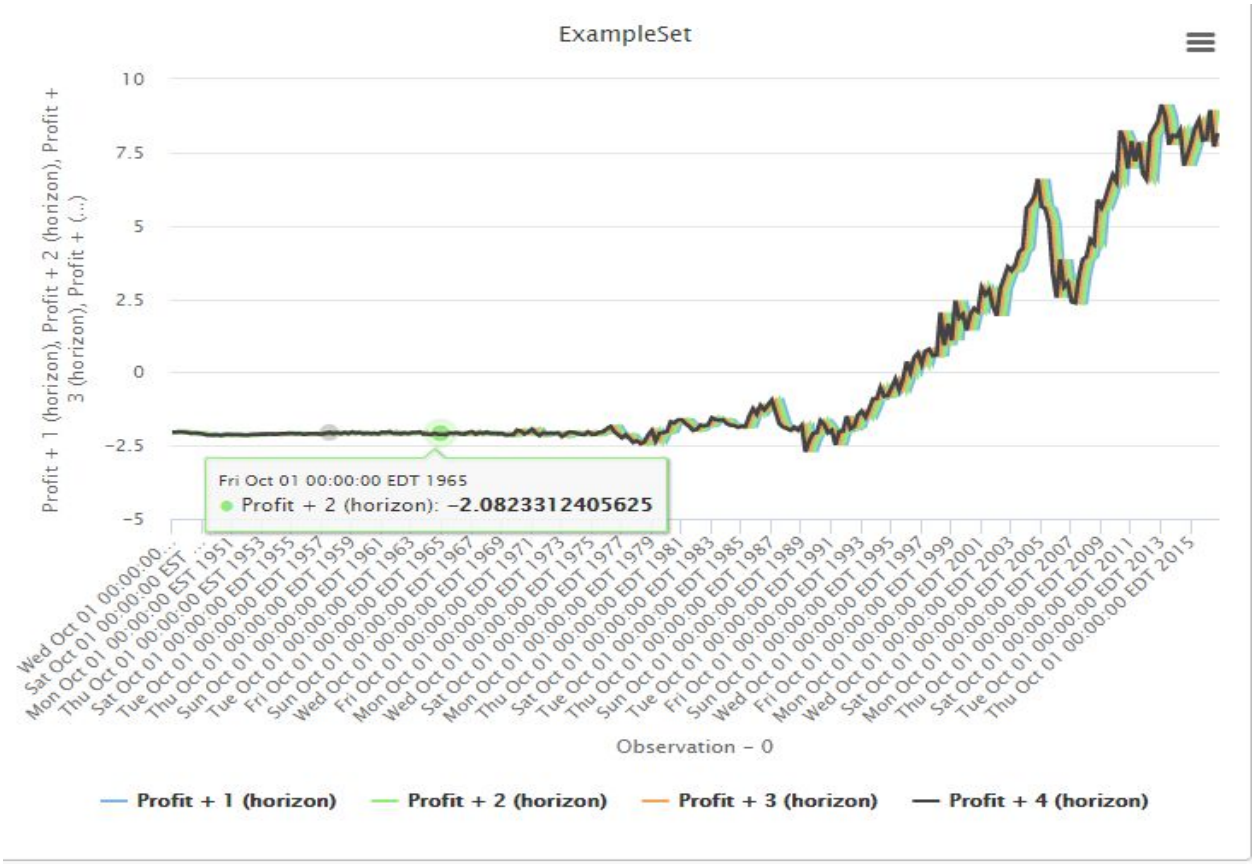

Figure 9. Predictions over time

One may zoom in and see the chronological results 7.859, 8.342, 8.603, and lastly 7.921. This predicts Aggregate Profit of the US economy to be 32.73 Billion for this upcoming year. We are coming off of a 32.74 2018 performance. Though the model predicts a decline, it is very slight meaning this fiscal year should be economically rewarding to companies nationwide. The third quarter is predicted to be the most profitable quarter of 2019.

To revise the validity of our predictions, we chose to test the model against answers that we already had. By this we mean that we deleted the data from the last four quarter(2018 year), leaving the model with the 2017 fourth quarter being the last of the data given to the model. Below is the graph of profits without the 2018 quarters input data.

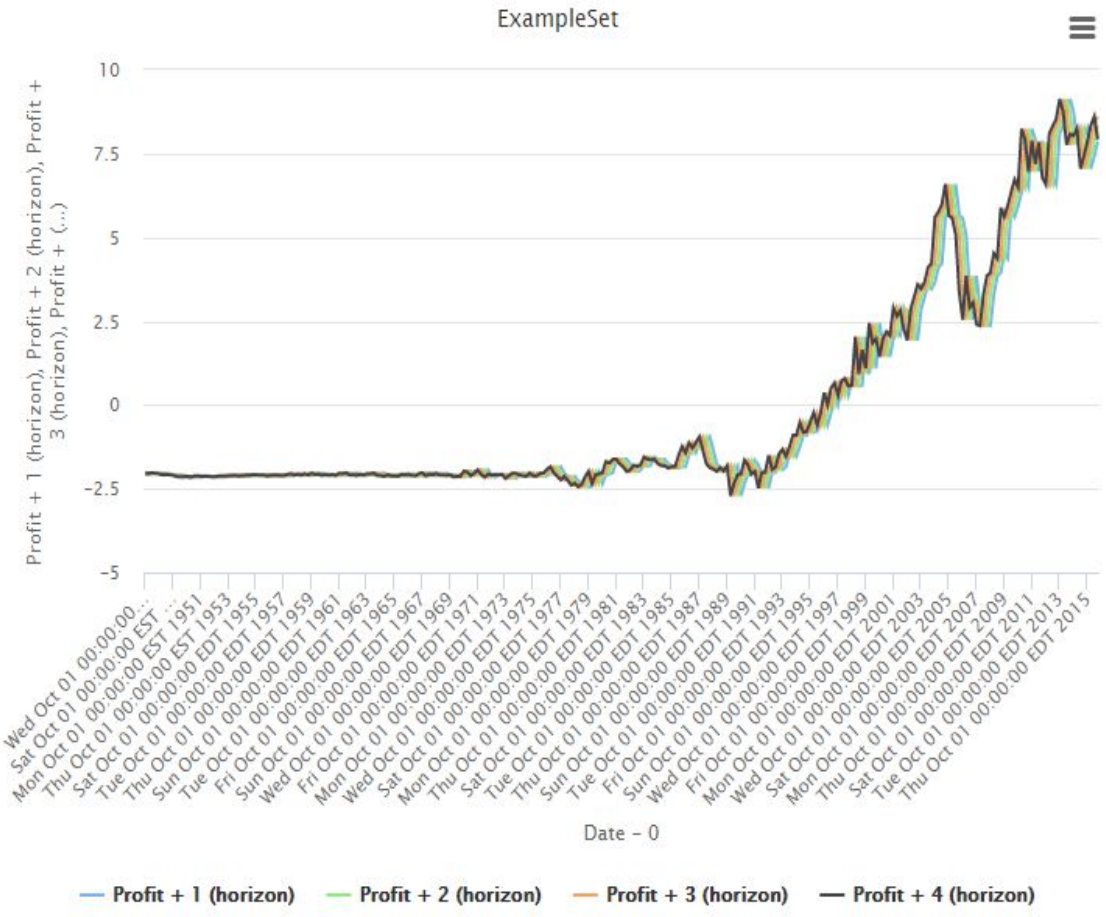

Figure 10. Model Predictions Chart

The model predicted the chronological 2018 quarters to be 7.422, 7.048, 8.251, and 8.031 while the actual quarterly profits were 7.944, 8.949, 7.691, and 8.155. The 4th quarter of 2018 was the closest prediction to the actual value. Though the predictions are not exact, we see 2018 Aggregate profits of 2018 to be roughly 33 billions while the model predicted 31 billion in profit this past year. Therefore, on an annual level this form of Machine Learning proves to be useful to getting close results.

We then used RapidMiner's Auto Model as another method of forecasting. We realized there were six different analyses that came with Auto Model. Each had a simulator that ranked the performance of each model based on the usefulness of the predictions, which are based on the attributes given from the data. The more useful the attributes, the higher the score is and the better the performance is as well. Deep Learning ranked the highest at 0.591, as shown in the image below.

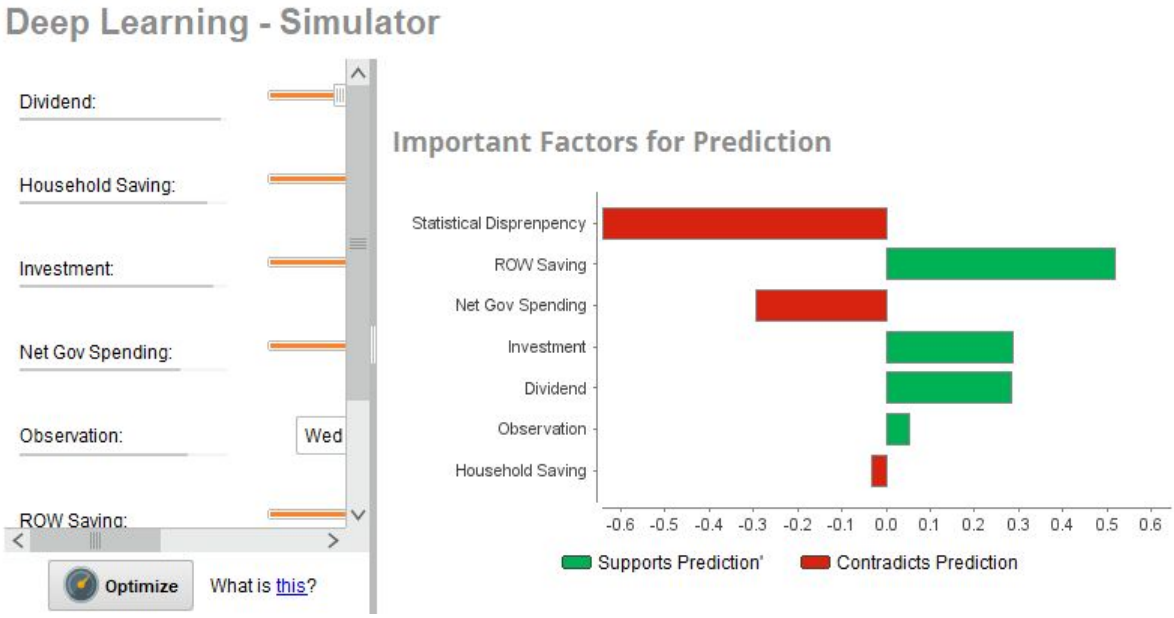

Figure 11. Deep Learning Simulator Results

The model does not predict four quarters in advance but only one quarter ahead at a time. We received a prediction of 8.030 for the first quarter of 2019. If that quarter represents a similar for the quarters to come, we can assume the Windowing Operators 32.73 annual profit predictions to also be supported by what we found in our Deep Learning Results.

We then followed the same strategy we did for our Machine Learning. We have the actual results of 2018 so we wanted to see how Auto Turbo would predict 2018's first quarter. 2018's actual first quarter was 7.944 and Auto Turbo predicted it to be 7.904. Deep Learning shows to be more accurate than Machine Learning. If this quarter represented the rest of the 2018 year that would be an approximate 32 Billion, which is close to the actual 32.74 Billion of this past. Rapid Miner's Deep Learning and Machine Learning tools seem to be truly effective.

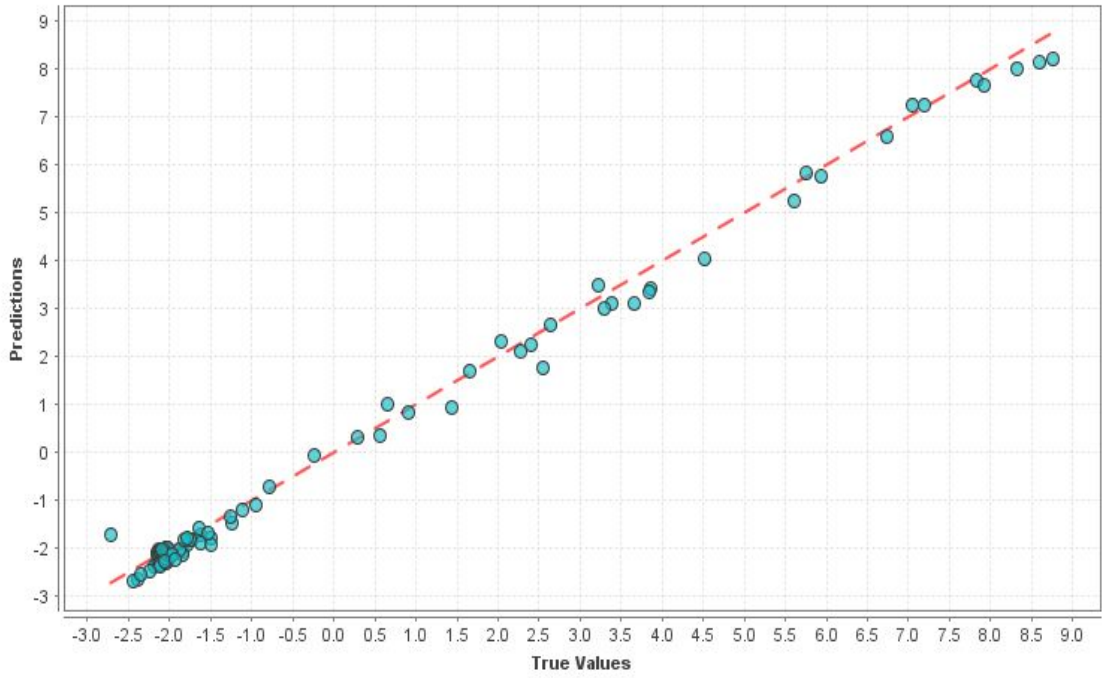

Figure 12. Deep Learning Prediction Chart

Above is the Deep Learning Prediction Chart that gives an idea of how accurate or the model has been. Though comparing the actual values to predicted values proves to be a good way to validate results, RapidMiner has more ways to valid results. The Simulator, Correlation, and Root Mean Squared Error help validate the results and performance of the model. In order

to understand the results one must first understand what they represent. All these methods are evaluators of regression analysis often used in the practice of Econometrics.

"RMS error measures the differences between values predicted by a model or an estimator and the values actually observed" (Boundless, n.d.). These individual differences between the two values are called residuals, however when they are computed out-of-sample they are called prediction errors. "68% of points on a scatter diagram are within one RMS error of the regression line, and about 95% are within two" (Boundless, n.d.). The results are shown below.

Figure 13. Deep Learning Preformance Results for Root Mean Squared Error

We were given a 0.388 RMS error size, proving RapidMiner Deep Learning AutoModel tool to be very useful.

Correlation is a statistical technique that displays the relationship between the attributes and profits predicted in the model (Creative research systems, n.d.). The correlation based on

deep learning predictions and the attributes is incredibly high at 0.992, with 1 being the highest, 0 being no relation at all, and -1 being negative correlation.

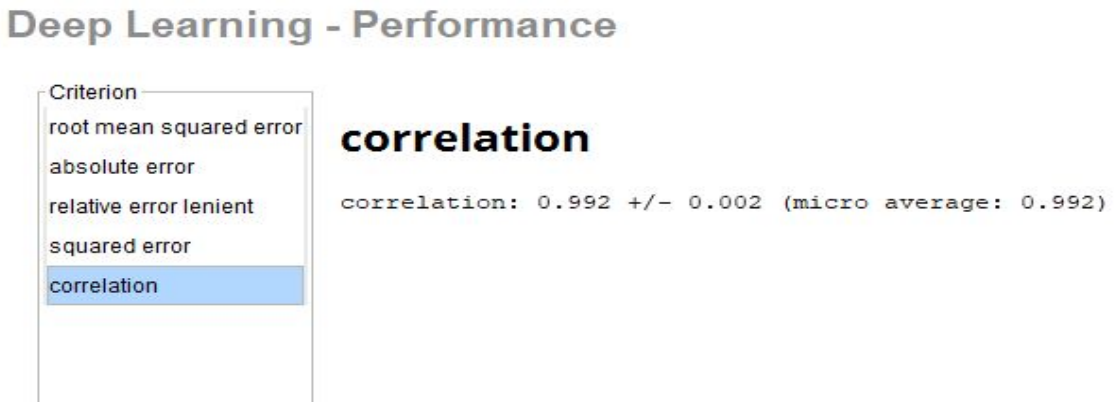

Figure 14. Deep Learning Preformance Results for Correlation

The Simulator is a useful tool because it shows which attributes contradict and support the model's results. It shows that Statistical Discrepancy, Net Government Saving, and Household Saving all are contradictory variables, while Observation, Investment, Dividend, and ROW Saving are all supporting variables.

4.2 Implications

These forecasts can be interpreted several different ways. Some include insights on the value of having two different methods of forecasting, which method is stronger, and how this affects the relationship between workers and capitalists in America from different perspectives. We used pure data science and artificial intelligence to make forecasts, without the use of economic theory. We now make sense of the results and tie it into economic disputes of the past

and how it even spreads into politics today as we see with the views of Democrats vs Republicans.

The simulator used in Auto Model is very unique. It helped rank Deep Learning over the other 5 methods. But it also displayed contradicting and supporting attributes. What is most interesting here is that when the model is rerun without the contradictions, it gives a worse prediction, lower correlation, and lower simulator ranking score. This implies that contradictory attributes make for a better model.

The results received from Deep Learning and Machine Learning were also very interesting. Deep Learning gave us better results for quarterly predictions, however Machine Learning was helpful in that we knew how it was getting the predictions. We believe it is useful to have both since there are pros and cons with each of them. Deep Learning is said to get better with data while Machine Learning plateaus, so long term it is better to stick with Deep Learning for more accuracy. The RMS error result proves how close the predictions are from actual value and further supports Deep Learning as an effective tool.

Overall the forecast points towards 30+ Billion in profits for the United States economy. This will bring companies much success at the expense of the working class as per Levy and Kalecki and the communist way of thinking. This thinking is more related to the Democratic Party in the country. On the contrary, the Republican side of the nation sees America becoming "Great Again". The forecast of 30+ billion in profit suggests a healthy job market, where people are making money and can make even more money by differentiating themselves in the marketplace.

4.3 Limitations

We had great success with our models. However, there is always room for improvement. To further improve our findings we believe the main focus could be on the windowing operator. We used a window size of four and a step size of one to predict and forecast the four quarters ahead of time. Using the actual values of 2018's four quarters we feel our window and step size could be tweaked to find even closer quarterly profit predictions. If this is done this could even make a case that the Windowing Operator would be better to use for understanding accurate predictions than the Auto Model, since the windowing operator takes outside tampering whereas Deep Learning does not. Our project is also only based on the Profit Equation of Levy-Kalecki. Too dive deeper maybe one could find an alternative profit equation and model that equation to test against Levy and Kalecki.

4.4 Modern Day American Politics

Kalecki, of Eastern European descent, worked to understand profits and tie the concept into Marxist economic theory. Understanding profits brings us to the long standing debate between Marxists and capitalists. From there we move closer to the present with the Cambridge Controversies and then up until modern day American politics.

Cambridge controversies directly relate to this project as there are two different interpretations to why aggregate profits could be rising. From the MIT side, this could mean an increase in productivity, as production and output rise. From the Cambridge university perspective, higher leverls of output relate more to higher exploitation of the labor force.

As shown before, more spending by businesses owned by capitalists means a better future for everyone. Under this model, it makes sense for President Trump to lower corporate tax. The United States now allows capitalists to spend more here and this serves as fuel to the economy. However, these models show that the worker-capitalist relationship goes beyond the amount of money put in and how hard a person works. These models can dynamically show that the capitalists have ultimate power in this society since they can create or take away opportunities from the masses who are in majority workers. Kaldor and Pasinetti are of the same school of thought as Kalecki, and through their models and results on power within capitalism we see the Marxist roots in their work as well as the importance of profits to an economy.

This same ideology of profits takes us from the 20th Century to modern day American politics. Our Democratic Party seems to closely mimic some ideologies of Marxism. They believe workers are exploited and that free trade brings out the greed out of our economic system, whereas the Republicans believe there is a competitive market of winners and losers that is apparent everywhere in the universe. In the current economic state of the United States, the stock market and employment rate show that higher profits make America a better place to live for the workers, however the Democratic party believes more should be done to bridge the gap between the wealthy and the poor. Understanding how profits would look in the future could tell us if workers will be exploited or if the winners will continue to win beyond any political perspective.

5.0 Conclusion

The research we have done does not suffice for a comprehensive framework, as it does not account for a multitude of risks that are typically considered, and makes several simplifying assumptions. However, from this research we do get impressive forecasts that can easily be replicated.

Our results suggest 2019 will be another profitable year from firms in the United States. Through these predictions we took a look at how this will affect the workers and capitalist relationship in this country, and used the tools of data science and artificial intelligence to help out with the analysis. One particular area this model could improve is in finding a better window and step size for the Windowing Operator to give even more precise forecasts. In addition to this, further research can be carried out to compare the results using different profit equations but the same forecasting methods as we used.

This model provides a foundation for research on the aggregate profits and its effect on America and so much more can be done with this research. There is a proven correlation between economic collapses, debt, and employment in the United States. We would like to challenge other undergraduates to maybe take the framework that we set forth and dive deeper to make predictions of the effects that aggregate profits could have on these specific factors of the economy. We also recommend RapidMiner as an incredible software with abundant tools for quick and precise results for future Economic Science Undergraduates here at WPI.

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