Comparing Automation and Income Inequality in the United States: Impact of the Automated Teller Machine*

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Abstract

The goal of this paper is to gain insight as to the relationship between increasing automation technology (machines that seeks to replace human labor) and income inequality within the United States, by using a specific example of automation technology, the Automated Teller Machine (ATM). Building upon a theoretical model I present, which argues that the quantity of human banking tellers would have been higher if not for technological displacement, I utilize ATM data, in terms of how the number of ATMs in use grew over a forty-year time period in the United States, and compare that data to changes in different income inequality measures, including the US Gini coefficient and percentages of the income share for different portions of the US population, over a similar time period. I also use data that tracks bank-owned ATM locations in New York state, and compare that to county level Gini coefficients. I find that, on the national level, there is a statistically significant correlation between the rise of income inequality, by any of the measures I used, and the rise of ATMs in service. Furthermore, I find that there is a statistically significant correlation between the number of ATMs and the amount of income inequality measured in New York counties.

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1. Introduction

Income inequality has been a topic of interest for the past few decades, but has been of particular concern in the United States recently. Contemporary conversation among policy-makers, political candidates, academic researchers, and the public in general, has been fixated upon pinpointing the reason why seemingly a small number of individuals make a relatively large amount of income, while a large number of individuals make a relatively small amount of income. As it relates to "middle class" job losses, the leading candidates for blame in regards to income inequality in the public consensus includes "bad trade deals," outsourcing of production to other countries, and illegal immigration. Another possible culprit being given attention by researchers is the matter of automation, the creation and implementation of robots and machines as a replacement for human labor.

The rise in income inequality is evidenced in many ways. An analysis of tax data has reviled a rising US Gini Coefficient, as well as rises in the income percentages for the top 10% and top 1% of earners (Piketty, Saez, and Zucman, 2017), Another striking demonstration of this issue is viewed in the form of the following graph that compares the path of productivity and worker compensation in the United States from 1948 through 2013. More specifically, this graph shows the level of compensation of "production/nonsupervisory workers in the private sector" as well as the "net productivity (growth of output of goods and services less depreciation per hour worked)" of the total economy.[1] (Bivens et al, 2014)

The data shows that during the period from 1948 to 1979, the percentage rise in productivity was matched by a similar rise in hourly compensation. This suggests as the

[1] Figures were derived from data from the Bureau of Labor Statistics (BLS) Current Employment Statistics, Bureau of Economic Analysis (BEA) National Income and Product Accounts (NIPA) interactive tables, and BLS Employer Costs for Employee Compensation.

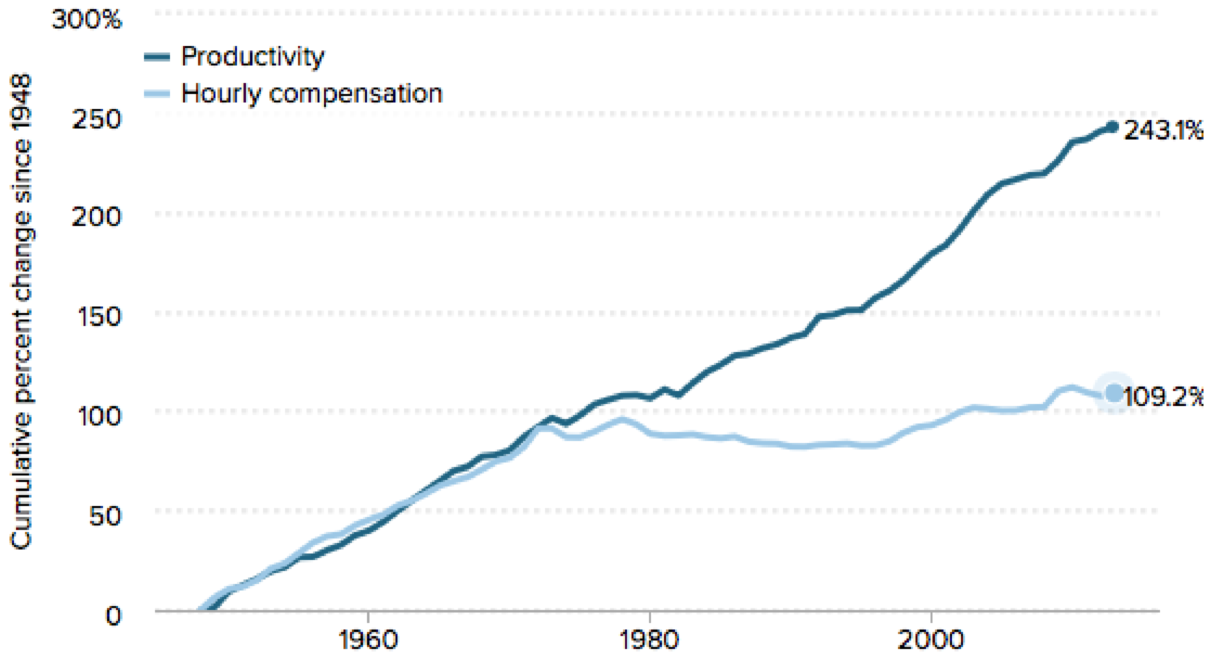

Figure 1: Productivity vs hourly compensation in the United States. (Bivens et al, 2014)

American worker was successful at being more productive, they were rewarded financially for their achievements in the form of higher wages. However, in the time period moving forward from 1979, hourly wages stagnated while productivity continued on a relatively steady climb. Apparently, despite increasing productivity and generating more value, the American worker no longer was receiving their share of that added value. This observation leads to many questions: Where did that value go? Who ended up with the profit of that progress? Is this part of the reason why so few are making so much income, while so many others are making so little? Arguably, such questions merit investigation.

Existing research has looked at the issue of income inequality and automation directly and indirectly of each other, and from many different perspectives. Some have endeavored to measure the impact automation has had on the wages provided by working low-skill jobs, as well as how that has driven a wage "skill premium," where those with the skills necessary to repair, maintain, and operate automation technology are earing higher wages then workers without those skills (Hemous and Olsen, 2014). Others have been interested in how the number of jobs have changed with the increases to automaton. (Bessen, 2015) However, I have not seen many papers that try to establish a direct causal link between inequality and specific measures of automation, or at least attempt to witness a correlation.

In choosing an appropriate specific measure of automation, inspiration came from the following source. Paul Volcker, who served as Chairman of the Federal Reserve from August 1979 to August 1987 under President Jimmy Carter, as well as President Ronald Reagan, and served as chairman of the Economic Recovery Advisory Board under President Barack Obama from February 2009 until January 2011, offered a fairly critical observation at a 2009 event that took place in the United Kingdom called the “Wall Street Journal Future of Finance Initiative.” When asked about ideas for reforming financial services that had been in place for some time (and were facing scrutiny in the wake of the ongoing economic recession), Volcker offered the following quote:[1]

> I hear about these wonderful innovations in the financial markets and they sure as hell need a lot of innovation. I can tell you of two — Credit Default Swaps and CDOs — which took us right to the brink of disaster: were they wonderful innovations that we want to create more of?... The most important financial innovation that I have seen the past 20 years is the automatic teller machine, that really helps people and prevents visits to the bank and it is a real convenience.

[1] This quote is reported as transcribed by The New York Post, December 2009.

This quote motivates the following question, which I attempt to explore in this paper: Just as innovations can have consequences for society, what type of consequences did the automatic teller machine have for society, in terms of income inequality. While it may be reasonable to conclude that ATMs may have provided a convenience for consumers of banking services, is it reasonable to conclude that ATMs were successful at decreasing the amount of middle class jobs, and in doing so, just as perhaps any other automation innovation that successfully replaces middle class human labor with a machine, would be positively correlated with the rise in income inequality? This paper hopes to explore this question, and to add to the discussion of a possible correlation or causal link between income inequality and automation. Intuitively, I expect to find a positive correlation between the rise in ATMs and the rise in income inequality, because I suspect that technology meant to replace human labor will have the effect of reducing the amount of potential middle class human labor employment in the U.S., which in turn has the effect of increasing wage polarization as workers either rise up to higher skill, higher wage jobs or sink to lower skill, lower wage jobs.

This paper endeavors to address this question outlined in the paragraph above in three different ways.

First, I provide a theoretical framework in an attempt to explore and convey the economic mechanisms underlying the issue being studied, including supply and demand curves, as well as welfare analyses. The argument for this theoretical framework is as follows: As the growing U.S. economy fostered a growing demand for banking branches (and the financial services they provide) after the 1970s, the invention of the cost-saving automated teller machine allowed the supply of bank branches to increase at a higher rate, along with the demand for bank branches.

While this expansion, thanks to the technological innovation of the ATM, lead to more consumer and producer surplus in terms of banking branches, the use of ATMs did not foster a similar welfare benefit for human tellers. These surplus benefits can be viewed through models and welfare analyses of the markets for bank branches and for human tellers, which are provide below in Section 3.

As new bank branches and their ATMs sprouted into new neighborhoods and communities, human teller jobs did not sprout in kind, and thus, these communities did not reap financial benefits in terms of employment opportunities, just as banking institutions were reaping financial benefits from the spread of their branches. Not only did this serve as a form of welfare loss for middle-class workers, would-be human tellers were left to seek gainful employment elsewhere, including other middle-class work, higher paying skill jobs and lower paying service industry jobs.

However, as automation makes for a shrinking pool of middle-class work, this outcome for would-be human tellers' links with other individuals impacted by technological displacement. This motivates the bigger question of how automation and income inequality are linked together. With less middle-class jobs available, are displaced workers stuck with the choice of either attempting to gain the skills needed for higher paying jobs, or settling for lower-paying jobs such as those found in the growing service economy, a situation which potentially fosters the growing income polarization and inequality issues we are observing in the United States? (Autor et al, 2008)

Secondly, this paper attempts to predict the level of income inequality in a given year using the measured number of ATMs in service in a given year in the United States. To do this, I utilize an Ordinary Least Squares regression with time fixed effects. As a measure of the level of income inequality in a given year in the United States, I will be using three different statistical measures: the Gini Coefficient measured in the U.S., with this data ranging yearly from 1990 to 2013, as reported by the U.S. Census Bureau, and income share data, as percentages, of the top 10% and 1%, from 1970 to 2013, as compiled by Thomas Piketty and Emmanuel Saez in their work entitled "Income Inequality in the United States" (updated, 2016). To measure the number of ATMs in the United States during the time period from 1970 to 2010, I will be using data from the Bank of International Settlements, Committee on Payment and Settlement Systems (Bessen, 2015).

After having run these regressions, the findings were as follows. The number of ATMs in service was shown to have a statistically significant correlation with all three measures of income inequality used, the Gini Coefficient, and the incomes shares of the top 10% and 1%. This result was reached using both the number of ATMs, as well as the log number of ATMs. On average, a 100% change in ATMs in service increased the US Gini coefficient by 0. 0177, as well as increased the income share percentage of the top 10% and top 1% by 3.068 percentage points and 2.422 percentage points, respectively.

For the purposes of a robustness check, data with regard to the number of full time human tellers employed by the banking industry was compiled from the Bureau of Labor Statistics, Occupational Employment Survey (Bessen, 2015). With the goal of comparing how the income inequality measures were effected by humans versus machine, I ran Ordinary Least Square Regressions with time fixed effects, in once case using full time human tellers as a predictor in place of ATMs, and in another case using full time human tellers as a predictor alongside ATMs.

When human tellers were the only regressor utilized, for the purposes of a placebo effect check, a statistically significant correlation with the income share percentages of the top 10% and top 1% of earners was found. On average, a 1 unit (in thousands) rise in human teller employment increased the income share of the top 10% and top 1% by 0.04 and 0.026 percentage points, respectively. However, when both human tellers and ATMs were used as regressors, human tellers did not show to have a statistically correlated impact on any of the measures of income inequality, while ATMs did continue to have a statistically significant impact on all measures of income inequality used. This held when looking at the number of ATMs or the log number of ATMs.

These national level findings support the hypothesis that there is a significant correlation between the number of ATMs in service and the amount of income inequality experienced in the United States. Further study must be done in order to establish more of a causal effect.

Finally, this paper attempts to take a more granular look at the issue under discussion by attempting to predict the level of income inequality, as well as the median household income levels, in a given county using the measured number of ATMs in service in a given county in the state of New York. To do this, I utilize an Ordinary Least Squares regression, with county fixed effects. As a measure of the level of income inequality in a given year in the counties of New York, I will be using the Gini Coefficient of the counties in New York, measured as measured by the U.S. Census Bureau. To measure the number of ATMs in the counties of New York, I utilize data published at the website Data.gov, which is hosted and managed by the U.S. General Services Administration, Technology Transformation Service. This particular dataset is listed as having been published by the State of New York.

After having run these regressions, the findings were as follows. With controls which account for outlier New York counties included in the regression, on average, one more ATM in a given county in the state of New York is associated with a $69.47 rise in the median household income measures in that county. Similarly, with controls included, on average, one more ATM in a given county in the state of New York is associated with a 0.0000617 rise in the Gini Coefficient measures in that county.

Once again, these granular level findings support the hypothesis that there is a significant correlation between the number of ATMs in service and the amount of income inequality experienced in the United States. Further study must be done in order to establish more of a causal effect.

I have organized this paper in the following sequence. In section 2, I will explore existing literature that provides important background and context for the issue being studied, and offers insights and analysis to the topics of income inequality and automation. In section 3, I will provide an economic theoretical framework that describes outcomes in the bank branches market and the human teller market, as well as provides a counterfactual description of how outcomes in those markets might have been in a world without ATMs, in the hopes that this framework can be improved upon and generalized for applications to other instances of automation and technological displacement in the U.S. economy.

In section 4, I will provide a qualitative analysis of the issue being studied, in the context of the economic theoretical framework presented in section 3. I will discuss the past, present, and projected future of ATMs, bank branches, and the banking industry as a whole, along with their possible connection with the rise of income inequality in the United States. Additionally, I will provide a normative analysis of what might be done about the situation moving forward.

In section 5, I will discuss the methodology behind the empirical studies conducted, the different models I constructed to address my question, and the data that I have gathered in more detail. In section 6, I will present the results of the empirical analysis of my paper. Finally, in section 7, I will conclude with a brief recap of my results, their interpretations, and what I feel should be done moving forward along this path of inquiry.

2. Literature Review

In the interest of providing a contextual background within which to frame this paper, in this section I provide a brief review of existing literature that discusses topics of automation, unemployment, income inequality, and the possible links that exist among these issues.

A fair amount of effort has been undertaken by economists and other academics to study the realities, mechanisms, and consequences associated with the rising amount of income inequality in the United States. Comprehensive reviews of published works have concluded that, while it is important to study issues that arise in terms of labor supply factors (such as immigration, social norms, and federal assistance programs) and labor market institutions and frictions (such as minimum wage, the decline in unionization, and the continuous rise in the incarceration rate of US citizens over the past decades), rises in unemployment are primarily driven by labor demand factors such as the amount of trade a country engages in and the growing role that robots, computers, and other technological forms have in the business and manufacturing world today (Abraham and Kearney, 2018).

While there are many studies that focus on the income inequality impacts with regards to the trade portion of labor demand factors (Arndt, 1997; Beyer et al, 1999; Mahadevan et al, 2017), there is an acknowledged and unfortunate lack of research on the technology side of the issue. It has recently been remarked that "the academic evidence about the role of technology on net employment rates… is actually somewhat thin and suggests modest negative employment effects, at least to date" (Abraham and Kearney, 2018). Given that the uncovered evidence to date has been successful in yielding important, albeit modest, results, I argue more research needs to be conducted on the issue of technological displacement in order to truly ascertain the magnitude of employment effects, if any, that technology is responsible for. This paper attempts to add to that research.

Many different factors can be examined in an effort to understand the causes and drivers of income inequality, including top income shares, the profit share, the unionization rate, the minimum wage, the unemployment rate, and computer investment per worker, which is a form of automation (Wolff, 2014). Data of this type is available over a wide period of time, and allowed for a study of the "shift of national income from the labor share towards a higher profit share" in the United States (Wolff, 2014).

Some papers endeavored to go beyond the questions of my paper to address and predict other consequences. By investigating automation, and including the idea of horizontal innovation, David Hemous and Morten Olsen were able to construct an endogenous growth model to not just describe what we see today in terms of automation and income inequality, but predict what will happen in terms of low-skill wages in the long run (2014). Given more time, a similar attempt could be made in terms of just automation and income inequality, it all its various forms.

The consequences of income inequality due to automation have also been studied on their own. Models have been constructed that demonstrate the existence of an education wage premium, due to the rise in demand for employees with skills (due itself to skill-based technical change) and a deceleration in the supply of college workers (due to rising costs to attend school).

It was noted that there was a “deceleration in demand growth for college workers in the early 1990s”, and a “polarization of skill demands in which employment has expanded in high-wage for and low-wage work at the expense of middle-wage jobs” (Autor et al, 2008) The culprit for this may be automation, replacing middle-wage jobs, which consisted of tasks easy to accomplish, and thus easily automatable.

In recent decades, declines in middle-class jobs have been observed along with rises in service sector jobs. This has been observed outside of big cities, where shifts in “rural employment from goods-producing industries to service industries has caused a decrease in low-skill jobs” (Gibbs et al, 2004). Furthermore, it has recently been found that “local labor markets that specialized in routine tasks differentially adopted information technology, reallocated low-skill labor into service occupations (employment polarization), experienced earnings growth at the tails of the distribution (wage polarization), and received inflows of skilled labor” (Autor & Dorn, 2013).

Not only have there been rises in the service sector of the economy, laborers have been finding other ways to cope with the decline in middle-class jobs. As traditional “nine-to-five” jobs experience a decline, there has been a rise in self-employed freelancer work, as well as being employed by contract firms that feed clients out to other companies. Practices such as these, referred to as “alternative work arrangements,” have ben becoming more and more commonplace. “The increase in alternative work arrangements from around 10 percent of the workforce in the 1990s to 16 percent today is probably largely driven by secular factors associated with rising inequality and technological changes making it easier to standardize and contract out work. (Katz and Krueger, 2017)

However, it has been argued by some that automation has not caused as much damage to middle-wage jobs as may be suspected. In his article "Toil and Technology", Jim Bessen offers the following quote:

> Thanks to the ATM, the number of tellers required to operate a branch office in the average urban market fell from 20 to 13 between 1988 and 2004. But banks responded by opening more branches to compete for greater market share. Bank branches in urban areas increased 43 percent. Fewer tellers were required for each branch, but more branches meant that teller jobs did not disappear.

I believe an important fact is being overlooked in this assessment. If the number of human tellers had been allowed to grow as the number of bank branches grew, more middle-income employment would have been available to those communities. However, since the number of human tellers employed remained steady as the number of bank branches in the United States increase, the human teller-to-branch ratio fell. More branches, while leading to more bank profits, didn't necessarily lead to more overall human teller income. Thus, the gained income went not to middle class workers, but to the producers of the bank branches and people in the top percentages of the income share distribution, who arguably likely had stakes in the profitability of those banks. This argument is explored in more formal detail in the following section of this paper.

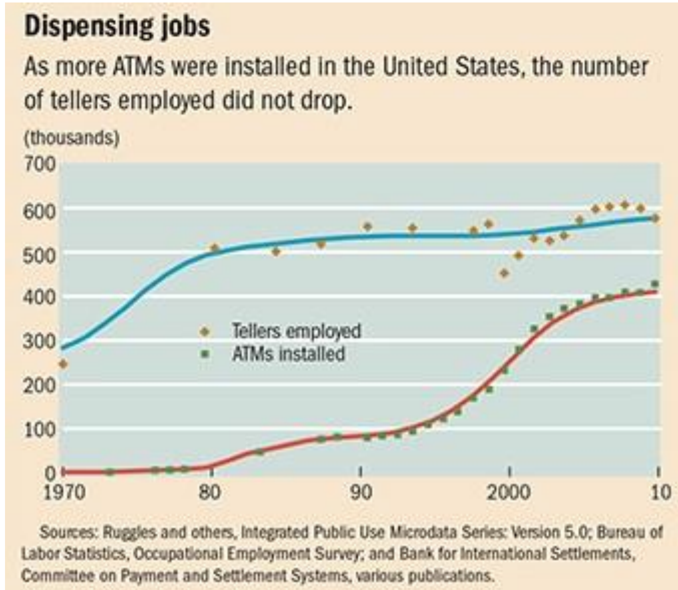

Figure 2: Full time human tellers employed versus ATM's in use. (Bessen, 2015)

3. Theory: Lack of Human Teller Job growth.

This section will attempt to provide a theoretical framework for analyzing the growth of bank branches due to ATMs, the coinciding lack of growth for human teller jobs, and the resulting welfare implications of these market outcomes, as well as what the welfare implications would have been in a counterfactual world devoid of ATMs, as these outcomes relate to all actors involved.

As discussed in the previous section, from the time period of 1970 to today, the number of ATMs in service in the United States grew quickly, while at the same time the number of human teller jobs in the United States remained relatively constant. Furthermore, as the number of ATM's grew, the number of bank branches in the United States also rose quickly, allowing more customers and communities to have more convenient access to them. Figure 3 provides summaries of the numbers that chart the growth of human tellers, automated teller machines,

	1970	1980	1990	2000	2010
Human Tellers	250,000	500,000	550,000	450,000	575,000
ATMs	0	25,000	95,000	240,000	400,000
Bank Branches	21,839	38,738	50,897	64,916	82,646
Labor Force	82,771,000	106,940,000	125,840,000	140,863,000	153,484,000

Figure 3: Descriptive statistics regarding trends in human tellers, ATMs, bank branches, and the U.S. Labor Force over the span of 40 years. (Bessen, 2015; Federal Deposit Insurance Corporation; Bureau of Labor Statistics)

bank branches, and the U.S. labor force, decade by decade, over the time period from 1970 to 2010.

However, as can be observed in figure 3, as the number of bank branches grew over time, the number of human tellers did not grow in tandem. It can be reasonably argued that part of the reason bank branches were able to spread throughout the country so quickly was because of the cost-saving innovation that was the Automated Teller Machine. This meant that as more communities and neighborhoods had more access to bank branches, they did not have more access to more jobs.

Figure 4 provides insights regarding the human teller job as ratios of other measures. When compared against the US labor force, human teller jobs were growing from 1970 to 1980 (this was a decade where the ATM was relatively new, and did not experience much growth). However, in the following three decades, the ratio of human tellers to labor force dropped. This drop was also witnessed in terms of the human teller to bank branch ratio. In 1980, there were almost 13 human tellers for every branch. By 2010, there were less that 7 human tellers for every branch. An even more striking figure emerges from calculating the ratio of human tellers to ATMs. In 1980 there were 20 human tellers for every 1 ATM, but the ratio dropped very quickly. In 2010 there were only 1.5 human tellers to every ATM, demonstrating the extent of which ATMs had replaced human tellers.

	1970	1980	1990	2000	2010
Human Teller/Labor Force	0.30	0.47	0.44	0.32	0.37
Human Teller/Branch	11.45	12.91	10.81	6.93	6.96
Human Teller/ATM		20.00	5.79	1.88	1.44

Figure 4: Descriptive statistics regarding ratios of human tellers versus the U.S. Labor Force, bank branches, and ATMs in use. (Bessen, 2015; Federal Deposit Insurance Corporation; Bureau of Labor Statistics)

Economic and welfare implications of this development are modeled in figures 5 and 6. In 1970, there were specific market supply and demand curves related to bank branches, as reflected in figure 5. Over time, as a reaction to the growing U.S. economy, demand for branches rose as individuals required more access to locations where they could consume financial services. This would be represented as an exogenous shift in the bank branches demand curve. Owing to the cost-saving technological innovation of the Automated Teller Machine, bank branches were easier to supply. This would result in an exogenous shift in the bank branches supply curve.

At today's equilibrium, a greater quantity of bank branches would be in existence, as observed by the shifts in supply and demand above in figure 5. In terms of welfare, consumer surplus (enjoyed by the consumers of bank branches and their services) would rise from a smaller amount of welfare in 1970 (the area in the graph labeled “A”) to a larger amount of welfare today (the area in the graph labeled “A”, “B”, and “C”). Meanwhile, producer surplus (enjoyed by the banking institutions who provide the branches) would rise from a smaller amount of welfare in 1970 (the area in the graph labeled “D”) to a larger amount of welfare today (the area in the graph labeled “D”, “E”, and “F”).

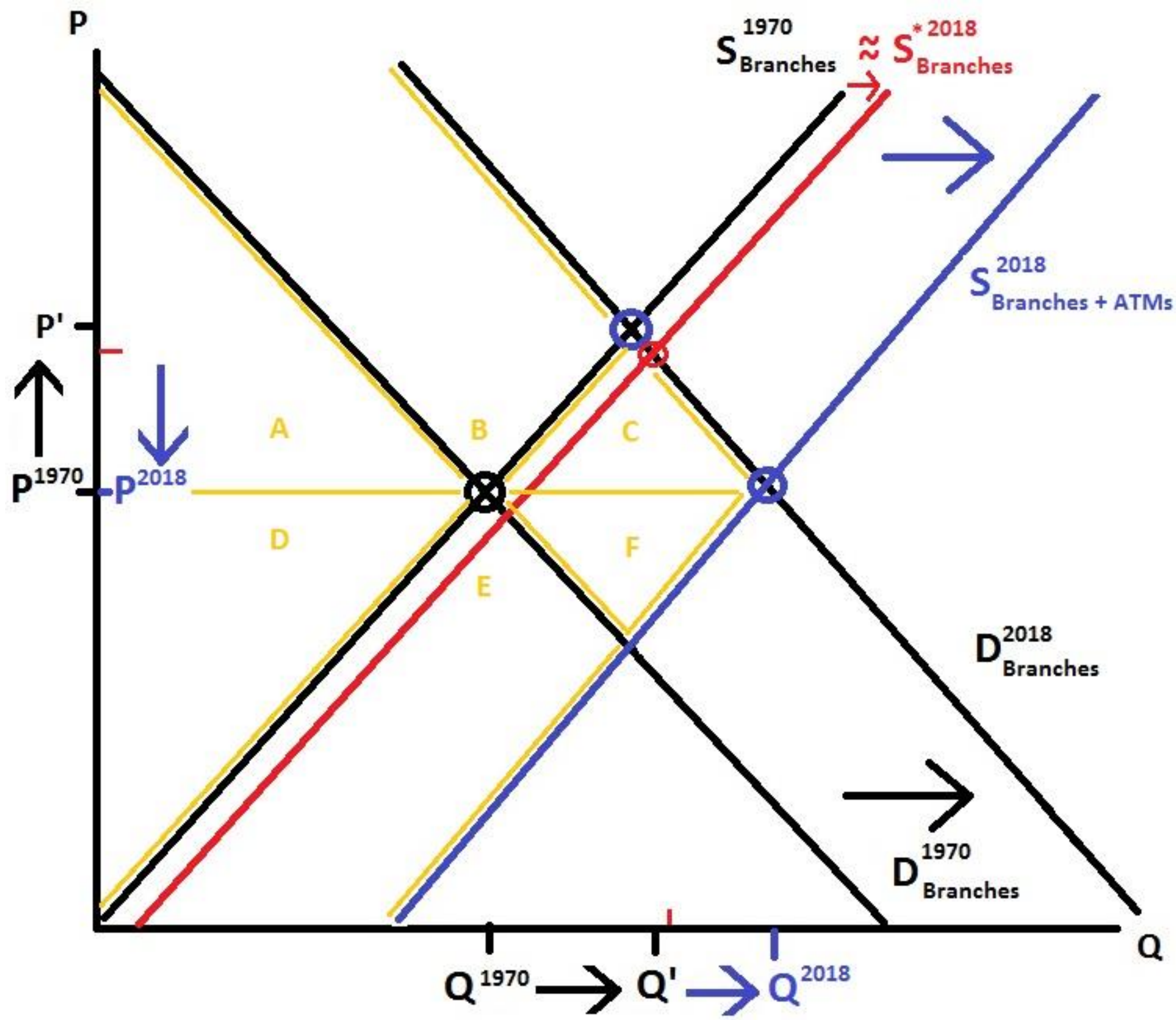

Figure 5: Supply and demand model for banking branches.

In a counterfactual world where there are no ATMs in existence, the bank branches supply curve would not be able to shift out so quickly because the cost-saving effects of the ATM would not be enjoyed by producers. The bank branches supply curve might shift out some, as depicted by the red bank branch supply curve in figure 5, but consumer demand would have to be met some other way. It is logical to assume that banks might resort to other means of supplying financial services more conveniently to consumers, including the use of micro-branches (as have actually been observed in shopping malls, grocery stores, and other places) and kiosks (like the currency exchanging kiosks visible in airports). In this scenario, with all these different methods banks devise so that they can conveniently reach their customers, human tellers would be needed to interact with customers and provide the financial services that are in demand. Thus, in this counterfactual world without ATMs, the number of human tellers employed would be allowed to rise.

Figure 6 shows a model representing this counterfactual world without ATMs. In 1970, there were specific market supply and demand curves related to human teller labor. As demand for branches increased (as shown in figure 5), the demand curve for human tellers would also exogenously shift out. In a world without ATMs, this would result in more human tellers being employed, and it would result in a higher wage being set by the market, owing to the new demand for human tellers.

In this counterfactual world, the increasing wages for human tellers, as well as the expansion of points of service discussed above (micro-branches, kiosks, etc.), would most likely result in more participants in the U.S. labor force, including but not limited to the neighborhoods and communities where these new points of service have expanded into, seeking to become human tellers, resulting in an exogenous shift in the supply curve of human tellers. This would have the result of lowering wages, presumably back to around their previous levels, but more importantly, the entire economic process would result in a higher number of human tellers employed, collectively at bank branches, micro-branches, and kiosks across the United States.

In terms of welfare, producer surplus (that is, the economic welfare that goes to the human teller workers) would rise from a smaller amount of welfare in 1970 (the area in the graph labeled “D”) to a larger amount of welfare today (the area in the graph labeled “D”, “E”, and

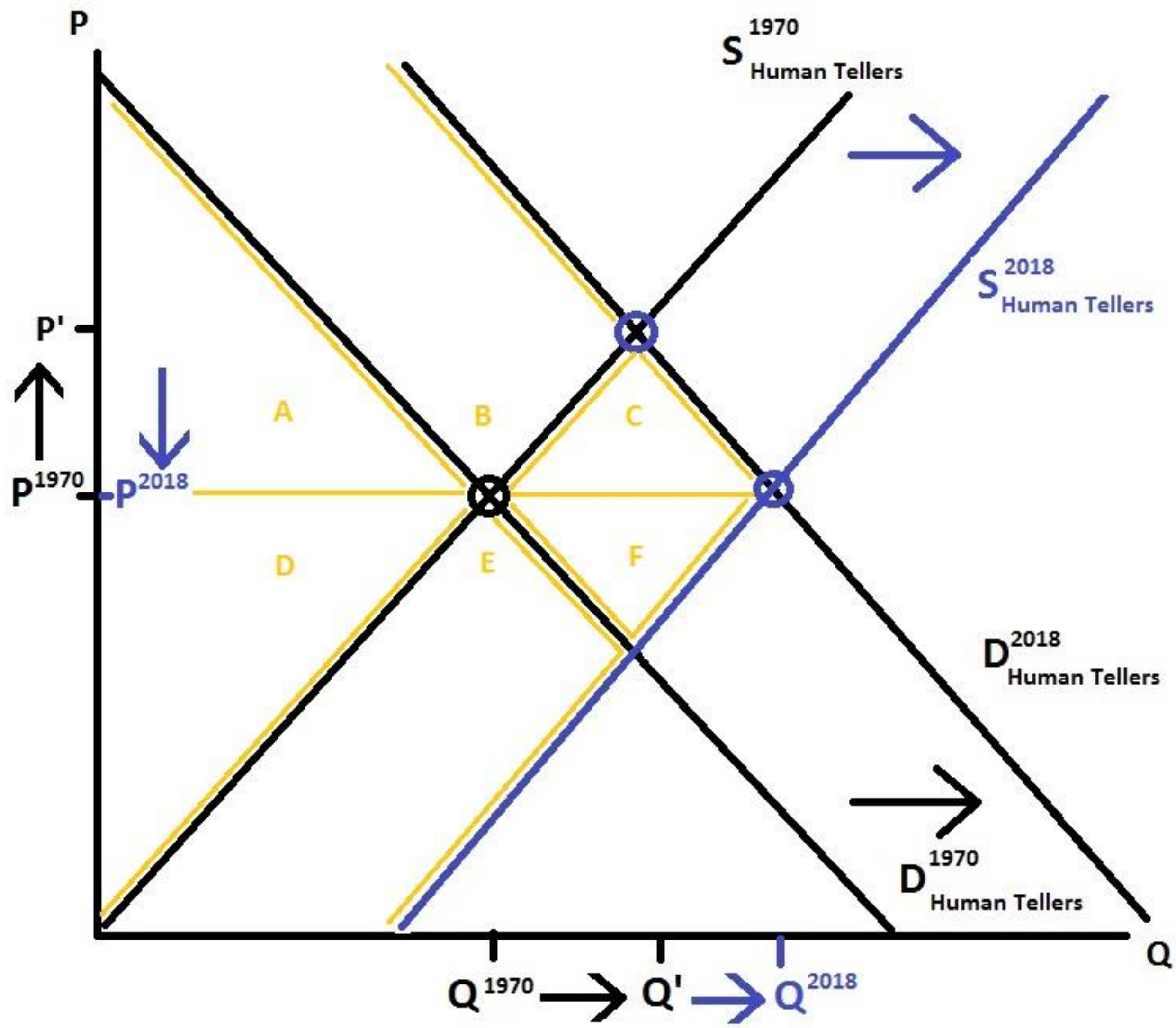

Figure 6: Counterfactual supply and demand model for Human Tellers.

"F"). At the same time, consumer surplus (that is, the economic welfare that goes to the human teller employers, the banking institutions) would rise from a smaller amount of welfare in1970 (the area in the graph labeled "A") to a larger amount of welfare today (the area in the graph labeled "A", "B", and "C".)

In terms of welfare outcomes, in the counterfactual world that is without ATMs, consumers would still get their boost in surplus because micro-branches and kiosks would have been there to supply to them in lieu of bank branches. Banking institutions (the producers of branches and consumers of human teller work) would also be receiving their share of surplus, due to the rise in demand of financial services. Finally, human teller workers, those who were already employed and those who were drawn into the job by the rising quantity of positions, would have also enjoyed their share of producer surplus, as shown in figure 6.

However, in the real world today, as shown by the model and by the empirical numbers reported in figure 3, the amount of human teller jobs has remained relatively the same, which means the gains in human teller producer surplus shown in figure 6 has not been realized by workers who could have been human tellers. This means that, while consumers (actual and potential human tellers included) and producers are enjoying their observed welfare surpluses as discussed above, the additional welfare not enjoyed by potential human teller workers because of technological displacement (as well as the money multiplier effects from the wages they would have made being reinvested into the economy) represents a deadweight loss to society and the economy. Instead, as discussed in the studies mentioned above, the shrinking pool of middle-class work, including human teller positions, meant that those who had or were able to acquire the necessary skills were able to take higher paying skill jobs, while those who were not skilled or could not acquire the necessary skills would have to take jobs in the rising service industry, or make alternative employment arrangements, which has been argued as resulting in observed increases in income polarization and inequality.

Human bank tellers are not the only type of job that is or can be susceptible to the impacts of automation. As was outlined above, many lines of employment, including manufacturing jobs, have been and can be automated. If the modeling methods discussed in this section can be improved upon, generalized, and used to model other sections of the economy that are at risk of automation, not only could researchers have a greater understanding of what is and might be occurring in the present and in the future of those economic sectors, informed discussions can be held about which societal consequences are and are not foreseeable and acceptable, as well as what policy responses should and should not be made.

4. Qualitative Analysis

This section will provide a qualitative analysis of the issue being studied, in the context of the economic theoretical framework presented in section 3, with the hopes of providing a narrative of the rise of the automated teller machine, and its impact this technological innovation has had on the banking industry. I believe that this history serves as a microcosm of the rise of automation and its impact on the labor market in the United States. I will discuss the past, present, and projected future of ATMs, bank branches, and the banking industry as a whole, along with their possible connections with the rise of income inequality. Additionally, I will provide a normative response to the question of what might be done about the resulting situation moving forward.

The automated teller machine did not simply pop into existence in the form we recognize it as today, but came from a series of innovations. The earliest example to appear in the United States was a Luther Simjian invention called the Bankograph that debuted in New York in the early 1960s. This machine only accepted envelope deposits, did not dispense cash, and did not catch on with consumers. Meanwhile in Europe, bankers who wanted to get a handle on rising labor costs began investing in technological solutions of their own (Batiz-Lazo, 2015). By the end of the 1960s, three new inventions with different mechanics emerged; the Bankomat in Sweden, and the Barclaycash and the Chubb MD2 in the United Kingdom (Batiz-Lazo and Reid, 2008).

As ATMs caught on with the American public in the 1970s, this innovation caused various behavioral, economic, and situational changes for banking customers, the banking industry, and human bank tellers.

For bank customers, ATMs provided a fancy new form of convenience, one that would represent a rise in economic consumer surplus. The machine would allow for a faster, more efficient method of making deposits and withdraws, making it unnecessary to enter a bank branch, wait in a long line, then converse with a human teller until the transaction was complete. Perhaps more importantly, the technological innovation made it possible for customers to have access to cash at times when the bank branches were closed. As a result, customers not only experienced a change in the way in which they could consume banking services, but a change in how they could consume in general. The typical day-worker no longer had to plan their consumption in advance in order to visit branches when they were open during weekdays, or forgo consumption altogether if they simply could not get time off of work in order to visit a branch. They were now free to indulge in more impulse spending (Batiz-Lazo, 2015).

For the banking industry, added consumer surplus paid off in terms of more business from a wider range of customers. Customers could complete transactions at your machines, even if they weren't a member of your bank, or if they did not have a credit card. Added revenue meant bank branch expansion was possible, which in turn would mean reaching many more customers. The number of bank branches started to rise. Bank profits also rose, which I will discuss in more detail shortly.

Despite growing welfare for banks and bank customers, bank tellers arguably did not reap as much benefit. As discussed above in figure 4, the number of bank branches began to steadily rise, but the ratio of bank tellers to branches began to drop. While the number of total bank teller jobs did rise, the use of ATMs allowed banks to hire less tellers then they would have needed to otherwise. This means that communities across America that witnessed the opening of new bank branches did not get the boost in employment opportunities they might have expected. Thus, gains in the labor market did not equal gains in the banking industry; worker welfare missed out on the progress.

Not only were there less human teller jobs than might have been expected, the presence of the ATM caused important changes in the nature and necessities of the human teller job itself. "As the routine cash-handling tasks of bank tellers receded… bank personnel (became) involved in 'relationship banking.' Increasingly, banks recognized the value of tellers… not primarily as checkout clerks, but as salespersons, forging relationships with customers and introducing them to additional bank services like credit cards, loans, and investment products" (Autor, 2017). As a consequence of this development, banks were in a position to expand revenue-producing opportunities and sell more financial products, while workers were required to be even more skillful, in terms of their sales abilities, in order to claim and keep their low-level teller jobs. "A bank teller who can tally currency but cannot provide 'relationship banking' is unlikely to fare well at a modern bank" (Autor, 2017). This development would take on an even darker dimension, will I will discuss shortly.

There are studies that claim the banking industry did not enjoy statistically significant reductions in costs and added benefits due to the advent of the ATM (Humphrey, 1994). However, these studies do not take all the factors discussed above into account, which arguably amount to an indirect way in which banks were made better off by the ATM. Evidence of how the banking industry has benefited can be seen simply by reviewing the gains in their collective bottom line over time. In 1978, commercial banks combined to hold a total of $1.2 trillion of assets (53% of U.S. GDP). That number grew to $11.8 trillion (84% of U.S. GDP) in 2007. In 1978, the average per-person compensation in the banking sector was about the same as in the overall private sector, but by 2007, that average (now going to fewer people) had more than doubled the overall private sector average (Johnson and Kwak, 2010), arguably an example of income inequality.

The theoretical framework outlined in section 3 suggests that in the world of today, consumers of banking services are also enjoying greater consumer welfare, meaning the banking industry are not the only winners. With check-cashing stores, to micro-branches inside of grocery stores, to the beginning of online and mobile banking, consuming bank services has never been more cheap or convenient. Considering this, we may ask the question of whether or not society has gained more on balance. That is, are the welfare gains being enjoyed by consumers high enough to compensate society for the unfortunate welfare loss being suffered by laborers.

When considering this question, it becomes important to not only take stock of the positives as it relates to the current state of the banking industry due to automation, but also the negatives. In the world of today, brought on by the advances of yesterday, consumers have taken many hits by the policies and actions of the financial industry which seeks to gain revenue however it can. Consumers in desperate need of cash face extremely high APRs, ranging from 260% to 520%, from consuming payday loan services at check-cashing stores (Prager, 2009). Consumers face the costly dangers of getting caught by “unfair” overdraft fees that banks find ways to charge, totaling $11.45 billion in 2017 alone (Smith, 2018). The selling of unstable financial products helped fuel the Great Recession of 2008, which greatly harmed consumers (Johnson and Kwak, 2010). In 2016, Wells Fargo Bank admitted that they had allowed millions of accounts to be created without the permission or knowledge of their customers, saddling them with undeserved fees and ruined credit scores (Tayan, 2019). Low-level employees complained of how management pressured them into selling as many financial products as possible (Recall how earlier I discussed how ATMs allowed tellers to become salespeople). These are just a few of many examples of how consumer welfare was diminished by actions of the banking industry. It should not be overlooked that all of this is happening at a time when the banking industry achieved “its third year of record profits in the past four,” raking in $171.3 billion in 2016 alone (Egan, 2017).

It is important to understand the impacts of automation from the past to now and apply those lessons in the future, so we as a society can reach what we would consider to be optimal societal outcomes. Technological advancement shows no signs of slowing down in the future, and the banking industry is always working to figure out how to implement innovations and reshape how they engage their customers, which will have more impacts on consumers and workers.

There are some who suggest that technological advancement should not be as grave a concern because, even though “automation does indeed substitute for labor – as it is typically intended to do… automation also complements labor, raises output in ways that lead to higher demand for labor, and interacts with adjustments in labor supply” (Autor, 2017). I argue that we should be concerned because automation, not just in the banking industry but in all industries, can lead to outcomes that cause great pain to many people, and income inequality is a specific example of such an outcome. As Autor concedes, “changes in technology do alter the types of jobs available and what those jobs pay. In the last few decades, one noticeable change has been ‘polarization’ of the labor market, in which wage gains went disproportionately to those at the top” (Autor, 2017).

The banking industry is currently analyzing and projecting what their future will look like. They currently are predicting that customers are going to want all the convenience they can get. According to the American Bankers Association, mobile banking is on the rise, and some consumers are looking to avoid brick-and-mortar banks altogether and do their business only on their smartphone, with online banks such as Ally, Chime, and Aspiration. This doesn’t mean traditional institutions are looking to do away with branches altogether, as they currently feel they can still be useful to promoting brand image and providing live customer support should the need arise. However, the advent of online and mobile banking could certainly mean fewer bank branches, which in turn could mean that, while the human teller job may not be completely phased out, it may shrink to an even smaller size. According to the Occupational Outlook Handbook of the Bureau of Labor Statistics, “employment of tellers is projected to decline 8% from 2016 to 2026.”

I argue that the story of automation in the banking industry is a microcosm, a cautionary tale, for the greater U.S. economy, as it relates to income inequality. With more factories being run by robots, and self-help kiosks being installed at grocery stores and fast food restaurants, more human jobs are under threat of being lost, just as potential human teller jobs were since the introduction and mass adoption of the ATM. This will have negative economic welfare effects on American workers. What will they do if they lose their jobs? What should we as a society do? Technology doesn’t necessarily have to be harmful and negative. It can be a great positive to society, so long as we choose to respond to the consequences of its implementation in ways that are helpful to members of that society, and mitigate the harms of technological displacement. As

President Clinton said in 1993, “the urgent question of our time is whether we can make change our friend and not our enemy.”

One needn’t look too far back into history for an example of how America responded to a time of economic hardship. During the Great Depression, as many Americans were suffering the effects of unemployment brought on by the reckless actions of an elite few, the government finally put aside the “do nothing and let the free market fix everything on its own” argument that had only prolonged the suffering, and engaged in a series of interventions that would collectively be referred to as the “New Deal,” providing jobs, social safety nets, and unionization protections to benefit the many American workers. This was done for the sake of helping America, and its people, survive and thrive.

Just as government interventions worked to help the many in their time of need during the mid-1900s, new government interventions can be researched, decided upon, and implemented in the present, with the goal of addressing the issues and correcting the harms brought on by inevitable technological displacement. Such solutions could include strengthening our social safety nets, maintaining general education and job retraining programs to prepare workers for the labor markets of tomorrow, or even designing and implementing some form of a universal basic income. Solutions such as these could help reverse the trend of income inequality. It is observable from current trends and historic examples that income inequality does not simply go away by itself.

Inevitably, just as was the case during the Great Depression, there will be some will argue that such government interventions are fundamentally wrong, and even anti-American. They will contend that by letting people “pull themselves up by their bootstraps,” the strong will survive. They will insist that just letting the free market play out will lead to better outcomes in the long run.

Some, especially those who are already at the top, will even argue that there's not even a problem to begin with. Eric Schmidt, who serves as the executive chairman of Alphabet, which is the parent company of Google, denied that technological displacement within the banking industry existed. At the Global Digital Futures Policy Fourm in 2017, he insisted "There are more bank tellers now than ever because banks are more efficient" (Townsend, 2017), ignoring the teller-to-branch ratio decline.

History shows that all these arguments that were voiced in an effort to stop the New Deal government interventions failed to do so, and the government programs that were put in place made a positive different in the lives of Americans, not just in the immediate, but also in the distant future. It is my hope that this time around, if we learn and implement lessons from the past, as well as properly study and understand the problems of today, we can act in an informed manner to make things better for our society now instead of waiting to act once matters get much worse.

Having just concluded a narrative of the situation at hand, along with a normative analysis of what should be done, the rest of this paper will attempt to provide a quantitative analysis of the relationship between automation and income inequality, using the specific example of automation, the ATM.

5. Model, Methods, Data

It is my goal to observe the relationship, if any, that income inequality may have with automation in the United States on a national level. In pursuit of this goal, I investigate the data I have collected with an Ordinary Least Squares regression, with time fixed effects, using the following model:

$$Y_t = \alpha + \beta_1 X_t + e$$

where Y is the inequality measure at a given time, and X is the automation measure at a given time.

To measure the level of inequality in a given year in the United States, I will be using three different statistics. Firstly, I will be using the United States Gini Coefficient, ranging yearly from 1990 to 2013, acquired from the United States Census Bureau. The Gini Coefficient serves as a measure of the income distributions of the residents of a country, where a value of 0 represents perfect equality in the distribution of income of all residents, and a value of 1 represents perfect inequality in the income distribution (effectively, only one person makes all the income). In the United States during this time period, the Gini Coefficient ranged from a minimum of 0.43 to a maximum of 0.48, which is high compared to other developed nations (Desilver, 2013)

Secondly and thirdly, I will be using the income share, as percentages, of the top 10% and 1% of earners in the United States, for a 40-year time period from 1970 to 2013. This data was originally compiled by Thomas Piketty and Emmanuel Saez in their work entitled “Income Inequality in the United States” (2003, updated 2016). It is worth noting how the income shares fell flat in the 2000s, relative to the steady rise they experienced during the time period before. I believe that these valleys were caused by two major events experienced in the United States, the first being the World Trade Center attacks that took place on September 11, 2001, and the second

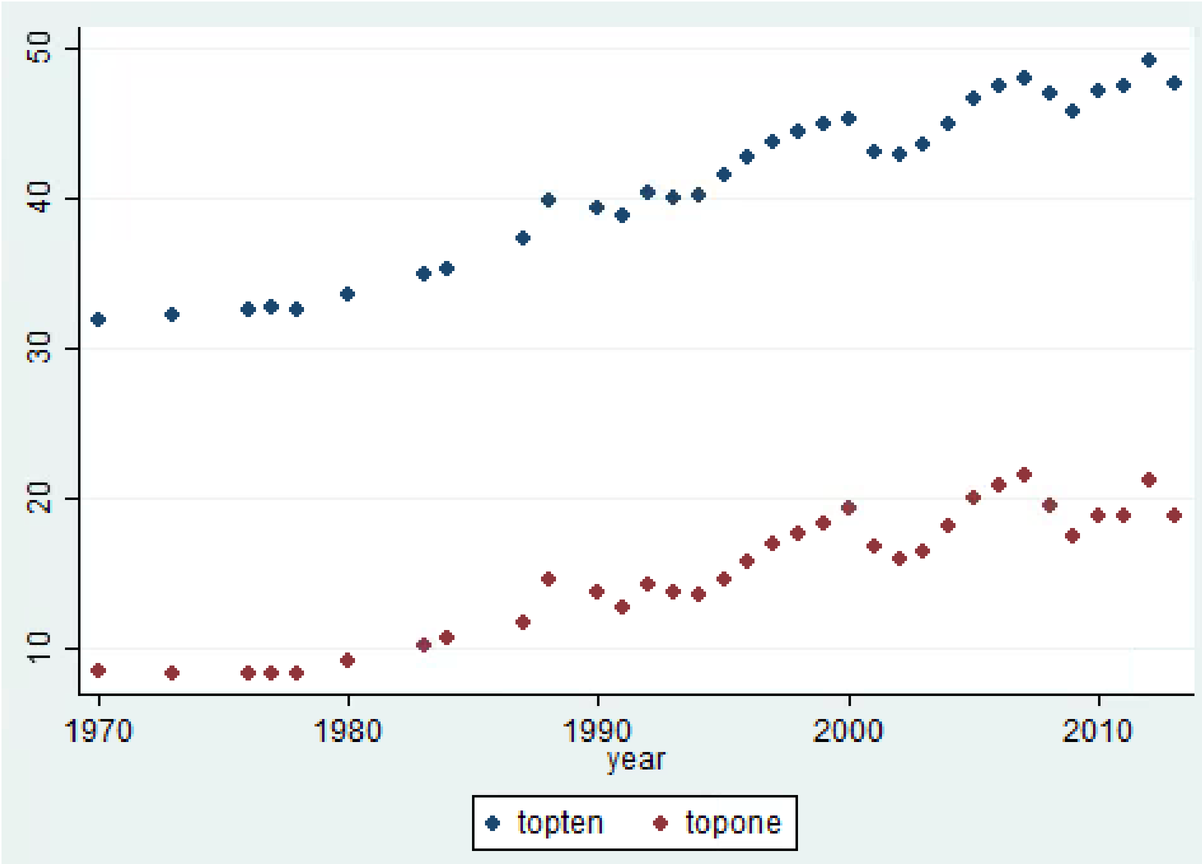

Figure 7: Rise in income share percentage for the top 10% of earners (in blue) and the top 1% of earners (in red). (Piketty and Saez, 2016)

being the Great Recession of 2008. In both cases, there was a bounce-back experienced soon thereafter.

To measure the number of ATMs in the United States, I will be using data from the Bank of International Settlements, Committee on Payment and Settlement Systems (Bessen, 2015). For the purposes of a robustness check, data with regard to the number of full time human tellers employed by the banking industry was compiled from the Bureau of Labor Statistics, Occupational Employment Survey (Bessen, 2015). This data charts how the number of ATMs in service and the number of full time human tellers grew over the same 40-year period, from 1970 to 2010, as shown by figure 2 above. While the actual numbers for ATMs in service were found,

	ATMs (1000)	Log ATM	Gini (US)	Income Share of Top 10%	Income Share of Top 1%
Mean	195.51	4.68	0.46	41.33	15.11
SD	151.27	1.48	0.01	5.42	4.22
Sample Size	27	7	24	34	34
Min Value	1.66	0.5	0.43	31.91	8.33
Max Value	425	6.05	0.48	49.18	21.51

Figure 8: Descriptive Statistics regarding the number of ATMs in service, the Gini coefficient, and the income shares of the top 10% and 1% in the United States (Bessen, 2015; Piketty and Saez, 2016; U.S. Census Bureau).

I could not find the raw numbers of human tellers employed, so I imputed the values from the graph in figure 2 itself.

Having compiled this data, the following descriptive statistics are displayed in figure 8. I wish to emphasize that for the investigated time period, the income share of top 10% of earners rose from a minimum of 31.9% up to a maximum of 49.18%, and the income share of the top 1% of earners rose from a minimum of 8.33% to a maximum of 21.51%. These figures include income made from capital gains. It is arguably reasonable to assume that the top earners reflected in these statistics would have made money by making investments in, among other assets, automation technology, and so I decided not to use the figures that reflected income without capital gains. As the top earners gain more income share over time, that leaves less income share for the bottom earners and increases income inequality. It is this underlying fact that motivates this paper.

Potential weaknesses in this identification strategy include the following. Since we are looking at data that progresses over time, it may be more helpful to conduct a time series analysis of the data as opposed to an Ordinary Least Square with time fixed effects. Also, since inequality measures respond to many different stimuli in the economy of a society, only using one regressor may be insufficient.

In order to address some of these potential weaknesses, I will be utilizing the following robustness check. As a type of placebo test, I will use the model

$$Y_t = \alpha + \beta_1 X_t + e$$

where X now takes the form of the number of full time human tellers employed by the banking industry at a given time, in place of the automation measure of ATMs in service. In addition, I will test the model

$$Y_t = \alpha + \beta_1 X_t + \beta_2 Z_t + e$$

where X once again serves as the automation measure of ATMs in service at a given time and Z becomes the number of full time human tellers employed by the banking industry at a given time, in order to control for both effects on income inequality.

Additionally, it is my goal to observe the relationship, if any, that income inequality may have with automation in the United States on a more granular level. In pursuit of this goal, I investigate the data I have collected with an Ordinary Least Squares regression, with county fixed effects, using the following model:

$$Y_C = \alpha + \beta_1 X_C + \beta_2 D_C + e$$

where Y serves as the inequality measure in a given county, X serves as the automation measure in a given county, and D represents dummy variables for the four specific counties in and around the New York City area (Manhattan, Westchester, Kings, and the Bronx) that are statistical outliers due to their situational natures. I include these dummies as a robustness check for the model.

To measure the level of inequality in a given county in the state of New York, I utilize county level Gini Coefficients that were calculated for the year of 2016, acquired from the United States Census Bureau. Other than the four outliers mentioned above, the Gini Coefficient in the state of New York ranged from a minimum of 0.3996 (in Wyoming County) to a maximum of 0.498 (in Tompkins County). The Gini Coefficients for the four outliers were as follows: 0.501 in the Bronx, 0.5201 in Kings, 0.5382 in Westchester, and 0.5967 in Manhattan. In addition to using the Gini as a dependent variable, I also use the Median Household Income figures (in 2016 dollars), measured during the period from 2012 to 2016 by the United States Census Bureau.

To measure the number of ATMs operating in the state of New York at the county level, I utilize data that has been published and is available at the website Data.gov, which is hosted and managed by the United States General Services Administration, Technology Transformation Service. This particular dataset is listed as having been published by the State of New York, and was created in March, 2015. The website notes an update to the data was provided in February, 2018.

6. Results and Discussion

With the goal of understanding what type of impact automation (machines that replace human labor) has on income inequality at the national level, I conducted Ordinary Least Square regressions with time fixed effects on my data, attempting to predict the level of inequality, as measured by, using the number (as well as the log number) of automated teller machines (ATMs) that were in service in the United States during a 40-year time period, from 1970 to 2010. The results were as follows.

VARIABLES	(1) Gini (US)	(2) Top 10%	(3) Top 1%	(4) Gini (US)	(5) Top 10%	(6) Top 1%
ATM	7.76e-05***	0.0284***	0.0228***			
	(1.49e-05)	(0.00301)	(0.00255)			
Log ATM				0.0177***	3.068***	2.422***
				(0.00272)	(0.234)	(0.227)
Constant	0.438***	35.68***	10.63***	0.362***	26.86***	3.758***
	(0.00422)	(0.740)	(0.626)	(0.0147)	(1.149)	(1.111)
Observations	20	27	27	20	27	27
R-squared	0.603	0.780	0.762	0.703	0.873	0.820

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 9: Regression results, attempting to predict measures of income inequality using number of ATMs in the United States. Note: ATM units are measured in thousands.

The number of ATMs in service is shown to have a statistically significant correlation with every measure of income inequality used. It's important to reiterate that in the 40-year time period studied, the Gini Coefficient underwent a change from a minimum value of 0.43 to a maximum value of 0.48, a movement of 0.05 in the wrong direction for the segment of society vulnerable to suffering the worst from these effects. Regression 4 indicates that, on average, a 100% change in ATMs in service increases the US Gini coefficient by 0. 0177. It is also important to reiterate that in the same 40-year time period studied, the income share of top 10% of earners rose from a minimum of 31.9% up to a maximum of 49.18%, and the income share of the top 1% of earners rose from a minimum of 8.33% to a maximum of 21.51%, a substantial rise of 17.28% and 13.18%, respectively. Regressions 5 and 6 indicate that, on average, a 100% change in ATMs in service increased the income share percentage of the top 10% and top 1% by 3.068 percentage points and 2.422 percentage points, respectively.

These findings support the hypothesis that there may be an important positive connection between automation, in terms of ATM used in the United States, and the level of income inequality felt in that same region. While the study, as is, does not support any specific causal relationships between automation and income inequality, it does not outright eliminate the possibility of a relationship, suggesting that investing more time and effort to study how the two relate to each other, as well as what quantifiable confounders might be in play, is justifiable and worthwhile.

Along with not establishing a specific causal relationship between automation and income inequality, there are other critiques of this study as it stands. Firstly, this study employs a relatively small number of data points. Only 20 observations were used to relate ATMs with the Gini Coefficient, and only 27 observations were used to relate ATMs with the income share percentages of the top 10% and top 1%, all within a 40-year period. Secondly, this study employs data at the country level, and the goal of establishing causal links would be better served by utilizing a more granulated data set, with numbers reaching the state or county levels. I attempt to address this shortcoming by providing a New York county level study, the results of which are described below. However, it would indeed be worthwhile to compile a more comprehensive data set which addresses the complaints above on a nationwide level to provide a more robust analysis of the research topic being studied.

Finally, it can be observed that I have only cast a very small net, and since ATMs only represent a subset of automotive machines in the United States, methods should be generalized and datasets should be widened to include other methods of automation, perhaps including airport check-in kiosks, automated supermarket checkout stands, and machines and robots employed in the manufacturing sector.

However, in terms of understanding how well ATM data stands on its own as a predictor of income inequality, I performed the following robustness checks. Using data that measures how many full time human tellers were employed by the banking industry during the same 40-year time period, I reran the Ordinary Least Square regressions, once with human tellers as a predictor in place of ATMs, and once with human tellers as a predictor alongside ATMs. These regressions were conducted to re-predict all three measures of income inequality. Such a robustness check would allow me to compare the effects of man and machine upon income inequality, which is what this paper aims to address.

In running the regression with human tellers as a replacement for ATMs, the following results were observed.

VARIABLES	(1) Gini (US)	(2) Top 10%	(3) Top 1%
Human Teller	3.52e-05	0.0401***	0.0292***
	(6.74e-05)	(0.00997)	(0.00879)
Constant	0.443***	21.53***	0.858
	(0.0377)	(5.383)	(4.749)
Observations	15	18	18
R-squared	0.020	0.503	0.409

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 10: Regression results of robustness check, attempting to predict measures of income inequality using number of human tellers employed in the United States. Note: Human teller units are measured in thousands.

The number of full time human tellers employed does not show to have a statistically correlated impact on the Gini Coefficient, however is shown to have a statistically significant correlation with the income share percentages of the top 10% and top 1% of earners. On average, a 1 unit (in thousands) rise in human teller employment increased the income share of the top 10% and top 1% by 0.04 and 0.026 percentage points, respectively.

It was noted that the rise in the number of ATMs in use only resulted in a stabilization of the number of full time human tellers employed, not a decrease (Bessen, 2015). As this occurred in decade of the 2000s, the income shares of the top 10% and top 1% experienced some rises and falls, but stayed flat as well, relative to how they were rising before that time period. This could be the reason why a statistically significant correlation between them has shown. However, as full time human teller employment stayed flat in recent years, the Gini Coefficient kept rising, accounting for the lack of statistical significance of that estimator.

Another possible interpretation of this observation is as follows. Machines replace only the workers for the tasks which can be automated. The persistence of tasks that cannot be automated would account for why human tellers would still be needed. However, as previously discussed, since the number of human tellers employed remained steady as the number of bank branches in the United States increase, the human teller-to-branch ratio fell. More branches, while leading to more bank profits, didn't necessarily lead to more overall human teller income. Thus, the gained income went not to middle class workers, but to the people in the top percentages of the income share distribution, who arguably likely had stakes in the profitability of those banks.

In running the regression with human tellers as a predictor alongside ATMs, the following results were observed.

VARIABLES	(1) Gini (US)	(2) Top 10%	(3) Top 1%	(4) Gini (US)	(5) Top 10%	(6) Top 1%
ATM	6.93e-05***	0.0202***	0.0175***			
	(1.95e-05)	(0.00392)	(0.00436)			
Human Teller	-2.20e-05	0.0105	0.00466	-2.77e-06	0.0146	0.00813
	(5.17e-05)	(0.0114)	(0.0127)	(4.62e-05)	(0.00932)	(0.0111)
Log ATM				0.0160***	4.367***	3.810***
				(0.00385)	(0.667)	(0.793)
Constant	0.453***	32.29***	9.598	0.374***	11.73*	-8.317
	(0.0277)	(6.014)	(6.686)	(0.0308)	(5.439)	(6.460)
Observations	14	15	15	14	15	15
R-squared	0.542	0.747	0.624	0.616	0.822	0.699

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 11: Regression results of robustness check, attempting to predict measures of income inequality using number of ATMs in service and human tellers employed in the United States. Note: ATM units and human teller units are measured in thousands.

The number of full time human tellers employed does not appear to have a statistically correlated impact on any of the measures of income inequality when included alongside ATMs, which do have a statistically significant impact on all measures of income inequality used. This holds when looking at the number of ATMs or the log number of ATMs. This demonstrates that any significant effect the number of full time human tellers had on our measures of income inequality are inconsequential when compared to the significant effects the number of ATMs have on those measures. Therefore, the regressions using just ATMs are more valid then the ones using both.

Finally, with the goal of understanding what type of impact automation (machines that replace human labor) has on income inequality at a more granular level, I conducted Ordinary Least Square regressions with county fixed effects on New York county data, attempting to predict the level of inequality, as measured by county level Gini Coefficients, as well as attempting to predict the median household income levels, using the number of automated teller machines that were in service in the state of New York as of February, 2018. The results were as follows.

VARIABLES	(1) Income	(2) Income	(3) Income	(4) Income	(5) Gini	(6) Gini	(7) Gini	(8) Gini
ATM	52.57***	60.21***	55.33***	69.47***	0.000159***	0.000116**	9.37e-05**	6.17e-05***
	(14.10)	(17.77)	(19.36)	(17.26)	(4.85e-05)	(4.38e-05)	(3.67e-05)	(2.09e-05)
New York		-15,694	-12,580	-21,785**		0.0886***	0.103***	0.123***
		(11,012)	(11,998)	(10,728)		(0.0270)	(0.0225)	(0.0123)
Westchester			16,723***	12,270**			0.0757***	0.0857***
			(5,582)	(5,026)			(0.0104)	(0.00566)
Kings				-27,693***				0.0637***
				(6,081)				(0.00686)
Bronx				-27,331***				0.0586***
				(2,429)				(0.00305)
Constant	51,727***	51,289***	51,411***	51,240***	0.429***	0.431***	0.432***	0.432***
	(1,508)	(1,574)	(1,621)	(1,547)	(0.00364)	(0.00344)	(0.00333)	(0.00314)
Observations	62	62	62	62	62	62	62	62
R-squared	0.300	0.316	0.339	0.459	0.441	0.523	0.600	0.696

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 12: Regression results, attempting to predict measures of income and income inequality using number of ATMs in New York state, at the county level.

The number of ATMs in service is shown to have a statistically significant correlation with every dependent variable used, even when using dummy variables to account for outlier counties. It turns out that when controlling for the county of New York (more commonly referred to as Manhattan), its coefficient turns out to be statistically insignificant. However, all other control dummies return statistically significant coefficients. With no controls included in the regression, on average, one more ATM in a given county in the state of New York is associated with a $52.57 rise in the median household income measures in that county. However, when accounting for the nuances in the four outlier counties, the coefficient of ATMs rises. Because of the populations of these counties, the number of ATMs within these counties skew the regression results and give an ATM coefficient lower than what would have been when controlling for these counties. With controls included in the regression, on average, one more ATM in a given county in the state of New York is associated with a $69.47 rise in the median household income measures in that county. This result follows what I would have been expecting intuitively, that ATMs can be expected to be more prevalent in geographic locations where there are populations where the median income is higher.

Of more important note is the result that on the county level in the state of New York, it is significantly observed that higher levels of inequality, as measured by the Gini Coefficient, is found in counties where there are higher numbers of ATMs. With no controls included in the regression, on average, one more ATM in a given county in the state of New York is associated with a 0.000159 rise in the Gini Coefficient measures in that county. However, when accounting for the nuances in the four outlier counties by including controls in the regression, on average, one more ATM in a given county in the state of New York is associated with a 0.0000617 rise in the Gini Coefficient measures in that county. This demonstrates that without controlling for the outlier counties, which should be due to having much higher levels of inequality, the coefficient for ATM will be reported as being higher than it should. However, even when accounting for these outliers, there is still a significant positive relationship between the numbers of ATMs in a given county in New York, and the measured Gini Coefficient for that same county. In these regressions, all county dummy variable coefficients are statistically significant, including New York county.

7. Conclusion

I will conclude with a brief recap of my results, their interpretations, and what I feel should be done moving forward along this path of inquiry.

Upon regressing different levels of income inequality with the given measure of automation at the national level, it was found that the number of ATMs in service was shown to have a statistically significant correlation with every measure of income inequality used. This was shown using the number of ATMs, as well as the log number of ATMs. For the purposes of a robustness check, two additional tests were conducted. When human tellers were the only regressor, a statistically significant correlation with the income share percentages of the top 10% and top 1% of earners was found. However, when both human tellers and ATMs were used as regressors, human tellers did not show to have a statistically correlated impact on any of the measures of income inequality, while ATMs did continue to have a statistically significant impact on all measures of income inequality used.

Upon regressing levels of income and income inequality measures with the given measure of automation at the New York county level, it was found that the number of ATMs in service in a specific county was shown to have a statistically significant correlation with every dependent variable used. For the purposes of a robustness check, dummy variables were included to represent four separate counties that could have biased the regressions due to the specific natures of the counties making them outliers. Even with these dummies in place, the same results were observed, that ATMs predicted county median household income levels, and levels in the county Gini Coefficient.

These findings support the hypothesis that there is a significant correlation between the number of ATMs in service and the amount of income inequality experienced in the United

States. This goes along with my intuition that as more technology meant to replace human labor enters service, income inequality measures would rise as well. This suggests, but does not prove, that perhaps the higher numbers of ATMs in service has the effect of reducing the amount of potential middle class human labor employment, which in turn has the effect of increasing wage polarization as workers either rise up to higher skill, higher wage jobs or sink to lower skill, lower wage jobs.

This paper has attempted to analyze the issue at hand from both a normative perspective and a positive perspective. While voicing my concerns about the present situation as it relates to automation and income inequality, and the potential connection between the two, I reiterate that I am not anti-technology, anti-innovation, or anti-automation. Using technology to free our society from burdensome, boring, and annoying tasks could prove to be a great outcome, freeing people time for much more worthwhile pursuits, so long as people are not left to suffer simply because they do not hold a job. Furthermore, I have attempted to ascertain the theories and evidence as they pertain to the true market drivers and outcomes, as they relate to automation, in a positive manner, as such facts would be important to informing any debates on the policy implications of these and other such findings.

I strongly advocate for more study to be conducted along the path of inquiry explored in this paper. More granulated data should be gathered, in terms of ATMs and other measures of automation, including numbers of automated service kiosks, numbers of robots employed in U.S. manufacturing, and even the growth of the amount of capital investments being made into automation technology by the business sector, as well as more measures of income inequality, in hopes of establishing a wider understanding of the unfolding phenomenon, as well as attempting to establish evidence of a more causal relationship between automation and income inequality.

Furthermore, to establish more external validity, more global data should be gathered along these parameters to see if these results will hold in countries other than the United States. Such efforts would go a long way in helping accentuate the positives and minimize the negatives that come along with technological assimilation in the United States and throughout the world.

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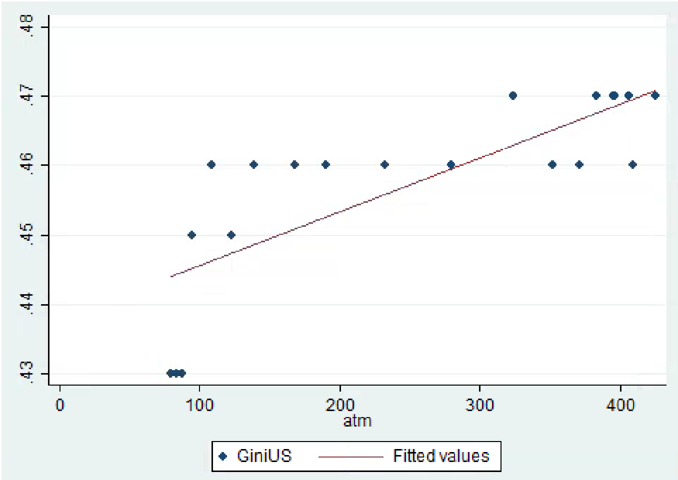
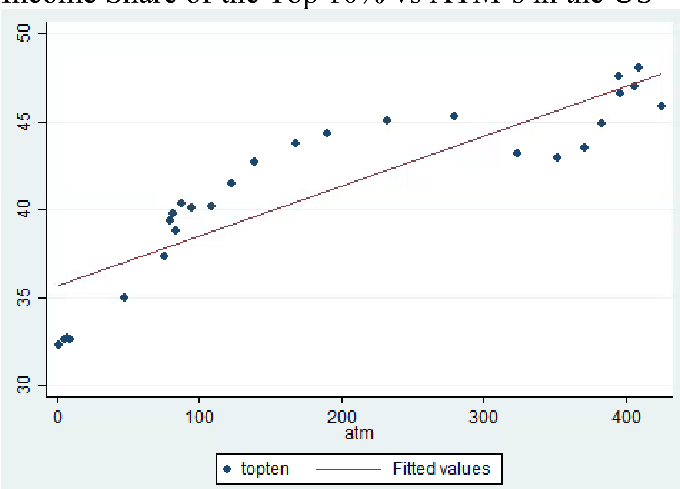
Appendix 1: Regression Graphs

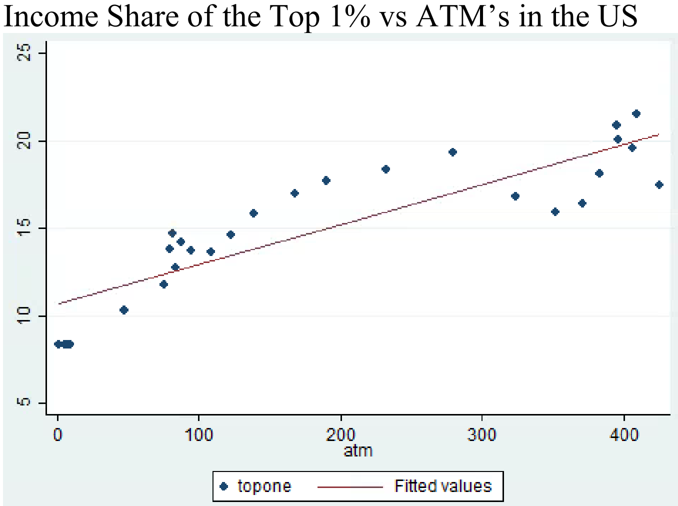
Gini Coefficient vs ATM's in the US



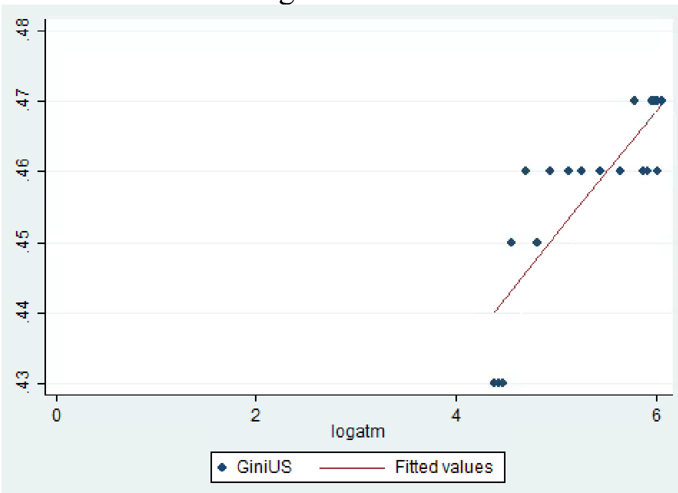
Income Share of the Top 10% vs ATM's in the US



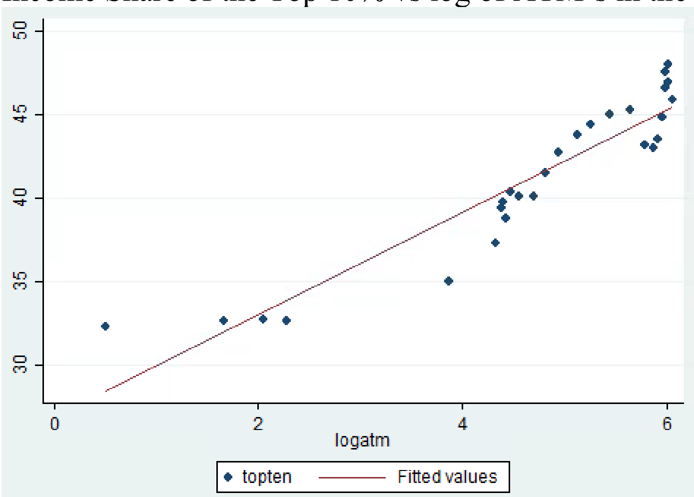
Income Share of the Top 1% vs ATM's in the US



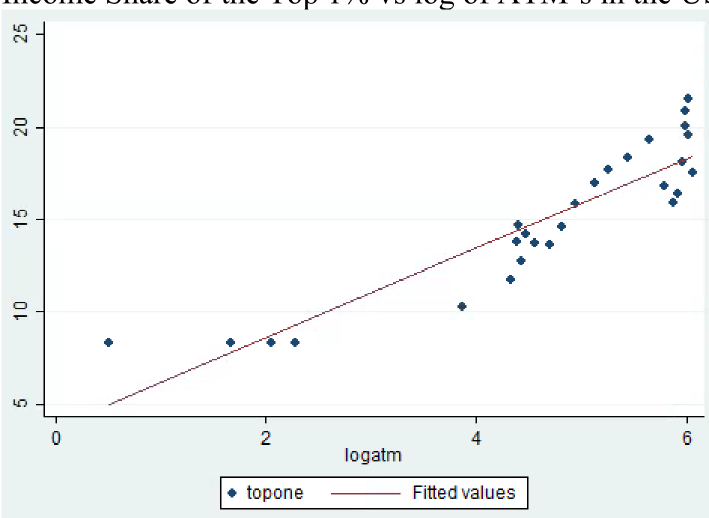
Gini Coefficient vs log of ATM's in the US



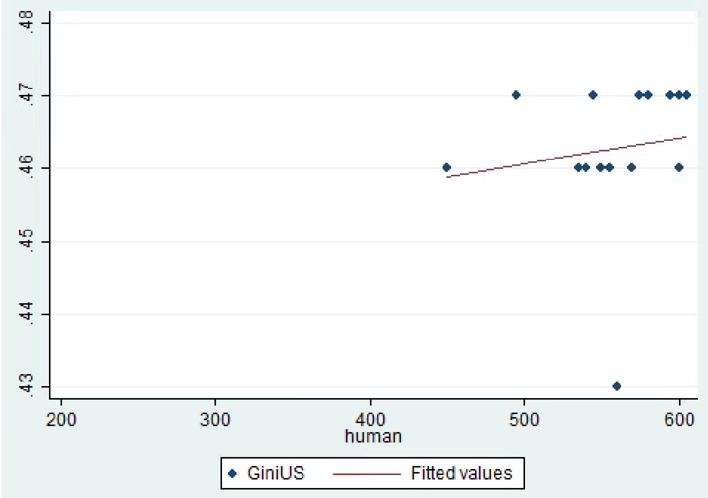
Income Share of the Top 10% vs log of ATM's in the US



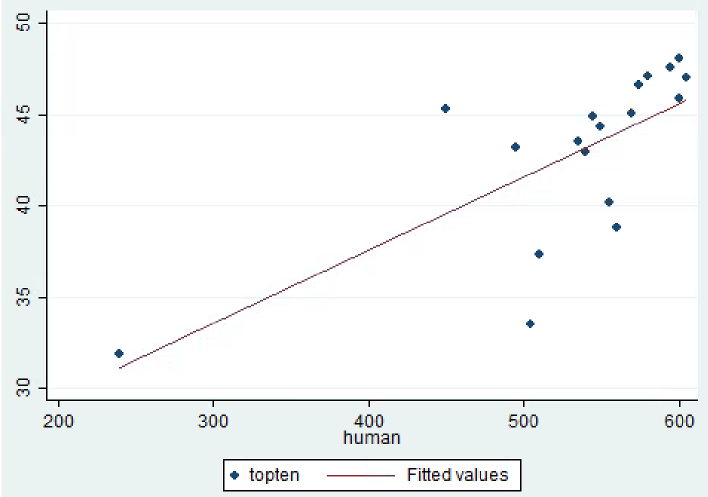
Income Share of the Top 1% vs log of ATM's in the US



Gini Coefficient vs full time human tellers employed in the US



Income Share of the Top 10% vs full time human tellers employed in the US



Income Share of the Top 1% vs full time human tellers employed in the US