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Dear Reader,

We are excited to present the Winter Issue of the *Stanford Undergraduate Research Journal*, Volume 21. In continuing to promote intellectualism and uplift diverse voices, our authors explore themes from queer representations to policy challenges in measuring data center water usage in water-stressed regions. The Humanities & Social Sciences section investigates U.S. sanctions and Iran's economic landscape, presumptive tax regimes for employee income in Indonesia, and the redefinition of legal personhood and political jurisdiction through *Citizens United v. FEC*. In the Natural Sciences & Engineering section, authors examine the effects of OM chants on human brain activity using EEG and machine learning and the impact of ancymidol on tall mutant *Brassica rapa* growth.

Since its founding in 2001, SURJ has produced intellectually vibrant collections of outstanding undergraduate research to celebrate students' accomplishments, share their discoveries, and promote an investigative spirit among undergraduates. SURJ's mission is to encourage, recognize, and reward intellectual activity outside the classroom, and we hope that through this publication, we can continue to foster undergraduates' pursuit of creativity and knowledge.

We would like to thank our journal's advisor and professor emeritus of the Stanford Graduate School of Education, Dr. John Willinsky, for his guidance and support. Without him, it would not have been possible to get the journal up and running again. We would also like to thank Mr. Wilson Wang, the Assistant Director of Data Science at the GSE for his help behind the scenes with Open Journal Systems (OJS). Finally, we would like to express gratitude for our Review Board and their dedication to providing detailed feedback on every article.

Congratulations to all of the talented authors who were selected for publication. We were thoroughly impressed and inspired by this work and hope that you will be too!

Sincerely,

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HUMANITIES &  
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# Silent Fury: U.S. Sanctions & Iran's Economic Landscape

**ANAÏS ACREE**  
*GEORGIA TECH*

The economic effects of U.S. sanctions concerning trade and investment on Iran since the days of the Iranian Hostage Crisis of 1979 have been significant, primarily impacting domestic production, altering trade relationships, and reducing foreign investment. The major research question is: What are the economic impacts of United States sanctions on Iran, and how did they change domestic production, trade, and foreign investment? The investigative method used a combination of quantitative analysis using macroeconomic trends and qualitative research from policy documents and stakeholder interviews. Results indicate that United States sanctions spurred the economic decline in Iran in the short run; rising inflation, reduced foreign investment, and alteration of trade partners. However, Iran weathered the adverse effects by cultivating domestic industries and establishing new international ties. The study suggests that sanctions can maintain viable impacts on the economy of the target in the short term; however, the longevity of those impacts is dependent on the ability of the target to resist. These results may have major implications for policymakers attempting to use economic sanctions as a tool of statecraft.

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## Introduction

Sanctions are vital tools of foreign policy used to influence the behavior of a given target country. They must be used strategically – at the right place and at the right time in order to be fully effective. When imposed, their effects can create lasting change and often alter the trajectory of relations between the imposing and recipient states for significant lengths of time. Depending on the nature of the sanction and the parties involved, it may create a certain precedent, whereby allied countries apply similar sanctions in an act of solidarity. In today's inexplicably complex world, where the United States acts as the leading hegemon, explicit examples abound of sanctions of all types. In this paper, we will discuss American sanctions against the Iranian regime since the 1979 Iranian Hostage Crisis, where 53 American diplomats and citizens were held in Iran until January 20, 1981 [1]. This event, which saw the strict Islamic theocratic regime replace the monarchical dictatorship of the Shah, has often been cited as the turning point in Iranian-American relations and, importantly, the global community's reliance on American foreign policy when dealing with the Iranian regime.

What are the economic ramifications of United States sanctions on Iran, and how have these measures influenced domestic production, trade, and foreign investment in Iran? These are factors by which we can measure Iran's economic failure or success. Domestic Production shows how quickly Iran's firms adapted by

developing manufacturing industries post U.S. sanctions. Trade highlights their changes in trading partners and whether they lost important deals with previous partners or secured partnerships with other countries. Foreign investment demonstrates whether or not Iran was able to forge new strategic alliances with other countries. This enables Iran to recover the necessary exports and imports that were lost by enterprises. Through foreign capital and technology, it can also develop new domestic expertise and gain a comparative advantage by operating corporations inside Iran. It is necessary to examine multiple economic factors to analyze the changes in these measures on Iran's economy due to the United States sanctions. Multiple sanctions have been imposed on Iran by the U.S., different European countries, and even the United Nations Security Council [2]. The United States typically leads the way by putting sanctions on Iran. As a hegemon, they are then followed by other countries and the UN Security Council. The U.S. and Iran have had antagonistic relations since the Hostage Crisis, which forced the start of the sanctions. While they go through relative cyclical periods of cooling and thawing, relations have never returned to the height of pre-1979 levels, and sanctions have been used by the U.S. to influence Iran's behavior [3]. Understanding Iran's successes and failures in light of American sanctions will allow us to determine their overall effectiveness and utility as a tool in a given country's foreign policy.

## Background

U.S. sanctions have had multiple determining effects on Iran's economy since 1979. From various sources, two main arguments emerge as having the most impact on Iran's economy, sparking debate between two camps of scholars offering different perspectives on the use of sanctions. The first camp argues that U.S. sanctions have worked by worsening Iran's economy, leading to inflation, shortages, and restricted access to vital imports [4]. The second camp argues that U.S. sanctions have gradually lost their effectiveness over time and have prompted economic progress in Iran by fostering self-sufficiency and forging new global alliances with countries such as Russia and China [5].

The first school of thought is based on the argument that the United States sanctions have worsened the economy in Iran. Inflation and shortages of essential goods have decreased the availability of products drastically due to restricted access to international markets and decreased financial transactions. One such source highlights the negative impact U.S. sanctions have had on the Iranian economy, including the increased inflation after they were put in place and the limited access to vital imports [4]. The shortages include essential drugs and supplies for medical facilities due to difficulties in processing financial transactions and shipping internationally, which resulted in not only higher prices but even increased deaths, especially during the Covid pandemic [6].

Conversely, the second school of thought is centered on how the United States sanctions have helped progress Iran's economy. This group argues that U.S. sanctions have prompted economic progress in Iran by fostering self-sufficiency and new global allies [5]. Out of necessity, Iran was forced to form alliances with different nations beyond the United States and Western Europe, now including Russia, Asia, and other Pacific Rim countries. [7] argues that U.S. sanctions prompted Iran to seek opportunities for economic advancement by creating domestic firms to gain self-reliance and reducing its dependency on imports by finding new avenues for trade and investment. Many corporations that had previously traded with Iran stopped exporting goods to them, forcing Iran to learn to develop and produce on its own. Policymakers [8] discuss how Iran aimed to protect and incubate infant industries and expand their technology despite the inferior quality of their products.

## Research Design

Referencing multiple journal articles, the findings in this paper have used a mixed-method approach that integrates both quantitative and qualitative analyses to examine the economic repercussions of the United States sanctions on Iran. Using the evolution of U.S. Foreign policy towards Iran as a case study and the analysis of trends from different periods, this study examines U.S. sanctions between 1979 and 2024, and how these events impacted Iran's economy.

The quantitative analysis uncovers several economic trends that impact Iran's domestic production, trade, and foreign investment. The sources of data are from the literature annotated, including international organizations, and governmental bodies such as Iran's Central Bank and statistical agencies. The analysis will include multiple economic indicators to provide evidence for the measures in my research question. A comparative analysis will be the most useful to enable empirical comparison over time to analyze the impact of sanctions on Iran's economy across different periods and

policy contexts. These sources include official statistics on important topics, including GDP, inflation, trade, and sectoral economic performance. These relevant indicators are used to understand and explain the broad economic impact of U.S. sanctions. GDP is an important bellwether indicator of economic growth and reflects Iran's stability in the presence of external pressure, while inflation shows the most immediate and direct effects of sanctions on prices and the purchasing power of citizens. Trade patterns reveal changes in international alliances and the level of economic isolation Iran is experiencing, with foreign investment showing the confidence of other countries to put their money on the line in the presence of risk. Domestic production levels are relevant indicators of Iran's ability to become less dependent and acclimate to an environment with fewer imports.

Qualitative analysis from interviews, policy documents, and scholarly literature provides more detail on the impact of U.S. sanctions on Iran. Interviews that have been conducted with Iranian citizens, stakeholders, and policymakers help document the perceptions and experiences of those impacted by the sanctions. Policy documents and scholarly literature, including reports, journals, empirical studies, NGOs, and International Organizations, explain policy responses and strategies of U.S. sanctions on Iran. Categorical analysis identifies repeating patterns to help extract and advance conceptual economic arguments. These sources were chosen based on their relevance, reliability, and capacity to provide a backdrop to support the quantitative trends.

By integrating these quantitative and qualitative sources, this research employs a mixed-methods approach that juxtaposes numerical trends against more social lived experiences and policy responses, allowing for a comprehensive understanding of the multifaceted impact of U.S. sanctions on Iran.

| Turning Points: U.S. Sanctions Reshaping Iran's Trajectory | Year(s)       |
|--|---------------|
| Iran Hostage Crisis  | (1979-1981)   |
| Designation of Iran as a State Sponsor of Terrorism        | (1984)        |
| The Iran-Iraq War  | (1980-1988)   |
| Iran's Nuclear Program and Sanctions Escalation            | (2000s-2010s) |
| Negotiations and the JCPOA                                 | (2015)        |
| Withdrawal from the JCPOA and Reimposition of Sanctions    | (2018)        |

Figure 1. U.S. Sanctions on Iran Case Studies Case Studies

## Case Studies

These cases serve as a chronological record of events related to the imposition and re-imposition of the relevant U.S. sanctions, including the Joint Comprehension Plan of Action (JCPOA) a 2015 Nuclear Agreement between Iran and the P5+1 countries (USA, UK, France, China, Russia, and Germany) to limit Iran's nuclear program for sanctions relief. Negotiated and enacted during the Obama administration, the US unilaterally withdrew from the JCPOA during the Trump administration. Analysis of various sectors of Iran's economy, from energy and finance to healthcare and manufacturing, helps explain the breadth of their effects. The events include the Iranian Revolution (1979), the Iran-Iraq War (1980-88), the Designation of Iran as a State Sponsor of Terrorism (1984), Iran's Nuclear Program and Sanction Escalation (2000s-2010s),

Negotiations and the JCPOA (2015), and the U.S. Withdrawal from the JCPOA and Reimposition of Sanctions (2018). These events represent key moments of U.S. sanctions against Iran, which reflect shifts in economic measures to address Iran’s nuclear program and regional activities [9].



Figure 2. Iranian Inflation

### Inflation

These case studies are correlated with short-term negative impacts on Iran’s economy. For example, when the U.S. designated Iran as a state sponsor of terrorism in 1984 (in addition to imposing many new sanctions), there was a rise of over 20% in inflation in the two years that followed (10). More importantly, we see that when sanctions are not implemented, there is a substantial decrease in inflation. After the Iran-Iraq war ended in 1988, inflation decreased by approximately 20% in two years. After the JCPOA deal in 2015, which included sanction relief for Iran, inflation dropped by approximately 25%, and only began to rise after the Trump Administration reimposed them in 2018 [11]. From this data, it is apparent that U.S. sanctions sparked an immediate economic decline in Iran [12]. However, despite this, the “rogue state” has learned to adapt and has experienced long-term economic growth. Thus, the U.S.-imposed sanctions are strongly correlated with short-term inflation in Iran and are a contributing factor to Iranian inflation rates.

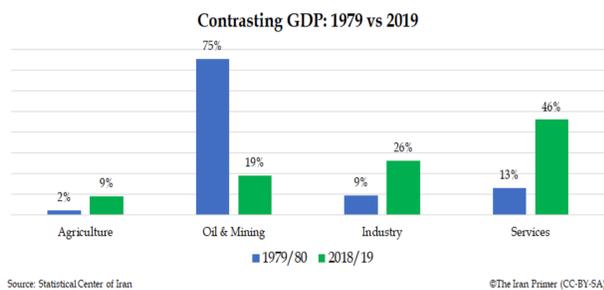


Figure 3. Contrasting GDP: 1979 vs. 2019 Domestic Production

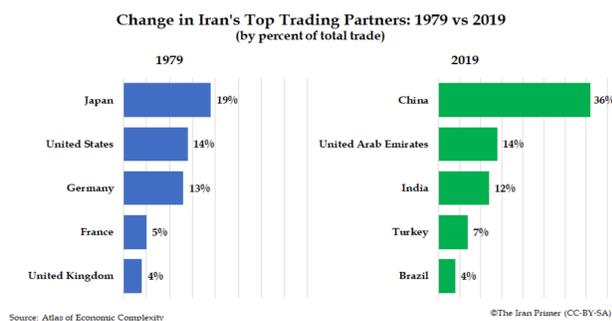
### Domestic Production

Regarding Iran’s domestic production, after forty years’ worth of sanctions, all of Iran’s critical sectors have grown, with the exception of oil and mining, which have experienced a significant drop. This

exception can largely be attributed to high oil prices during the Shah’s reign and the blow to oil demand as a result of a surplus in supply. However, regarding the remaining major sectors, we see a substantial shift in GDP makeup [13]. Services and Industry, previously accounting for a combined 22% of Iran’s GDP, now make up roughly three-quarters of it [11]. As a result of the various sanctions imposed, Iran has spent the last 40 years adapting its economy and has become increasingly self-reliant, particularly in the services sector, including education, healthcare, banking, insurance, and communications.

### Foreign Investment

Yet Iran does not totally rely on foreign investment. U.S. sanctions have scared away companies across the globe from doing business with Iran. It was not until the JCPOA that an increased number of European and Asian companies viewed Iran as a potential investment opportunity. This all quickly subsided in 2018, as the U.S. withdrew from the JCPOA (much to the chagrin of its global partners). Despite the pushback from allied countries globally, the weight of American sanctions was simply too much for businesses across all sectors to overcome. As a result, companies ceased doing any business with Iran [14]. For example, Maersk (a renowned shipping company) halted all shipments of Iranian oil. Its CEO detailed the move as a prioritization of pursuing its business interests with the United States. Likewise, Peugeot, a prominent French automobile manufacturer, reneged after signing agreements with Iran’s Khadro Industrial Group to manufacture vehicles in Iran. Iran responded with the development of its Import Substitution Industrialization plan, which further reduced its reliance on imports to advance its industrialization [15]. Having faced decades of sanctions has not stopped Iran from indulging in some of the most famous Western consumer items. The most prominent example of this is the world-renowned Atlanta-based product Coca-Cola, which previously sold its concentrated syrups to Iran. With sanctions in place, Iran no longer has access to the sugar delight, and began to develop their off-brand version “Zam-Zam”. The knockoff soft drink is produced by local firms such as Khoshgovar Mashad Co., which is tied to a conglomerate of Iran’s Shiite theocracy. The copying does not end with Coke, as duplicates run far and wide with knockoff versions of Heinz Ketchup, Oral-B mouthwash, Levi Jeans, and even Tabasco Hot Sauce being widely used. After these companies divested from Iran to comply with U.S. policy, similar versions of these products were recreated and have become available from local Iranian distributors [16]. American and Western culture continues to persist in Iran despite opposition to all things “Western”, as young Iranians embrace U.S. products and copies thereof. Iran has become self-sufficient in creating and producing makeshift replicas of these goods that they can no longer import, which has grown their industry and services sector.



**Figure 4:** Change in Iran's Top Trading Partners: 1979 vs 2019 Trade

## Trade

In Trade, Iran has made drastic changes concerning its choice of trading partners. Prior to the change in regime, Iran maintained transcontinental partnerships with many different Westernized nations. The top five countries accounted for 55% of its total trade. Now, the picture is much different. In 1979, Iran's top trading partners were Japan (19%), United States (14%), Germany (13%), France (5%), and the United Kingdom (4%). These 5 countries accounted for 55% of its trade, and Iran was extremely diversified, exchanging 45% of its goods with other countries. Now Iran relies on new trading partners who are less allied to the United States and not as much by the whims of the United States. While Iran has expanded domestic manufacturing of many products, the trade needed to receive other necessary goods now occurs between fewer countries. China has taken the number one spot, accounting for a rather significant 36% of total trade. In 2019, Iran's top trading partners were China (36%), the UAE (14%), India (12%), Turkey (7%), and Brazil (4%). These countries all account for 73% of Iran's trade which is quite remarkable considering none of them accounted for even 4% back in 1979 [11]. Most striking is that none of the top 5 trading partners with Iran remained top trading partners in 2019. In 2024, Iran has advanced relations with Russia, which now carries over 6% of its trade; this is largely due to Russia's war with Ukraine, and once again highlights Iran's relative resilience in combating sanctions [17]. Clearly, Iran has learned to adapt after losing trading partners and has forged new allies to recover trade losses. Not only have the partners changed, but also the types of goods. During the Shah's time, luxury goods, including color televisions, stereos, and household electronics, dominated the list of imports. The more modest Islamic Republic focused more on bare necessities such as basic food items. They could no longer rely on Westernized countries for machinery to process domestic agricultural products like cereals. For example, wheat product imports increased from just 426,000 tons in 1978/1979 to 2,000,000 tons in 1980/1981 [18].

## Economic Impact of Sanctions

JCPOA negotiations were put in place under President Obama's administration with China, France, Germany, Russia, the EU, and Iran, ending a multitude of sanctions in return for reduced nuclear activity in 2015. Just three years later, the Trump Administration withdrew from the deal, which worsened Iran's economy. Iranian

economist Masoud Nilli discusses how the U.S. sanctions create a serious and unstable environment. He shares that if the U.S. did not withdraw from the JCPOA deal, the Iranian rial would be trading at 100,000 rial against the U.S. dollar, but currently it is over 600,000 and counting [17]. He has based this estimate on trends since the early 2000s and concluded that while the rial would have naturally lost value over the past 5 years, the pace would be more manageable. Iran's currency traded at 70 to the dollar before the 1979 revolution, but through the decades following, the rial value has steadily declined and has experienced about a 10,000-fold fall in value. In the trends for more than two decades, he argues that the average annual inflation rate remained around 16 percent, except for the 5 years after the withdrawal from JCPOA. For January 2023, the inflation rate was drastically higher at more than 50 percent [17]. The economist argues that the wide difference is due to the sanctions that the United States imposed. However, the Biden administration has criticized the withdrawal from the JCPOA deal, emphasizing that the U.S. sanctions have been ineffective in the most important topic of impeding Tehran from expanding its nuclear program [19].

Following the JCPOA deal, Iran experienced immediate growth in its economy. Its GDP increased (adjusted for inflation) at a growth rate of 8.8 percent from USD 408 billion in 2015 to USD 444 billion in 2016 [20]. This growth rate is higher compared to rates of its regional neighboring countries: Egypt (4%), Turkey (3.3%), Saudi Arabia (1.67%), Pakistan (5.5%), and Nigeria (-1.61%). This temporary period of economic growth was shattered by implementing the 'maximum economic pressure' ordered by the Trump Administration. Through this policy, Iran's GDP growth rate dropped significantly after the reimposition of sanctions at -2.25% in 2018 and -2.65% in 2019. In 2018, the largest decline was in the industry sector, -9.1% compared to 2017, following -2.4% in agriculture, and an insignificant impact of -0.05% in the services industry. In 2019, the industry sector declined by -9.7% compared to 2018, -0.18% in services, and an increase in agriculture by +9.2%, and manufacturing by +4%. The pivotal driver in Iran's overall decline in GDP from 2018 to 2019 was the fall in their industrial production due to the oil embargo set by the United States. Iran has learned to remain stagnant and resistant to U.S. sanctions, demonstrating their steadiness in the services and agriculture sectors, which serve Iran's domestic market.

According to the head of Iran's Food and Drug Organization, Iran produces 97 percent of the medicine consumed in its country [21]. In 2018, all food groups in Iran increased a year after the re-imposition of sanctions with the highest inflation rate observed in the vegetable, meat, and fruit groups. Food insecurity in urban households increased from 2017 to 2019 from 8.84% to 11.2%, and increased in rural households from 25.17% to 29.2% before the Covid-19 pandemic hit [22]. The average cost annually of a healthy diet for an average Iranian family household of 3.3 people based on current prices is 341,866,008 IRR (\$2849 US). This increased over 3.6 times compared to the average amount Iranian families spent the previous year at 94,505,000 IRR (\$788) [22]. From this data, it is apparent that U.S. sanctions hurt Iran's economy during this period in the short term.

The Covid-19 pandemic hit Iranians harder than other countries in the region, but its economy didn't worsen as much as theirs. In August 2021, only 3% of Iran was vaccinated compared to 12% worldwide, 70% in the UAE, 50% in the EU, and 32% in Turkey

[20]. The cumulative confirmed death rate from COVID-19 in Iran rested at 1,061 per million people compared to 541 per million globally. Even though there was significant human loss in Iran during the pandemic due to the lack of access to vaccines, the economic impact of COVID-19 was less significant than in other countries. Iran had annual growth rates of GDP (adjusted for inflation) from 3.3% in 2020 to 4.7% in 2021. Iran was able to react strongly to the COVID-19 restrictions due to its adaptation to sanctions and becoming more self-sufficient. This is partially due to the fact that Iran had a lower dependency on sectors that were highly affected by Covid, such as tourism, and had already experienced a lower economic baseline following the economic contraction from U.S. sanctions [23].

### Impact on Iranian Citizens

Social implications are impacted by access and availability of healthcare and drugs, particularly during the Covid-19 pandemic. Shortages and restrictions on financial transactions disrupt the supply chain of essential goods, increasing hardships on the population. Policy responses are used to mitigate these disruptions by fostering resilience. These are achieved by diversifying trade partners, investing in domestic industries, creating social welfare programs, and pursuing diplomatic engagement. After the withdrawal from the JCPOA deal, ordinary Iranian citizens have suffered the most from the U.S. sanctions which deter international banks and firms from engaging in financial transactions with Iran [21]. As a result, this is hurting Iran's access to medicine and treatment options, and basic healthcare needs. The sanctions cause suffering to the Iranians afflicted with a range of diseases and medical conditions, the worst including patients with rare diseases requiring specialized and advanced treatment for conditions such as leukemia, epilepsy, and chronic eye injuries, and other permanent injuries from the Iran-Iraq War. With epilepsy, there is less access to foreign-made medicines, which can prevent uncontrolled seizures and permanent brain damage. An Iranian journalist shares how a Caesarean section procedure uses a "non-standard" anesthesia medication because of the lack of access to a higher quality medication provided in the Western world [21]. Human Rights Watch interviewed Iranian patients who described worsened side effects from lower-quality medications compared to what was used before sanctions. From a medical standpoint, the lack of access to drugs and medicine has hurt Iran, increasing the number of deaths compared to years in which sanctions were temporarily eased. Access to modern medicine and treatments has had a large impact on Iran's healthcare system, hurting the Iranian people who need it the most. Food insecurity is yet another issue facing the Iranian people, who have less access to nutrition due to unsustainable domestic production and insufficient imports.

With the ongoing 2023 conflict between Israel and Hamas, the U.S. has decided to impose economic sanctions on Iran's drone production as an economic, rather than military, response. This decision potentially reflects a political consideration in light of the upcoming election year. The co-founder of Energy Aspects shares, "All sanctions are sanctions on paper with anything that remotely causes all prices to go up. I just don't see myself believing that they will enforce it strongly" [24]. This regularly occurs during election years as administrations try to resonate with certain voter demographics concerned about security and international relations

to bolster support for their reelection campaign. However, the 12-Day war between Iran and Israel in 2025 escalated with the U.S. involvement in Operation Midnight Hammer. The U.S. struck three nuclear facilities in Iran with B-2 bombers and Tomahawk missiles to further set back Iran's nuclear program. Post-war, the Iranian government took priority in reconstruction and defense spending over investments in public services, leading to the economic decline and food shortages for Iranians [25]. In November 2025, Iranians spent 50% more on food than they did exactly a year prior [26]. Protein and dairy have now become out of reach for the average Iranian, with food affordability worsening and malnutrition rising to unsustainable levels.

### Results

In both the quantitative and qualitative analyses, the results varied but drew similar conclusions. The utility of U.S. sanctions on Iran's economy has sparked debate among scholars. While some argue that sanctions have worsened Iran's economy (as a result of persistent inflation, shortages, and restricted access to vital imports), others suggest that sanctions have promoted economic growth by fostering self-sufficiency and forging new alliances. The truth is largely dependent upon the period that is being discussed. Despite facing short-term economic challenges, Iran has made great strides in bolstering domestic production across sectors.

The social implications of U.S. sanctions with regard to food security and healthcare access have only exacerbated the challenges ordinary Iranians face every day. The limited access to these goods further marginalizes vulnerable groups that are most in need of these types of products, including women, children, the elderly, and the impoverished. Reduced revenues, budget constraints, and limited access to financial resources have hindered the government's ability to address humanitarian efforts and economic challenges, widening social disparities. The impact on healthcare access has been the most prominent effect of U.S. sanctions and has underscored the humanitarian consequences that these sanctions have had, highlighting the need for policymakers to consider the broader implications and effects of these types of measures.

The United States, with its immense degree of influence, has all but forced its foreign partners to impose sanctions in the wake of its own. While it may not always be the case, American influence remains ever-present as a major economy, and multinational corporations interested in doing business in America must comply with its laws, both domestic and extraterritorial. Thus, in practice, the United States continues to have tremendous influence over Iran, whether or not there is true agreement in the global community.

The research conducted suggests that U.S. sanctions do, initially, exacerbate economic challenges in Iran. Sanctions from the majority of the rest of the international community, who often follow the U.S.'s lead, have created additional challenges for Iran, and the collective effort has deteriorated Iran's economic conditions, forcing major disruptions across various sectors. Because of the U.S., Iran has faced headwinds in attracting foreign investment, developing domestic production capacities, and creating a robust supply chain network. Overall, the country is handcuffed in a way that has hindered its ability to thrive on a global scale. This research shows that there is indeed a strong correlation between U.S. sanctions and key economic indicators such as GDP and inflation.

Sanctions directly diminish GDP and heighten inflation rates, which impact Iran's trade, foreign investment, and domestic production decisions. However, despite these initial adverse (and intentional) effects, Iran's economy has recovered time and again: when one door closes, another one opens. The nuanced interplay of intended and unintended consequences continues to raise the question of the true utility of the widely used foreign policy tool: sanctions. Looking forward, the U.S. must be careful when imposing new sanctions, as they may create a more self-reliant foe in the long term instead.

### Policy Recommendations

With Iran as an example, this research creates claims that economic sanctions can achieve specific foreign policy goals but often have unintended consequences. Governments implement economic sanctions to harm their adversaries and to force them to open the door to new negotiations. When deciding to enforce sanctions, there are multiple results to consider in terms of their effectiveness.

These findings present three questions for further research. First, when economic sanctions are ineffective, why does the United States still enforce them? Second, when economic sanctions do not achieve their purpose, are there situations that can make them more effective in the future? Third, to what extent do the true effects of sanctions challenge traditional notions of diplomacy, statecraft, and conflict resolution, and their alternatives to emerge in response to their limitations and unintended consequences?

The case of Iran offers insights into the strengths and limits of the use of sanctions as a tool of statecraft, which underscores the need for careful consideration and calculation when enforcing foreign policy. The examination of United States sanctions towards Iran underscores the interconnectedness of worldwide politics, economics, and security in pursuits to shape global affairs. From shifts in exchange patterns and economic resilience to humanitarian issues and diplomatic tensions, the ripple effect of sanctions reverberates across borders and leaves a long-lasting effect on the geopolitical panorama. In light of those complexities, sanctions constitute a project and opportunity for policymakers and students. While they will exert strain and coercion to pursue strategic goals, they also raise profound moral and legal questions about their efficacy, legitimacy, and accidental effects. By deepening our knowledge of the complex dynamics at play, we can create more powerful and sustainable strategies to cope with global worrying situations and improve the motive of peace, protection, and justice within the global world.

In terms of effectiveness, sanctions are limited by international support and the general agreement of the international community. A sanction can be ineffective due to differing opinions between various countries and administrations, as well as black markets that circumvent the restriction. Sanctions are also meant to induce uprisings among the target population to pressure changes in the behavior of their government/ruling establishment or to weaken its power. However, after four decades, the opposite is displayed in Iran with sanctions strengthening the state, impoverishing ordinary Iranian citizens, increasing state repression, and surging Iran's military position toward the U.S. and its allies. Since Iranian leaders rule the country with an iron fist, grassroots protests and demonstrations are quickly squashed and have negligible impact.

"Rather than hurting the Iranian regime leaders, sanctions have strengthened the Iranian state and military, and ended up

hurting the exact people they're supposed to help—the middle class," Vali Nasr said (Professor of International Affairs and Middle East Studies at the Johns Hopkins SAIS) [27]. According to the World Bank, more than 20% of the middle class has fallen below the poverty line, with 80% of citizens now relying on government handouts [28].

For sanctions to be effective in non-Democratic countries, they should be enacted in smaller doses to achieve the desired effect. Over-sanctioning the target country often proves ineffective because their leaders would have to bow to the U.S. and lose credibility with their population by appearing weak - not something an authoritarian is willing to do. Maximum sanctions would also only further isolate the target country, forcing it to seek new trade partners and close diplomatic ties with the United States, shutting the door to direct negotiations.

Soft power is a tool that the U.S. can wield over countries to achieve desired results. A key component of this is having them dependent on trade agreements and preventing their ability to exchange goods in the free market. However, by imposing full sanctions, this leverage is lost. By imposing sanctions incrementally, the target country can feel the pain, like a band-aid being pulled off slowly, and through this, the target country can be lured back onto the negotiation table. By applying full sanctions, the band-aid would be removed too quickly, and with the risk of no more pain, they will seek alternative solutions because they will have nothing to lose. Thus, the fear of additional sanctions can be a powerful deterrent. However, if sanctions are already applied to the extreme, the imposing power runs out of legitimacy for this type of coercion.

When a country decides how and when to apply sanctions, it is important for it not to lose track of its primary objectives. In the case of Iran, the U.S. had two clear primary goals: to limit its nuclear capability and maintain stability in the region. With full sanctions in place and no dependence on the U.S., Iran has no incentive to strive for either, especially Middle East stability, as demonstrated by the 2024 missile and drone attack against Israel. A secondary objective of the U.S. was not to harm ordinary everyday people, but rather to apply pressure on the government. Unfortunately, this has not been achieved either.

Perhaps the biggest policy lesson the U.S. has learned by engaging with Iran is that when they ask them to exercise restraint in their activities, the U.S. should likewise show restraint from imposing excessive sanctions, to keep diplomatic channels open, and to retain some level of influence. When sanctions are applied to the extreme with the hope that their leadership takes corrective measures, they should likewise consider reducing sanctions, for example, reengaging the JCPOA, so when Iran considers rogue actions, they will consider what they have to lose. These lessons can be applied to other countries as well, especially to those without free elections and thus no opportunity for their citizens to democratically make course corrections away from despotic leadership. The silent fury of U.S. sanctions will continue to influence the target country's economic landscape, reminding policymakers and scholars of the pivotal role that calibrated coercion plays in tactical and strategic international relations.

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# Presumptive Tax Regimes for Employee Income: Opportunities for Tax Simplification and Challenges to Compliance and State Revenue in Indonesia

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This study explores the potential implementation of a final or presumptive tax regime for employee income in Indonesia as an effort to simplify tax administration and improve voluntary compliance. Under the current system, Income Tax Article 21 presents significant complexity, particularly for small-scale employers and employees with limited tax literacy. Drawing from international best practices and domestic MSME final tax success, the study employs a SWOT analysis to assess the strengths, weaknesses, opportunities, and threats of applying a simplified tax scheme for employee income. Findings suggest that a final tax regime may enhance administrative efficiency, reduce compliance costs, and broaden the tax base. However, it also poses challenges such as potential regressivity, loss of tax equity, and risks of system abuse. A microsimulation analysis reveals that lower-income earners may bear a heavier burden under a flat final tax compared to the existing progressive scheme, emphasizing the need for careful policy design. The study recommends a selective, data-driven approach to policy formulation, including minimum income thresholds, optional participation, and periodic evaluation mechanisms. While a final tax on employee income is not a panacea, it may serve as a transitional tool within a broader strategy for tax reform and inclusivity.

**Keywords:** Presumptive Tax, Final Tax, ITA 21, Tax Compliance, Tax Administration, Withholding

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## Introduction

### *A. Background*

Indonesia's tax system adheres to the principle of self-assessment, where taxpayers are given the confidence to calculate, deposit, and report their own tax obligations. However, this principle requires an administrative system that is simple and accessible to all levels of society. In practice, the calculation of Income Tax Article (ITA) 21 for employees is still considered complex, especially for small and medium-scale employers who do not have sufficient resources for tax administration [1].

Income Tax Article 21 recognises various layers of progressive rates, non-taxable income (PTKP), and certain deductible expenses, which require technical understanding from both taxpayers and tax withholders. This complexity often leads to calculation and reporting errors, and creates a high administrative burden [2].

In comparison, the government has enacted the Final Income Tax scheme for micro, small, and medium enterprises (MSMEs) through Government Regulation No. 23/2018, which offers a single rate and simple calculation of gross income. This scheme is proven to increase voluntary tax compliance and reduce administrative burden for MSME taxpayers [3]. A similar approach could be considered for employee income, especially for certain

segments that have fixed and relatively homogeneous income characteristics.

Simplification of taxation through a final system on employee income has the potential to provide benefits such as efficiency in employer withholding, predictability of employee tax burden, and increased voluntary compliance. However, this scheme also needs to be carefully assessed in terms of tax fairness, its impact on state revenue, and the potential for abuse of the system by certain parties [4].

Against this background, it is important to further examine the potential implementation of a final tax scheme on employee income in order to simplify tax administration and improve taxpayer compliance.

### *B. Problem Formulation*

- Can the final tax scheme be applied to employee income in Indonesia?
- What is the potential impact of the policy on tax administration and employee tax compliance?

### *C. Research Objectives*

This study aims to analyse the potential of implementing a final tax on employee income as an alternative to a simpler taxation scheme and to evaluate its impact on tax administration and tax compliance.

#### **D. Benefits of Research**

- Academically, it contributes to the literature on tax system reform, especially related to the simplification of the collection mechanism.
- Practically, it provides considerations for tax authorities in designing policies that encourage efficiency and compliance.
- In terms of policy, it is the initial reference for the trial or simulation of the implementation of the final tax on employee income.

### **Theoretical Framework and Hypothesis Development**

#### **A. Concept of Employee Income Tax and Final Tax**

##### *Employee Income Tax Theory of Tax Policy*

Income Tax (PPh) on employee income is regulated in Law Number 7 of 1983 concerning Income Tax as amended several times, most recently by Law Number 7 of 2021 concerning Harmonisation of Tax Regulations (UU HPP). This tax is withheld by the employer and is progressive in accordance with Article 17 rates, which range from 5% to 35% depending on the amount of annual taxable income earned by the employee [5].

The calculation of Income Tax Article 21 for employees is based on gross income minus deduction components such as job expenses, pension contributions, and non-taxable income (PTKP). Although this system reflects the principles of vertical and horizontal equity, in practice it requires adequate technical understanding and administrative resources from both employers and employees [6].

The administration of Income Tax Article 21 withholding also requires accuracy in the classification of types of income, the application of different PTKP provisions based on family status, and reporting in the form of periodic tax returns. This complexity is often a burden, especially for small business entities that do not have tax experts [7].

##### *Final Tax*

Final tax is a form of taxation imposed directly on the tax object with a certain rate that is fixed and does not take into account deductible costs. In the context of Indonesian taxation, final tax is applied as a form of simplification of tax administration, especially for taxpayers with a certain economic scale, such as MSME players.

A concrete example is the implementation of Final Income Tax based on Government Regulation No. 23/2018, where MSMEs are subject to a rate of 0.5% of gross turnover without taking into account net profit or expenses [8]. This system is proven to reduce compliance barriers, increase tax revenue from the informal sector, and reduce administrative costs for both taxpayers and tax authorities [3].

The application of final tax has the main characteristics: (1) a flat rate, (2) imposition on gross income, (3) no recalculation at the end of the tax year, and (4) not creditable against annual tax. Despite offering convenience, final tax schemes are often perceived as not accurately reflecting taxpayers' ability to pay [4]. Therefore, the final

tax policy should be designed by considering aspects of efficiency, fairness, and potential tax avoidance.

#### **B. Tax Compliance Theory**

Tax compliance is a key element in the effectiveness of a self-assessment-based tax system. In this context, tax compliance is defined as the willingness of taxpayers to fulfil tax obligations in accordance with applicable regulations voluntarily [9]. The level of tax compliance is influenced by various factors, both economic, psychological, and administrative.

##### *Economic Theory of Tax Compliance*

This theory departs from the rational model that taxpayers will consider the benefits and risks in fulfilling their tax obligations. In the Allingham-Sandmo (1972) model, taxpayers are considered rational individuals who will comply if the costs of non-compliance (e.g. sanctions or audit risk) outweigh the benefits of tax avoidance. Thus, factors such as tax rates, audit probabilities, and the amount of penalties play an important role in influencing taxpayer compliance [10].

However, this theory does not fully explain compliance in countries with low levels of supervision but high levels of compliance. Therefore, other approaches are needed to complete the explanation.

##### *Psychological and Social Theories of Tax Compliance*

The psychological and social approaches view tax compliance as not solely based on economic calculations, but also on social norms, perceptions of fairness, and trust in the tax authority. The slippery slope framework theory developed by Kirchler, Hoelzl, and Wahl [11] explains that compliance is influenced by two main aspects: power of authority and trust in authority. Compliance will increase if the tax authority not only has the ability to force, but also gains legitimacy and trust from the public [11].

In the Indonesian context, this trust factor is particularly important given that the level of tax literacy is still low, and perceptions of tax administration complexity tend to be high [12]. Therefore, simplifying the tax system can be one of the strategies to increase positive perceptions of the system, which in turn has an impact on voluntary compliance.

##### *Administrative Compliance Approach and Economic Foundations*

This approach emphasises the importance of simplicity, certainty, and convenience in the tax administration system as determinants of compliance. The more complicated the tax reporting and payment process, the greater the likelihood of intentional or unintentional non-compliance [13]. In this case, the final tax offers convenience because the calculation is made on the basis of gross income without taking into account various deduction components.

Thus, the implementation of a simple and transparent tax system can improve administrative efficiency and strengthen tax compliance in a sustainable manner [14].

#### **C. Regulatory Framework and Related Tax Policies**

Tax regulations in Indonesia are continuously reformed to adjust to economic dynamics and fiscal administration needs. In the context of employee income taxation and the possibility of implementing a final scheme, there are several key regulations that are relevant.

*Income Tax Law*

Law Number 7 Year 1983 on Income Tax, as last amended by Law Number 7 Year 2021 on Harmonisation of Tax Regulations (HPP Law), regulates the legal basis for tax collection on individual and corporate income. Article 17 regulates the progressive rate of personal income tax, which is the basis for calculating the current employee income tax.

*Regulations Related to Final Income Tax for MSMEs*

The implementation of Final Income Tax is regulated in Government Regulation No. 23/2018, which provides an alternative tax imposition at a rate of 0.5% on gross turnover for small and micro businesses with certain gross turnover (maximum of IDR4.8 billion per year). The purpose of this policy is to encourage compliance through simplicity, while increasing revenue from the informal sector [8].

*Tax Administration System (DGT Online and e-SPT)*

Through the Directorate General of Taxes, the government continues to develop electronic systems to facilitate tax reporting and payment. However, the administration of Income Tax Article 21 withholding is still considered complicated by many small businesses because it requires individualised calculations of different types of allowances and deductions [6].

The Final Income Tax scheme on employee income has not been explicitly regulated, but it can be studied as a form of special tax regime policy based on simplification of collection and legal certainty, with reference to the principle of ease of administration as mandated in the HPP Law.

***D. Previous Studies on Simplification and Final Taxes Table of Compliance Theory and its Implications in Indonesia***

Previous studies have examined the effectiveness of tax simplification policies, including the application of final tax, in improving compliance and efficiency of tax administration. These studies provide an important empirical basis for analysing the possibility of expanding the final tax scheme, including to employee income.

*Simplification of Tax Administration and Compliance*

James and Alley [13] emphasise that an overly complex tax system not only burdens taxpayers, but also creates opportunities for unintentional non-compliance. They suggest that simplifying the tax system can reduce compliance costs and improve administrative efficiency. This is supported by research by Tran-Nam et al. [15] who found that tax complexity in developing countries is often a major impediment to compliance, particularly among small and medium economic actors.

In the Indonesian context, Rosdiana and Irianto [7] also stated that tax reform that focuses on the aspects of simplicity and legal certainty can expand the tax base and increase voluntary compliance.

*Effectiveness of MSME Final Income Tax*

Several studies examine the impact of the implementation of Final Income Tax on MSMEs in Indonesia as a form of simplification. Research by Nurhidayat and Oktaviani [3] shows that the

implementation of the Final Income Tax rate of 0.5% based on PP No. 23/2018 significantly encourages the level of compliance of MSME taxpayers, especially due to the ease of calculating and reporting taxes.

The same thing was revealed by Mustika [16], who found that the imposition of final tax increases the participation of MSME players in the formal tax system. However, this study also noted that the flat final tax rate does not take into account the real ability to pay, which may create an excessive burden on MSMEs with low profit margins.

*Potential Final Tax Expansion*

The study by Bird and Zolt [4] examined the implementation of final tax in developing countries and concluded that the scheme is effective in the short term to broaden the tax base and simplify compliance. However, they emphasise that the final tax should be used as a temporary or transitional solution towards a fairer net income-based tax system.

In relation to employee income, not many studies have explicitly evaluated the possibility of implementing a final tax. However, a study by Shome [17] suggests that a simplified withholding system for certain income groups could improve efficiency and reduce administrative burden for both tax authorities and employers.

***E. Potential Decrease in Tax Revenue due to the Implementation of Final Tax on Employee***

The introduction of a final tax on employee income may have the consequence of simplifying administration and improving tax compliance, but on the other hand, it also has the potential to reduce overall tax revenue, especially if the final tax rate is lower than the progressive rate in the current personal income tax scheme [4].

*Potential Sources of Revenue Decline*

Some of the causes of the decline in state revenue due to the implementation of the final tax include:

- Eliminate the element of progressivity: The final rate system is proportional (flat), so taxpayers with higher incomes pay less than if a progressive system was used.
- Substitution effect: Taxpayers may shift some income to final tax schemes to avoid progressive rates, as found in Keen's (2008) study on tax shifting.
- Imposition of low rates: To incentivise compliance, the final tax rate is usually lower than the normal rate, which directly reduces the revenue potential if not accompanied by tax base expansion.

*Mitigation Strategy for Declining Tax Revenue*

To reduce the negative impact on state revenue, several approaches have been developed in various countries and can be considered for Indonesia:

- Careful and data-driven final tax rate setting  
The study by Toder and Viard [19] emphasises the importance of using microsimulation models to calculate a final tax rate that does not lead to fiscal losses. The rate is set based on income distribution and compliance elasticity.
- Limited application to certain segments

As in the Philippines and India, the final tax system only applies to employees or taxpayers with income below a certain threshold. This maintains fiscal equity and limits the impact on revenue.

#### **F. Implications for Tax Policy in Indonesia**

From the description above, it can be concluded that the application of final tax on employee income does carry the risk of reducing tax revenue, but this can be mitigated by designing policies that are data-based, selective, and accompanied by an evaluation system. In the Indonesian context, the successful implementation of the Final Income Tax on MSMEs is a foothold that can be expanded, while still paying attention to fiscal capacity and tax fairness.

#### **G. International Case Studies on Income Tax Simplification and Final Taxes**

In an effort to simplify income tax systems and improve compliance, some developing countries have adopted a final tax approach or presumptive tax regimes. The following case studies illustrate how this approach is applied in some countries and its implications for tax administration and taxpayer compliance.

##### *Philippines: Optional Standard Deduction and MSME Final Tax*

The Philippines offers Optional Standard Deduction (OSD) and Final Tax options for micro and small enterprises to avoid the burden of complex administration. This scheme is proven to increase the tax base of MSMEs and speed up tax reporting as the process is much easier compared to the comprehensive system. In addition, the withholding system on employee income has also been simplified so that taxpayers do not need to file annual returns, as long as the tax has been deducted correctly [22].

##### *India: Presumptive Taxation Scheme for Small Taxpayers*

India has a Presumptive Taxation Scheme (PTS) under Section 44AD of the Income Tax Act, which allows taxpayers with a turnover below INR 2 crore to be taxed based on a certain percentage of turnover, typically 6%-8%, without the need for full bookkeeping. This scheme is effectively like a final tax as it does not require a detailed calculation of net income.

According to India's Ministry of Finance [23], this policy has encouraged formalisation of the informal sector and increased the tax base. However, there are challenges in monitoring as the very simple nature of the scheme opens up opportunities for underreporting of turnover.

##### *African and Asian Countries: Presumptive Tax Regimes*

Many developing countries in Africa and Asia, such as Kenya, Uganda, Pakistan, and Bangladesh, have implemented presumptive tax regimes as a way to reach micro and informal sector taxpayers who are difficult to reach with the regular tax system. These regimes set taxes based on certain indicators (such as turnover, size of business premises, or type of activity) at predetermined rates.

According to the International Monetary Fund (2014), this system is effective in reducing tax administration costs for both authorities and taxpayers, as well as being a transitional tool towards a regular tax system. However, there is a need for periodic evaluation so that this scheme is not utilised as a permanent means of tax avoidance.

##### *Georgia: Comprehensive Tax Reform and Electronification*

Following the tax reforms of 2004-2006, Georgia simplified its tax system by reducing the number of tax types, lowering income tax rates, and adopting an automatic withholding system. One of the main innovations was the online tax reporting and withholding system for personal income. Based on a study by the OECD [24], Georgia recorded significant improvements in tax compliance and collection, without the need for a major expansion of collection resources.

##### *Russia: Flat Rate Tax and Withholding System*

Russia has since 2001 implemented a flat personal income tax of 13% through a system of direct employer withholding. According to a study by Ivanova, Keen, and Klemm [25], this change succeeded in increasing tax compliance and improving state revenue in the short term, as the system became simpler and more transparent. Although the system has been criticised for not being progressive enough, its implementation shows that simplifying rates and administration can have a positive impact on taxpayer compliance.

#### **H. Relevance of International Studies to the Indonesian Context**

International case studies show that simplification approaches such as final tax and presumptive tax regimes:

- Can improve voluntary compliance and tax ratios in the informal sector or lower middle income groups;
- Lower administrative burden and compliance costs for both taxpayers and tax authorities;
- This needs to be balanced with careful tariff policy design so as not to cause a significant decline in revenue.

The implementation of the MSME Final Income Tax in Indonesia has shown early success in these aspects. Therefore, a similar approach on certain employee incomes (e.g. non-permanent employees, or employees with low to medium income) could potentially provide similar benefits, as long as it is carefully and selectively designed.

## **Research Methodology**

### **A. Type of Research**

This research uses a qualitative approach with the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis method to evaluate the potential implementation of final tax on employee income. SWOT analysis was chosen because it is able to identify and evaluate internal and external factors that can affect the success of employee income tax simplification policies.

### **B. Data Source**

The data used in this research is secondary, obtained from:

- Literature and scientific journals related to income tax, final tax, and tax compliance;
- Tax laws and regulations in Indonesia;
- Official reports and documents of the Directorate General of Taxes (DGT);
- Relevant previous studies and research results.

### **C. Research Framework**

This research departs from the understanding that a complex tax system has the potential to reduce the level of taxpayer compliance, especially for employees and small to medium-sized businesses [13]. The current concept of employee income tax uses an Income Tax Article 21 withholding mechanism that is quite complex, thus creating an administrative burden for employers and taxpayers [6].

Alternatively, Shome's [17] research suggests simplification through withholding and final tax systems, which can reduce compliance costs and improve administrative efficiency. Empirical studies in Indonesia also show that the implementation of Final Income Tax for MSMEs has successfully increased compliance due to the ease of reporting and clear rates [3].

Based on tax compliance theory [11] and the results of these studies, it can be formulated that simplifying the employee income tax withholding system through the application of the final tax has the potential to increase voluntary compliance by reducing administrative burdens and strengthening taxpayers' trust in the tax system.

Therefore, this research uses a SWOT analysis approach to identify strengths, weaknesses, opportunities, and threats in the implementation of final tax on employee income as an effort to simplify administration and improve tax compliance.

### **D. SWOT Analysis Procedure**

The SWOT analysis procedure in this research includes stages:

1. Identification of Internal Factors  
Includes an analysis of the strengths and weaknesses of the current employee income tax system and the potential for simplification using a final tax. Aspects analysed include ease of administration, compliance costs, and clarity of tax rates.
2. Identification of External Factors  
Includes opportunities and threats originating from the external environment, such as fiscal policy developments, taxpayer compliance levels, and economic and social dynamics.
3. Evaluation and Synthesis  
Combining the results of the analysis of internal and external factors to formulate an optimal strategy for implementing final tax on employee income that can improve administrative convenience and tax compliance.

### **E. Data Validity**

To ensure data validity, this research uses triangulation of data sources by comparing various references, official documents, and results of previous studies. In addition, analyses were conducted systematically and based on relevant theories and conceptual frameworks.

## **Results and Discussion**

### **A. Strengths of Final Tax Implementation for Employees**

The implementation of final tax on employee income offers a series of strengths in terms of administration and collection effectiveness. Based on practices that have been implemented in the Final Income Tax for MSMEs, this system significantly reduces the burden of reporting and calculating taxes [3]. This is particularly relevant for small and medium-sized employers who have experienced difficulties

in calculating ITA 21 due to the complex calculation of components [6].

The final tax scheme also increases the predictability of the tax burden, which in turn can strengthen voluntary compliance. With a flat rate and simple procedures, employees can easily know the amount of tax levied on their income, without the risk of miscalculation that often occurs in progressive rate systems.

It also has the potential to reduce compliance costs for both taxpayers and tax administration, as emphasised by [13] and [9]. Simplification of the system means savings in time, resources, and reduced conflict between taxpayers and tax authorities.

### **B. Weaknesses of Final Tax Implementation for Employees**

Despite its strengths, the final tax also presents a number of weaknesses that need to be scrutinised. The most significant is the loss of vertical equity, as the flat rate system does not differentiate between low- and high-income taxpayers [4]. This potentially leads to an uneven proportional burden, where low-income employees will pay the same percentage of tax as high income earners.

In addition, this scheme also does not take into account the subjective conditions of taxpayers such as family dependents or other deductible expenses that have been taken into account in the Income Tax Article 21 system. This may reduce the positive response from the community, especially if there is no alternative or compensation mechanism provided.

Another drawback is the potential for abuse, where entities or individuals with high income can change the income scheme to appear as if it falls under the final tax category to obtain a lower rate [25].

Furthermore, three additional weaknesses were identified:

1. Potential for a heavier burden on low incomes: If the final rates are set without a minimum income threshold, very low-income employees could pay higher taxes than under a progressive system that provides a personal allowance. This could lead to resistance from vulnerable groups.
2. Loss of incentives to report additional income: Under the final regime, there is no benefit for employees to report additional income as it does not affect their tax liability. This could reduce transparency and accountability.
3. Elimination of Social Deduction Components: The final tax system does not take into account family dependents, pension contributions, and other important expenses that are typically compensated under the ITA 21 system. This could create horizontal inequity.

### **C. Opportunities for Final Tax Implementation for Employees**

Indonesia has a great opportunity to implement a final or presumptive tax regime for certain groups of employees. Case studies in India and the Philippines show that this approach can reach more taxpayers and promote significant tax base expansion [22].

With the high number of non-permanent and informal employees in Indonesia, a simple scheme can be a solution for segments that are difficult to reach with a complex formal tax system. Digitalisation of the DGT system also opens up opportunities for the implementation of automated and real-time withholding schemes, as successfully implemented in Georgia [24].

Another opportunity is the reinforcement of voluntary compliance, as described in the slippery slope theory [11]. When the system is perceived as fair, easy, and does not pose an excessive burden, the level of compliance tends to increase naturally without coercion.

#### ***D. Threats of Final Tax Implementation for Employees***

The main threat of this policy is a decrease in tax revenue if the final rate is set too low or the tax base is not optimally expanded. A study by Toder & Viard [19] confirms that without data driven simulations and fiscal modelling, changes to the tariff structure can be costly in the long run.

In addition, tax fairness may be compromised, especially if there are no firm restrictions on the segment of taxpayers who are eligible to use the final scheme. This may trigger resistance from certain groups of society, as well as weaken the legitimacy of the tax system as a whole.

Another threat is the fragmentation of the tax system if there are too many special regimes without sufficient consistency and control. As noted by the IMF [21], many developing countries have failed to maintain efficient presumptive tax systems due to weak postimplementation evaluation and control.

This research also identifies several additional threats:

1. **Vulnerable middle class segmentation:** Middle-class employees with incomes slightly above the final tax threshold may be subject to double taxation if they are ineligible but lack the resources for regular tax administration.
2. **Potential tax arbitrage by employers:** Companies may convert permanent employees to non-permanent status to qualify for the final tax scheme with lower rates, thereby avoiding annual reporting obligations.
3. **Data gaps and audit capacity:** In the absence of robust data infrastructure, the risk of abuse of the final tax scheme increases as tax authorities struggle to verify the accuracy of status and actual income.

#### ***E. Strengthening and Mitigation Strategies***

Based on the SWOT analysis above, suggested policy strategies include:

- **Segment restriction:** Application of the final scheme only to non-permanent employees or those earning below a certain threshold.
- **Optimal tariff determination:** Based on a simulation model of income distribution and its impact on state revenue.
- **Periodic evaluation and adjustment:** Ensure the scheme is not utilised for tax evasion or cause fiscal distortions.
- **Intensive education and socialisation:** Increase public understanding and acceptance of the new scheme.

#### ***F. Distributional Impact Simulation: Estimating the Burden Shift under Final Tax Regime***

To strengthen the practical relevance of the proposed final tax scheme on employee income, a simple microsimulation was conducted to estimate the distributional impact across different income groups. Five representative income brackets were used: very low (IDR 40 million), low (IDR 60 million), middle (IDR 90 million), high (IDR 150 million), and very high (IDR 300 million)

annual gross income. The simulation compares the tax liability under the current progressive Article 21 regime (considering PTKP of IDR 54 million) and a proposed 3% flat final tax on gross income.

The results (Appendix A & B) indicate that the final tax scheme imposes a heavier burden on low-income employees, especially those whose incomes are currently below the PTKP threshold and thus pay no income tax under the progressive system. Conversely, high-income earners stand to benefit significantly from the simplified scheme due to the absence of progressive marginal rates and deductibility limits.

This suggests that applying a flat-rate final tax indiscriminately across all employee categories would result in a regressive burden, undermining vertical equity principles. The risk is particularly acute for very low-income earners who could be taxed under the final regime despite being exempt under the current structure.

## **Conclusions and Suggestions**

### ***A. Conclusions***

This study finds that the implementation of a final tax regime on employee income in Indonesia holds considerable promise as a means of simplifying tax administration, reducing compliance costs, and expanding voluntary tax compliance, particularly for non-permanent and low-to-middle-income employees. Drawing from successful implementations in countries such as the Philippines, India, and Georgia, the key potential of such a system lies in its administrative efficiency and clarity.

However, the study also reveals significant challenges that require careful policy design. These include:

- **The risk of fiscal regressivity**, particularly for very low-income earners who may be worse off compared to the current progressive scheme with PTKP protections.
- **Loss of vertical and horizontal equity**, due to the elimination of family-based deductions and progressive marginal rates.
- **Administrative threats**, such as employer-driven tax arbitrage and risks of non-disclosure of income due to lack of incentive in the final tax design.
- **Audit and data limitations**, which pose risks of abuse if the system is implemented without robust monitoring mechanisms.

Simulation results indicate that while the final tax regime reduces burdens for high-income earners, it increases effective tax payments for lower-income groups—calling for policy safeguards to avoid unintended regressive effects.

Overall, a final tax scheme could serve as a transitional or segmented solution within a broader reform agenda, but must be applied selectively, guided by data, and coupled with ongoing evaluation mechanisms.

### ***B. Suggestions***

Based on the findings, the following recommendations are proposed:

1. **Minimum Income Threshold**  
Establish a lower income limit (e.g., IDR 75 million/year) to ensure that low-income employees who are currently exempt under PTKP do not become unfairly taxed under the final scheme.
2. **Targeted Segmentation**

Limit the application of the final tax to specific employee segments, such as:

- Non-permanent or contract-based workers
- Employees without dependents or with simple tax profiles

### 3. Optional Final Tax Scheme

Allow taxpayers the option to choose between the final and regular ITA 21 schemes. This voluntary model can be enhanced by offering administrative incentives (e.g., exemption from annual tax returns).

### 4. Data-Driven Tariff Design

Use microsimulation models to calibrate a flat tax rate that balances equity and fiscal adequacy, referencing income distribution and compliance elasticity (as per Toder & Viard, 2016).

### 5. Periodic Evaluation and Adjustment

Implement a dynamic policy mechanism for reviewing rate structure and eligibility thresholds, ensuring that the scheme adapts to economic changes and taxpayer responses.

### 6. Strengthening of Digital Infrastructure and Oversight

Invest in DGT's digital capacity to enable real-time verification and reduce reliance on manual compliance. This also includes the development of selective audit strategies to counter abuse.

### 7. Extensive Socialisation and Guidance

Provide clear technical guidelines and targeted socialisation to ensure both employers and employees understand the structure, eligibility, and obligations under the final tax regime.

## Implications and Limitations

This research is limited to analysing the potential implementation of final tax on employee income in Indonesia from the point of view of tax administration and compliance, without conducting primary data collection or direct surveys to taxpayers or related institutions.

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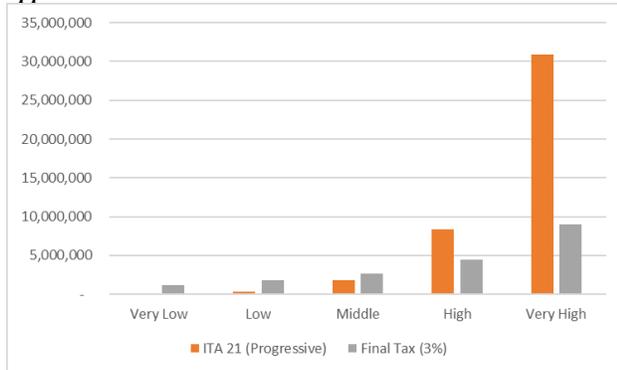
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**Appendices**

*Appendix A*

| Income Category | Gross Income (IDR) | PPh 21 (Progressive) | Final Tax (3%) | Difference  | Lighter Scheme |
|-----------------|--------------------|----------------------|----------------|-------------|----------------|
| Very Low        | 40,000,000         | 0                    | 1,200,000      | 1,200,000   | ITA 21         |
| Low             | 60,000,000         | 300,000              | 1,800,000      | 1,500,000   | ITA 21         |
| Middle          | 90,000,000         | 1,800,000            | 2,700,000      | 900,000     | ITA 21         |
| High            | 150,000,000        | 8,400,000            | 4,500,000      | -3,900,000  | Final Tax      |
| Very High       | 300,000,000        | 30,900,000           | 9,000,000      | -21,900,000 | Final Tax      |

*Appendix B*



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# *In Hot Water: Challenges with Measuring Data Center Water Usage*

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With the development of emerging technologies, data centers have emerged as critical yet resource-intensive facilities. While much scholarship has focused on their growing energy demands, far less attention has been given to their water consumption—despite its escalating scale and concentration in water-stressed regions. This article examines the challenges of measuring data center water usage by focusing on Water Usage Effectiveness (WUE), the industry’s primary water efficiency metric. We trace the development of WUE, evaluate its widespread use in industry reporting, and identify three major limitations: its dependence on IT energy consumption as a denominator, its seasonal variability, and its failure to account for water type and geographic context. We argue that while WUE provides value for internal benchmarking, its application as a regulatory instrument risks underestimating true water impacts and misdirecting policy. We conclude that policymakers should adopt a set of holistic water usage metrics to effectively analyze and reduce the impact of data center water demands.

**Keywords:** Data Centers, Sustainability metrics, Energy-Water nexus, Water, Environmental policy, Technology policy, Science & technology studies

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## **Introduction**

As emerging technologies like Artificial Intelligence, large language models, and 5G continue to expand, so do the digital infrastructures they rely upon. The largest of these are data centers, which are the infrastructures responsible for storing and computing all of our data. While these facilities are the backbone of all social and economic life, they historically have remained invisible to the public eye, and so too has their environmental impact. Over the past decade both academic researchers and popular news outlets have documented the massive energy demands of these infrastructures. To document these impacts, researchers are now contributing to the emergence of a new interdisciplinary field known as Critical Data Center Studies [1, 2]. As the material nature of the cloud continues to be unveiled, much of the research still focuses on their increasingly large power demand [3, 4, 5]. In comparison, much fewer examine data center water demands.

Data centers are extremely water-intensive. For instance, Meta totaled 3.1 billion liters of water in 2023 across all its data centers and offices [6]. For 2024, Microsoft reported using a total of 5.8 billion liters of water [7]. In the same year, Apple reported 6.8 billion liters employed, with 87% being freshwater [8]. Similarly, Google reported 30.7 billion liters of water used, with 27.3 billion liters (~88%) originating from freshwater sources [9]. In total, the International Energy Agency estimates that “global water

consumption for data centres is currently around 560 billion litres per year, and this could rise to around 1200 billion litres per year in 2030” [10]. But most of these estimates only account for the water that data centers use for cooling their servers. This omits the massive amount of water that data centers use in the construction phases of their projects and the even larger amount of water used for cooling the energy sources they depend on. In fact, the Lawrence Berkeley National Laboratory estimated that in 2023, the indirect water footprint of data centers in the United States was nearly 800 billion liters [11]. This is even more problematic considering that, in the United States, two-thirds of data center developments have been placed in highly water-stressed regions since 2022 [12].

Academics have begun to examine data center water usage. Some have shown the physical entanglements between data centers and their water usage in drought-ridden communities [13, 14]. Others have advocated for more transparency and reporting from big technology companies on their water usage [15, 16]. And a few are examining potential regulations for data center water usage in the context of emerging technologies [17]. Given this emerging focus, it is important to consider the metrics used to understand data center water usage. While there is a wide variety of research that critiques data center energy efficiency metrics, there is much less examining data center water metrics. In this article, we analyze Water Usage Effectiveness (WUE), which is the primary sustainability metric that

policymakers are considering to use for data center water usage regulation. First, we define WUE and track its development since being established in 2011. Second, we examine some of the ways in which WUE can be manipulated, making it difficult to use as a policy tool. Finally, we look to show that a holistic and multi-dimensional understanding of these impacts is essential to improving measurements for them.

### Water Usage Effectiveness

The most common metric that is used in the data center industry for water efficiency measurement is WUE. The definition of WUE (per ISO/IEC 30134-9:2022) is the ratio of the data center water consumption (in liters) to the sum of energy consumed by IT equipment (in kilowatt-hours) and is measured in liters over kilowatt-hours (L/kWh). A lower value indicates greater water efficiency; an ideal value close to 0 would indicate negligible or no water use. The metric was first established by the Green Grid in 2011, where they noted the importance of having both a WUE score and a WUE score that included both facility-based water usage and water used in the production of energy for the data center (WUE source) [18]. However, WUE source calculations are complex and highly vary based on the source of electricity, resulting in most users only tracking the efficiency of their facility-based water usage [11]. The WUE metric joined two other Green Grid data center metrics, Power Usage Effective (PUE) and Carbon Usage Effectiveness (CUE), to form the xUE family of metrics. It was designed to equip data center operators with the tools to produce a quick sustainability assessment for their facilities [19, 20]. Despite being in the same suite of metrics, PUE is utilized and reported far more than CUE or WUE. This has resulted in most of the research surrounding sustainability metrics for data centers to focus on PUE instead of other sustainability metrics [21, 22, 23]. However, some companies do report WUE and are using it to showcase sustainability improvements.

While WUE is a less commonly reported metric than PUE, it is still used widely throughout the data center industry as the primary water efficiency metric. A study by Lawrence Berkeley National Laboratory estimated that the average WUE of data centers in the United States for 2023 was 0.36 L/kWh [11]. Many large technology companies claim to be much more efficient. Microsoft, for instance, claims that they have improved WUE by over 80% from the early 2000s to 2023 [24]. In 2025, they reported an annual average WUE of 0.30 L/kWh, noting that direct to-chip liquid cooling was a major driver of their progress [7]. Amazon reported an average WUE of 0.15 L/kWh in 2024, a 17% improvement from the previous year [25]. Meta reported their WUE of 0.18 L/kWh in 2023, noting their progress from using air-cooling methods [6]. While it can be tempting to compare these figures, it is important to note that WUE varies widely by region. For instance, temperature fluctuates and more water is required for cooling in warmer regions, leading to a higher WUE. In addition, data center size has similar effects, where economies of scale cause larger data centers to typically have a smaller WUE [11].

Given the prominence of the metric, governments are looking to use WUE to regulate data center water usage. The European Union's Code of Conduct for Energy Efficiency in Data Centres now mandates the reporting of Water Usage Effectiveness for data centers [26]. The newly implemented German Energy

Efficiency Act requires this as well [27]. Singapore's Green Data Centre Roadmap also calls for the reduction of WUE to 2 L/kWh over the next decade, after the country's median WUE for large data centers was 2.2 L/kWh in 2021 [28]. China is also in the process of establishing data center water usage benchmarks using WUE, though it hasn't chosen an exact number [29]. While these policies are well-intentioned, they may fall short in reducing data center water consumption given some of the pitfalls of WUE.

### A Watered-Down Metric

While WUE is a standardized metric, it was primarily designed as a tool for internal benchmarking. As a result, it can be easily manipulated when used as a metric for public policies. Concerns have been widely documented regarding the data center industry's circumvention of sustainability metrics like the energy efficiency metric PUE [30, 31, 32]. However, critiques of WUE in the context of policy-making have not been widely discussed. There are three primary challenges with WUE that may water down the regulations that use it.

First, the denominator of WUE is the sum of energy consumed by IT equipment. This means that any data center operators who are solely focused on reducing WUE may potentially stop reducing (or even look to increase) their energy consumption, as higher energy usage would lower WUE scores. This becomes more concerning in the context of emerging cooling technologies. For example, hyperscale data centers turning to immersion cooling will dramatically reduce their water usage, while potentially increasing energy usage [33]. Despite the WUE showing an improvement for direct water usage, in reality, the same amount continues to be used. The resulting effects on the environment are actually worse because of power usage increases, which in turn also increases indirect water usage.

Second, WUE can change with the seasons. Given that much of direct data center water consumption comes from cooling, data centers have a smaller WUE during colder months and a larger WUE during hotter ones. Some data centers even use different cooling techniques during different seasons [34]. One study of a medium-sized data center in Maryland found that WUE varied from 1.3 L/kWh to 2.5 L/kWh over the course of the year [35]. Depending on how regulators monitor WUE, one could imagine that companies only measure their WUE during a cold month and report that score, which isn't truly reflective of the data center's water efficiency. As such, operations could exceed the regulations placed by policies without consequence, which ultimately makes legislation ineffective.

Third, WUE does not account for where the water is sourced. While some data centers are looking to use recycled water or non-potable water to cool their data centers, most still use freshwater [15, 36, 37]. Additionally, many data centers are placed in water-stressed areas [12, 16, 38]. While it's better for data centers to draw from non-freshwater resources or from areas with an abundance of water, WUE does not reflect either of these important factors. This is important for policymakers, as most policies are meant to cut down on freshwater consumption, especially excessive amounts in drought-ridden communities. If WUE is the only metric used for doing so, policymakers won't be effective at limiting these developments or supporting innovations that truly protect their communities.

In addition to all of these challenges, there are concerns that policymakers may misinterpret what WUE truly measures. WUE does not measure the total water consumption of data centers, nor the efficiency of water consumed by producing the vast amounts of energy these facilities require (unless they are using the WUE source metric), nor any of the water used in the supply chain. Mistaking WUE as a measurement that examines water use instead of water efficiency may leave policymakers believing a data center isn't draining their water resources because of a low WUE, while in reality, these facilities are using millions of gallons of water per year.

### Glass Half-Full or Half-Empty?

As policymakers look to limit the massive environmental impacts of data centers, they cannot afford to ignore their water usage. When considering the methods for regulating data center water usage, they must be careful in picking which metrics to focus on. While WUE is great for internal usage by data centers to compare the water efficiency of different cooling systems, it was never designed to be used to compare data centers, measure their water usage, or to inform regulation.

This doesn't mean that WUE should never be used by policymakers. It is still a widely accepted metric for measuring water efficiency, and has the advantage of being commonly understood and implemented by the data center industry. Governments mandating the reporting of WUE are gaining essential data that can help guide them to create stronger policies in the future. However, policymakers looking to limit the impact of data centers' water usage on their communities should use WUE in conjunction with other metrics designed to measure total data center water usage, including WUE site metrics that account for water type (fresh vs. non-potable) and source location (water-stressed or water-abundant). By using a more holistic suite of metrics, policymakers will have a stronger chance to curb the impacts of data centers on their communities' water supply.

While it can be tempting to see the large water demands of data centers as a glass half empty, it is not out of the question to see the glass as half full. Data center companies are increasingly reporting their water usage, implementing emerging technologies or restoration projects to reduce them, and policymakers are looking for ways to protect their communities from water stress. Further research into data center metrics, whether it be methods the data center industry is currently using or novel ones (perhaps accounting for water strain), may help create a digital future where the glass is no longer half-full, but overflowing.

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# Ekphrasis and the Other Point of View: Reinterpreting Grimké, Loy, and Rukeyser Through a Queer Lens

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This paper reinterprets ekphrastic modernist poetry through a queer lens, examining works by Angelina Weld Grimké, Mina Loy, and Muriel Rukeyser to challenge the patriarchal and heteronormative assumptions embedded in traditional ekphrastic analysis. The research asks: how does applying queer theory to modernist ekphrasis illuminate suppressed meanings and desires within these poems? Using a comparative literary methodology grounded in queer and feminist theory, the research is based on three poems that, when "queered," reveal subversive expressions of female and androgynous desire that dismantle the male gaze and disrupt the subject-object binary that underlies canonical interpretations of ekphrasis. The results demonstrate that Grimké rewrites the blazon form to express lesbian desire, Loy constructs androgynous poetics to subvert gender binaries, and Rukeyser uses poetic fragmentation and female-centered motifs to reject patriarchal artistic legacies. This paper concludes that queer ekphrasis offers a powerful interpretive tool, reshaping understandings of visual-verbal relationships in modernist poetry and expanding literary canon formation. The implications suggest that integrating queer analysis into ekphrastic studies can recover marginalized voices and transform how we engage with the intersections of gender, identity, and art.

**Keywords:** Queer Studies, Modern Poetry, Female Writers, Ekphrasis

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Virtually all of the canonical, published poets from the first half of the twentieth century have written an ekphrastic poem. Evidently, ekphrasis, the literary description of visual art, was a popular genre throughout the modernist era.<sup>1</sup> Ekphrasis continues to be important as contemporary scholars commonly recognize the relevance of images in wider society: "... when ekphrasis, broadly considered, may be the paradigmatic act in a culture of images" [11, p. 28]. A "culture of images" indicates the influence of art on the masses, so ekphrasis is significant because it represents how the public interacts with art. Notably, women and people of color also began to receive recognition in the modernist era, however, a standardized, white patriarchal lens has remained dominant in the ekphrastic genre, resulting in either a lack of recognition or a variety of views among scholars on many of those poets. This issue clearly manifests in W.J.T Mitchell's seminal essay "Ekphrasis and the Other," although recent feminist interventions have played an essential role in revising his argument. Nonetheless, LGBTQ writers could rarely be "out" in the modernist era, so it may not yet have seemed instinctive to pursue queer analyses of ekphrastic poetry.

Reconsidering modernist ekphrastic poetry with a more radical viewpoint is necessary to uncover alternative messages that are excluded by scholarly deficits. One way to do this is by applying a queer ekphrastic lens illustrated in a case study of poets Angelina Weld Grimké (1880-1958), Mina Loy (1882-1966), and Muriel

Rukeyser (1913-1980). In her poetry, Grimké expresses explicit lesbian desire for a female art object, thus applying queer content to traditional poetic forms. Loy uses formal poetic innovation alongside androgynous imagery. Finally, Rukeyser expresses lesbian eroticism in innovative feminine forms that draw on queer precedents like Gertrude Stein. After applying a new method for analysis to Grimké's "A Mona Lisa," Loy's "Brancusi's Golden Bird," and Rukeyser's "Waterlily Fire," the poems' meanings transform: they display greater attention to female desire and simultaneously deconstruct masculine understandings of Western art.

Scholar of literature and art history, W.J.T Mitchell, presents a well-known theory about the relationship between poetry and art in his 1994 essay, "Ekphrasis and the Other." Mitchell defines the concept of 'the other,' as "rival, alien modes of representation called the visual, graphic, plastic, or 'spatial' arts" [14, p. 156]. Specifically, he argues that ekphrasis is a means of confronting and engaging with the "other" by bridging the verbal and visual realms; a reader's empathy and imagination bolsters this concept, allowing them to understand others' experiences through this bridge [14, p. 152]. Mitchell explores how authors can utilize ekphrasis to represent and engage with marginalized voices, as art and literature can challenge dominant narratives [14, p. 162]. While Mitchell provides extensive insight into the effects of ekphrasis, his essay falls short in discussing female writers. He addresses this, saying, "My

examples are also canonical in ... the image identified as feminine, the speaking/seeing subject of the text identified as masculine. All this would look quite different, of course, if my emphasis had been on ekphrastic poetry by women” [14, p. 180]. Here, Mitchell is working within the male-dominated canon, completely overlooking poets like Grimké, Rukeyser, and Loy.

In an introduction to the 2008 book *Twentieth-Century Poetry and the Visual Arts*, scholar Elizabeth Bergmann Loizeaux offers a revised reading of ekphrastic poetry that complicates the established binary by including women writers. Like Mitchell, she looks at the longstanding popularity of ekphrasis, connecting ancient Greece and modern poetry; this highlights the genre’s potential as a tool for understanding social dynamics, as an ekphrastic poet is always responding to an artwork that already presents some certain view of the world [11, p. 5]. Loizeaux recognizes influential scholars writing about ekphrasis, and consequently, praises Mitchell’s recognition of the inherently social nature of ekphrasis. However, she contends that “Otherness is not always ‘rival,’ even when it is ‘alien,’” because ekphrasis transcends physical boundaries to connect the poet, art, and audience [11, p. 16]. Loizeaux also explains that ekphrasis is closely tied to its context, allowing for interpretations such as “Moore and Rich forging a twentieth-century American feminism through ekphrasis” [11, p. 18]. Along these lines, context will be crucial to understanding the poetry of Grimké, Rukeyser, and Loy. Furthermore, Loizeaux asserts that looking is not ethically neutral: she references Richard Wilbur’s 1947 poem “A Dutch Courtyard,” which exemplifies a male gaze imposed onto, and controlling, a female image [11, p. 8]. Loizeaux presents a valuable intervention by demonstrating the confines of ekphrasis and considering female poets, but she ultimately does not fill the gap in queer ekphrastic theory.

As follows, I will reexamine ekphrastic poems by three women poets: Grimké, Loy, and Rukeyser. Although none of these poets publicly identified as lesbian, Grimké and Rukeyser express same-sex erotics while Loy offers an androgynous perspective. Applying a queer lens to these poets entails critical analysis that “dismantles traditional assumptions about gender and sexual identities, challenges traditional academic approaches, and fights against social inequality” [7]. “Queering” a text does not necessitate that a writer is definitively queer, as the framework is intended to create avenues for new possibilities or readings. In addition, to battle the masculine narrative in the arts, it will be necessary to invert Mitchell’s theory of ekphrasis by studying women poets looking at male artists and building on Loizeaux’s deconstruction of the binary between poet and artwork. The remaining question is, how does looking at Grimké, Loy, and Rukeyser’s poems through the same queer ekphrastic lens offer transformative, unconventional readings?

Despite numerous analyses of each of the three poets over time, there are gaps in the overlaps of queer and ekphrastic readings. Scholar Maureen Honey, however, does consider sexuality in relation to ekphrasis, specifically looking at Angelina Weld Grimké. Honey writes, “Another way Sapphic modernism offers us a useful perspective is that it refers to Grimké’s generation of New Women, who challenged traditional gender roles through art and unconventional lives with a particular emphasis on love between women as a counterweight to male dominance” [6, p. 35]. This observation reflects a theme among scholars of Grimké: they connect the poet’s evident queerness to their interpretations of her love

poems. Honey looks at the 1927 poem “A Mona Lisa,” with an erotic interpretation. She compares Mona Lisa to an “irresistible siren” [6, p. 46] who the speaker engages with intensely and passionately. Though Honey considers Grimké’s queerness, she does not show that the poet expresses her same-sex desire within traditional forms of love poetry, in turn subverting the male observer versus female object norm.

Grimké was a biracial woman raised by her Black father. She was born to a well-known family in 1880 in Boston and completed a degree in Physical Education, but then started teaching English, which allowed her to pursue poetry and playwriting with a focus on the injustices faced by African Americans [6]. But, largely in the 1890s and 1920s, Grimké turned to love and female erotics as poetic inspiration [6, p. 32]. Grimké’s diaries and journal entries romantically focused on both males and females, though she would not have been able to publicly identify as queer. Many scholars believe her father knew of and disapproved of her romantic attraction to women [6]. Along these lines, much of Grimké’s love poetry expresses the torment of unachievable desire; she revealed in a letter that she is fascinated with the forbidden [6, pp. 29-31].<sup>2</sup> Therefore, it should be no surprise that these feelings manifest in “A Mona Lisa.”

In Grimké’s two-part poem, a speaker addresses “A” Mona Lisa—not “*The*” Mona Lisa (Fig. 1). They first think of Mona Lisa’s features, imagining interacting with them: the speaker “creeps” (line 1) and “sinks” (line 12) and “drowns” (line 15) in Mona Lisa’s eyes and lashes, creating a dangerous tone [5]. Yet, a sense of desire underlies these mysteriously vague lines and phrases, with the repetition of “I should like” (lines 1, 4, 8, 12) and soothing imagery of “leaf-brown pools” (line 6) and “glittering waters” (line 10) [5]. The use of first-person pronouns by a female writer, with the absence of an objectifying or otherwise obviously male gaze, indicates that the speaker is a female desiring a Mona Lisa, also female. Given the poem’s queer context, this speaker is likely Grimké or inspired by Grimké’s experiences. In fact, Honey notes, “Strengthening a reading of her speakers as female is the fact that Grimké often uses the pronouns ‘I’ or ‘my,’ reinforcing a connection between the poet’s gender and that of her speakers” [6, p. 33]. By closely observing Mona Lisa’s body, Grimké rewrites the blazon form and breaks down the subject-object dichotomy presented by Mitchell. Blazon poetry, traditionally by males and especially popular in the Elizabethan era, closely observes and lists a subject’s desirable physical features [3]. Through her observation of the Mona Lisa, Grimké removes the male gaze imposed onto the female body and embraces lesbian sexuality.

Though Grimké learned traditional verse in her schooling, she later practiced a modernist style of writing, including imagism and free verse. This shift allows for the intimate expression of “feeling and mood, immersion in the moment, and exploration of sexuality as a site of self-realization” [6, p. 37]. For example, in the first part of the poem, a consistently-structured description of the speaker’s cautious advance ‘into’ Mona Lisa transitions to a climax: “I should like to sink down / And down / And down . . . / And deeply drown” [5, lines 12-15]. Here, each line indents further than the prior, so that repeated words and sounds build on top of each other while visually pushing further into the page. The choice and arrangement of words conveys an impeding image that immerses the reader and then sets up a conundrum of the self and sexuality. After

the speaker moves closer to Mona Lisa and even seems to reach an erotic culmination, she existentially questions her place in her relationship with the subject: “Would I be more than a bubble breaking? / Or an ever-widening circle / Ceasing at the marge?” [5, lines 16-18]. While Honey views Mona Lisa as a dangerously alluring siren here, the danger doesn’t seem to come from Mona Lisa, but rather something internal in the speaker. When “A Mona Lisa” was written in the late 1920s, Grimké was fixated on death, often including motifs related to suffocation, burial, and drowning in her poetry—as is the case here. This imagery recalls the forbiddenness of queer relationships; therefore, the poem’s dark tone reflects the impossibility of a Sapphic lifestyle in Grimké’s contemporary world [6, pp. 68, 37].

Mona Lisa being Grimké’s subject is also significant because it challenges the traditional understanding of women in Western art. A large majority of recognized painters are men, often that represent idealized nude female bodies. In fact, Leonardo da Vinci’s famous 1503 painting was so desirable that it was stolen from the Louvre in the early twentieth century. “A Mona Lisa” undermines these expectations by pulling the speaker into unusual details of the painted woman and subverting the heterosexual norm. For example, in the painting, Mona Lisa has brown eyes, but no lashes like the subject of the poem, and Grimké’s “grasses” and “waters” are just hazy background elements of da Vinci’s composition. In addition, the title being “A Mona Lisa” rather than “The Mona Lisa” removes the societal hyperfixation on a certain woman. Loizeaux’s reimagining of a female subject from Wilbur’s “A Dutch Courtyard” is similar, to consider alongside “A Mona Lisa”: “When combined, as it often is, with the female gendering of the work of art in ekphrasis, the moving image can exert her power over the typically male viewer, sometimes rising up and speaking” [11, p. 20]. Neither the female in Wilbur nor Grimké’s poems literally confronts the viewer, however, Mona Lisa is undoubtedly exerting her power by rejecting the male viewer, and so is Grimké by actively creating this narrative.

While there is ample evidence of Grimké’s homosexuality, that is often not the case with other female poets. Nonetheless, queer ekphrastic theory is even illuminating in the case of heterosexual poets, such as Mina Loy who had queer aspects of her identity. However, due to this seeming contradiction, analysis of Loy’s 1922 poem “Brancusi’s Golden Bird” is strictly ekphrastic, as is the case for scholar Ashley Lazevnick. Lazevnick compares Loy’s poem to Constantin Brancusi’s sculpture (Fig. 2) and contextualizes the publication of the poem, including images of its composition in *The Dial* magazine (Fig. 3). She argues that Loy uses syntax to create a new understanding of artistic space. For example, the line indentations of “Brancusi’s Golden Bird” mirror the shape of the sculpture, and Loy uses alliteration and consonance to make the poem sound both “hard (like metal) and soft (like a bird)” [10, p. 196]. This reading of Loy’s poetry rarely strays from descriptions of words and art. In contrast, a queer ekphrastic reading of Loy’s poem reveals that she uses formal innovation with androgynous imagery.

Loy was born in 1882 in London and studied art in Munich. In 1916, she moved to New York, where critics labeled her a “modern woman,” and she found her place alongside magazine writers and artists. Loy’s early poems are autobiographical, satirically pulling on her view of misogynistic Futurists and observations of female oppression. These works received little critical attention but

anthologies such as *Others* and *The Dial* published them [10]. Loy was traditional in so far as she had male romantic partners, yet she still subverted the social norm in her explorations of androgyny. Poets from *Others* who explored hermaphroditism also surrounded Loy (i.e. Frances Gregg and H.D.). She even depicted figures of unclear gender in her paintings, such as “L’amour Dorloté par les Belles Dames” (1913) (Rosenbaum). However, most notably, scholars understand Loy to have been androgynous, and she is even quoted as saying, “Of course being the most female thing extant—I’m somewhat masculine.”<sup>3</sup> Further evidence that a queer ekphrastic framework is applicable is that Loy can also be thought of as queer in her rejection of traditional female sexuality. For example, in her 1914 “Feminist Manifesto,” she writes, “For the harmony of race, each individual should be the expression of an easy & ample interpenetration of the male & female temperaments... Woman must destroy in themselves, the desire to be loved—” [13]. This excerpt demonstrates a clear rejection of the submissive female/dominant male expectation.

Applying a queer ekphrastic reading to “Brancusi’s Golden Bird” allows for unconventional, unfeminine aspects of Loy’s identity to manifest. Loizeaux writes of minimalist art, “It understands the work of art as an object and is principally concerned with the relation of the beholder to that object: ‘the experience of literalist art is of an object in a situation - one that, virtually by definition, includes the beholder’” [11, p. 10]. Loy acts as the beholder in “Brancusi’s Golden Bird,” and she is thus included in her interpretation of the artwork. In the first half of the poem, the speaker imagines God creating the sculpture. But, more relevant to Loy’s position, themes of androgyny and the body are particularly noticeable in the second half of the poem through the combination of masculine and feminine imagery. For example, in the fourth stanza, Loy writes, “The absolute act / of art / conformed / to continent sculpture / —bare as the brow of Osiris— / this breast of revelation” [12, pp. 16-21]. The naming of Osiris, the ancient Egyptian god of death and rebirth, is an interesting reference to androgyny: he is a male figure, but also associated with creating life, and then here is followed by the image of a breast. However, the sculptural form itself restricts this “act of art,” serving as a possible double message: conformity among the masses ostracizes people who oppose the mainstream, and art constantly objectifies female bodies.

Another possible example of androgyny can be found in the fifth stanza. Loy continues to describe “The Golden Bird,” saying, “an incandescent curve / licked by chromatic flames” [12, pp. 22-23]. The “curve,” an image used to describe females, merges with the “flames,” where fire would be traditionally associated with masculine energy and gender expectations. Considering the smooth and solid material of Brancusi’s sculpture, one can read the curve and flames as becoming one, gender-fluid form. Loy’s poem connects an androgynous speaker and an androgynous art object, in turn breaking down Mitchell’s male-female binary. Loy also rejects the traditional poetic forms utilized by Grimké, for instance using fragmented lines and a complete lack of punctuation. This style leaves no semblance of male love poetry, allowing for a demonstration of queerness outside of masculine frameworks.

Another poet who utilizes stylistic innovation, but who is more evidently lesbian, is Muriel Rukeyser. Scholar Raphael C. Allison discusses Rukeyser’s ekphrasis generally, with a political, biography-based angle. Allison argues that by incorporating multiple

perspectives—image and word—through political ekphrasis, Rukeyser was supporting post-WWI democratic pluralism [1, p. 3]. This point of view is attributed to Rukeyser's time working in the 1940s as a "Visual Information Specialist" for the Office of War Information, which distributed 1.5 million war-posters [1, pp. 2, 4]. Rukeyser's 1962 poem "Waterlily Fire" has not attracted much attention from scholars in recent years, but Allison argues that it follows this legacy politically and ekphrastically. Allison also adds that "It is worth suggesting here that the war-poster was a particularly "masculine" genre, at least in terms of its reception, something else that perhaps turned Rukeyser's attention toward a different way to present visual experience" [1, p. 9]. Although Allison recognizes Rukeyser's use of ekphrasis to present alternative, overlooked perspectives and create societal change, he does not discuss Rukeyser's sexuality, excluding a major component of her life that is affected by political landscapes. A queer ekphrastic reading of "Waterlily Fire" would situate Rukeyser's poetic innovation within the legacy of other queer writers and reveal specifically-female desires.

Rukeyser was born in 1913 in New York City and grew up with aspirations to be a writer. She attended Vassar College, where she helped create an alternative literary magazine, reflecting her interest in political poetry. From then on, she wrote poetry about injustices facing people globally [9]. Her subjects range from international wars to her own identity as a Jewish woman, with popular themes including eroticism, passion, and love as responses to harm in the world [17]. During and after World War II, Rukeyser turned to life-writing, exploring her own and others' emotions [8, p. 258]. Considering this in conjunction with her work's popular themes, it is necessary to discuss Rukeyser's queerness, to try to understand the personal sentiments underlying her writing. She was in a long-term romantic partnership with her female literary agent, Monica McCall. Towards the end of her life, she was supposed to speak at a 1978 Lesbian Poetry Reading, but never did—and as such, her sexuality was never confirmed, and her intimate life continued to be private [8, p. 260].

Rukeyser's queerness nonetheless translates into her five-part poem "Waterlily Fire," inspired by the poet's experience seeing Claude Monet's *Waterlilies* (Fig. 4) catch on fire in the Museum of Modern Art. The first part of the poem, titled "The Burning," describes the destruction of the painting: "An arm of flame reaches from water-green glass, / Behind the wall I know" [16, lines 15-16]. Whereas Loy spends the entirety of her poem describing *Golden Bird*, Rukeyser proceeds to focus on everything but the painting, from the deterioration of New York to the birth of children. Similarly, the second section of "Waterlily Fire" focuses on change and growth rather than the painting, for example, seen in the floral line "Where blossoms like sex pink, dense pink, rose, pink, red" [16, line 68]. Despite this line solely consisting of flowers and colors, the repetitive listing is too definitive and intense to describe Monet's painterly composition of water lilies. Rather, the imagery metaphorically conjures female sexuality and genitalia, producing a sense of intimacy. Furthermore, Rukeyser's use of free verse and repetition is reminiscent of openly lesbian poet Gertrude Stein's, as seen in Stein's "Tender Buttons" (1914): "A sight a whole sight and a little groan grinding makes a trimming such a sweet singing trimming and a red thing not a round thing but a white thing, a red thing and a white thing" [18]. By evoking lesbian eroticism through

modernist forms, Rukeyser propels the legacy of formally innovative queer ekphrasis.

In addition to lesbian desire, "Waterlily Fire" expresses matriarchal desire in section five, which is about the changes one's body encompasses throughout their lifetime. The body, particularly as it relates to female sexuality, childbirth, and motherhood, is a motif in Rukeyser's work [2, p. 104]. The following lines describe the creation of life, removed from any indication of heterosexuality: "We pray: we dive into each other's eyes. / Whatever can come to a woman can come to me. / This is the long body : into life from the beginning, / Big-headed infant unfolding into child, who stretches and finds" [16, lines 134-137]. Rukeyser's focus on female subjects and experiences here is similar to ideas posed by *écriture féminine* ("women's writing"), a 1970s French feminist movement that sought to express a specifically feminine perspective because Western societies repress women's desire and language alike. Prominent thinker from the movement, Hélène Cixous, relevantly critiques the standard that "men create and women procreate" to establish a role for women as both mothers and writers that also deconstruct patriarchal binaries [4]. This seems to be a similar message conveyed by Rukeyser, where she centers matriarchal desire in her writing to challenge the notion that desire is inherently tied to traditional gender roles.

Rukeyser also defies gender roles by applying ekphrasis to the ruin of male art. Loizeaux considers other poems about Monet's waterlilies, but only ones by men, specifically Robert Hayden and Lawrence Ferlinghetti. In both cases, the poets described an eternal, ethereal quality in the artwork [11, p. 22]. Funnily, Rukeyser conveys exactly the opposite: she highlights the corporeal nature of art, despite its attempt to withstand the tests of time, by describing the destruction of Monet's painting. This poem reinforces that idea of time, such as in the lines "Stigma of dead stone, inert water, the tattered / Monuments rivetted against flesh" [16, line 80], which evoke something like a crumbling classical temple. Given that Rukeyser was surrounded by so many masculine war posters in the 40s, it is especially powerful that she describes art radically by separating it from its male creators.

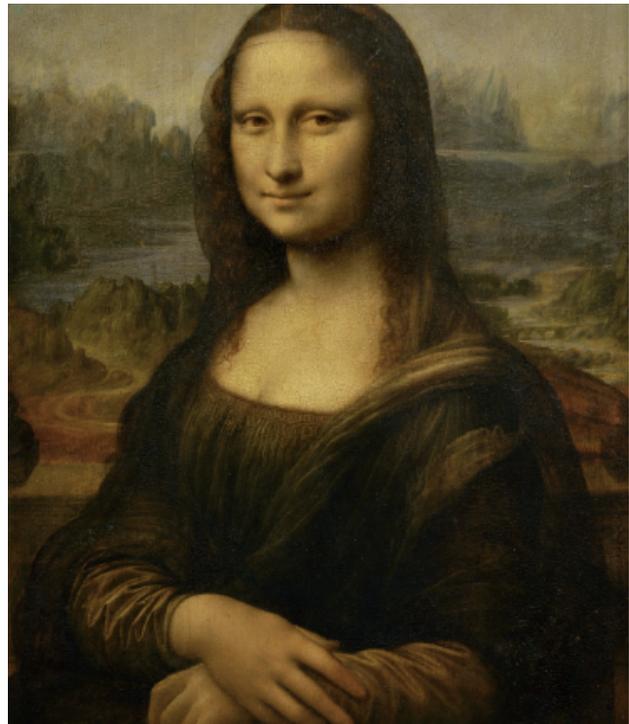
Looking at Grimké, Loy, and Rukeyser through one, queer ekphrastic lens liberates them from specific, exclusive readings. Thus far, there has been a discrepancy in how scholars look at poets. Honey does not describe the artistic implications of Grimké choosing "The Mona Lisa" as a subject, and neither Lazevnick nor Allison consider their poets' queerness. In conclusion, the exploration of ekphrasis within the context of queered modernist poetry reveals its potential for uncovering hidden meanings through alternative perspectives and challenging dominant narratives within the genre. Grimké, Loy, and Rukeyser radically reimagine both visual arts and poetic forms, challenging established patriarchal norms across their unique styles. As scholars continue to engage with and critique the intersections of poetry, art, and identity, it becomes increasingly clear that the study of queer ekphrasis offers a fertile ground for reexploring the modernist canon.

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## Appendix



**Figure 1:** . Leonardo da Vinci. Mona Lisa. c. 1503-1506. Artstor, [library.artstor.org/asset/LESSING\\_ART\\_1039490423](https://library.artstor.org/asset/LESSING_ART_1039490423).



**Figure 2:** Constantin Brancusi. Golden Bird. c. 1919-1920. The Art Institute of Chicago, <https://www.artic.edu/artworks/91194/golden-bird>.

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# The Influential Authority of the Corporation: How Citizens United v. FEC Redefined Legal Personhood, Political Jurisdiction, and the Societal Paradigm

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This paper examines how the landmark decision in *Citizens United v. Federal Elections Commission* reinforced corporate personhood by establishing the constitutional provision that corporations could influence electoral outcomes by way of monetary campaign support. Using early modern political theory, contrasted with the legislative history of corporate influence, this paper aims to define corporate personhood and assess its sociopolitical authority. With some reference to trade and labor statistics, the analysis mainly leverages a theoretical framework to answer the following questions: Which collective person is more powerful, the state or corporation? How do they operate under the social construct of artificial or collective personhood? By what metrics can we measure their authority? Through historical, theoretical, and legislative analysis, I conclude that corporations are issued an avenue of political autonomy that grants them a degree of control over the initial governing body that provided them this very freedom. Because corporations have influence over electoral outcomes, namely by unlimited monetary contributions to established Super PACs, their political personhood fundamentally informs the authority of the state. Finally, this paper examines the ideological component of corporate personhood's influence with reference to Wendy Brown's theory of "the neoliberalization of politics." This idea supports the general argument by underlining the ideological principles that promote neoliberalism in electoral or political contexts.

**Keywords:** Corporations, Legal Personhood, Citizens United, Neoliberal Order

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## Introduction

Democracy is constituted by electoral governments, and capitalism by a market economy. Together, the political-economy refers to the societal complex of government-market relations. Taking a closer look at the constitution of these structures calls into question the artificial personhood of both figures: the state, a collective person composed of individual subjects, generally represented by a governmental authority; the corporation, a collective person composed of individual managers and employees, oftentimes represented by a CEO and characterized as a market symbol. These two bodies come together to provide services, goods, and freedoms to their respective constituents: citizens and consumers. However, given these two artificial persons dictate nearly all sociopolitical dynamics, the authority of their personhood further distinguishes them from the natural persons they provide for.

According to modern political theory, representative governments are granted their authority from civil society, particularly the electoral means by which citizens give voice to their state. By this principle, it is the societal collective of the citizenry that

informs political outcomes. Corporations are granted their authority through the market and the financial institutions which regulate supply and demand. Accordingly, it is also the sociocultural body of consumers that informs economic dynamics. These dialecticals suggest that the collective holds the ultimate authority in political-economic affairs. However, considering the collective bodies afford their figures of authority the power of administration, it begs to question the implications of granting them constitutional personhood.

While theoretically, representative states govern all sociopolitical affairs, I argue that corporations are ultimately more powerful than any government on the basis that they are constitutionally-protected under the same rights and recognition as natural persons, who are the fundamental determinants of government authority. In other words, because corporate persons are deemed equal to citizens in juridical terms, corporations also become foundational to the establishment of states, making them not only the primary figures of societal authority, but legally constitutive of representative governments. Additionally, while it may be the

administrative jurisdiction of the state that grants corporations the rights of persons, it is ultimately the corporation that can influence the sociopolitical realm into expanding the constitutional terms of legal personhood.

### State Personhood

Understanding the development of corporate personhood requires a historical approach to the establishment of sovereignty and governance. In his book, *Leviathan*, published in 1651, Thomas Hobbes theorized that it is through “covenant” that individuals come together to form a civil society, effectively exiting the state of nature and placing authority in one figure, or the “head” of the state [1, p. 102]. About a century later, Jean-Jacques Rousseau expanded this theory under democratic principles, suggesting it is through elective participation that the authority of state personhood is made valid—direct democracy for the manifestation of the general will.

According to Hobbes, “a person is he whose words or actions are considered either as his own or as representing the words or actions of another” [1, p. 101]. In this context, Hobbes outlines the concept of artificial personhood as it pertains to the representatives of a society. This asserts the idea that one who represents the will of another is legally a person, granted authority by the terms of the aforementioned covenant. By this principle, the state is the personified will of the collective people it represents. This idea set the foundation for subsequent theorists to develop modern social contract theory. Notably, John Locke expanded on the principles of statehood in his 1689 publication, *The Two Treatises of Government*. The Lockean state is characterized by the separation of powers between distinct branches of government, coupled with the function of government power as “limited to the public good of society” [2, pp. 162-163]. These modifications progressed the concept of collective personhood through the figure of the civil state. In particular, Locke’s interpretation of the social contract reduces the power of the state from Hobbes’s appraisal of “absolute sovereignty” in the position of the representative [1, p. 138]. Instead, Locke suggests government authority based on the “consent of the governed” [2]. This revision of social contract theory established the ultimate authority of the governed as the vehicle allowing for a sovereign government; in essence, the virtue of popular sovereignty.

Decades later, Rousseau conveys his theory of state personhood through democratic virtues, including a defined figure who is tasked with establishing the ideological institutions necessary to create a properly-informed, civil society. In Book 2, Chapter 7 of *The Social Contract*, Rousseau, citing Montesquieu, states “it is the chiefs of republics who make the institution, and after that it is the institutions that form the chiefs of republics” [3, pp. 70-74]. According to Rousseau, the state is established through the institutions that create moral, civil, political agents; democratic people capable of maintaining democratic institutions. Once again, the state is depicted as the personification of the people’s will, and in Rousseau’s words, their “social spirit” [3, p. 73]. As a solution to the paradoxical relationship between a pre-existing society and initiating sovereign governance, Rousseau suggests that the “lawgiver,” or the representative, enacts legislative governance and establishes a just, democratic polity [3, p. 73]. As a representative of the society that grants the law-making powers, this figure initiates civil society by creating laws and institutions from which its people can have a general, collective will.

Together, these thinkers outlined the philosophical and political foundations for the Western models of sovereign government, noting that the state exists as the personified general will of its people. By this principle, the state is a person representing a collective, granted authority of governance by election from its own constituents. Put differently, it is the people, the collective, or the civil society that awards its institutions of governance the authority to rule, prosecute, and enact legislation. This idea laid the groundwork for the fundamental principles of the U.S. Constitution—the juridical doctrine that effectively grants corporate persons the legal and political rights of citizenship—as well as the framework for other forms of collective persons, including unions, churches, universities, and in the case of this analysis, corporations.

### Corporate Personhood

Hobbes also briefly points out the distinction between authorities of possessions and of actions: “...for that which in speaking of goods and possessions is called an *owner*, speaking of actions is called author” [1, p. 101]. By this logic, a company’s shareholders are the formal “owners” of the corporation, ultimately controlling it in the same way a sovereign would a state. The joint stock structure allows for a more distributed constitution of the corporation, but it nonetheless demonstrates the fundamental grounding for the corporate person, particularly Hobbes’s definition of personhood as representation; the corporate person *represents* the general interests and will of its many owners or shareholders. Considering the logic of incorporation, individuals collectively enter into a contractual relationship under the entity of the corporate name. The abbreviation “Inc.” indicates the process of “incorporation” of several individuals entering into the body of one company, creating a legally-distinct figure to represent their collective will, assets, and activity. This title not only implies the integration of many into the body of one, but it simultaneously awards the company with formal recognition from the state where it was established [4].

Another variety of modern business models, limited liability companies, are the legal distinctions of a natural person from their market body. While not necessarily corporations by definition, LLCs demonstrate the “separate entity status” that affords corporations distinct personhood, legally autonomous from the natural persons that create them [4]. According to the IRS, an LLC can be represented as either a corporation, a partnership, or as part of the owner’s tax return, “a disregarded entity” separate from the owner [5]. The natural person and the corporate person are held to distinct rights and responsibilities, shielding one another from the potential liabilities of the other body. As a result, the company exclusively represents the private interests of the corporate body, which are legally separate from the natural persons that form it.

Elizabeth Pollman’s work on “Reconceiving Corporate Personhood” offers a comprehensively historical, philosophical, and legal analysis of corporate personhood, concluding with a proposition for an alternative approach to understanding corporate rights and responsibilities. She mentions the “contractual” and “aggregate” conceptions of corporate personhood, the former being the notion of corporate personhood in order to protect individuals’ property and rights, as is the case with the LLC; the other being the idea that a corporation is the compound of its many shareholders or owners, as in the legal process of incorporation [6]. Ultimately, she argues, neither one of these conceptions align with the principles of

the modern corporation; rather, the modern business corporation has been made equivalent to the individual citizen, making it a distinct sociopolitical personality [6].

Under legal jurisprudence, it is the state that initially established corporate personhood through constitutional rights and political freedoms. The 1886 decision in *Santa Clara County v. Southern Pacific Railroad Co.* ratified the validity of corporate persons by extending the Equal Protections Clause under the Fourteenth Amendment to corporations. Interestingly, this idea was highlighted not in the Court decision itself but in part of a headnote written by a court reporter quoting Chief Justice Morrison: “The Court does not wish to hear argument on the question whether the provision in the Fourteenth Amendment to the Constitution which forbids a state to deny to any person within its jurisdiction the equal protection of the laws applies to these corporations. We are all of opinion that it does” [7]. Section 1 of the Fourteenth Amendment famously affirms the rights of U.S. citizenship, most notably, the rights to equal protection of the law and due process, specifically the principle that the state cannot “abridge the privileges and immunities” of those born or naturalized in the country [8]. This means that any “Inc.” or “LLC” established in the United States is automatically “born” into the constitutional rights awarded to all U.S. citizens. By expanding the rights of citizenship to corporations, the decision in *Santa Clara County v. Southern Pacific Railroad Company* ultimately ratified the legality of corporate personhood by expanding constitutional protection against infringement by the state to corporate entities. This juridical development brought forward the legal question of collective persons, as in states and corporations, as well as their degrees of authority relative to one another.

### **A Brief Juridical History of Federal Election Regulations**

The Federal Elections Campaign Act of 1971 established a comprehensive overview of federal campaigns regulations, requiring quarterly disclosure reports and developing a framework for political action committees [9, p. 3]. The following 1974 amendments formally established the Federal Elections Committee and also placed contribution and spending limits [9, p. 3]. However, in 1976, the decision in *Buckley v. Valeo* ruled that campaign spending limits violated the First Amendment [9, p. 3]. Decades later, the Bipartisan Campaign Reform Act of 2002 (BCRA), co-sponsored by Senators John McCain (R) and Russ Feingold (D) prohibited national parties, candidates, or officeholders from soliciting soft money contributions (influential funds not regulated by campaign finance laws) [9, p. 4]. BCRA also prohibited corporations and unions from using funds to finance electioneering communications which were eventually overturned in subsequent cases [9, p. 4].

Most recently, the landmark decision in *Citizens United v. FEC* (2010) further expanded the political agency of corporate persons. As stated by Chief Justice Kennedy, “The Court has recognized that First Amendment protection extends to corporations” [10]. This decision overturned part of *McConnell v. FEC* (2003) that upheld §203 of BCRA which had prohibited monetary disbursements for electioneering communications from corporate or union entities [11]. Similarly, in 2014, *McCutcheon v. FEC* determined aggregate contribution limits invalid [9, p. 10].

Not only did these court decisions reaffirm corporate personhood, they simultaneously reshaped the very nature of representative democracy; if governments are constituted by citizens, and corporate persons are granted the same political rights as citizens, then corporations fundamentally become part of the collective that comprise democratic states, existing as political constituents possessing the constitutional freedoms of political speech.

Theoretically, if the administrative jurisdiction of government is the technical vehicle of politics and legislation, it is seemingly the state that holds dominion over all sociopolitical affairs. However, a greater paradigmatic shift has seemingly reversed this power relation: corporations now possess the right to influence political outcomes with capital, and the very economic logic inherent to the corporate person is now superstructural to the procedures of governance, law, and society. In general terms, the personhood of states is granted by the elective constitution while the personhood of corporations is rooted in the capacity to enact sociopolitical and cultural changes.

As demonstrated by juridical and legislative history, the question of corporate personhood is predominantly a legal debate. However, the behavioral practices of the corporation suggest an interest in continued existence—the capacity for cultural influence, legal responsibility, private interests, and monetary freedom, infamously manifested in the accumulation of capital profits. A 2003 documentary, *The Corporation*, examines the psycho-social characteristics and externalities of capital transactions imperative to the survival of corporate persons [12]. The film reviews various case histories of the harms and damages committed by corporations, including threats to labor relations, harm to human and non-human lives, as well as pollution of the biosphere [12]. The film cites destructive instances of anti-union tactics, widespread layoffs, habitat destruction, animal testing, CO<sub>2</sub> emissions, among other externalities as examples of how it is the *ontology* of corporations that makes them not only person-like, but significantly influential against others, including natural persons, landforms, other collective persons, social relations, and more [12]. This suggests that corporations’ influence spans far beyond the political-economy, posing consequences on humanitarian, environmental, and paradigmatic levels.

### **Which person is more powerful? How do they impact one another?**

The question of which collective person has more power is essentially a matter of context. Legally, government representatives have the authority to grant and withhold freedoms but societally, corporations bear the economic and cultural influence to enact political change by participating in the electoral institution.

It is important to note that there are specific bureaucratic and militaristic liberties in the hands of states that corporations lack. For example, the capacity to sign treaties, go to war, suspend or enforce laws when necessary—these are all instances of freedoms exclusive to governments and their administrative authority. However, these instances of political affairs can often be credited to the economic incentives for contract or war: entering trade agreements and tax treaties, or mediating disputes over commodity control by enacting trade wars via tariffs or sanctions. While these examples are only indicative of some instances of foreign affairs

driven by economic factors, they are becoming increasingly relevant in contemporary global politics; for instance, the 2020 termination of the North American Free Trade Agreement (NAFTA), which reduced trade barriers between Canada, the United States, and Mexico since taking effect in 1994 [13]. Despite NAFTA's replacement by the more comprehensive and modernized United States-Mexico-Canada Agreement (USMCA), the Trump administration launched a trade war against Mexico and Canada beginning in February 2025, citing national security threats as reason to exercise the International Emergency Economic Powers Act [14]. While the provocation of this cross-border political issue is more militaristic in nature, the actions by which the politics are fought are inherently economic. This suggests that while administrative capacity defines the authority of states, it is instead the economic sphere, and thus the corporation that carries greater weight in determining contemporary political affairs.

This also raises the question of global jurisdiction. If a state is limited to the scope of its national borders, is a multinational corporation not by its very nature more far-reaching and influential than a single state? Through foreign direct investment, MNCs wield capital influence over international trade, the global labor market, sociocultural demand, and other avenues of the global political-economy. For instance, according to OECD data, MNCs accounted for 36 percent of global exports in 2016 and over half of imports, particularly in “knowledge-intensive” goods and services [15]. Additionally, based on a study conducted by the National Bureau of Economic Analysis, increased production offshoring (defined as investing in foreign affiliates by vertical multinational corporations) drives declining employment among non-multinational firms in the same industry [16]. Not only do MNCs have a growing influence over the circulation of goods and services, they also possess greater access to international labor and consumer markets. In the globalized world, an increasing number of corporations extend across borders, influencing foreign trade of products, labor, and consumers. This development conveys that multinational corporations possess a global influence that individual states often lack, suggesting that corporations hold the potential to supersede global economic authority. Moreover, enforcing international trade regulations is often a complex and nuanced issue, offering an advantage to these enterprises in the global marketplace. This demonstrates that corporations are not only more powerful than governments, but they can balloon into hegemonic global figures, also impacting smaller, local corporate persons.

Ultimately, sociopolitical influence is the primary factor driving the argument that corporations wield political authority. Wendy Brown, a political theorist whose work spans from the topics of the political-economy to critical legal theory, speaks on the ideological influence of the neoliberal order, expressing issues with how economic market principles override the political. Brown not only discusses the legal history of corporate personhood, but ultimately alludes to a greater structural argument about the transformative influence of corporations on sociopolitical ontology, what she deems “the neoliberalization of politics” [17, p. 155]. Her central argument is that political speech has become equated with capital; since the corporation's capacity for speech is limited to campaign spending, the market logic of capital flow becomes increasingly superstructural to the political realm. Brown's analogy of democratic politics as a “marketplace” wherein the “goods” of

opinions, ideas, and votes are established through free speech demonstrates the economization of politics; in this metaphor, “speech” is the capital of the political marketplace [17, p. 155]. This means that the constitutional development of *Citizens United* made the freedom of speech equivalent to the unlimited campaign contributions allowed by corporations; in effect, the civil liberties of the First Amendment also became capital rights [17, p. 160].

It is primarily through unlimited contributions to certain political actions committees (PACs) that corporations can exercise the right to free speech, specifically political speech—a right granted to them in the *Citizens United v. FEC* decision. Super PACs, according to the Federal Election Commission, “are independent expenditure only action committees” [18], meaning any contributions they receive finance elections communications that express advocacy for a campaign or other independent political activity [19]. Unlike traditional political action committees, Super PACs may raise unlimited funds from contributing figures, whether it be individuals, unions, or corporations [18]. PACs are the most significant contributors to federal campaign funds. According to 2024 FEC data, the vast majority of federal campaign funding came from political action committees; by April 2024, total campaign financing was just over \$8 billion, \$5.6 billion of which was contributed by PACs [20]. While Super PACs are not the only avenue through which corporations can influence an electoral campaign, they are the most indicative of corporate authority to assume the political liberty of providing limitless financial support for or against electoral campaigns. Based on the legal precedent that corporations are considered equal to individual citizens, campaign contributions from natural persons and corporate persons are, by definition, also equal; meaning each dollar donated by an individual or a business holds the same value—only most businesses often have much more to offer than individual people. This begs the question: whose interests are more likely to influence political affairs?

According to David Harvey in his book *A Brief History of Neoliberalism*, the neoliberal order largely manifests in the institutional frameworks of private property, deregulated markets, and free trade [21]. Harvey asserts that under neoliberalism “the role of the state is to create and preserve these practices” through its administrative, militaristic, and legal jurisdictions [21]. The late 20th century witnessed a significant neoliberal shift from the post-war era of Keynesian economics wherein state intervention and market regulation were imperative; this suggests that neoliberalism can also be defined as a societal paradigm. This is supported by Brown's analysis in that the neoliberal rationality not only influences economic and political affairs, but as made evident by juridical history, now establishes principles for interpreting the Constitution [17, p. 164]. Harvey's and Brown's critical analyses also suggest the preeminence of economic determinism, the idea that the economy is foundational to sociological and political dynamics.

Quoting the opinion in *McConnell v. FEC* (2003), Chief Justice Kennedy states, “The fact that a corporation, or any other speaker, is willing to spend money to try to persuade voters presupposes that the people have the ultimate influence over public officials” [10]. Accordingly, political action committees use money to influence voters, which presumes that voting is the definitive mechanism of political change. However, could this principle not also suggest that votes are merely a medium through which corporations can influence legislation [17, p. 155]?

Consider this thought experiment: if a polity votes to reduce corporate personhood, that is, enact strict market regulations or reduce corporate freedoms, would the polity be the ultimate authority? By this logic, the constituents, by way of state representation, control the capacities and scope of the corporation. What if instead a corporation lobbies government officials into lifting regulations or enacting business tax cuts, effectively strengthening the political autonomy of the market? Is the power in the hands of the elected representatives that grant the freedoms or in the corporations that influence the representatives toward passing certain legislation?

In all, corporate persons have become increasingly influential in the sociopolitical realm. As expressed by Brown, quoting Foucault, “the juridical brings form to the economic,” particularly in the neoliberal paradigm [17, p. 151]. Brown’s analysis expands this theory even further: law and legal reasoning fundamentally economize other ideological spheres, particularly the political [17, p. 151]. As a staunch example, *Citizens United* determined the right to free speech as applicable to the voices of individual citizens *and* to campaign financing from corporations. The neoliberal order has intensified the role of the corporation from an ideological perspective, exemplified by the proliferation of conservative administrations, welfare retrenchment, the deregulation of the private sphere, and austerity-based policy agendas. Through its artificial personhood, the corporation personifies the essence of neoliberalism; as a result, the vehicle of social change is neither driven by the individual person nor the collective, but instead the artificial.

### Conclusion: How do we define authority?

Evidently, as collective legal persons, the state and the corporation are members of a greater sociopolitical network. In the game of the political-economy, states and corporations play for opposing teams, the public and private spheres. Each player is equipped with different instruments of influence, legislation or capital. To further this analogy, the score of the political-economic game is ever-changing. Historically, the state was embodied by an absolute sovereign, as in the Hobbesian case, but currently, the neoliberal paradigm positions corporations in an exceedingly influential role. In the end, we must ask ourselves, what *kind* of authority is more powerful: governance or influence?

Having established the juridical personhood of states and corporations, society manifests itself through these two collective avenues: democracy and capitalism. While topics this grand cannot be thoroughly analyzed in just one paper, the legal equivocation of their value poses ideological questions worthy of our inquiry: How is artificial personhood different from the natural? In what ways is the corporate person more or less powerful than a natural person? How do other entities contrast with the collective person, such as landforms, animals, or artificial intelligence? Is it the prospective scope or the retrospective qualifications of personhood that determines who (*or what*) is (*or is not*) a person? Put differently, is it that we expand the definition of legal personhood to extend its privileges, or instead that these non-human entities develop into persons based on our understanding of personhood?

In terms of a normative argument, I fundamentally agree with Pollman in that I do not think corporate personhood should be equated in the constitutional bounds of natural citizenship [6].

Legally, corporations must be recognizable for the purposes of accountability or liability— otherwise, they could commit atrocious human rights violations or pollute protected lands without any consequence. However, affording corporations the civil rights of free speech and equal protection poses a threat to the representative framework of democracy. The political sphere fundamentally decides the composition of the state, meaning the more corporations can contribute to politics, the more representation they will see in government.

Throughout my research I encountered an array of philosophical debates and ontological questions, many of which are not only subjective, but seemingly indefinable. However, my greatest takeaway is best conveyed in Astra Taylor’s discussion of democracy. Citing Hannah Arendt, she states that “Rights are not inborn or ‘inalienable.’ Instead they are agreed upon, or ‘socially constructed’... We possess rights only when we are counted as members of a particular political entity that recognizes and ensures them” [22, p. 96]. By this principle, corporate personhood is made powerful by our *recognition* of it. The decision in *Citizens United v. FEC* simply made this a juridical question rather than a philosophical one. Ultimately, however, the more value we place in the economic realm, the more the corporation is liberated in its scope and freedoms to influence the political. In order to preserve the integrity of democratic values, it must be the collective of natural persons that give voice to the corporate, not the reverse.

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**SURJ**

**NATURAL SCIENCES  
& ENGINEERING**

# Effects of Ancymidol on Tall Mutant Brassica Rapa Growth

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This experiment investigates the effects of ancymidol, a gibberellin (GA) inhibitor, on the stem growth of wild-type (WT) and tall mutant Brassica rapa (*B. rapa*). GAs are plant hormones that promote stem elongation. The tall mutant which overproduces these GAs, was said to show reduced elongation when treated with ancymidol. To test this, both genotypes were divided into control and experimental groups, and developed over thirteen days with treatments on Days 0 and 7 and measurements on Days 0, 4, 7, 10, and 13. WT plants showed no significant response to ancymidol, with final heights nearly identical between groups. However, the tall mutants exhibited a visible effect and those treated were significantly shorter than the control. These results support the hypothesis that ancymidol inhibits growth in GA concentrated plants.

**Keywords:** Brassica Rapa, Mutation, Hormones, Gibberellin, Inhibitor, Ancymidol

**DOI:** <https://doi.org/10.60690/yrbzm094>

## Introduction

*B. rapa*, or Wisconsin fast plant, is an upright species of fast-growing plant in the mustard family (Brassicaceae) [1]. It is considered a model organism for study because it has highly responsive hormone signaling pathways and various available mutants [2]. Plant hormones act as chemical messengers that regulate growth, development, and environmental responses. Synthesized in specific tissues, they are transported via the phloem, xylem, or cell-to-cell diffusion to reach various regions of the plant. The hormones then bind to specific receptor proteins and elicit a cellular response. This movement is referred to as a hormone signaling pathway [3].

*B. rapa* is exceptionally responsive to hormones like GAs, which visibly affect traits such as plant height and flowering time. Through cell expansion, GAs contribute to the elongation of stems and other organs, making them key determinants of a plant's height. Cell expansion is triggered when GAs activate enzymes that break down the cell wall, decreasing the cell's water potential, and allowing the cell to expand [4]. Ancymidol, a growth retardant, inhibits GA production by blocking an enzyme known as monoxygenase, a catalyst in GA biosynthesis [5].

The tall mutant exhibits significantly elongated stems compared to the WT. This is caused by low levels of a GA regulator protein called phytochrome B. Lower levels of this protein are due to the fragmenting of the PHYB gene, disrupting how the gene is expressed [6]. Phytochrome B typically acts as a brake on GA synthesis, but its absence allows the hormone to accumulate unchecked. Ancymidol offers a way to test the relationship between GA and plant height experimentally. This study centers on the hypothesis that the tall mutant treated with ancymidol will have a

reduced height, similar to the untreated WT *B. Rapa* plant. The experimental results of this study provide significant evidence that ancymidol does decrease the height of the tall mutant, and that this result is similar to that of the controlled WT *B. rapa* plant.

## Materials & Methods

### *A: Organisms*

In this experiment, WT and tall mutant strains of *B. rapa* were used. Two styrofoam quads were prepared for each genotype, four quads in total. Each contained at least eight plants to allow for statistical significance. All plants germinated under identical conditions, and experimental treatments began eight days later.

### *B: Chemical Treatment*

Ancymidol, used at a molar concentration of  $4 \times 10^{-4}$  M, was purchased from Sigma Chemical Company (St. Louis, MO). Genotypes were divided into experimental (treated with ancymidol) and control (treated with double-distilled water) groups.

### *C: Growth Equipment and Setup*

Height was measured using 15, 30, and 45 cm rulers. On Day 0, wooden stakes were inserted into the soil of each quad and tied to the stems below the apical bud using sewing thread. No more than two stems were to be tied to each stake. Labels were attached to quads to indicate genotype and treatment group. Height was measured from the base of the soil to the tip of the apical bud; once flowering occurred, measurements extended to the tip of the flower. Micropipettes were used to treat each leaf. All equipment was purchased from Carolina Biological Company (Burlington, NC).

#### D: Growth Conditions

All quads were placed on a moist felt mat connected to a water reservoir, allowing constant irrigation. Each quad had wicks extending from the bottom, enabling water to move through the felt into the soil. All plants received equal exposure to light and were housed in a communal room to maintain uniform temperature (20°C). Light duration was constant and was provided by an artificial light source.

#### E: Timeline

This study lasted 13 days, including two treatment and five measurement days. Treatments occurred on Days 0 and 7, while the height was noted on Days 0, 4, 7, 10 and 13.

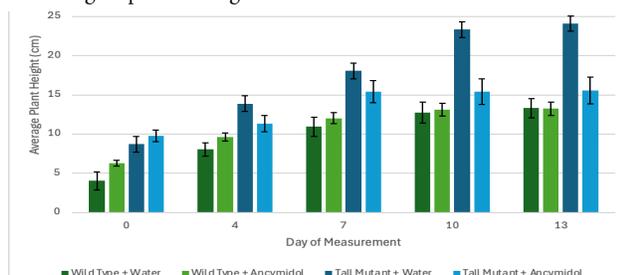
#### F: Data Logging

Measurements were entered into Microsoft Excel. The mean, standard deviation, and standard error of plant height were calculated for each treatment group and time point. Statistical significance was then assessed by the evaluation of the standard error bars. If bars overlapped, there was no significant difference. The procedures followed in this experiment were based on the Laboratory Manual for Organismal Biology [7].

### Results

Stem height measurements revealed apparent differences in growth patterns between treatments and genotype groups. On Day 0, heights were comparable; the WT control group began with an average height of 4.02 cm, while the experimental group began at 6.26 cm. Despite this slight difference, the two groups had no statistically significant differences throughout the procedure, as the error bars on the graph overlapped at all points (Figure 1). By Day 13, the WT control and experimental groups reached final heights of 13.30 cm and 13.23 cm. This outcome was unexpected, as we believed that ancymidol would reduce *B. rapa* plant height. This suggests that WT *B. rapa* may be less sensitive to GA inhibition than previously thought.

In contrast to the WT, the tall mutant groups displayed a pronounced response to ancymidol. As early as Day 4, a statistically significant difference in height between the treated and control mutant groups emerged, as seen by the separation of the standard error bars in Figure 1. This supported our hypothesis, and from Day 4 on, this trend continued to increase. By Day 13, the untreated mutant group reached an average height of 17.38 cm, while the treated mutant group measured only 13.25 cm, closely resembling the WT groups' final height.



**Figure 1:** Average *B. rapa* Height; Treatment of Wild Type and Tall Mutant Plants with Ancymidol and Water

### Discussion

The limited effect of the ancymidol on the WT genotype was unexpected. We initially believed that applying ancymidol would inhibit GA biosynthesis by limiting the needed production of the monooxygenase enzyme, thereby reducing stem length. However, the treated WT plants showed little to no difference in growth compared to the control group. This could be attributed to several factors, including already low endogenous GA levels in the WT, hormonal feedback mechanisms, or insufficient ancymidol concentration. A study by John Shive and Hugh Sisler [8] supports the interpretation of WT plants having lower endogenous GA levels. Their study confirms that ancymidol targets GA biosynthesis, but more importantly, suggests that ancymidol is most effective in plants with high endogenous GA activity. This discovery aligns with our findings that the tall mutant, with its elevated endogenous GA levels due to a defective phytochrome B pathway, responded strongly to the treatment. In contrast, the WT with lower levels did not.

The tall mutant's strong response to ancymidol further supported our initial hypothesis that the treatment will reduce stem elongation in the mutants. The tall mutant has an abundance of endogenous GA and depends heavily on GA signaling to maintain its elongated nature. Therefore, adding ancymidol, which inhibits monooxygenase, significantly disrupted this process. As a result, there was a significant reduction in stem growth between the ancymidol treated experimental and untreated control groups. The experimental group ultimately had a final height comparable to that of the WT plants because the ancymidol's regulation of GA biosynthesis reduced the hormone's activity to levels more characteristic of the WT.

Overall, this experiment highlights the utility of hormonal mutants in investigating plant development and chemical regulation. The tall mutant demonstrates how a single mutation can shift hormonal balance and physical outcomes. These findings have broader applications, mainly in agriculture, where understanding hormone regulation can inform selective crop growth, controlled breeding, and the usage of growth inhibitors to manage plant size. Farmers could use tactics such as adding an inhibitor like ancymidol to reduce stem elongation without affecting flowering, or adding a substance similar to GAs to increase crop yield. In future experiments, we could have improved our procedure by testing different concentrations of ancymidol to see varying effects based on dose and if a limiting threshold exists. This study demonstrates that growth regulators such as ancymidol serve as powerful tools for investigating and controlling hormonal function in plant development, particularly when applied to mutant genotypes with altered hormone signaling pathways.

Wild type and tall mutant *B. rapa* plants were treated with ancymidol, a growth inhibitor, and were measured every 3 to 4 days. The standard error is significant for the tall mutant plants but not for wild type plants. Overall, the ancymidol did not affect the wild type plants, but decreased growth for tall mutant plants compared to the controls.

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# NeurOM: Analyzing the Effects of OM Chants on Human Brain Activity Using EEG and Machine Learning

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This study investigates the impact of OM chanting on human brain activity through the analysis of EEG signals. Utilizing a dataset of over 10,000 EEG recordings, we extracted features such as skewness, variance, kurtosis, and Shannon entropy. Machine learning models, including Support Vector Machines (SVM) and Random Forests, were employed to classify pre- and post-meditation states. The Random Forest model achieved an accuracy of 84.2%, outperforming the SVM model. SMOTE was applied to handle class imbalance, further enhancing accuracy to 89.1%. These findings provide quantitative insights into the neurophysiological effects of OM chanting, contributing to the scientific understanding of sound-based meditation practices.

**Keywords:** OM chanting, EEG analysis, machine learning, Random Forest, Support Vector Machine, SMOTE, meditation effects

**DOI:** <https://doi.org/10.60690/vy449t92>

## Introduction

Meditation practices, particularly those involving sound, have been integral to various cultures for promoting mental well-being. OM chanting, regarded as a primordial sound, is believed to resonate with the universe's natural frequency, potentially influencing brain activity. This study aims to quantitatively assess the effects of OM chanting on the human brain by analyzing EEG signals and employing machine learning techniques to classify changes in brain states.

Research has consistently shown that meditation can modulate brainwave activity, promoting relaxation, emotional stability, and cognitive focus. However, there is limited exploration of the specific effects of sound-based meditation, particularly OM chanting, using EEG data and machine learning.

This paper addresses this research gap by analyzing EEG signals collected during OM meditation and using machine learning to classify pre- and post-meditation brain states. Additionally, it highlights the effect of SMOTE on improving model accuracy by balancing class distributions.

## Literature Review

### *A. Meditation and EEG Analysis*

Studies have shown that meditation increases alpha and theta brainwave activities, which are associated with relaxation and focus. These effects have been observed across various meditation techniques, including mindfulness and transcendental meditation.

### *B. Sound-Based Meditation*

OM chanting has been shown to influence brainwave patterns, promoting a sense of calm and reducing stress levels. However, the specific neurophysiological changes induced by OM chanting remain underexplored, particularly using advanced analytical methods such as machine learning.

### *C. Machine Learning in EEG Analysis*

Machine learning models have been widely used to classify EEG signals for applications such as cognitive load assessment, mental health diagnostics, and emotion recognition. This study leverages these techniques to analyze the effects of OM chanting on brain activity, addressing a significant gap in existing research.

## Methodology

### *A. Data Collection and Preprocessing*

EEG data were collected from 10,000 participants under controlled

conditions. Each participant engaged in a 30-minute OM chanting session, with EEG signals recorded both before and after the session. These recordings captured brain activity across multiple channels, providing a comprehensive dataset for analysis.

- 1) SMOTE for Class Imbalance Handling: The dataset was initially imbalanced, with fewer samples in the postmeditation state (Class 1). SMOTE was applied to balance the dataset, generating synthetic samples for the minority class and significantly improving model performance.

### B. Feature Extraction

Statistical features were extracted from the EEG signals:

- Skewness: Measures the asymmetry of the EEG signal distribution.
- Variance: Captures the signal's variability.
- Kurtosis: Quantifies the "tailedness" of the EEG signal distribution.
- Shannon Entropy: Represents the complexity of the signal.

### C. Model Training and Implementation

- Support Vector Machine (SVM): A supervised learning algorithm that identifies a hyperplane to best separate the pre- and post-meditation EEG data points.
- Random Forest: An ensemble learning method that constructs multiple decision trees to classify EEG signals. Predictions from all trees are aggregated for a final decision.

The dataset was split into training and testing subsets using an 80-20 split. Hyperparameter tuning was performed to optimize each model's performance.

#### Feature Extraction Code:

```
import numpy as np

def extract_features(eeg_signal):
    skewness = np.mean(eeg_signal)
    variance = np.var(eeg_signal)
    kurtosis = np.mean((eeg_signal - np.mean(eeg_signal))**4) /
                (np.var(eeg_signal)**2)
    shannon_entropy = -np.sum(eeg_signal * np.log2(eeg_signal + 1e-10))
    return skewness, variance, kurtosis, shannon_entropy
```

#### Model Training Code:

```
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score

# Train SVM Model
def train_svm(X_train, y_train):
    svm_model = SVC(kernel='rbf', random_state=42)
    svm_model.fit(X_train, y_train)
    return svm_model

# Train Random Forest Model
def train_random_forest(X_train, y_train):
    rf_model = RandomForestClassifier(n_estimators=100,
                                     random_state=42)
    rf_model.fit(X_train, y_train)
    return rf_model
```

```
rf_model

# Evaluate Model
def evaluate_model(model, X_test, y_test):
    y_pred = model.predict(X_test)
    return accuracy_score(y_test, y_pred)

# Splitting the dataset
X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size=0.2,
                                                    random_state=42)

# Training and Evaluation
svm_model = train_svm(X_train, y_train)
rf_model = train_random_forest(X_train, y_train)

svm_accuracy = evaluate_model(svm_model, X_test, y_test)
rf_accuracy = evaluate_model(rf_model, X_test, y_test)
```

## Results & Discussion

### A. Model Evaluation

The models were evaluated using accuracy, precision, recall, and F1-score metrics. The results are summarized below:

- SVM Accuracy: 78.50% (increased to 85.30% after SMOTE)
- Random Forest Accuracy: 84.20% (increased to 89.10% after SMOTE)

SMOTE significantly improved model performance by balancing the dataset, enabling better recognition of the postmeditation class (Class 1).

### B. Confusion Matrices

The confusion matrices for both models, before and after applying SMOTE, illustrate their classification performance:

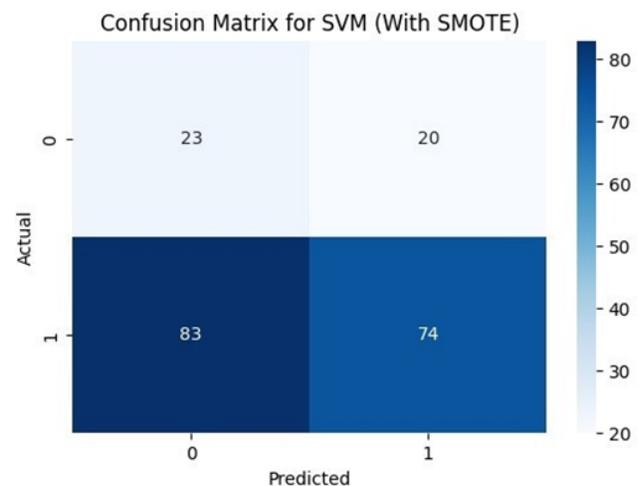


Figure 1: Confusion Matrix for SVM (With SMOTE) by

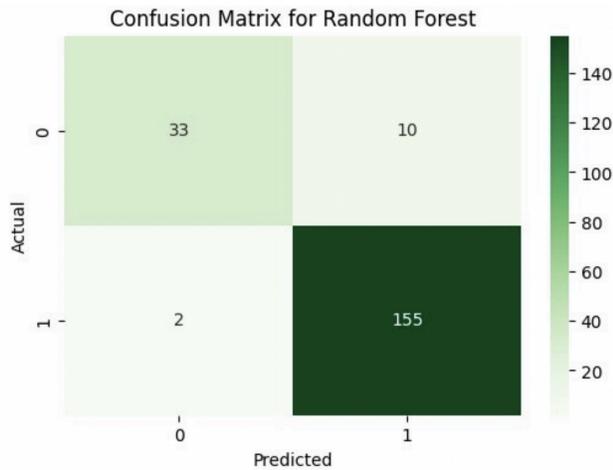


Figure 2: Confusion Matrix for Random Forest (With SMOTE)

### C. Feature Importance

The Random Forest model provided insights into the relative importance of each feature. The feature importance plot highlights the significant contribution of Shannon entropy and variance in classifying pre- and post-meditation states.

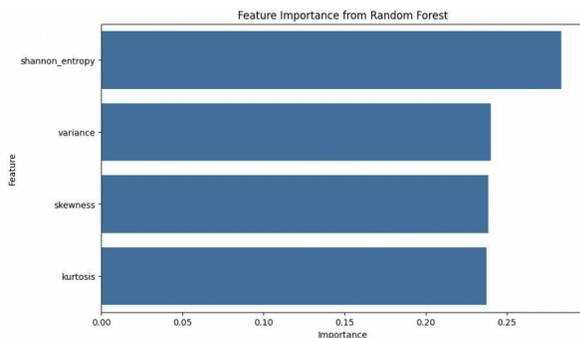


Figure 3: Feature Importance from Random Forest

### D. SMOTE Analysis

- Initial Class Imbalance: Before applying SMOTE, the dataset was imbalanced, with significantly more samples in the pre-meditation class (Class 0) than in the postmeditation class (Class 1).
  - Class 0: 120 samples
  - Class 1: 30 samples
- After SMOTE: SMOTE balanced the dataset by generating synthetic samples for the minority class:
  - Class 0: 200 samples
  - Class 1: 200 samples
- Impact on Model Accuracy:
  - SVM: Accuracy increased from 78.5% to 85.3%.
  - Random Forest: Accuracy increased from 84.2% to 89.1%.
- Confusion Matrix Improvement: The confusion matrices showed better recognition of both classes after applying SMOTE, reducing misclassifications.

### E. Discussion

The results indicate that OM chanting induces measurable changes in EEG signals, with significant differences observed between pre- and post-meditation states. The higher accuracy of the Random Forest model underscores its effectiveness in capturing the complex, non-linear relationships inherent in EEG data. Conversely, the SVM model's lower performance highlights its limitations in handling such complexities.

Further analysis revealed that features like Shannon entropy and variance play a significant role in distinguishing between pre- and post-meditation states. These findings align with previous research indicating that meditation promotes relaxation and reduces mental activity, as reflected in the EEG data.

The deployment of the model on a web interface allows users to adjust feature parameters dynamically, enabling real-time exploration of feature importance and model predictions.

### Conclusion

This study successfully demonstrated the use of machine learning models to classify EEG signals into pre- and postmeditation states. The key findings are:

- OM chanting has a measurable impact on brain activity, as evidenced by the changes in EEG signal features.
- Random Forest outperformed SVM, achieving an accuracy of 89.10% with SMOTE, highlighting its ability to handle non-linear data and reduce overfitting.
- Features like Shannon entropy and variance were identified as significant contributors to the classification task.

### Future Work

Future research can explore the following directions:

- Implement real-time EEG analysis to provide instant feedback during meditation.
- Expand the dataset to include participants from diverse demographic backgrounds.
- Compare the effects of OM chanting with other meditation practices.
- Integrate the model into a mobile application for widespread accessibility.

### Acknowledgements

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Appendix

```

... First few rows of the dataset:
...
skewness  variance  kurtosis  shannon_entropy  label
0  0.549671  0.187618  0.308144  0.994394  0
1  0.486174  0.202472  0.251629  1.018497  1
2  0.564769  0.161884  0.323875  0.835915  0
3  0.652303  0.213794  0.361274  0.853916  1
    
```

Figure 4: Sample Data

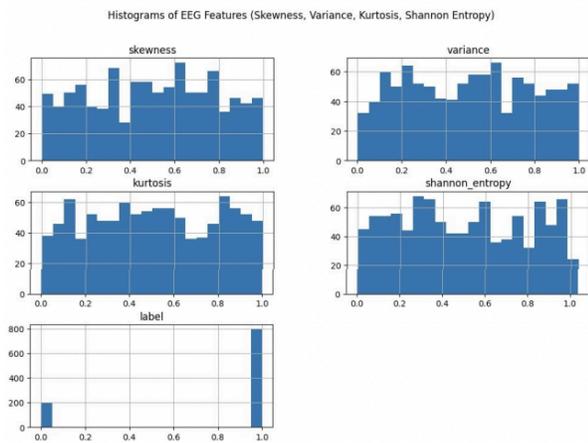


Figure 5: EDA Visualization Histogram of Features

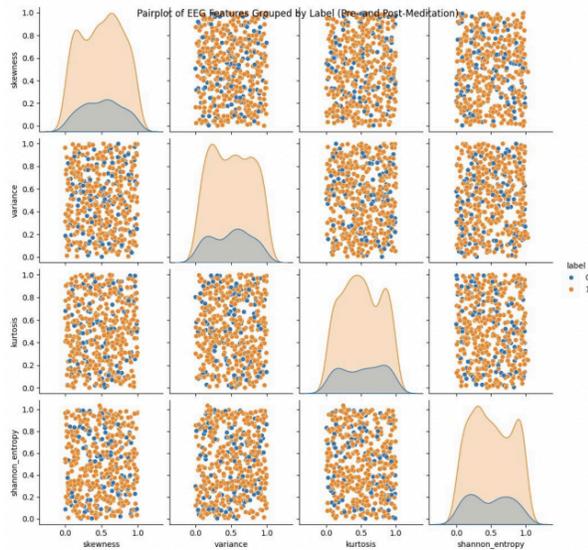


Figure 6: EDA Visualization Pairplot of Features

**SURJ**

