PRINCETONIAN JOURNAL OF SCIENCES

RESEARCH ARTICLE

PRINCETONIAN JOURNAL OF SCIENCES

VOLUME 1, ISSUE 3

Princetonian Journal of Sciences is published by the Princetonian Institute.

See here: https://princetonian.org/journal-info

Princeton, NJ

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Editorial Introduction – Volume 1, Issue 3

Princetonian Journal of Sciences

It is with great enthusiasm that we present Volume 1, Issue 3 of the Princetonian Journal of Sciences. Continuing our mission to highlight the intellectual rigor and creativity of emerging scholars, this issue brings together five diverse contributions that traverse the fields of economic history, climate policy, financial inclusion, happiness economics, and environmental responsibility in the digital age. Collectively, they showcase the analytical sophistication and global awareness of high school researchers engaging deeply with some of the most pressing questions of our time.

Agastya Sidher's "The Economic Parallels Between the 1930s and Today: Learning from the Ripples of History" offers a rich comparative analysis of the Great Depression and the contemporary global economy. Drawing on historical data and modern indicators, Sidher identifies striking parallels in protectionism, monetary policy, political polarization, and fiscal response, underscoring how lessons from the past can illuminate today's policy challenges and the importance of transparent, coordinated action in averting systemic crises.

Sin Eike's "Comparative Analysis on Carbon Emission Reduction Policy between the US Inflation Reduction Act and the EU Emissions Trading System" examines two landmark climate policies, one subsidy-driven, the other rooted in cap-and-trade, and assesses their relative effectiveness in reducing emissions. Through theoretical frameworks and empirical data from multiple jurisdictions, Eike advocates for a hybrid approach that harnesses the short-term impact of subsidies with the long-term efficiency of market-based mechanisms.

Eric Ma's "Does Mobile Money Substitute or Complement Traditional Banking? An Empirical Analysis of Sub-Saharan Africa" investigates whether mobile money services and formal banking compete or reinforce each other. Using panel regressions and correlation analyses from seven African countries over 15 years, Ma finds that mobile money initially complements

banking growth but increasingly substitutes for it in later stages, offering nuanced policy recommendations for expanding inclusive financial ecosystems.

Annie Zhang's "Spending for Smiles: How Government Investment Shapes National Happiness in ASEAN During COVID-19" explores how the scale and composition of government spending influence well-being during a period of acute crisis. Using cross-country regression analysis, Zhang finds that investments in health and education significantly boost happiness, while military spending shows the opposite effect, providing timely guidance for post-pandemic fiscal priorities.

Finally, Emilia Lun's "The Influence Emissions Fee: Should Viral Creators Pay for Climate Impact?" advances a provocative conceptual framework linking viral digital content to measurable carbon emissions. Drawing on environmental economics, media theory, and consumer behavior research, Lun proposes an "Influence Emissions Fee" for high-reach creators, opening a novel debate on environmental accountability in the digital economy.

Together, these articles embody the journal's commitment to interdisciplinary inquiry, methodological rigor, and the tackling of globally consequential issues. They remind us that emerging scholars are not only capable of engaging with complex debates, but are also shaping the questions and solutions that will define the decades ahead.

On behalf of the Editorial Board,
The Princetonian Journal of Sciences

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The Economic Parallels Between the 1930s and Today: Learning from the Ripples of History

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Doi: 10.5281/zenodo.16877839.

Abstract

This paper conducts a historical-economic comparative analysis of the Great Depression of the 1930s and contemporary global economic conditions, focusing on parallels in trade policy, monetary systems, shifting political power, and fiscal responses. Drawing on both primary historical data and recent economic indicators, it examines how protectionism, inequality, and political polarization have re-emerged in modern contexts, and how investor expectations can precipitate or amplify crises. Figures and comparative timelines illustrate similarities and differences in tariff escalation, monetary interventions, unemployment patterns, and democratic erosion. The analysis finds that while today's policymakers operate with more tools, faster fiscal channels, and global institutions that still function, the role of narrative and public confidence remains as critical as in the 1930s. The paper concludes by emphasizing the importance of coordinated, transparent policy communication to mitigate market panic and political destabilization.

Keywords

Great Depression; Protectionism; Monetary Policy; Political Economy; Comparative Economic History

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(1) Introduction

In recent months, headlines like the Financial Times' "Trump Turns Back the Clock on Globalization" have reignited a familiar debate: are we, once again, stepping into the mistakes of the past? As former President Trump's policies suggest a strong move toward economic nationalism, through tariffs, tighter immigration controls, and global disengagement, the parallels to the 1930s become harder to ignore. Back then, protectionist policies like the Smoot-Hawley Tariff and deepening inequality led not only to economic devastation but also to political instability worldwide. Today's global tensions, wealth gaps, and rising populism echo many of the same warning signs. Although history does not repeat itself exactly, it often rhymes. To understand whether today's world risks making similar errors, it's important to study the economic, social, and political patterns of the Great Depression alongside today's challenges.

This study is primarily a historical-economic analysis but also incorporates prescriptive policy discussion where lessons from the past have clear relevance to current decision-making.

This paper will first review existing literature comparing the Great Depression and today's global economy, highlighting recurring themes such as protectionism, inequality, political extremism, and government responses. It will then present data showing specific economic parallels in areas like monetary policy, trade, shifting political power, and fiscal spending. Afterward, it will draw lessons for current policymakers based on these parallels and discuss what the future might hold if these patterns continue.

(2) Literature Review

When looking at the Great Depression and today's global economy, researchers and historians have long debated the extent to which past patterns can inform present-day policy. While the circumstances aren't identical, there's a recurring theme: when economies fall into crisis, governments often turn inward, inequality deepens, and political systems get strained.

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One of the most referenced events in this conversation is the Smoot-Hawley Tariff Act of 1930. Economists like Douglas Irwin (2008) argue that while Smoot-Hawley wasn't the sole cause of the Great Depression, it dramatically worsened global economic conditions by choking off international trade. Countries retaliated with tariffs of their own, and by 1933, world trade had shrunk by over half. That pattern, of using protectionism as a defense mechanism during economic anxiety, has re-emerged in recent years. The U.S.-China trade war, covered extensively by Bown and Kolb (2020), illustrates how even today, trade policy can quickly become a political tool, often with unintended economic blowback like supply chain disruptions and price hikes.

Building on this, Antras (2020) examines the long-run consequences of deglobalization, arguing that a sustained retreat from globalization, similar to what occurred in the 1930s, could lower productivity growth, worsen inequality, and leave economies more vulnerable to future shocks. His work reinforces the idea that rising nationalism today risks setting up the same economic vulnerabilities that plagued the interwar years.

Beyond trade, researchers have also explored how financial crises and inequality draw direct lines between past and present. Thomas Piketty's Capital in the Twenty-First Century (2013) points out how both the 1920s and the post-2008 world experienced massive asset bubbles, first in stocks, now in housing and tech, and how policy responses often helped the wealthy recover faster than the broader population. This uneven recovery is a recurring theme in the post-COVID economy as well, with researchers like Saez and Zucman noting that stimulus efforts, while necessary, failed to address deeper wealth dis

Similarly, Rajan (2010), in Fault Lines, emphasizes that financial instability driven by inequality and political pressure to expand credit mirrors the pre-Depression period. Rajan warns that without tackling the structural roots of inequality, crises will continue to repeat, a concern that remains highly relevant today.

On the political side, historians like Eric Hobsbawm and economists like Barry Eichengreen have long argued that economic distress breeds political extremism. Eichengreen, in particular,

draws a strong comparison between the populist movements of the 1930s, which brought authoritarian leaders like Hitler to power, and the modern rise of nationalist movements in the U.S., Brazil, and parts of Europe. He argues that when people lose faith in markets and institutions, they often turn to leaders who promise radical solutions, even if those solutions come at the cost of democracy.

Supporting this, Funke, Schularick, and Trebesch (2016) conducted a broad study showing that financial crises often lead to surges in support for far-right parties. Their work across multiple countries highlights how economic shocks can fuel political polarization, echoing the erosion of democratic norms seen during the 1930s.

Finally, the discussion around government responses has been shaped by scholars like Christina Romer and Ben Bernanke. Romer (2009), who served as Obama's economic adviser, stresses that the New Deal's true success lay not just in the money spent but in shifting public expectations toward recovery. Similarly, Bernanke's research into the Federal Reserve's mistakes in the 1930s influenced how central banks responded during the 2008 crisis and the COVID recession: by acting quickly, injecting liquidity, and prioritizing market confidence. Eichengreen and O'Rourke (2012) further argue that while modern policymakers moved faster and more aggressively than their 1930s counterparts, challenges like inequality and political polarization remain difficult to fix even after initial recovery efforts.

However, while the literature draws strong parallels between protectionism, financial instability, inequality, and political extremism, there are still notable gaps. Most existing research focuses heavily on the 2008 financial crisis as the modern point of comparison, rather than on newer dynamics like post-2020 trade fragmentation, rising defense spending, or shifts in global political power. In particular, the longer-term risks of sustained protectionism, strategic decoupling, and growing nationalism have not been fully explored. Identifying these emerging structural gaps will be key to understanding whether today's patterns truly echo the 1930s, or represent something even more complex.

Overall, the literature is clear: while the causes and technologies may differ, the emotional and economic patterns of the 1930s and today share a common thread. Trade wars, inequality, financial risk, and political uncertainty continue to test how we respond under pressure. Yet, understanding what has changed and what remains unresolved will be crucial for navigating the future.

While historical literature highlights strong similarities between the 1930s and today, data trends help reveal how these patterns are unfolding in real time. By examining monetary policy decisions, trade relationships, political shifts, and fiscal spending, it becomes clear that some of the same stresses that contributed to the Great Depression are reappearing. Though the world today is different in important ways, the basic warning signs are strikingly familiar.

(3.1) Trade and Trade Policy

Trade policy was a major accelerant of the Great Depression, and today's rising protectionism mirrors many of the same risks. In the early 1930s, the Smoot-Hawley Tariff Act dramatically raised U.S. tariffs on over 20,000 imported goods. Retaliatory tariffs quickly followed, leading to a collapse in world trade. Between 1929 and 1933, global trade fell by more than 50% (U.S. Census Bureau, 1975).

However, the most striking aspect of Smoot-Hawley was not just its economic effect, it was the market panic it unleashed before the tariffs were even signed into law. As early as May 1929, when the House passed the first version, global markets started reacting negatively. By the time Hoover reluctantly signed it in June 1930, the damage was already done: confidence had evaporated, capital had fled, and a trade war had begun. Investors anticipated catastrophe, and their fear triggered it.

Today's trade conflicts resemble the 1930s in important ways, but they also differ in critical aspects. Under President Trump, the United States raised tariffs aggressively, particularly against China, sparking a modern trade war. However, unlike Smoot-Hawley, which broadly raised tariffs against almost all trading partners, Trump's tariffs were far more targeted. Many tariffs

against allies like Canada, Mexico, and the European Union were either retracted or delayed, with 90-day negotiation windows offered before full tariffs were enforced. This shows a more strategic and battle-focused approach, an attempt to weaken specific competitors rather than globally disengage.

full tariffs were enforced. This shows a more strategic and battle-focused approach, an attempt to weaken specific competitors rather than globally disengage.

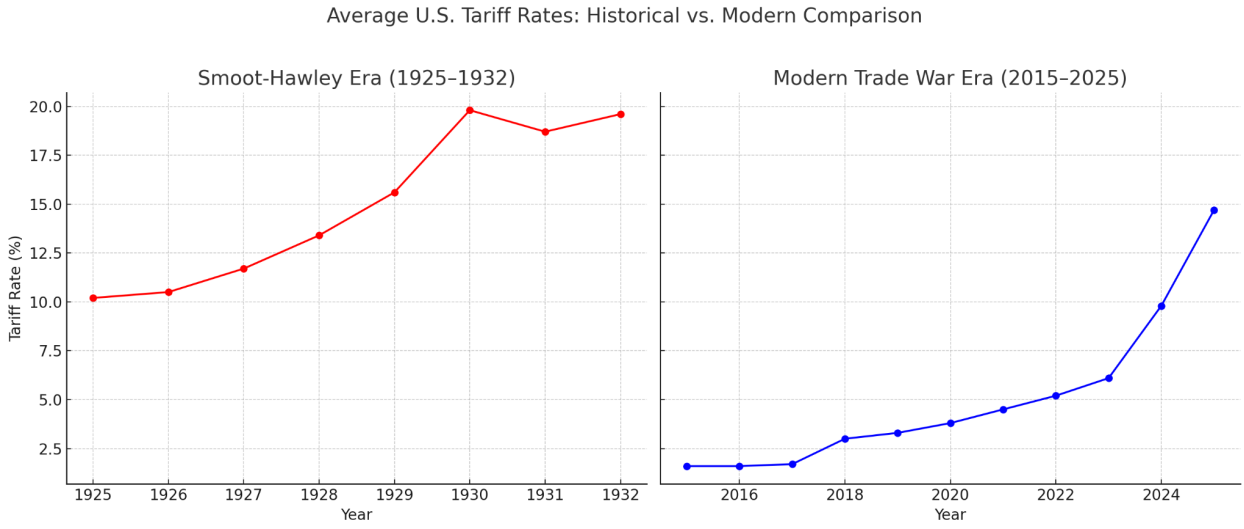

Figure 1: Average U.S. tariff rates across all imports during the Smoot-Hawley era (1925–1932) compared to the modern trade war era (2015–2025). Data sources: U.S. Census Bureau Historical Statistics (1975), World Bank World Development Indicators (2025), and Bown & Kolb (2020).

Figure 1 juxtaposes the tariff rate spikes from two distinct eras, highlighting the recurrence of protectionist policies during economic and geopolitical uncertainty. During the Smoot-Hawley era, tariffs escalated sharply from around 10% to nearly 20% in less than five years, driven primarily by isolationist economic policy and nationalistic sentiments. This abrupt increase severely disrupted global trade, as retaliatory tariffs quickly followed, reducing international commerce by more than half (Irwin, 2011). The persistent elevation of tariffs well into the early 1930s highlights the inertia inherent in reversing protectionist trade policies once they are

politically entrenched. This phenomenon aligns closely with Douglas Irwin's analysis in "Peddling Protectionism," which argues that tariffs not only restricted trade but significantly amplified uncertainty and investor panic, thereby deepening the Great Depression.

In contrast, the modern trade war era graph demonstrates a more strategic but similarly destructive pattern. Starting from relatively low baseline tariffs (around 1–2%), the rapid escalation post-2018, driven primarily by the U.S.-China trade conflict, led tariff rates to exceed 14% by 2025. Unlike the indiscriminate tariffs of the 1930s, contemporary tariffs selectively targeted strategic geopolitical rivals, thereby intensifying global economic fragmentation. Chad Bown (2020) highlights that contemporary tariff, despite being narrower in scope, have substantial unintended spillover effects such as supply chain disruptions and inflationary pressures. Notably, the modern escalation occurred more swiftly than during the Smoot-Hawley period, underscoring how rapidly globalized markets today respond to economic policy uncertainty. This comparative analysis demonstrates how protectionist policies, regardless of their intent, risk destabilizing global economic integration and deepening market volatility.

(3.2) Monetary System

The monetary response to crises shows another strong parallel between the Great Depression and today. In the 1930s, the Federal Reserve failed to act decisively when early signs of recession appeared. Instead, it pursued contractionary monetary policies, raising interest rates to defend the gold standard and contain speculative bubbles, which only deepened the economic collapse. Banks failed at an alarming rate, credit markets froze, and deflation set in. By the time the Fed realized the extent of the problem and began cutting rates, it was too late to prevent the worst damage (Bernanke).

Following the 2008 financial crisis, however, policymakers moved far more aggressively. The Federal Reserve cut interest rates to near zero almost immediately and introduced massive quantitative easing programs to inject liquidity into the banking system. Again, during COVID-19, the Fed reacted quickly, implementing emergency lending facilities and balance sheet expansions. A time series comparing interest rates during the 1930s and the post-2008 world

shows remarkably similar patterns: sudden crises, steep cuts in rates, and prolonged periods of ultra-low borrowing costs (U.S. Federal Reserve; FRED).

Yet beneath the surface, today's monetary system faces a new layer of risks. While the collapse of the gold standard led to competitive devaluations in the 1930s, today the U.S. dollar remains the global reserve currency. However, cracks are appearing. Countries like China, Russia, and others are increasingly pushing for alternatives to the dollar, developing new payment systems, expanding gold reserves, and exploring digital currencies. While no immediate collapse of dollar dominance seems likely, these slow shifts mirror the gradual disintegration of the gold-based system before it suddenly fell apart in the 1930s.

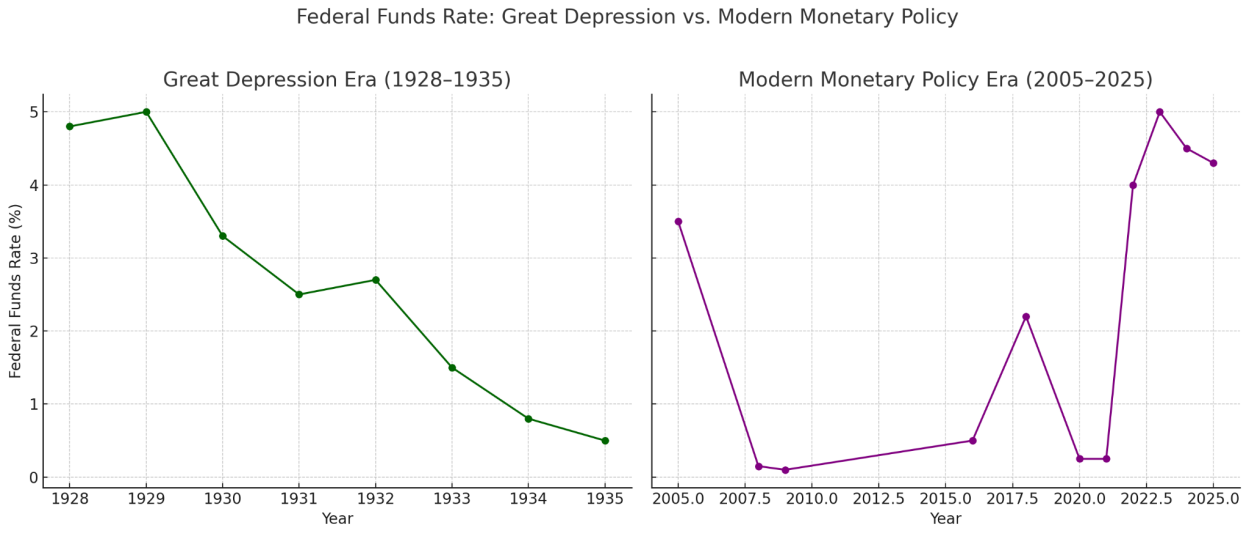

Figure 2: U.S. Federal Funds rate comparison between the Great Depression era (1928–1935) and the modern monetary policy era (2005–2025). Data sources: FRED (2025), Bernanke (2000), Dallas Federal Reserve Historical Dataset (2025).

As shown in Figure 2, during the Great Depression, the Federal Reserve followed a mostly linear path of rate reduction, dropping from above 5% in 1929 to nearly zero by 1935, and staying there. This reflects the early central bank's hesitation to act quickly during deflation and

economic collapse. In contrast, the modern era saw far more volatile monetary policy. Following the 2008 financial crisis, the Fed slashed rates to near zero, held them through most of the 2010s, and then rapidly raised them post-2016. These increases reversed again during COVID and spiked again post-2021 to combat inflation. While both periods featured near-zero rates, only the modern era shows repeated, sharp turns in direction, revealing the Fed's stronger role as an active counter-cyclical agent.

The key insight from this comparison lies in the difference between passivity and preemption. The 1930s Fed lacked tools and political autonomy, allowing collapse to deepen. The modern Fed, though more empowered, still grapples with the timing of its responses, often arriving after private markets and inflationary pressures gain momentum. Interestingly, both eras end with rates stabilizing at low levels due to macro uncertainty, despite different causes: deflation then, inflation volatility now.

(3.3) Shifting of Power

Political shifts during periods of economic crisis are another striking parallel between the Great Depression and today. In the 1930s, the economic collapse fundamentally weakened democratic institutions across Europe and Asia. Rising unemployment, collapsing banks, and failing governments created a political vacuum that authoritarian leaders quickly filled. Germany, Italy, Japan, and Spain all saw the rise of regimes that prioritized nationalism, militarization, and expansion over cooperation.

Today, political institutions are again under pressure. Freedom House data shows that global democracy scores have been declining steadily since the mid-2010s. Populist movements in major democracies, including the United States, Brazil, India, and Hungary, have challenged established political norms, weakened independent institutions, and promoted nationalist rhetoric. Economic dislocation caused by globalization, automation, and crises like COVID-19 has fueled these political shifts, much like the economic devastation of the 1930s.

However, there is an important difference. In the 1930s, much of the world turned away from international cooperation entirely. Today, while multilateral institutions like the UN, WTO, and IMF are under stress, they still exist and exercise influence. Trump's foreign policy, for example, did not seek total withdrawal from the global stage. Rather, it aimed to realign relationships, force renegotiations of trade deals, and push allies to increase military spending. His tariffs and diplomatic strategies, especially toward China, were calculated efforts to reshape power balances, not dismantle them.

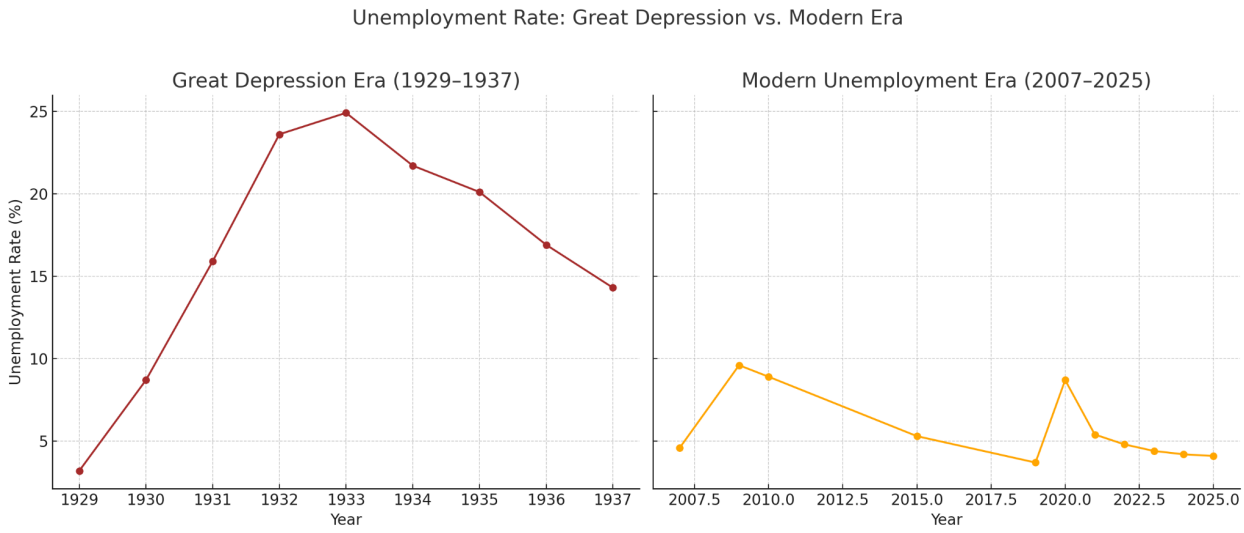

Figure 3: U.S. unemployment rate comparisons during the Great Depression (1929–1937) and the modern economic period (2007–2025). Data sources: Bureau of Labor Statistics (2025), Investopedia (2023), FRED (2025).

Referring to Figure 3, The juxtaposition of unemployment trends during the Great Depression and modern economic shocks provides insights into the effectiveness and limitations of contemporary economic stabilization policies. In the Great Depression, unemployment surged dramatically from about 3% to nearly 25% within just four years. The lack of sufficient unemployment insurance, fiscal stimulus, and monetary support during this era prolonged the economic crisis, leaving millions persistently unemployed. Scholars such as Christina Romer

(2009) argue that it was not until large-scale fiscal interventions via New Deal programs that the employment situation slowly improved.

In contrast, the modern era experienced sharp but shorter-lived unemployment spikes, notably reaching nearly 10% during the 2008–2009 financial crisis and around 9% during the COVID-19 pandemic in 2020. Rapid fiscal stimulus, expanded unemployment benefits, and aggressive monetary easing allowed for quicker labor market recoveries compared to the Depression-era scenario. However, a deeper examination suggests modern unemployment statistics mask underlying structural issues, including increased job precarity, rising gig economy dependence, and labor force participation declines (Self Inc., 2024). Thus, while modern interventions effectively reduce headline unemployment, they also highlight growing labor market inequalities and vulnerabilities that may exacerbate future economic downturns.

Fiscal responses to crises provide yet another parallel between the Great Depression and today. During the 1930s, Franklin D. Roosevelt's New Deal programs expanded government spending dramatically, especially in areas like public works, job creation, and social welfare. Although initially limited compared to the scale of the problem, New Deal spending was revolutionary in embedding the government deeply into the economic fabric of the nation. By the late 1930s, rearmament and defense spending further increased public expenditures, setting the stage for the massive military mobilization of World War II.

Today, political institutions again face significant pressure from sustained economic dislocation, rising inequality, and global crises. Data from Freedom House indicates a steady and alarming decline in global democracy scores since the mid-2010s. Populist movements have increasingly taken root across established democracies, including the United States, Brazil, India, Hungary, and Turkey, actively challenging traditional political norms, weakening judicial and media independence, and promoting nationalist, isolationist rhetoric. Barry Eichengreen (2018) underscores that the economic grievances fueling today's populism parallel those in the 1930s, where declining faith in institutional efficacy directly correlated with the rise of extremist political ideologies.

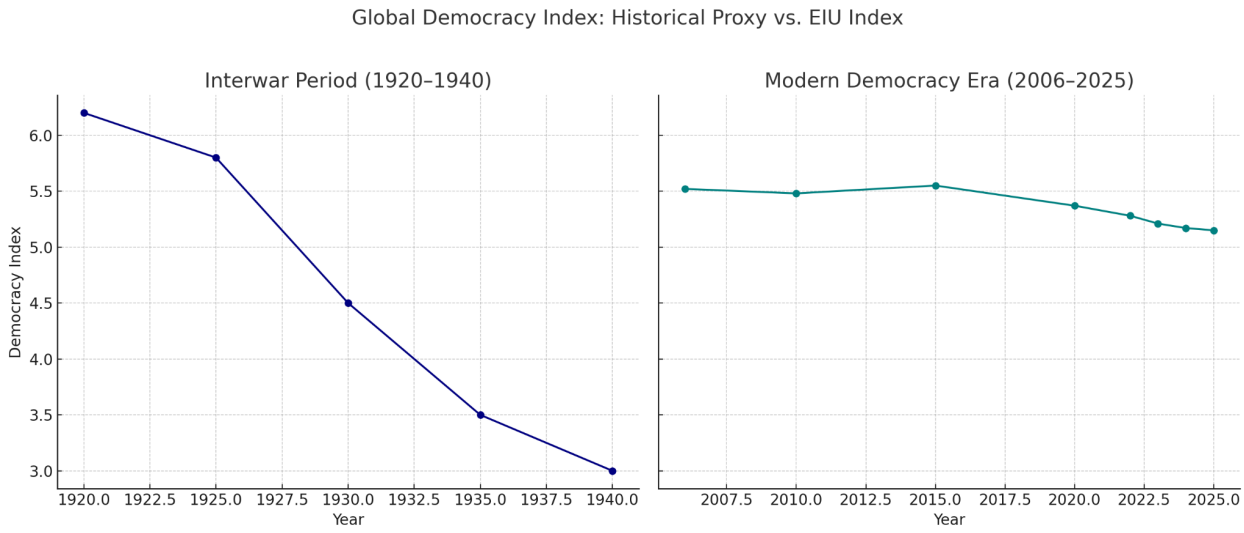

Figure 4: Decline in global democracy during the interwar period (1920–1940, historical proxy) versus the contemporary period (2006–2025). Data sources: Economist Intelligence Unit Democracy Index (2025), Freedom House (2023), Eichengreen (2018).

In Figure 4, the Democracy Index comparison graph reveals critical insights into the patterns of democratic erosion across two distinct historical periods. In the interwar era, democracy scores fell sharply and swiftly, corresponding directly with economic crises and the rapid ascent of authoritarianism. The profound economic hardships of the Great Depression eroded institutional legitimacy so severely that democracies collapsed or significantly weakened within mere years. Conversely, the modern decline is more gradual but no less concerning. A steady decrease from an index of approximately 5.52 in 2006 to about 5.15 by 2025 suggests a continuous, insidious erosion of democratic standards and practices rather than sudden collapses.

Funke, Schularick, and Trebesch (2016) argue that financial crises consistently bolster support for extremist political groups, leading to gradual but sustained democratic erosion if unaddressed. Unlike the dramatic shifts of the 1930s, modern democratic declines might initially appear subtle, causing complacency among policymakers and citizens who fail to recognize creeping authoritarian tendencies until they become deeply entrenched. Today's erosion

primarily manifests through incremental weakening of judicial independence, erosion of media freedom, increasing executive authority, and the normalization of populist rhetoric. As Eichengreen emphasizes, while the path of decline differs from the interwar period, the eventual outcome, if unchecked, could mirror the political upheaval of the past.

Despite these parallels, critical differences exist. Unlike the 1930s, contemporary global institutions like the United Nations, International Monetary Fund, and the World Trade Organization, although strained, remain operational, potentially serving as mitigating forces against full-scale democratic collapses. Moreover, modern global interconnectedness creates economic incentives to maintain a certain level of international cooperation, contrasting sharply with the outright isolationism and nationalism of the 1930s. Trump's foreign policy, characterized by aggressive renegotiation rather than total withdrawal, exemplifies this nuanced form of modern nationalism, aimed more at restructuring international power balances than dismantling them entirely.

In summary, while the political-economic parallels between the 1930s and today are evident, the contemporary landscape presents both familiar risks and unique challenges. Understanding these nuances and the incremental nature of modern democratic erosion will be crucial for policymakers aiming to prevent history from repeating its most destructive patterns.

(4) Policy

Across the Great Depression and our modern era, the most critical economic shocks have stemmed not from policies themselves but from shifting expectations. In 1929 and early 1930, investors began to anticipate significant tariff increases even before Smoot-Hawley became law. As a result, capital began to flee global markets and bankers tightened credit, creating a self-fulfilling prelude to collapse (Archibald, 1998). In today’s environment, digital markets and media amplify signals immediately. Trump-era rhetoric about deglobalization, manufacturing on-shoring, and confrontations with China triggered capital reallocations and risk rebalancing before the tariffs were formally enacted (Giglio, 2020). This demonstrates that in both eras, markets react to the narrative, they expect what they fear.

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In the 1930s Roosevelt's greatest tool was not just spending but restoring faith in future institutions. Christina Romer (2009) and Ben Bernanke (2000) emphasize that public confidence rebounded after visible, persistent government action through New Deal programs and communication. That shift in psychology helped stop the downward spiral even before unemployment peaked. Today, policymakers operate in a faster information environment: expectations change within hours based on tone and consistency, not merely on technical interventions.

Protectionism must be strategic and backed with substantive reinvestment rather than symbolic or blunt isolation. Smoot-Hawley applied universal tariffs on thousands of goods, worsening retaliation and global contraction in trade (Irwin, 1996). Modern protectionist strategies, as seen in the Trump era, were more targeted, focused on select industries like steel or high-tech supply chains. Yet without domestic reinvestment in those industries, tariff-only moves are short-sighted and risk creating inefficiencies rather than strengthening sovereignty. In this sense, modern moves differ in intent but echo past fragility when they lack integrated industrial policy.

Investor behavior and the timing of market reactions also reveal stark differences. In the 1930s fear set in when trade disruption reached only 1–2 percent of GDP, yet capital behavior precipitated further crises before policy change (Mitchener, 2022). Today, market flows are far larger and faster. Delayed monetary response or inconsistent messaging may induce selloffs or risk-off modes well before economic indicators shift, often resulting in cascading effects that amplify downturns.

The interplay between economic power and political legitimacy is another critical dimension. Unemployment during the Depression surged from 3 percent to nearly 25 percent, eroding democratic legitimacy and paving the way for authoritarian regimes in multiple countries (Eichengreen, 2018). Modern spikes, while shorter-lived, still carry political risk. The temporary plunge to nearly 10 percent unemployment in 2020, though reversed quickly, accelerated political polarization and populist sentiment in many countries. Moreover, labor precarity,

expanding informal work and gig economies, may mask deeper structural labor vulnerabilities that undermine long-term social cohesion.

Therefore, policymakers today must focus less on rigid categories of ideal policy types, and more on how policies are perceived and communicated. Consistency, transparency, and coordination across government entities are essential. Whether it's trade, monetary policy, or fiscal stimulus, effective policymaking now involves both the substance of the intervention and the narrative framework surrounding it.

(5) Conclusion

Trump's economic strategy, while polarized in public discourse, projected a deliberate vision of centered U.S. manufacturing and national economic resilience. This vision diverged from 1930s isolationism in intention, yet markets responded similarly, pulling capital, rooting in volatility, and reconfiguring expectations. Stock markets crashed before tariffs were even passed in the 1930s. In our era, markets reacted within seconds to geopolitical tweets or unexpected tariff announcements.

What ties these eras together is that economic disruptions often start in the mind. Investor expectations, drawn from rhetoric, tone, or symbolic policy shifts, drive real capital flows and behavioral shifts ahead of real economic change. That means the difference between recession and depression may hinge more on perception than fundamentals.

Compared to the 1930s, governments today operate with far more tools, monetary flexibility, faster fiscal pipelines, and global institutions that still exist. But they must still grasp that managing fear, expectation, and narrative is foundational to stability. Coordination between treasury announcements, central bank messaging, and fiscal action is now policy in itself.

History does not repeat, but it rhymes. Trump's rhetoric may differ from Hoover's style, modern markets differ in speed and data, but the underlying tune, that confidence matters more than policy detail, remains constant. Failure to manage expectations can destabilize economies faster

than tariffs or bank failures alone. The task for modern policymakers is not merely to react but to anticipate, to manage narrative as much as it manages stimulus, to forestall panic before it unfolds.

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Comparative Analysis on Carbon Emission Reduction Policy between the US Inflation Reduction Act and the EU Emissions Trading System.

Sin Eike[1]

United World College South East Asia Dover Campus

Doi: 10.5281/zenodo.16877851

Abstract

The purpose of this paper is to examine the two carbon policies of the EU and the US to determine which is superior environmentally and economically. I focus my research on the EU Emissions Trading System (ETS) and the US Inflation Reduction Act (IRA) from 2005 to 2024. Using regression analysis with total emissions, CO_2 per capita, and CO_2 per GDP, I show that the ETS appears more effective over the long term in reducing emissions, based on the available data. Additional data from China and Canada are used to compare the cap-and-trade system of the ETS with more subsidies and carbon tax approaches. Previous research has focused on conducting separate research between the two countries. Attempts at comparing the two policies were not very successful, given the recent implementation of the IRA, which led to no long-term data. This paper explains the relative economic theories behind the IRA and ETS and aims to establish the severity of the current carbon crisis. Then, I attempt to find an objectively superior policy for all countries to implement. This study finds that a combination of ETS and short-term subsidies has a positive impact on seeing immediate results in emissions reduction, whilst being sustainable by not increasing debt-to-GDP levels in the long term.

Keywords: Carbon Emissions; Cap-and-Trade; Inflation Reduction Act; EU Emissions Trading System; Climate Policy

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Introduction

Global temperatures peaked in 2024, with the Northern Hemisphere seeing a 1.75°C increase over historical averages. In 2022, the US aimed to reduce emissions by 40% (Bistline J, 2023) by increasing subsidies on renewable energy sources through the Inflation Reduction Act (IRA, P.L. 117-169). Meanwhile, in Europe, the Emissions Trading System (ETS) was implemented back in 2005. By 2023, emissions from covered sectors decreased by 48% compared to 2005 levels. The IRA mainly uses subsidies, while the ETS relies on cap and trade alone. There have been countless disputes amongst economists to determine which set of government policies should be implemented to maximise a reduction in carbon emissions. This paper argues that adopting a hybrid approach of cap and trade and subsidies provides the highest economic and social gains. Firstly, this paper discusses subsidies and carbon tax, establishing the economic merits and their limitations using the IRA. Then, I will analyse cap and trade along with the ETS. Finally, I will discuss why the combination of cap and trade and subsidies on renewable energy is a better alternative, given how they balance each other's weaknesses.

Literature Review

The US Inflation Reduction Act (IRA) was enacted in 2022. Those who support the policy mostly indicate a fall in emissions. According to Bistline (2023), there will be a 43-48% reduction in emissions below that of 2005 levels by 2035 under the IRA, with Jenkins (2023) suggesting similar results with the IRA doubling emission reduction from 2% to 4%. EPA (2023) agrees with the above claims as the energy/power sector is capable of reaching 69-83% less emissions by 2030 due to tax credits and subsidies provided by the IRA. IRA subsidies also encouraged private investment of $493 billion in clean technologies in the first two years (RMI, 2024). The IMF (2025) projected the per-ton cost of Carbon falling from $400 to $50 between 2022 to 2035. However, these estimates often prioritise short-term impacts that may underemphasize cost and risk.

There are critiques regarding IRA subsidies, as these projections would cost trillions to implement because they combine both subsidies and tax credits. The majority of the disagreements stem from financial difficulties the government will face, yet there are rarely any disagreements on the IRA's ability to reduce emissions. Bauer (2023) concluded that uncapped tax credits would increase total climate spending beyond $1 trillion. Cato Institute (2025) suggested subsidies could reach $4.7 trillion, far above projections of $270 billion over a decade. IMF (2024) models conclude annual cost would be roughly 0.25% of GDP by 2030, which is more than double the initial estimates. These sources suggest the biggest issue is the IRA's uncapped fiscal commitments. An example is the US battery storage decreasing by 18% post-IRA, yet the EU reached solid-state battery breakthroughs (Kleimann, 2023). There are political tensions with the IMF (2024) estimating it will reduce emission reductions by 32% due to long approval timelines, with an average of 4.5 years. This increases the risk of a "subsidy cliff," where 73% of renewable projects funded in 2025 would be unprofitable if credits expire abruptly (Cato Institute, 2025).

The EU Emissions Trading System (ETS) was implemented in 2005 and has since been considered somewhat effective. Most supporters point to the visible decrease in emissions over the last 19 years. Bayer and Aklin (2020) determined an 11.5% reduction in emissions between 2008-2016 of 1.2 billion tons of CO_2. Di Foggia (2024) used matrix techniques to conclude a 15.4$ reduction in industrial emissions in EU nations between 2005-2020. The cap and trade system of ETS proved to be effective with €65/tCO_2 in 2024, down from €83.60/tCO_2 in 2023.

There are disagreements, but they mostly occurred during the first few years of the ETS's inception, attributed to a lack of information and uncertainty. Laing (2014) identified flaws with over-allocation of allowance and price volatility, which decreased incentives, particularly in the 2008 financial crisis. Further issues arose with Chan (2013) and Böning (2023)'s conclusion of carbon leakage due to production shifts to non-regulated regions. Beccarello (2023) came to similar conclusions by highlighting distributional inequities with EU imports gaining competitive advantages. However, these estimates often solely encompass the early stages of the ETS and not the 2025 ETS policies. To address criticisms over import advantages, plans were made by the

European Parliament (2023) to introduce the Carbon Border Adjustment Mechanism (CBAM) implemented in 2026 to reduce leakage. Even so, CBAM is often understated in favor of the initial stages of the ETS that garnered more uncertainty and loopholes.

While ETS and IRA aim to accelerate green transition, they are fundamentally different. The ETS relies on market mechanisms to internalize externalities. The IRA, meanwhile, relies on public investment to incentivize firms. The ETS is more predictable, but faced volatility in the early stages. Conversely, IRA has rapid effects, though having higher costs and inefficiencies. Generally, the IRA accelerates technology deployments, whereas ETS demonstrates scalability and innovation (Böning, 2023).

Attempts have been made to compare the ETS with the IRA. Kleimann (2023) noted the IRA's reliance on local requirements. Landais (2023) concluded similar results. While several studies evaluate cost-effectiveness, few compare long-term carbon and economics effects. Böning (2023) argued ETS carbon price in cap-and-trade more directly incentivizes decarbonization but the IRA avoids negative energy cost impacts. McKinsey & Company (2022) advocates for a hybrid approach for the IRA of carbon tax and subsidies to reduce costs and achieve net-zero, projected 4-7 years faster than subsidy-only measures. Yet, there has been no work that objectively suggests a better policy for general carbon reduction.

Methodology

This paper adopts a method of supply and demand analysis, marginal private and social cost analysis, marginal cost of reducing emissions analysis, cap and trade analysis, and secondary data research.

Supply and demand curves reveal the quantity of goods/ services producers and consumers are willing to purchase at a given price. The demand curve is downward sloping because the higher the price is, the fewer consumers would like to purchase, as they have a fixed amount of disposable income and want to maximize utility. The supply curve is upward sloping because higher prices give producers more incentive to produce, as they are profit-motivated. Equilibrium occurs at a given price where both consumers and producers reach an agreement where there is

no excess demand or excess supply. Demand and supply curves in this paper are used to identify how government intervention to reduce emissions would influence market equilibrium and the price of goods/ services. Taxes would impose an additional financial burden on firms, leading to an increased cost of production. As a result, it reduces firms' willingness or ability to supply goods at previous levels, thereby shifting the supply curve to the left. Subsidies, meanwhile, are issued by the government as financial assistance - decreasing the cost of production and increasing firms' willingness or ability to supply goods at previous levels - shifting the curve to the right. The equilibrium price in this analysis represents the optimum price for producers and consumers with government intervention. As a result, the demand and supply curves can be applied to the effectiveness of carbon emission reduction policies in markets related to carbon emissions.

The marginal private and social cost curve explores the difference between the different optimum equilibria. One accounts for externalities, where marginal social cost equals marginal social benefit. Whereas the other ignores externalities, leading to marginal private cost equaling marginal private benefit. Ignoring negative externalities results in the third party, the entity that is not directly involved in the economic transaction between two parties (usually the buyer and seller), leading to market failure where there is excess production of goods beyond what is socially optimal. The difference in private and social costs explains welfare loss - the loss of economic efficiency when resources are not allocated efficiently. Comparing the two would allow a deduction of whether different government policies are successful in shifting the private equilibrium closer to the socially optimal equilibrium. It allows for deeper analysis on whether resources are allocated closer to the economic optimum.

The marginal cost of reducing emissions curve successfully evaluates and compares the efficiency of different forms of government intervention. The marginal cost of reducing emissions curve increases exponentially due to diminishing marginal returns for investment in carbon offsetting. Hence, the cost of reducing one unit of carbon would significantly increase as companies continuously invest in energy-saving methods. Comparing elements like cap and trade, carbon tax, and subsidies with said curve would allow visualisation of the degree of

success. It also points out limitations for each policy, facilitating a conclusion with a mix of policies for maximum reductions in carbon emissions.

The cap and trade graph analysis reveals the intricacies behind its implementation by visually comparing how different firms would have different levels of demand for permits. This demonstrates how the cap of permits issued by the government – along with a high tax price far beyond that of the market equilibrium – is capable of creating a market of supply and demand for carbon permits. Certain firms with less marginal cost of reducing emissions are more willing and able to reduce their carbon footprint and sell excess permits. Meanwhile, firms that find purchasing permits cheaper than reducing a unit of carbon emission would purchase the excess permits, creating a market mechanism and equilibrium. This can show the effectiveness and weaknesses of the EU Emissions Trading System (which uses cap and trade) in reducing carbon emissions, contributing to the comparative analysis of different carbon reduction policies.

Secondary data analysis uses existing data sets collected by others. The benefit of using secondary data lies in the large-scale data sets, which are collected on a wider scale. Hence, processing greater complexity, convenience, and time efficiency. This paper will use several sources of secondary data to test and complement my hypothesis. I will then combine elements of secondary data to create my own graphs to showcase which policy is superior.

Economic Problems Stemming From Carbon

In recent years, increasing carbon emissions have been a significant contributor to climate change, affecting the economy in countless ways. The most significant is the climate change costs stemming from carbon in the atmosphere. It increases the frequency of natural disasters, disrupting infrastructure and supply chains. Primary goods like fish stocks have seen entire ecosystems destroyed due to global warming and acidification from carbon being absorbed by oceans. This results in a chain effect on the fishermen involved, the distributing firms, and finally the consumers who have to pay higher prices for seafood due to a decrease in supply.

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Carbon emissions also bring health-related costs that increase cases of respiratory and cardiovascular diseases. The most prominent cases rest in specific industries with direct contact with carbon emissions, like industrial and construction workers. This not only increases healthcare expenses, leading to a strain in healthcare systems and an increase in premature mortality, but more pressingly decreases the working population. There is a limit to the labour force, especially in first-world countries that have seen a continuous decline in childbirth in recent years. More worker sickness leads to less production capacity, decreasing the supply once again and leading to market instability. As most carbon-related sickness arises in middle and low-income households who work in industrial sectors, having to shoulder medical treatment would further drive global inequality.

The externalities diagram (Figure 1), consisting of marginal social cost (MSC) and marginal private cost (MPC), precisely illustrates this issue. The equilibrium reached by the direct parties involved does not reflect the optimum equilibrium for the entire society. Through constructing the diagram, we can identify how the current carbon emission rate causes market failure.

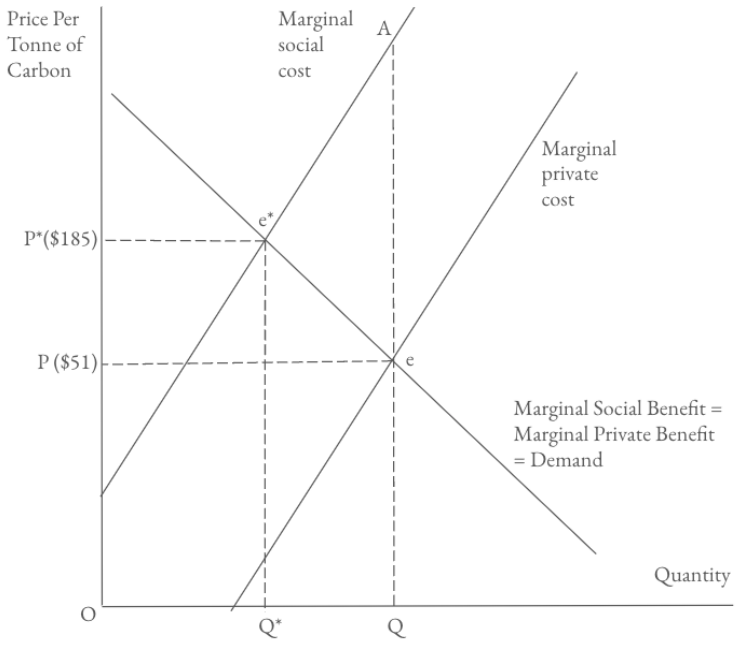

Figure 1: Externalities diagram for the socially optimal price per tonne of carbon emission

The social cost of carbon (SCC) is often used as a benchmark for the optimal carbon price. As shown in Figure 1, recent research indicated the socially optimal price to be $185 per tonne of carbon emission (Rennert, 2022), 3.6 times higher than the current US value of $51 per tonne of carbon. The x axis indicates quantity produced, with Q and Q* being the private and social quantity. The y axis and variable is the price per tonne of carbon, P and P* being private and social costs. In this case, the private equilibrium e causes an overproduction of QQ* from the socially optimal e*. This causes welfare loss, represented as the area Aee* in Figure 1, due to the loss of economic efficiency where the current equilibrium e does not align with the socially optimal equilibrium of e*. Equating the social and private costs are significantly important to prevent air pollution and resource depletion. It also assures that the economic activities do not disproportionately harm third parties and the environment - leading to less global warming.

Reducing welfare loss to e* is important, but the means of success vary depending on the intervention. The US currently uses the Inflation Reduction Act (IRA) while Europe uses the Emission Trading System (ETS).

US Inflation Reduction Act (IRA)

The US Inflation Reduction Act was signed into law by then-President Joe Biden on August 16, 2022. Originally aimed at reducing inflation, the act's primary purpose does not tie into carbon emission reduction. Political disagreements between parties also hindered its effectiveness - forcing funding to be reduced. With a total investment of $433 billion, $369 billion of it on energy security and climate change, the IRA became the most significant climate legislation in history (EPA, 2022). The IRA was initially part of the $3.5 trillion Build Back Better agenda in 2020 -2021 (Richmond, 2025). The agenda included the American Rescue Plan to relieve COVID-19, the American Jobs Plan aimed at climate change, and the American Families Plan that includes social policy initiatives. However, only the American Rescue Plan was enacted, leaving the other two to be combined into the Build Back Better Act, with spending cut down to $2.2 trillion. Due to challenges from Congress, the Act was transformed into the Inflation Reduction Act, and total spending decreased to the present at $433 billion (US Senate, 2022).

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Despite the decrease in investment, the IRA has created over 170,000 clean energy jobs and secured over $110 billion in clean energy manufacturing investments from companies within one year. This marks a significant step in the IRA's goals of reducing greenhouse gas emissions in the US by approximately 40% below 2005 levels by 2030. Currently, in this paper, I will analyse the economics behind the IRA and suggest why further introducing a carbon tax or implementing a nationwide cap and trade would be the superior choice.

The IRA primarily relies on subsidies and tax incentives to decrease carbon emissions. Both are forms of encouragement from the government to incentivize a shift towards production methods that produce less carbon. Subsidies are issued by the government as financial assistance to promote underutilized goods with positive externalities. In the case of the IRA, the majority of the subsidies are spent on cleaner alternatives like solar and wind energy. Tax incentives are government policies that reduce the tax liability to encourage specific behaviors, investments, or economic activities. The IRA includes tax incentives for electric vehicles (EVs) along with clean energy manufacturing companies. A supply and demand curve, with supply shifting right, would successfully convey the economic effect of subsidies and tax incentives.

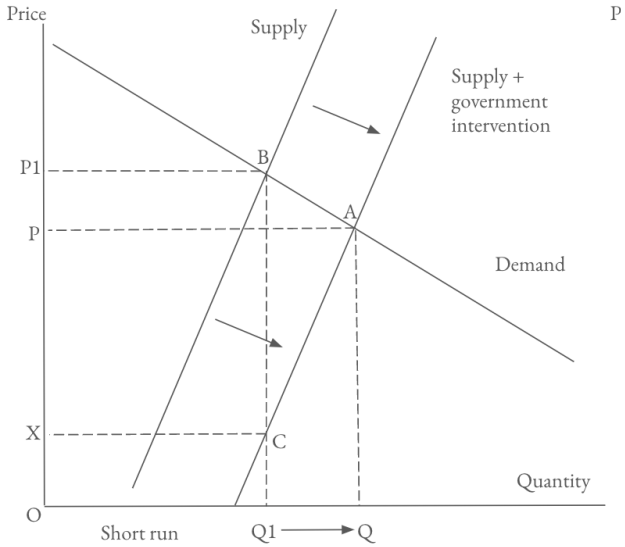

Figure 2: Short-term impact of subsidies and tax incentives on goods with less carbon emissions

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In Figure 2, the x axis indicates quantity while the y axis indicates price of a good. The supply curve is the variable with government interventions in the form of tax incentives and subsidies causing a parallel shift to the right, towards cleaner energy sources that emit less carbon. This occurs at every point of the supply curve; the government bears a portion of the manufacturing cost (BC on the graph). Hence, firms are more willing and able to produce said goods at cheaper prices, shifting the equilibrium from B to A. At point A, the price would decrease from P1 to P, and the quantity produced would increase from Q1 to Q. In general, as prices decrease, there would be higher demand as more firms are willing and able to change their production that generates excess carbon by adopting methods with less carbon emissions.

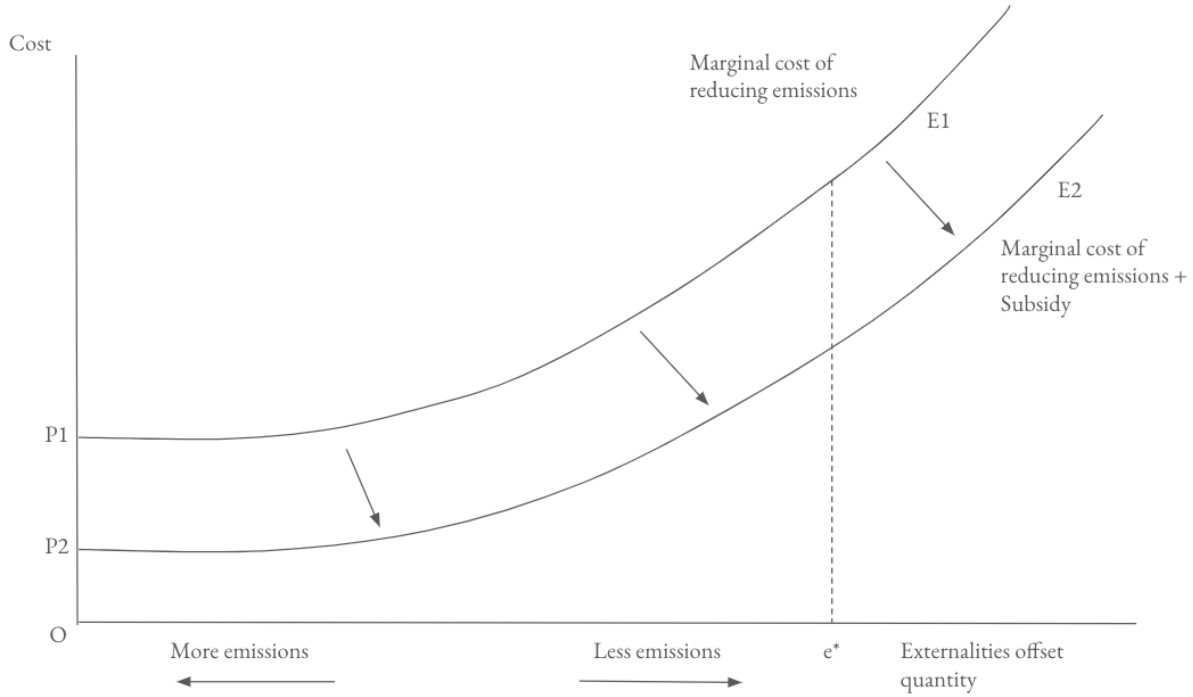

Figure 3: Marginal cost of reducing emissions for firms with subsidies

Subsidies, in general, can decrease the marginal cost of reducing emissions at every price level because the government shoulders part of the cost. In Figure 3, the x axis describes the amount of carbon reduced - points leaning to the right signally greater reduction. The y axis indicates the

cost on firms to reduce a unit of carbon emissions while being the variable. E1 highlights the marginal cost of reducing emissions before subsidies, while E2 is the same marginal cost of reducing emissions but after subsidies. Subsidies reduce the initial price to reduce a unit of emissions, P1, to P2. The cost of reducing emissions for every point along the curve would be decreased by P1P2, resulting in a parallel shift in the Marginal cost of reducing emissions curve from E1 to E2 as the government bears part of the cost. If the IRA were to focus on subsidising a firm's emissions for every unit of carbon reduced, it would be problematic, as the investment of $433 billion would not be sufficient. This is because the marginal cost of reducing emissions increases exponentially due to diminishing marginal returns. There is also no perfect information for governments to determine whether the firms are utilizing the subsidies to the intended effect.

The opportunity cost of such efforts also takes away from investing in innovation, especially in renewable energy sources, which will provide a greater return in the future. Therefore, it would be more beneficial to enact specific subsidies, such as renewable energy like solar. Globally, between 2010 and 2019, an estimated $2.9 trillion has been invested in green energy production subsidies (ITC, 2022). The US government introduced the investment tax credit (ITC) in 2005 with a 30% credit on solar installations. Such measures lowered renewable energy prices by 90% in the last decade and rendered solar 56% cheaper than fossil fuels (Figure 4) (Roesch, 2023). Specifying the specific areas subsidies will go towards would also alter the graph for the marginal cost of reducing emissions.

EU Emissions Trading System

The Emissions Trading System (ETS) relies primarily on cap-and-trade and was signed in 2005, and consists mainly of the European Union. As of 2024, the ETS covers over 11000 power plants in EU countries, including maritime transport systems and industrial installations. In 2023 alone, emissions decreased by 17%, the largest annual reduction, and by 48% compared to 2005 levels. Right now, the ETS is on track to reach said goals after 25 years, but not without compromises.

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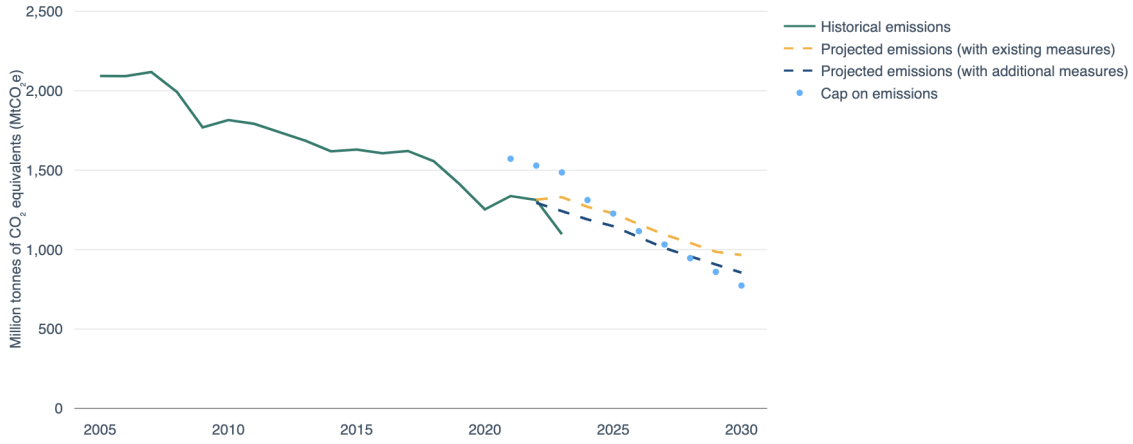

Figure 4: Historical and projected emissions from stationary installations covered by ETS in the European Economic Area (EEA, 2024)

The ETS system primarily relies on cap-and-trade, a relatively new policy that utilizes the market mechanism to reduce carbon emissions. The government sets a hard cap on the amount of emissions an economy can produce annually - with a penalty of €100 per excess tonne of CO_2 equivalent emitted and legislation for said companies to surrender missing allowances the following year. Every firm receives allowances in the form of tradable permits per annum based on its carbon footprint, each permit accounting for one ton of carbon emissions. They can then either trade by selling their excess permits to other firms. Firms that will pollute more than the permits they receive would purchase excess permits from less-polluting firms. To reduce CO_2 emissions early, the total permits would gradually decrease to promote innovation and pollution-cutting methods. This is shown in Figure 4 with x axis being the year - y axis and variable being total emissions from the EU. The emissions cap is reduced annually, increasing from 4.3% in 2024 to 2027 and 4.4% from 2028 onwards (Appunn 2025) to eventually reach the target 62% emissions by 2030 compared to 2005 levels.

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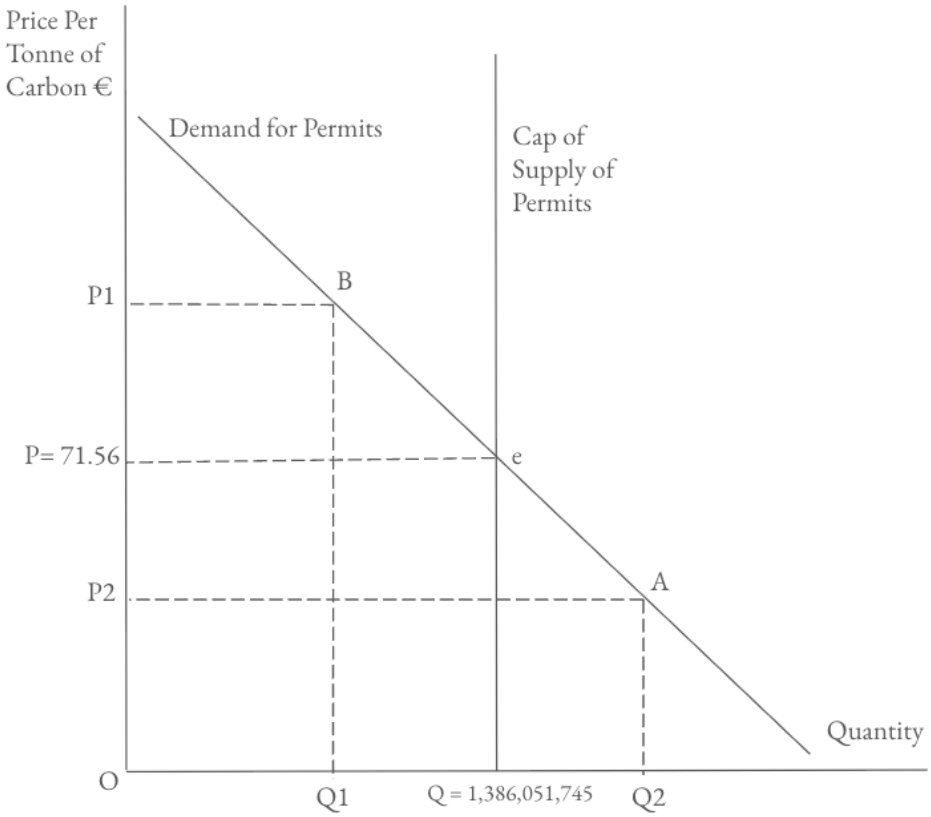

Figure 5: Cap-and-trade graph for 2024 quantity and price of carbon permits in the EU

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Figure 6: Historical 10-year trend for one carbon permit (Trading Economics, 2025)

As of January 1st, 2024, the price per carbon permit sits at around €71.50, and there were a total of 1,386,051,745 quantity permits for the entirety of the ETS system (Trading Economics, 2025). Figure 5 illustrates a cap-and-trade diagram where x axis is quantity of permits and y axis is the price per permit - variable being the price of the permit. With a reasonable assumption of no short-term change in permits, the government sets a cap at Q with a perfectly inelastic supply. Firms thus have to respond to the carbon price by referring to the internal costs of reducing one ton of carbon. Assuming, in Figure 5, it costs above P of €71.56 at point B, the cost of reducing one tonne of carbon (P1) is greater than the cost of purchasing a permit. As firms are profit-motivated, they would purchase a permit at the market price. In contrast, if the cost for reducing one unit of carbon is below P (take point A with price P2), it would be more profitable to sell the permit. One advantage of cap-and-trade is the reliance on market forces to determine the most cost-effective ways to reduce emissions. Given that no perfect information exists in the actual economy.

For the total cost of emissions for each individual firm, cap-and-trade encourages firms to determine the most cost-effective approach by using the market mechanism. Given that the quantity of permits is 1,386,051,745 and decreases per year, there is certainty about emission reductions by setting the fixed cap. For firms auctioning off excess permits, it generates revenue and profit, which incentivizes further innovation in carbon-cutting measures. Even for firms that pollute, they have the flexibility to purchase permits without getting penalized heavily by the government.

Historic trends suggest the cost of carbon permits has consistently been increasing, which encourages more companies to adopt carbon-cutting measures. Yet, according to Figure 6, which indicates the variable cost per carbon permit to year, the current cost per permit has decreased and reached an even point. The price volatility of carbon permits can thus create uncertainty for long-term investment into innovation, causing a hindrance to the reduction in pollution, as carbon prices might hinder profit. Even though the ETS was established in 2005, it took nearly a decade to see sustained growth due to the difficulties in its implementation. Cap-and-trade is incredibly difficult to implement and administer due to the governments having imperfect information over the current markets and internal cost structure for firms. An over-allocation of permits due to the cap being too high would result in no real decrease in carbon due, as it would be more profitable to purchase a permit. Additionally, there is a potential for market manipulation - notably the 2008 VAT fraud. Indirect taxes, VAT, are different in EU countries, and they did not affect permits back then. Hence, organizations bought permits in a country without VAT and sold them to a country with high VAT. They profited from the tax and caused an estimated loss of €5–10 billion. Even though the ETS has since introduced reverse-charge VAT mechanisms, there are still countless cases where cap-and-trade was abused for market manipulation.

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Comparison between IRA and ETS

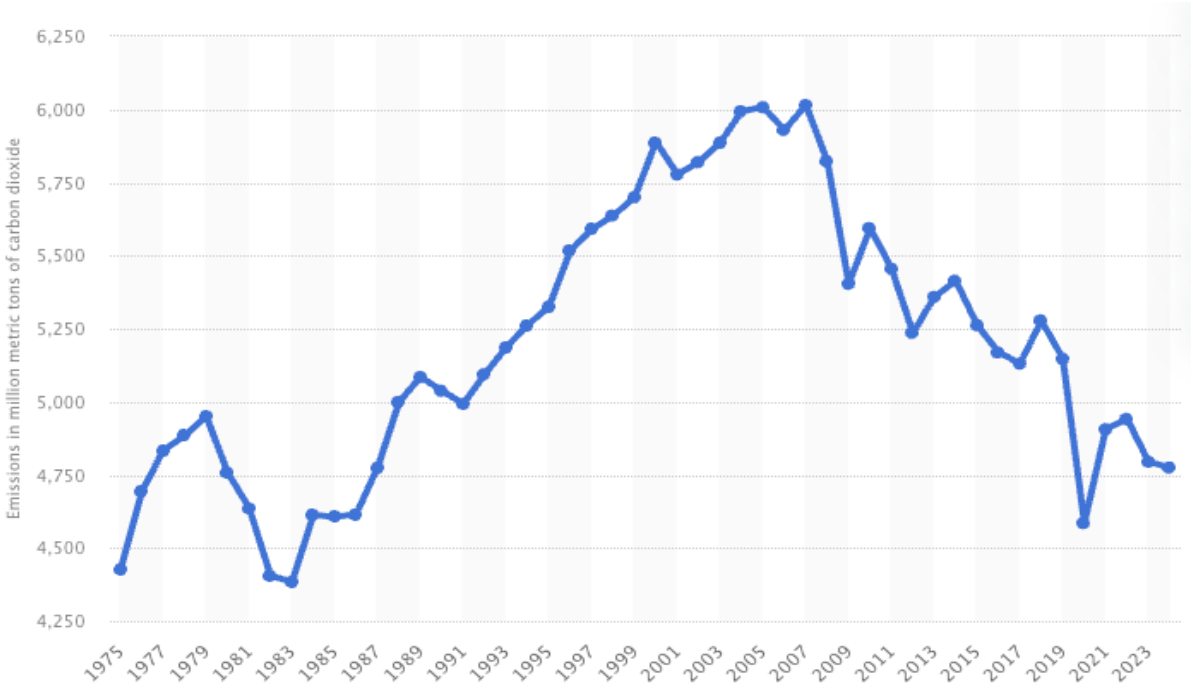

Figure 9: Carbon dioxide emissions from energy consumption in the United States from 1975 to 2024 (Tiseo, 2025)

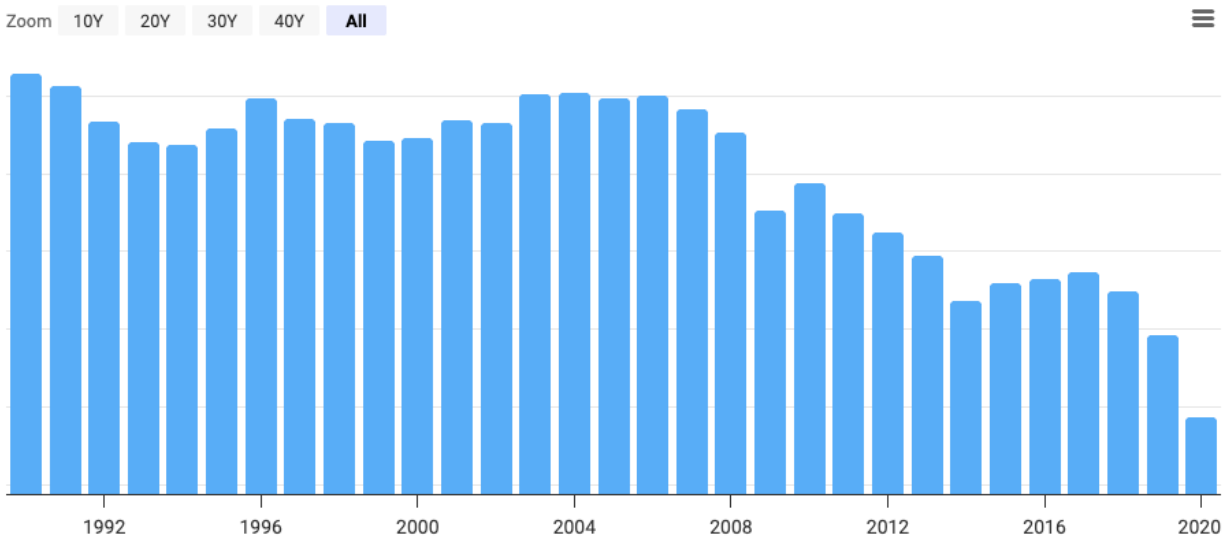

Figure 10: European Union Carbon (CO2) Emissions 1990-2025 (EEA, 2025)

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Figures 9 and 10 illustrate the varying levels of emissions from both the US and EU (y axis) ranging from the late 1900s to 2023 (x axis). The current IRA has only had 2 years since its establishment, so changes are minimal - yet there is certainly a large drop between 2022 to 2023 where it was issued. This might not be only due to the IRA, as the economy was still recovering from the pandemic that saw record lows in 2021. Meanwhile, due to the ETS having been established for two decades, there are far more observable trends. The general amount of carbon emissions has declined with a relatively strong correlation, going from 4,198,875 in 2005 to 2,843,246 in 2024. Yet, it would be difficult to compare how significant the ETS and IRA have been without illustrating the two side-by-side, which is what I did in the following.

For tables 1-3, an analysis of the relationship between the EU and the US with total emissions, emissions per capita, and emissions per GDP was conducted. To do so, secondary data were collected from 2005 to 2024, and a simple linear regression was used to assess the trends. Both descriptive statistics and inferential statistics were used. Descriptive statistics were used to summarize and organize data by reporting annual totals, calculating percentage changes, and describing such changes. Additionally, the data from the EU and the US are divided to show a ratio relationship, along with its changes over the 19 years. Inferential statistics are applied when using regression analysis to examine the three different relationships. I used the linear regression models to calculate r value (correlation coefficient) and the R^2 value (coefficient of determination) to determine whether there is a statistical trend, along with the strength of the trend. The analyses were all conducted using Google Sheets or Python to determine r and R^2 values and the relationship between the EU and US data.

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	Comparision between EU emission changes with US emission changes from 2005 to 2023			
Year	EU total emissions (KT)	Percentage change	US total emissions (KT)	Percentage change
2005	4,198,875	-0.41%	6,801,820	0.21%
2006	4,189,316	-0.23%	6,707,430	-1.39%
2007	4,175,670	-0.33%	6,797,860	1.35%
2008	4,055,152	-2.89%	6,619,980	-2.62%
2009	3,749,069	-7.55%	6,194,450	-6.41%
2010	3,830,837	2.18%	6,442,580	4.01%
2011	3,719,745	-2.90%	6,214,430	-3.54%
2012	3,657,834	1.66%	5,968,740	-3.95%
2013	3,559,373	-2.69%	6,108,670	2.34%
2014	3,435,183	-3.49%	6,129,040	0.33%
2015	3,494,766	1.73%	6,003,650	-2.04%
2016	3,492,159	-0.07%	5,907,270	-1.61%
2017	3,565,184	2.09%	5,842,800	-1.09%
2018	3,546,756	-0.52%	6,023,620	3.10%
2019	3,395,486	4.27%	6,039,739	0.27%
2020	3,103,023	-8.61%	5,505,181	-8.86%
2021	3,268,593	5.34%	6,340,000	15.16%
2022	3,192,218	-2.34%	6,343,000	0.05%
2023	2,907,204	-8.93%	6,152,710	-3.00%
2024	2,843,246	-2.20%	6,121,946	-0.50%

Table 1: Comparison between EU and US total and percentage emission changes from 2005 to 2024

According to Table 1, both the EU and the US have been continuously showing a decreasing trend in total carbon emissions - with the EU showing more consistent trends. Since the ETS's establishment in 2005, the EU's total emissions have reduced by 1,355,629 kilo-tonnes in 19 years. Meanwhile, the US only decreased by 679,874 kilo-tonnes in the same time frame. This highlights the effectiveness of ETS from a pure carbon reduction standpoint. Since the US IRA was established in 2023, following the highest increase in carbon emissions two years back with 15.16%, there was a 3% decrease in carbon emissions, as opposed to the EU 0.41% when the ETS was first introduced. This shows the immediate effect of placing large subsidies as incentives. The regression analysis produced an r value of -0.95 (R^2 of 0.9) for the EU, which indicates a very strong negative linear trend towards lower total emissions from 2005 to 2024.

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Conversely, there is a r value of -0.65 and R^2 of 0.42 for the US, indicating a moderate negative trend. However, the degree of effectiveness will require at least 10 years to determine the long-term viability of the IRA. Table 1, although highlighting the total emission percentage changes, does not take into account population size, as more populated countries, even having lower per capita emissions, generally have higher total emissions. More developed countries generally have higher per capita emissions as opposed to their counterparts - elements that are not accounted for in total annual emissions. For a fair comparison between the EU and US emissions after their respective policies, Table 2 will highlight the per capita emissions from both the EU and the US between 2005 and 2024.

		Comparison between EU and US emission per capita changes from 2005 to 2024					
Year	EU total emissions (T)	EU total population	EU CO_2 per Capita	US total emissions (T)	US total population	US CO_2 per Capita	US to EU ratio of CO_2 per Capita
2005	4,198,875,000	435,116,254	9.650	6,801,820,000	295,516,599	23.017	2.385
2006	4,189,316,000	436,521,866	9.597	6,707,430,000	298,379,912	22.479	2.342
2007	4,175,670,000	437,984,240	9.534	6,797,860,000	301,231,207	22.567	2.367
2008	4,055,152,000	439,386,639	9.229	6,619,980,000	304,093,966	21.770	2.359
2009	3,749,069,000	440,426,387	8.512	6,194,450,000	306,771,529	20.192	2.372
2010	3,830,837,000	441,041,446	8.686	6,442,580,000	309,327,143	20.828	2.398
2011	3,719,745,000	440,260,386	8.449	6,214,430,000	311,849,745	19.928	2.359
2012	3,657,834,000	440,905,186	8.296	5,968,740,000	314,361,094	18.987	2.289
2013	3,559,373,000	441,958,943	8.054	6,108,670,000	316,755,680	19.285	2.395
2014	3,435,183,000	442,883,888	7.756	6,129,040,000	319,297,805	19.195	2.475
2015	3,494,766,000	443,449,425	7.881	6,003,650,000	321,882,469	18.652	2.367
2016	3,492,159,000	444,320,232	7.860	5,907,270,000	324,426,311	18.208	2.317
2017	3,565,184,000	444,971,270	8.012	5,842,800,000	326,686,918	17.885	2.232
2018	3,546,756,000	445,982,757	7.953	6,023,620,000	328,571,142	18.333	2.305
2019	3,395,486,000	446,575,615	7.603	6,039,739,000	330,284,261	18.286	2.405
2020	3,103,023,000	446,547,542	6.949	5,505,181,000	331,577,720	16.603	2.389
2021	3,268,593,000	445,854,958	7.331	6,340,000,000	332,099,760	19.091	2.604
2022	3,192,218,000	446,833,687	7.144	6,343,000,000	334,017,321	18.990	2.658
2023	2,907,204,000	448,500,767	6.482	6,152,710,000	336,806,231	18.268	2.818
2024	2,843,246,000	449,206,579	6.329	6,121,946,000	345,426,571	17.723	2.800

Table 2: Comparison between EU and US emissions per capita changes from 2005 to 2024

Table 2 contains the per capita emissions for both the EU and the US, along with a ratio between the two. Consistently, the EU's carbon emission per capita has been more than 2 times less than that of the US, with the EU having more population yet less total emissions. The ratio between emissions per capita has also increased consistently over the 19 years from 2.385 to 2.8. Even when the IRA was introduced, the emissions per capita difference still increased. This suggests the EU ETS fosters more sustainable behavior across the population. The EU emissions per

capita to year relationship has an r value of -0.96 and R^2 of 0.93, indicating a strong negative trend. The US, although seeing a gradual decrease in total carbon emissions, still continuously has high carbon emissions per capita relative to the EU. Nonetheless, there is a r value of -0.86 and R^2 of 0.74, indicating strong but less consistent relationships between emission per capita and year as opposed to the EU. The ratio between the US and EU, however, has an r value of 0.63 (R^2 of 0.39), indicating a moderate relationship. Seeing that the ETS was introduced in 2005 and the gap between emissions per capita widened, there was a definite effect as the EU emissions relative to the US have decreased over the 19 years, ceteris paribus. One flaw in Table 2 is that it penalizes productive countries with high output, like the US, with 27 trillion USD GDP, because it might seem worse in per capita terms, despite the US being efficient. Additionally, when industries adopt cleaner technologies to reduce emissions per GDP, it rarely affects emissions per capita. To address these issues, Table 3 compares EU and US emissions per GDP changes from 2005 to 2024.

		Comparison between EU and US emission per GDP changes from 2005 to 2024					
Year	EU total emissions (T)	EU total GDP (bn $USD)	EU CO_2 per GDP	US total emissions (T)	US total GDP (bn $USD)	US CO_2 per GDP (kg)	US to EU ratio of CO_2 per GDP
2005	4,198,875,000	11,954.00	0.351	6,801,820,000	13,039.20	0.5216440	1.485
2006	4,189,316,000	12,768.00	0.328	6,707,430,000	13,815.60	0.4854968	1.480
2007	4,175,670,000	14,789.50	0.282	6,797,860,000	14,474.30	0.4696503	1.663
2008	4,055,152,000	16,365.10	0.248	6,619,980,000	14,769.90	0.4482075	1.809
2009	3,749,069,000	14,846.30	0.253	6,194,450,000	14,478.10	0.4278496	1.694
2010	3,830,837,000	14,643.40	0.262	6,442,580,000	15,049.00	0.4281069	1.636
2011	3,719,745,000	15,876.60	0.234	6,214,430,000	15,599.70	0.3983686	1.700
2012	3,657,834,000	14,733.00	0.248	5,968,740,000	16,254.00	0.3672167	1.479
2013	3,559,373,000	15,400.00	0.231	6,108,670,000	16,880.60	0.3618752	1.566
2014	3,435,183,000	15,764.80	0.218	6,129,040,000	17,608.10	0.3480807	1.597
2015	3,494,766,000	13,655.00	0.256	6,003,650,000	18,295.00	0.3281580	1.282
2016	3,492,159,000	13,990.30	0.250	5,907,270,000	18,804.90	0.3141346	1.258
2017	3,565,184,000	14,870.00	0.240	5,842,800,000	19,612.10	0.2979181	1.243
2018	3,546,756,000	16,091.50	0.220	6,023,620,000	20,656.50	0.2916089	1.323
2019	3,395,486,000	15,808.40	0.215	6,039,739,000	21,539.90	0.2803977	1.305
2020	3,103,023,000	13,580.30	0.228	5,505,181,000	21,354.10	0.2578044	1.128
2021	3,268,593,000	14,794.30	0.221	6,340,000,000	23,681.10	0.2677240	1.212
2022	3,192,218,000	16,995.30	0.188	6,343,000,000	26,006.90	0.2438968	1.299
2023	2,907,204,000	17,197.80	0.169	6,152,710,000	27,720.70	0.2219536	1.313
2024	2,843,246,000	17,935.50	0.159	6,121,946,000	29,167.70	0.2098879	1.324

Table 3: Comparison between EU and US emissions per GDP changes from 2005 to 2024

When comparing emissions per GDP, shown in Table 3, the ratio between the US and the EU dropped significantly as opposed to emissions per capita. Whereas the previous hovered around 2.5:1 and increased linearly with a relatively strong correlation, emissions per GDP saw the two hovering around 1.4:1 with a decreasing trend. Seeing that both EU and US emissions per GDP

have decreased, having the ratio between the two continuously decreasing as well shows US GDP to emissions decreases at a faster rate relative to the EU, even before the introduction of the IRA. However, since the establishment of the IRA, the ratio between emissions per GDP for the US and the EU has increased from 1.299 to 1.324. This shows that the IRA's influence in reducing emissions per GDP was not as effective in the short term. The EU CO_2 per GDP from 2005 to 2024 had an r value of -0.84, R^2 of 0.71, while the US has an -0.99 r value and 0.98 R^2 value. These show a very strong and consistent decline linearly in both the US and EU emissions per GDP, yet the US is considerably more consistent than its counterpart. Conversely, the ratio between the US and the EU has an r value of -0.77 - R^2 of 0.59 - indicating a moderate downward trend. Despite the EU having lower emissions per GDP, the US has been more effective in reducing its emissions per GDP relative to the EU without a clear carbon policy. This could be largely attributed to the US shifting its means of production to imports from other countries, whilst investing more in the tertiary sector (service-oriented goods). Consumer awareness also played a role in promoting cleaner energy transformations. Yet, the decrease in costs of renewable energy to a point where it is competitive with traditional coal-based power grids partially reduces the US emissions per GDP. However, more time will be needed to determine the effectiveness of the IRA in reducing emissions per GDP, as the ratio has increased since its inception. If the subsidies can negate the intermittency cost or result in greater energy efficiency for renewables like solar and wind, the emissions per GDP would make the US competitive with the EU.

Discussion

Three data points have been used to measure the effectiveness of different carbon policies - that being total emissions, emissions per capita, and emissions per GDP. After comparing the historical trends from 2005 to 2024, along with two other major countries with similar policies, there are consistent results. Since the establishment of the ETS, the EU has continuously decreased its total carbon emissions while the US has remained fluctuating. However, when the IRA was established, there was a sudden drop in total emissions with a 3% decrease, far greater than when the EU ETS was first established. This could be partly attributed to the nature of the

cap-and-trade system that the ETS relied on. Cap-and-trade requires long durations as it prioritises innovation and cost-cutting methods in production. It is used to incentivise change without having excess side-effects and opportunity costs in government spending. Additionally, long periods are required to properly allocate a sustainable number of permits that do not hinder growth, yet push cleaner methods. Some difficulties arise due to imperfect information, which increases the difficulty in allocating an effective number of permits to different firms. This is shown in emissions, seeing minimal decreases in the first 3 years after the ETS is established. However, after 3 years, the EU saw a continuous decrease in carbon emissions.

The IRA, on the other hand, underwent notable changes in total emissions due to the large subsidies the US government granted to firms to encourage lower emissions. Large government spending saw greater effectiveness, but the long-term costs would be unsustainable if the US government wishes to continuously see decreases in total emissions. Despite investing $433 billion on climate issues, the US still has one of the highest emissions per capita around the world - more than double that of the EU. This reveals how US emissions are far more unsustainable for the population. Even the largest manufacturer in the world, China, has under half of the US emissions per capita. It should be noted that the numbers have dropped significantly since the establishment of the IRA in 2023, but more time is needed to see the long-term effects. This is largely attributed to the large number of private cars and larger homes due to a low population density, especially in rural areas where there are no transportation alternatives. Consumer behaviours are difficult to alter in short periods, hence the emission per capita remains high even though there are large steps towards lower carbon output.

When comparing the emissions per GDP for both countries to determine emissions with economic growth, the US is still far higher than that of the EU, even when the IRA was established. As the US has the highest GDP in the world, with $30.51 trillion, the emissions per GDP were expected to be far lower. Part of it could be attributed to transportation patterns, with the US gravitating towards traditional combustion vehicles due to a less developed public transport system, while the EU uses public transportation and electric vehicles. The cities in the US are also spread out more than the EU, which encourages cars instead of public transport.

However, it does not explain how the ratio between CO_2 per GDP is this high. In the end, it could primarily be due to the EU ETS being in full effect for over 19 years by 2024 to put financial pressure on reducing emissions. The methods adopted by the US were not fully tailored for climate issues as the main objective is reducing inflation.

ETS is a system that requires no additional government spending and has outperformed the IRA across key metrics, though long-term trends for the IRA remain uncertain. Even though it is more difficult than subsidies to establish, it is more sustainable in the long term upon successful implementation as large amounts of government revenue do not have to be spent on climate-related issues. Although subsidies are useful in the short term to see fast reductions in emissions, the large cost ultimately makes it unsustainable for long periods. Seeing that the US is already under a large debt, changing the system by adding a carbon tax like Canada would be beneficial, as the revenue generated from taxation could be used to subsidise green sectors. Ultimately, based on a variety of current metrics from both the EU and the US, the EU ETS is superior in the long term compared to the US IRA.

Conclusion

The IRA, introduced in 2022, has yet to have time to determine the long-term consequences and benefits of a pure subsidies measure. Hence, it is difficult to deduce its effectiveness in CO_2 per GDP and CO_2 per Capita shortly. There are also cultural gaps between the EU and the US in terms of consumer behavior and habits, which influence CO_2 per capita, notably transportation. Such metrics have not been accounted for heavily in my conclusion. The ETS has had 19 years to evolve and refine, while the IRA only had 2, making it difficult to determine the effectiveness of the two when comparing them in the same time frame. Attempts have been made to compare the CO_2 per GDP and CO_2 per capita in the first three years of both the EU ETS and the US IRA, but political, habitual, and economic differences were drastic when comparing 2005 and 2022. I conclude that an ETS system utilizing a cap-and-trade system is superior to the IRA, which relies mainly on subsidies. ETS, although requiring a longer time to see visible progress, does not require additional government spending and has far lower opportunity costs than the IRA.

The historical trends with EU ETS seeing far lower CO_2 per capita than the US, along with nearly half of the CO_2 per capita and far less CO_2 per GDP, means it performs favorably across several key metrics. Yet, the ETS repeatedly saw little effect in the first few years of establishment, while the IRA saw an immediate 3% decrease in CO_2 per capita. Hence, if governments were to initially implement the ETS and use subsidies to stimulate faster adoption of cleaner and more innovative technologies, the biggest flaw of the ETS would be resolved. After the first few years, when the ETS reaches stability and prices stop fluctuating largely, stopping subsidies altogether can allow for more to be spent on alternatives like healthcare. In the process, the ETS does not require perfect information about the market and each firm. Instead, prompting firms to determine whether it is more profitable to purchase or sell permits. Similar effectiveness could be reached if the IRA were to include carbon taxes to further incentivize the adoption of cleaner technologies and gain revenue to invest in subsidies at the same time. However, as of right now, the ETS, having already been established and correcting its weaknesses prevalent in the first few years, appears to outperform IRA.

Appendix

Comparative analysis

Canada

Two other notable countries with distinct and effective carbon policies are Canada and China, which I will be discussing in brief detail for the global diversity of climate policy approaches. Canada's climate policy framework branches from the source "Pan-Canadian Approach to Pricing Carbon Pollution" in 2016. It allows provinces to tailor their carbon pricing but forces them to follow the general plan. Canada's system mainly includes two forms of carbon pricing: a tax on carbon emissions and clean energy subsidies. Taxes on carbon emissions reached CAD 65 (USD 47.50) in 2023 and CAD 95 (USD 69.38) in 2025, with planned increases of CAD 15 annually until reaching CAD 170 (USD 124.15) by 2030 (ICAP, 2025).

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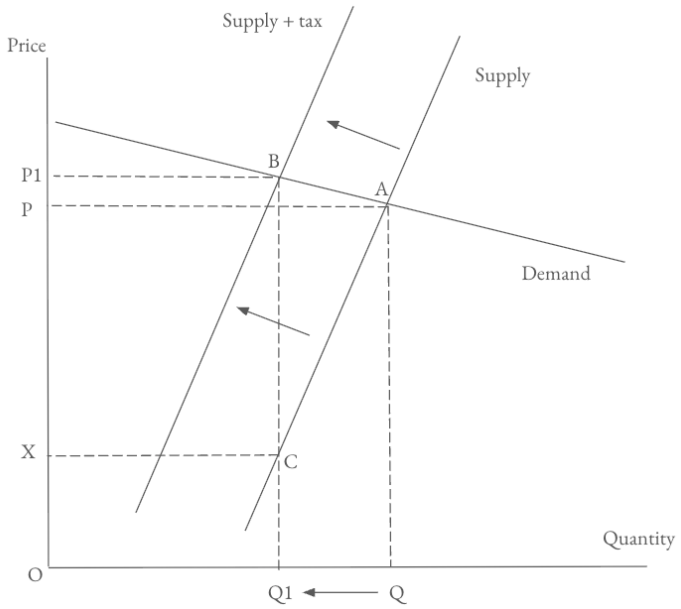

Figure 7: Canada carbon tax

The carbon tax highlighted in Figure 7 increases the cost of production by BC, with firms often being forced to internalise the majority of the costs. Not only would it encourage them to seek cost-cutting methods like green energy or methods that create less carbon emissions, but it would also generate government revenue. The equilibrium shifted from A to B after the increase in carbon tax, resulting in the quantity produced decreasing from Q to Q1, ceteris paribus. The government revenue in the new equilibrium would then be P1BCX. This pricing mechanism is responsible for 20-48% of Canada's projected emission reduction by 2030 (Canadian Climate Institution, 2025; Navius, 2025). However, the high carbon costs potentially drive certain companies out of the Canadian market, and certain firms might find it more profitable to bear the costs of carbon than invest in sustainable energy grids like solar, primarily due to the intermittency costs - hence the subsidies on green energy production.

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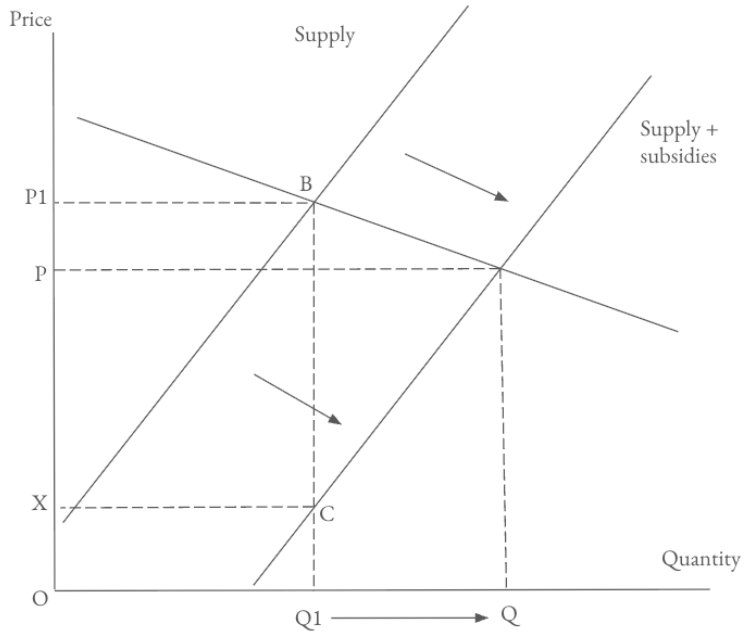

Figure 8: Canada green energy subsidies

Another core element of the Canada carbon policy is the 30% investment tax credit for renewable energy, shown in Figure 8, effective until 2034 as a countermeasure against the IRA. Tax credits are a form of subsidies in which the government provides financial assistance to cut part of the cost of production for certain goods or services, for more production, ceteris paribus. This makes renewable energy more profitable and encourages its adoption - evident in project values being projected to be more than 50% over their lifetime, with a typical 250-megawatt project in Canada now generating a full lifecycle net present value of $202 million after-tax, compared to $131 million before the tax credit implementation (Rystad, 2023). A combination of the two policies results in clean energy being the better option and less investment required due to carbon taxes generating a portion of the funds that could be reinvested into sustainability.

China

China's carbon measures draw similarities with the EU ETS, as China also created an emissions trading system in July 2021. The China ETS is the world's largest carbon market by coverage, with more than 2,000 companies and 26,000 annual CO_2 emissions. However, instead of absolute emission caps like the case of the EU ETS, the China ETS utilizes benchmarks with permits based on computer calculations. Since its establishment, the cost per permit skyrocketed from $6-9 USD to hovering around $12.50 USD as of April 2024 (Oxford Institute of Energy Studies, 2024). Compared to the EU, China's ETS, although created 15 years later, is far more stable and is expected to continue without large fluctuations as the system evolves.

However, instead of the democratic approach of the EU ETS, the Chinese ETS utilizes a non-democratic approach. Companies are to share emissions data with full transparency and allocated permits based on the information. To regulate this matter further, the penalty for emissions data fraud increased from USD 4,200 to USD 70,000 (Pollard, 2024). The centralized form of governance resulted in ETS compliance rates increasing from 99.61% in 2021 to 99.88% in 2022, far above the 97.15% EU ETS in 2021 (China Ministry of Ecology, 2024). While the EU ETS focuses on democracy between member states, with a need for coordination and compromise, the China ETS's centralized decision-making results in fast changes. However, it results in controversial policy-making and resistance from internal firms. There is also less international coordination due to the nature of the government framework, leading to less global integration. The low carbon prices of USD 12.50 are also far less than the EU €71.56 to raise questions about the actual effectiveness in incentivising firms to switch to renewable sources that cause less emission, rather than firms absorbing the entire cost of carbon prices.

Comparison between the US, EU, Canada, and China's Carbon Policies

Further steps were taken to measure the three metrics - total emission, emission per capita, and emission per GDP - by expanding the scope of countries to include China and Canada. This is indicated in tables 4-6 with percentage changes removed to simplify the data. The same descriptive and inferential analysis and r, R^2 values were conducted using Google Sheets and Python. Data for each country was gathered and ordered in separate tables to eventually compare and graph the relationships.

PRINCETONIAN JOURNAL OF SCIENCES

RESEARCH ARTICLE

			Comparision between EU, US, China, and Canada emission changes from 2005 to 2023					
Year	EU total emissions (KT)	Percentage change	US total emissions (KT)	Percentage change	China total emissions (KT)	Percentage change	Canada total emissions (KT)	Percentage change
2005	4,198,875	-0.41%	6,801,820	0.21%	7,263,559	11.92%	759,000	-3.60%
2006	4,189,316	-0.23%	6,707,430	-1.39%	7,942,464	9.35%	755,000	-0.53%
2007	4,175,670	-0.33%	6,797,860	1.35%	8,551,054	7.66%	774,000	2.52%
2008	4,055,152	-2.89%	6,619,980	-2.62%	9,200,000	7.59%	758,000	-2.07%
2009	3,749,069	-7.55%	6,194,450	-6.41%	9,800,000	6.52%	714,000	-5.80%
2010	3,830,837	2.18%	6,442,580	4.01%	10,400,000	6.12%	728,000	1.96%
2011	3,719,745	-2.90%	6,214,430	-3.54%	11,000,000	5.77%	738,000	1.37%
2012	3,657,834	1.66%	5,968,740	-3.95%	11,700,000	6.36%	741,000	0.41%
2013	3,559,373	-2.69%	6,108,670	2.34%	12,550,200	7.27%	750,000	1.21%
2014	3,435,183	-3.49%	6,129,040	0.33%	12,800,000	1.99%	747,000	-0.40%
2015	3,494,766	1.73%	6,003,650	-2.04%	12,900,000	0.78%	742,000	-0.67%
2016	3,492,159	-0.07%	5,907,270	-1.61%	11,775,000	-8.72%	725,000	-2.29%
2017	3,565,184	2.09%	5,842,800	-1.09%	12,014,199	2.03%	738,000	1.79%
2018	3,546,756	-0.52%	6,023,620	3.10%	12,524,335	4.25%	747,000	1.22%
2019	3,395,486	4.27%	6,039,739	0.27%	12,732,245	1.66%	747,000	0
2020	3,103,023	-8.61%	5,505,181	-8.86%	12,942,868	1.65%	682,000	-8.70%
2021	3,268,593	5.34%	6,340,000	15.16%	13,000,000	0.44%	694,000	1.76%
2022	3,192,218	-2.34%	6,343,000	0.05%	14,500,000	11.54%	700,000	0.86%
2023	2,907,204	-8.93%	6,152,710	-3.00%	14,900,000	2.76%	694,000	-0.86%
2024	2,843,246	-2.20%	6,121,946	-0.50%	14,393,400	-3.40%		

Table 4: Comparison between EU, US, China, and Canada emission changes from 2005 to 2024

Table 4 extends the scope of total carbon emission changes to include both China and Canada. As opposed to the EU and US, which saw mostly decreases in total carbon emissions between 2005 to 2024, China's carbon emissions have continuously increased due to more production. This is natural as China is now the world's largest manufacturer and producer with large exports, yet the total emissions have now become unsustainable. Since the 2021 establishment of the China ETS, there has been a large spike in CO_2 increases primarily associated with the pandemic. ETS also requires a long time to see strong changes, as shown in the EU needing 3 years before carbon emissions drop by over 2%. By 2024, the China ETS was successful in China, seeing a 3.4% decrease in emissions - the first decrease since 2016. Although more time is needed to determine the long-term success of the China ETS, there is promise due to large corporations from firms. Canada's data is more similar to that of the US, but way more consistent in the downward trend, with fewer fluctuations. Considering both use similar policies with the only large difference being the establishment of carbon taxes, data trends show Canada's approach to be superior in reducing total CO_2 emissions. Even during the 2021 pandemic,

Canada's carbon emissions did not increase drastically, and there are more cases of large percentage decreases in CO_2 emissions in a fiscal year than an increase.

	Comparison between EU, US, China, and Canada emission per capita changes from 2005 to 2024			
Year	EU CO_2 per Capita	US CO_2 per Capita	China CO_2 per Capita	Canada CO_2 per Capita
2005	9.650	23.017	5.000	17.770
2006	9.597	22.479	5.269	17.380
2007	9.534	22.567	5.697	18.180
2008	9.229	21.770	5.828	17.360
2009	8.512	20.192	6.213	16.180
2010	8.686	20.828	6.748	16.440
2011	8.449	19.928	7.337	16.670
2012	8.296	18.987	7.498	16.420
2013	8.054	19.285	7.814	16.510
2014	7.756	19.195	7.854	16.530
2015	7.881	18.652	7.712	16.290
2016	7.860	18.208	7.676	16.170
2017	8.012	17.885	7.805	16.170
2018	7.953	18.333	8.141	16.270
2019	7.603	18.286	8.308	15.720
2020	6.949	16.603	8.429	14.280
2021	7.331	19.091	8.914	14.610
2022	7.144	18.990	8.889	14.990
2023	6.482	18.268	9.305	17.858
2024	6.329	17.723	9.374	17.887

Table 5: Comparison between EU, US, China, and Canada emissions per capita changes from 2005 to 2024

CO_2 emissions per capita comparison between the EU, the US, China, and Canada is compared in Table 5. Despite China having the highest total emissions, the CO_2 emission per capita is still far below that of the US and Canada. Those that adopted the ETS - that being the EU and China - saw far lower emissions per capita than their counterparts with either subsidies or a mixture of carbon taxation and subsidies. However, the emissions per capita for China have continuously increased linearly between 2005 to 2024 nearly doubled. This could be partly attributed to China's development within the last 20 years - with development requiring more carbon

emissions as living conditions improve. Despite this, the emissions are still almost twice less than the US and Canada counterparts. The EU, meanwhile, despite having the same system, saw the opposite trends. The USA's CO_2 per capita has decreased, yet Canada continuously hovers around the 17 mark. Comparing the emission per capita changes from 2005 to 2024 reveals that the ETS generally has lower CO_2 per capita.

	Comparison between EU, US, China, and Canada emission per GDP changes from 2005 to 2024			
Year	EU CO_2 per GDP	US CO_2 per GDP (kg)	China CO_2 per GDP (kg)	Canada CO_2 per GDP (kg)
2005	0.351	0.522	0.900	0.370
2006	0.328	0.485	0.870	0.365
2007	0.282	0.470	0.840	0.360
2008	0.248	0.448	0.810	0.355
2009	0.253	0.428	0.780	0.350
2010	0.262	0.428	0.700	0.330
2011	0.234	0.398	0.670	0.320
2012	0.248	0.367	0.640	0.310
2013	0.231	0.362	0.620	0.300
2014	0.218	0.348	0.600	0.295
2015	0.256	0.328	0.600	0.290
2016	0.250	0.314	0.570	0.280
2017	0.240	0.298	0.550	0.275
2018	0.220	0.292	0.530	0.270
2019	0.215	0.280	0.510	0.265
2020	0.228	0.258	0.500	0.270
2021	0.221	0.268	0.480	0.260
2022	0.188	0.244	0.460	0.250
2023	0.169	0.222	0.458	0.248
2024	0.159	0.210	0.445	0.246

Table 6: Comparison between EU, US, China, and Canada emissions per GDP changes from 2005 to 2024

Table 6 reveals CO_2 per GDP for the EU, US, China, and Canada. China consistently has the highest CO_2 emissions per GDP, but has decreased drastically by more than halving in the duration of 2005 to 2024. Even though China's emissions have been increasing, CO_2 per GDP declined at a far greater rate. This reveals China has been able to make economic growth outpace

emissions growth, along with more efficiency in manufacturing. Since the establishment of the China ETS, even though there was the pandemic, CO_2 per GDP still declined drastically, with 2024 marking the lowest recorded year. Similar trends are visible in the EU ETS - highlighting how both systems are able to decrease emissions per GDP. Meanwhile, despite Canada seeing lower CO_2 per GDP, the rate of decrease is far less than the other three countries, with only a 0.124 kg decrease as opposed to the US 0.312 kg. Since the Pan-Canadian Approach to Pricing Carbon Pollution in 2016, there have been no drastic changes in emissions per GDP. Although the same is true for the US, more time is needed to determine the effectiveness.

After including China, a country that adopted an ETS system similar to that of the EU, and Canada, a country with a carbon policy similar to that of the US subsidies approach but carbon taxes as well, the results are similar. This is especially prevalent in CO_2 per capita, as the two countries that use ETS have far lower numbers than the other two. When comparing CO_2 per GDP, however, China ranked as the highest, while the EU ranked as the lowest. Despite this, CO_2 per GDP has decreased drastically since China introduced its ETS in 2021.

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Does Mobile Money Substitute or Complement Traditional Banking? An Empirical Analysis of Sub-Saharan Africa

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Doi: 10.5281/zenodo.16877860

Abstract

Mobile Money Services have become increasingly popular in the last two decades, particularly within Sub-Saharan Africa. These services do not exist in isolation, rather they exist alongside other financial services, most notably, traditional banks. This paper seeks to determine the relationship between these two types of financial services, through a dual-analysis approach upon data collected from 7 Sub-Saharan African countries between 2007 and 2021. After the data were analyzed with a two-way fixed effects panel regression as well as a correlation analysis, there was both a complementary and substitute relationship displayed between the two financial services, albeit during different stages of mobile money development. Notably, we found that in the early stages (i.e. pre-2015), usage of both Mobile Money and Traditional Banks increased, but in recent years (i.e. post-2015 to present), the usage of Mobile Money increased but there was a decline in the usage of banks. Through this, a set of policy recommendations were forwarded to improve the efficiency of both services within Sub-Saharan Africa, with the ultimate goal of increasing access to these financial services to the historically underserved, or unbanked.

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1 Introduction

The global financial sector is rapidly shifting toward digital platforms, leveraging the recent booms in technology. Notably, a significant 77% of consumers now prefer to manage their accounts and access financial services through a mobile app, or a computer (American Bankers Association, 2022). However, most of these changes are evidenced within developed countries (i.e. the US, EU, China), notably, ones with already rigid financial institutions like commercial banks, savings and loans associations, etc. Given the heavy capital dedicated to the financial sector in these countries, coupled with high incentives to invest, the transition from in person, old fashioned banking to online forms has been relatively seamless. On the other hand, counterparts in developing nations have had different paths to access new ways of managing money.

In the past two decades, mobile money has emerged as one of the most revolutionary financial technologies in the Global South, particularly in Sub-Saharan Africa. As of 2021, Sub-Saharan Africa accounted for nearly 70% of the world's $1 trillion mobile money transaction volume (GSMA, 2022). First pioneered by Kenya's M-PESA in 2007, mobile money enables individuals to store, send, and receive funds via basic mobile phones–expanding financial services to all populations, even those excluded from traditional banking systems.

While existing scholarly work comments extensively on the adoption of mobile money services, little research has been dedicated towards the impact these services have on the broader financial sector. Specifically, we ask the question: Are Mobile Money and Traditional Banks in Competition? To answer this, we compare the prevalence of Mobile Money to the prevalence of Traditional Banks over time, as well as plotting both variables up against general economic growth of specific countries.

Investigation into this topic can result in improvements within policy making and financial regulation within Sub-Saharan Africa. Notably, this allows for better collaboration between the two sectors of banking, giving users more versatility in their financial lives, but also making the sector more efficient rather than straddling upon two independent systems.

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2 Literature Review

2.1 Defining Mobile Money and Traditional Banking

When the tail of the global technological expansion finally dragged into Sub-Saharan Africa, specifically, the newfound access to mobile phone technology, there was drastic change across the entire region. Mobile phones revolutionized all aspects of Sub-Saharan African life – but most pertinently, it greatly increased financial inclusion (Osabutey & Jackson, 2024). Financial inclusion is a state in which individuals in society have easy access to financial products or services that meet their needs, thereby supporting things like entrepreneurship, development, and growth. (World Bank).

Mobile phones gave rise to electronic banking, enabling customers to bank 24/7, check account balances, pay bills, apply for loans, trade securities, conduct financial transactions, among other things, all from the comfort of their phone (Tchouassi 2012). The mechanism through which this is possible is known as Mobile Money. Defined explicitly by the Group Speciale Mobile Association, mobile money is a service in which the mobile phone is used to access financial services (GSMA). Mobile money is most commonly provided by telecommunications companies, for example, Safaricom's M-Pesa in Kenya. It is thus important to note that these systems lie outside the formal banking circuit, which traditionally include institutions such as banks or credit unions (Suri 2017). There are three key actors that allow mobile money to work effectively. Firstly, Mobile Network Operators (MNOs) are companies that provide wireless communication services to users–in the U.S., think AT&T, Sprint, Verizon, etc. (ScienceDirect). These companies are often very large, and in most cases within Sub-Saharan Africa, have a monopoly over the telecommunications industry (i.e. Safaricom in Kenya). Secondly, Mobile Money Agents are physical touchpoints that enable consumers to convert cash into digital currency–typical examples are kiosks, post offices, or local shops. The increase in the density of mobile money agents has been instrumental to increasing financial inclusion–prompting a whopping 148 active mobile money agents per square kilometer in 2018, more than double the figure in 2014. As such, MNOs have been more stringent on growing their distribution networks through MMAs, providing focused education and training to all branches (GSMA). Thirdly,

consumers are the driving force of mobile money. Consumers can deposit and withdraw money from their mobile account, and are able to send money through their SIM number to any other user within that same country (Suri).

On the other hand, traditional banking is a well-analyzed framework that incorporates essential services such as deposits, loans, and miscellaneous activities (i.e. transactions, financial advice, rewards programs) (Komandla & Perumalla, 2017). When speaking on traditional banks, most often researchers are referring to commercial banks that are government regulated. Oftentimes, these banks are heavily regulated by government authorities–leading to strict requirements consumers need to adhere to. This is exacerbated in countries within Sub-Saharan Africa where governments already intervene extensively in the financial system. As such, it is quite tedious for average citizens in these areas to open a bank account; as it requires a multitude of documents such as: valid ID, a letter of reference, proof of residence, passport sized photo, amongst others (Iluba & Phiri, 2021). It is also worthy to note the distribution of banks within Sub-Saharan Africa. Aduda & Kalunda, 2012 find that within Kenya, a country with one of the largest financial systems in East Africa, 93% of bank branches are in urban areas, and only 7% are in arid or semi-arid areas. Moreover, they posit that banks are often skewed towards large private and public enterprises, rather than focused on catering to more individualistic and menial needs of common folk.

2.2 Theoretical Frameworks: Substitution Effect and Complement Effect

Within existing literature, there are two general theories that have been posited regarding the two categories of financial services previously discussed.

The first theory is the Substitution Effect, stating that Mobile Money services and Traditional Banking are directly in competition with each other–consumers are either bound to one or the other as their main financial service providers. Previously, banks had dominated the financial system, but this is no longer true because the market share of these banks are falling due to the "scuffle by other financial institutions" (Rose and Hudgins, 2008). A big contention between the two services is the idea of servicing the unbanked–adults who do not use banks or banking

institutions in any capacity (Investopedia). Consumers are now opting for Mobile Money services, which brings a variety of benefits, including: 1) Reduced transaction cost with mobile money services, allowing households and individuals to better absorb large negative income shocks that are common in Sub-Saharan Africa (Jack & Suri, 2014), 2) Businesses have begun to adopt mobile payments because it decreases cash management costs, thereby improving customer service and overall profitability (Mallat and Tuunainen, 2008; David-West et al., 2019). The bigger issue with traditional banking is its seemingly static nature. Because of institutional lag with government oversight and the lethargic nature of brick and mortar establishments–there are two issues described by Flejterski & Labrum, 2016 that banks face: 1) IT infrastructure becoming obsolete, that is to say, it takes lots of capital for banks to adapt quickly to the evolving technological landscape within financial services, and 2) High switching costs–consumers are hesitant to switch between banks because of fees incurred during the transition (i.e. fees to open a new account), and thus, banks have less incentive to innovate in their services when they can safely guarantee a relatively loyal customer base. On a comparative note, banks still remain the number one choice for providing financial services to corporate entities (Iluba & Phiri, 2021), given that mobile money is less versatile in services like loans, mortgages, or long-term investments.

The second theory is the Complement Effect, stating that Mobile Money services and Traditional Banking synergize and work together to bolster financial services within Sub-Saharan Africa. Extending from previous commentary, it appears that the two services target different groups of people–mobile money provides convenience for individuals looking to perform basic transactions, and banks offer more robust and elaborate services to cater towards larger corporate entities. However, there have been positive sentiments that point to a collaboration between the two types of platforms. In Botswana, financial service users said they trust Mobile Operators and Banks 19.7% and 26.3% respectively, but together, they trust them 44.4%, with similar statistics in Ghana/South Africa (Tchouassi, 2012). Moreover, some commercial banks have begun to digitalize within Sub-Saharan Africa, but consumers are skeptical of these mobile apps–in Benin, Burkina Faso, Mozambique, and Nigeria, survey respondents indicated that they would trust

mobile banking more if backed by a mobile operator, showing the positive perceptual effects that would arise from a collaboration (Tchouassi, 2012).

2.3 Gaps in Existing Literature

The current literature analyzes benefits, drawbacks, as well as perceptual nuances regarding Mobile Money within Sub-Saharan Africa. More relevant literature even goes to explain how Mobile Money and more Traditional Forms of Banking may interact with each other. However, there is limited analysis done to compare the longitudinal progression of Mobile Money and Traditional Banking. This paper fills in that gap, by tracking how the two services have evolved over time, in tandem. Additionally, while researchers have extensively investigated how mobile money and other microfinance technologies have evolved in Sub-Saharan Africa, there is still a need for these financial services to be linked to overall economic growth–which is a large driving motive for developing countries in Sub-Saharan Africa. This paper consolidates findings and provides suggestions for Mobile Money and Traditional Banking to form a collaborative relationship going forward.

3 Methodology

3.1 Data Collection

We collected data for seven countries within Sub-Saharan Africa – Ghana, Kenya, Nigeria, Rwanda, Tanzania, Zambia, Zimbabwe. We measured six key indicators: 1) Internet users, percent of population, 2) Percent urban population, 3) Mobile phone subscribers, per 100 people, 4) GDP Per Capita, 5) Bank branches per 100, 000 people, 6) Registered mobile money accounts per 1000 people. Notably, the analysis incorporates an unbalanced panel of country-year observations from 2007-2021, with variations dependent on data availability per country. Here are the specific countries and their respective data ranges: Ghana (2012-2020), Kenya (2007-2021), Nigeria (2012-2020), Rwanda (2010-2020), Tanzania (2008-2014), Zambia (2009-2020), Zimbabwe (2012-2020)–with a total of N=72 observations. For entries in which certain data points were unavailable, we omitted those entries. Data were sourced from the World Bank's

World Development Indicators, the Global Findex Database, the Federal Reserve Bank of St.Louis, amongst other national financial access surveys.

3.2 Panel Regression

To analyze this data, we first used a **two-way fixed effects panel regression** to explore how mobile money adoption affects banking infrastructure. This allows us to account for unobserved heterogeneity across countries and over time.

The following linear regression equation was used:

$$Y_{it} = \beta_1 X_{it} + \beta_2 Z_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

where

Y_{it} = Number of bank branches per 100,000 people in country i at time t

X_{it} = Number of registered mobile money accounts per 1,000 people in country i at time t

Z_{it} = Vector of control variables (e.g., GDP per capita, urban population share, mobile subscriptions)

α_i = Country fixed effect (captures time-invariant characteristics of country i)

λ_t = Year fixed effect (captures shocks or trends common across all countries in year t)

ε_{it} = Error term (unobserved influences on Y_{it})

This model was estimated with the plm package in R. The core of this method was to better understand whether mobile money services complement or substitute traditional banking. Specifically, a negative coefficient on RegisteredMMAPer1K would support the substitution hypothesis; a positive and significant coefficient would suggest complementarity.

3.3 Correlation Analysis

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The second method used was a correlation analysis, comparing the numerical values of the number of bank branches and the number of registered mobile money accounts. Scatterplots were generated to help visually deduce the relationship between the two variables.

Two additional forms of analysis supplemented the correlation analysis, 1—Quadratic Regression, and 2—LOESS (Locally Estimated Scatterplot Smoothing).

Quadratic regression is a type of curve fitting that allows the relationship between two variables to bend rather than remain a straight line. In this study, it helps detect "inverted U" patterns, where the relationship is positive up to a point before turning negative. This could indicate that mobile money and bank branches complement each other initially but later start to substitute. In simple terms, an inverted U-shaped relationship means "the more, the better" at first, but beyond a certain point, adding more of one variable starts to coincide with less of the other. The following equation was employed for the quadratic regression:

$$\text{BankBranches}_{it} = \beta_0 + \beta_1 \text{MobileMoney}_{it} + \beta_2 \text{MobileMoney}_{it}^2 + \varepsilon_{it}$$

where

Y_{it} = Number of bank branches per 100,000 people in country i at time t

MobileMoney_{it} = Number of registered mobile money accounts per 1,000 people in country i at time t

$\text{MobileMoney}_{it}^2$ = Squared mobile money accounts (captures nonlinear effects — e.g., diminishing or reversing trends)

β_0 = Intercept term

β_1 = Coefficient on the linear mobile money variable

β_2 = Coefficient on the squared mobile money variable

ε_{it} = Error term (unobserved factors affecting Y_{it})

LOESS is a flexible, non-parametric method that draws a smooth curve through the data. LOESS does not assume any specific mathematical form but rather fits simple regressions to subsets of the data, then combining them to produce a smooth trend line. LOESS is especially useful here because it can reveal non-linear patterns in the relationship between mobile money and bank branches, even if those patterns vary over time or across countries. We utilized the geom_smooth(method = "loess") function within R's ggplot2 package to visually assess the shape of the relationship. A span value of 0.75 to capture the general trend while preventing overfitting.

Combined, these quantitative approaches provide both statistical inference and visual insights into the complex relationship between mobile money adoption and banking infrastructure in Sub-Saharan Africa.

4 Discussion

4.1 Two-Way Fixed Effects Panel Regression

Variable	Coefficient	Std. Error	t-value	p-value
Registered Mobile Money Accounts (per 1,000 people)	-0.000013	0.000036	-0.352	0.727
Internet Users (% of population)	0.0256	0.0423	0.605	0.548
Percent Urban Population	0.371	0.248	1.499	0.141

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Mobile Subscriptions (per 100 people)	0.105	0.0267	3.947	0.000**
GDP per Capita (USD)	-0.000942	0.000574	-1.642	0.107

Model Statistics

R-squared: 0.455

Adjusted R-squared: 0.159

F-statistic: 7.69 on 5 and 46 degrees of freedom (p-value = 2.53e-05)

Total Sum of Squares: 145

Residual Sum of Squares: 79.1

Panel Type: Unbalanced (n = 7 countries, T = 7–15 years, N = 72)

Model: Two-way fixed effects (country and year)

We begin by discussing the results from the two-way panel regression. Firstly, there seems to be a neutral relationship between the number of registered mobile money accounts (per 1000 people) and the number of bank branches (per 100, 000 people), with a coefficient of -0.000013; this is paired with a p-value of 0.727, indicating statistical insignificance. Thus, from the panel regression, there does not seem to be any clear positive or negative relationship between the two variables.

Next, we examine the relationship between our control variables and the number of bank branches, namely Internet Users (% of population), Percent Urban Population, GDP per capita (USD), and Mobile Subscriptions (per 100 people). The coefficient of 0.0256 seems to yield a

general positive relationship between the number of Internet Users and number of bank branches, but the complementary p-value of 0.548 deems the relationship statistically insignificant. Looking at the relationship between urbanization and bank branches, we see, again, a positive relationship with a coefficient of 0.371, but still statistically insignificant with a p-value of 0.141. The relationship between GDP per capita (USD) and bank branches is negative, with a p-value of 0.107, again, showing statistical insignificance.

Finally, we investigate the relationship between Mobile Phone Subscriptions (per 100 people) and the number of bank branches. Here, there seems to be a positive relationship between the two variables with a coefficient of 0.105. This result is also statistically significant with a p-value of approximately 0.000. Uniquely, this supports the idea that increased access to the cell phone has expanded the banking infrastructure within Sub-Saharan Africa. This is echoed in the analysis by Nyimbiri, 2021, where it was found that generally having more mobile money agents led to an increase in the use of financial services. Through this panel regression, we similarly are able to find that the mobile phone plays the foundational role of mobile connectivity in the development of the financial sector.

We examine the model strength, as well as limitations of this method. The model generates an R-squared value of 0.455, indicating that the model explains 45.5% of the variance in bank branch prevalence. The adjusted R-squared value is lower at 0.159, likely due to the limited number of observations and inclusion of fixed effects. While fixed effects account for time-invariant country characteristics and common time shocks, the model may still be subject to omitted variable bias. For instance, data on financial literacy, digital banking quality, or agent network density were not available. Overall, this represents a moderate explanatory power, and cannot fully extend to causality.

4.2 Correlation Analysis

The correlation analysis produced both quadratic regressions and LOESS fitted graphs for each country. We first begin by analyzing three countries that produced similar patterns observed within the graphs, Kenya, Rwanda, and Zambia.

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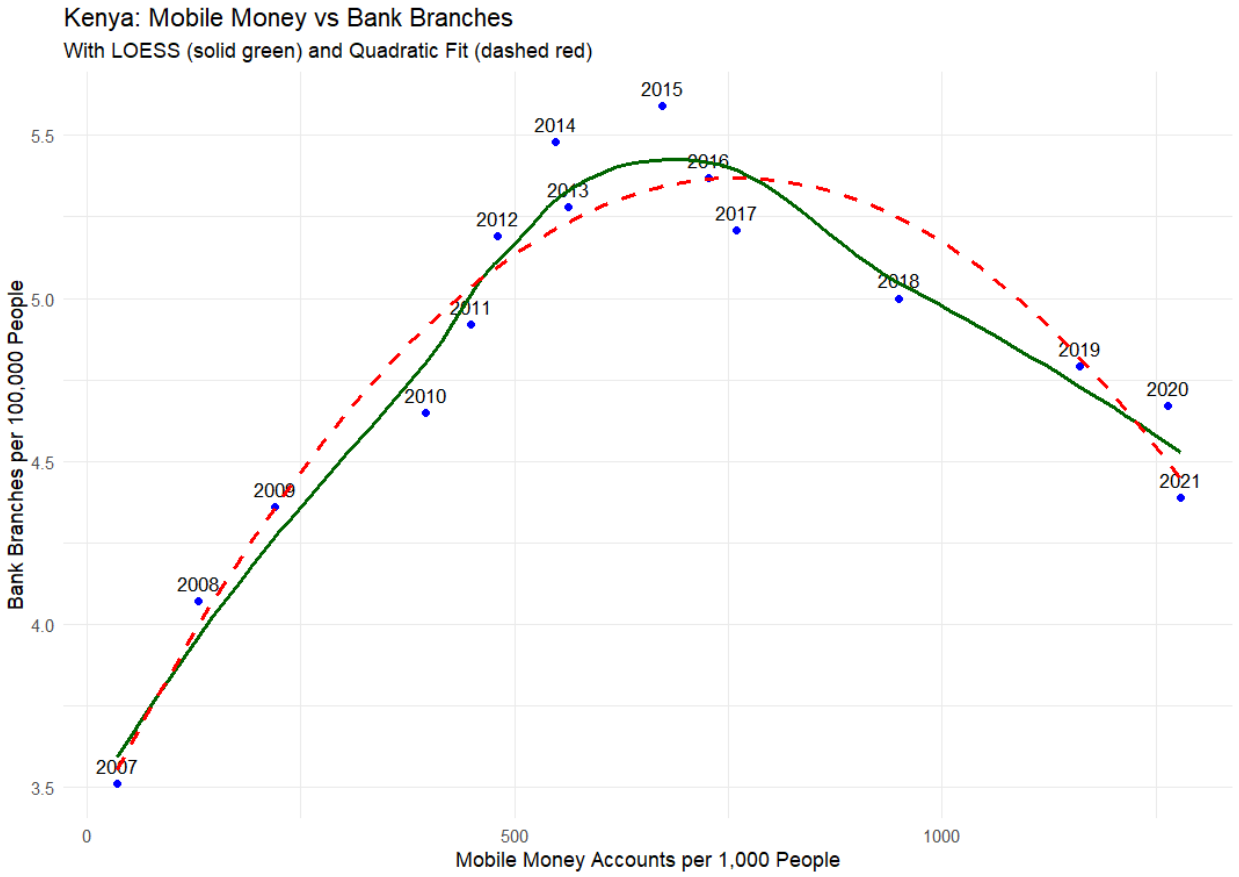

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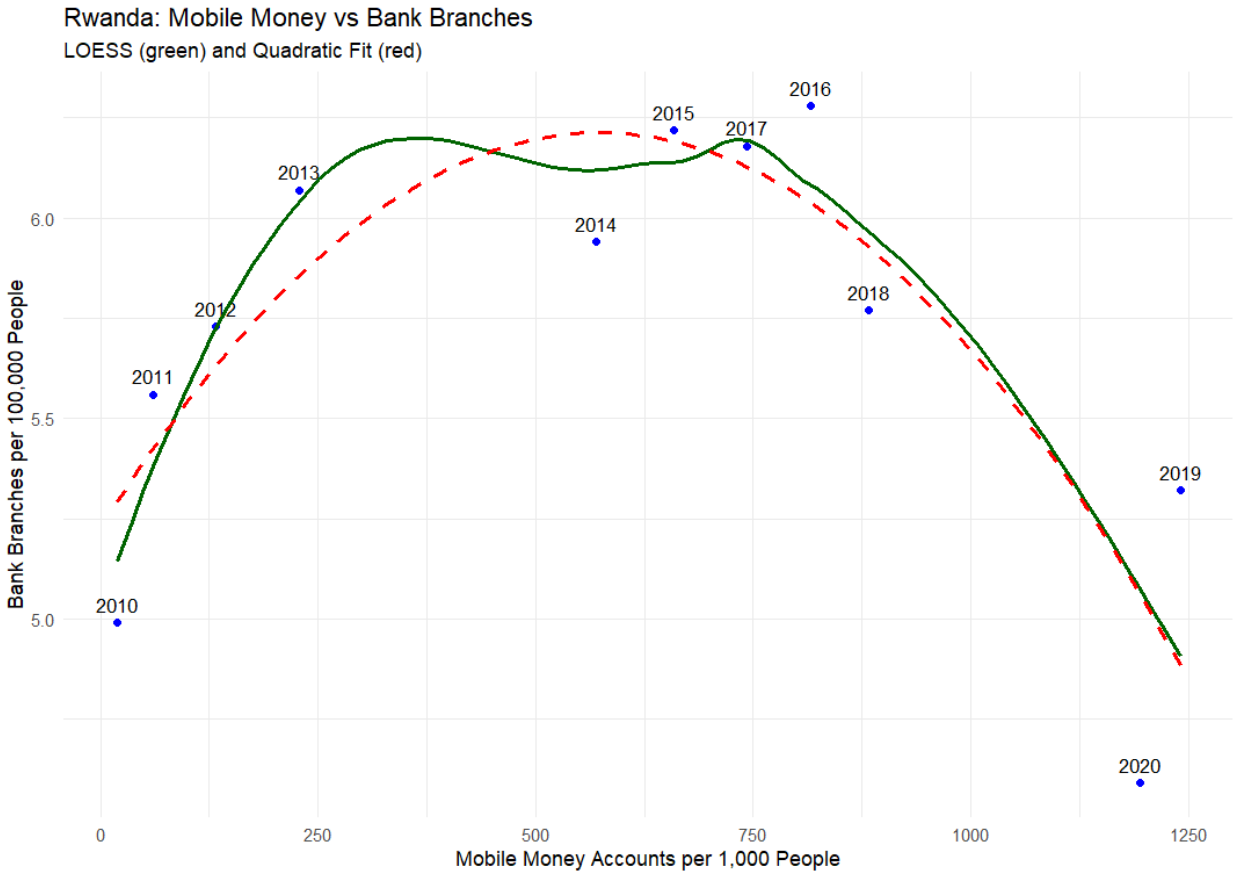

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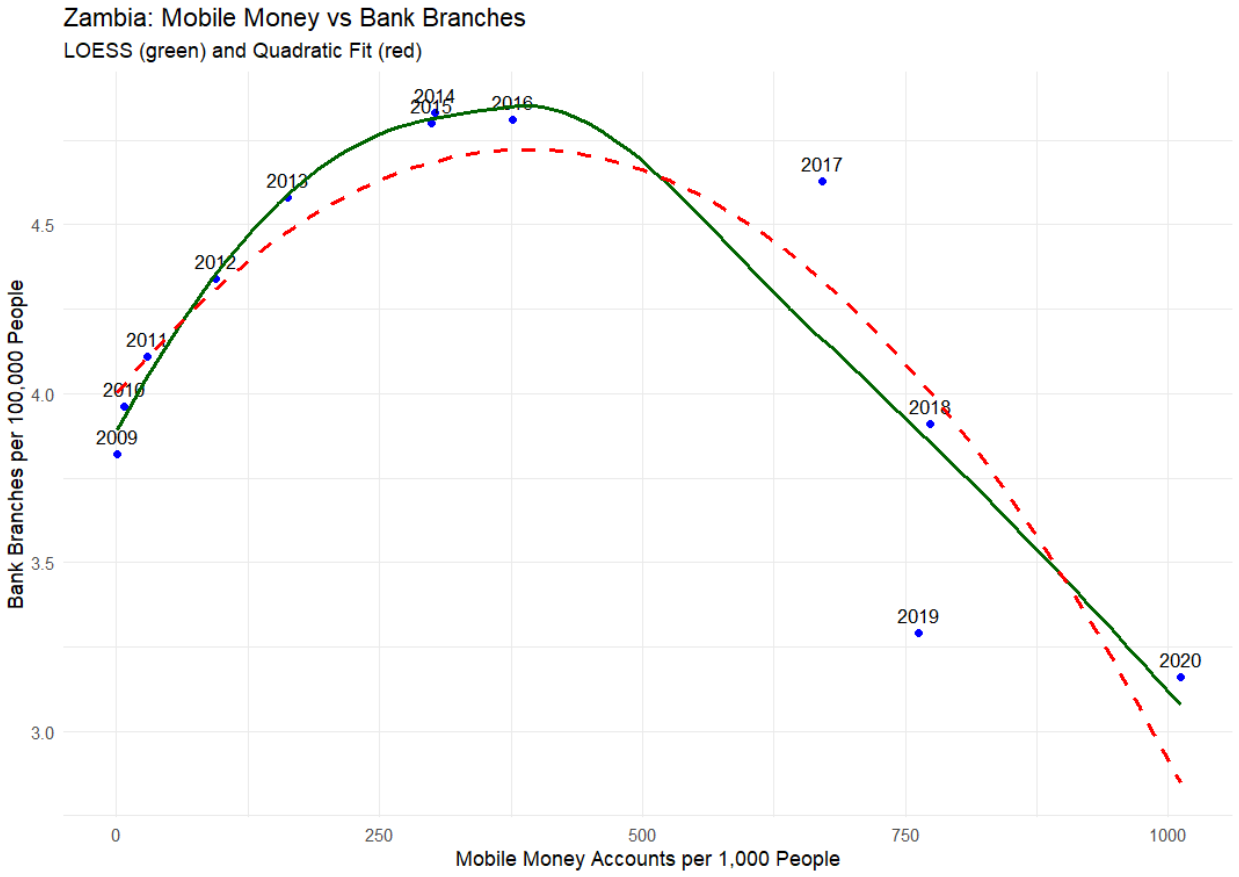
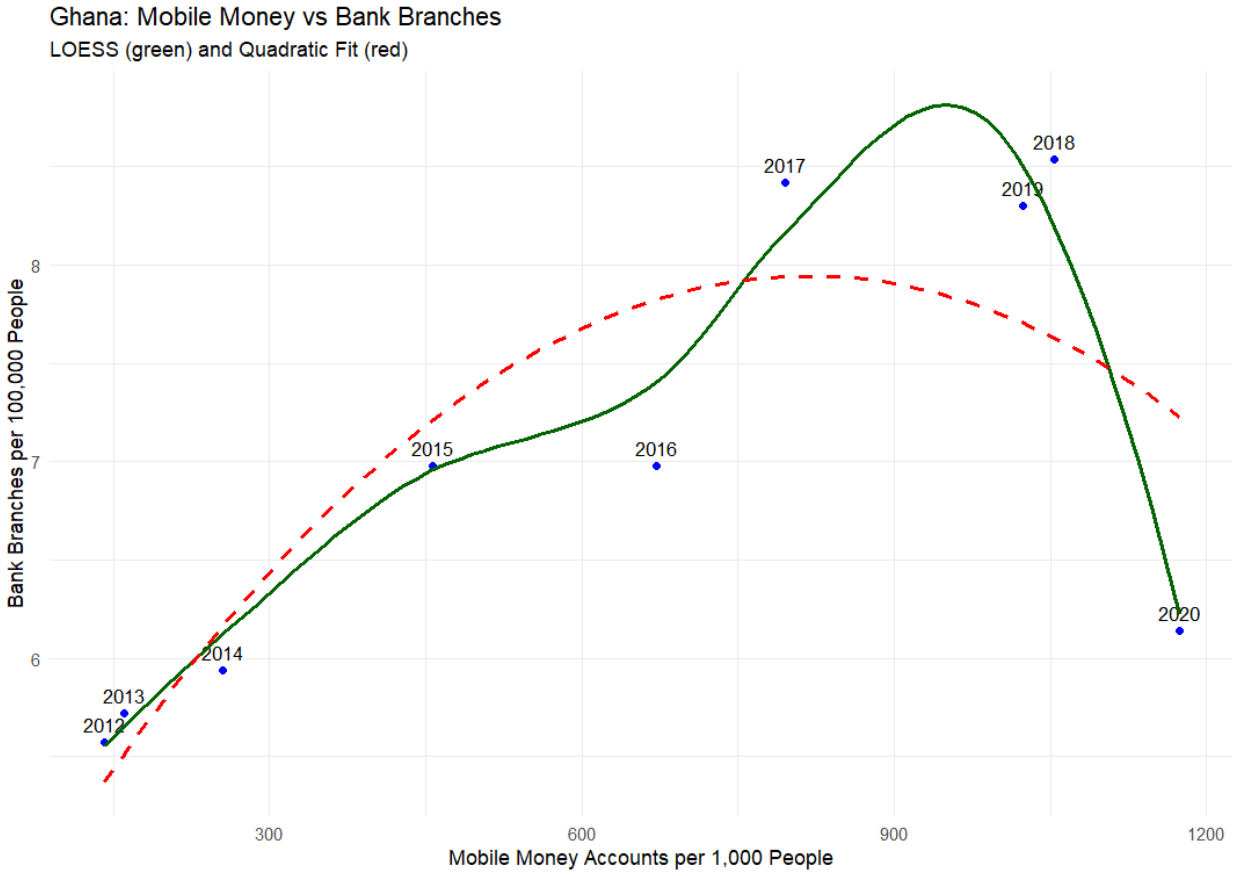


There is an evident “inverted U” trend that emerged in the early 2010s/late 2009s and continues until the late 2010s/early 2020s. An “inverted U” relationship in this context means that as mobile money usage first increases, the number of bank branches also tends to grow up to a certain peak point. Beyond that threshold, further growth in mobile money usage coincides with a decline in bank branch numbers. This suggests that mobile money initially complements traditional banking by reaching new customers, but over time begins to substitute for physical branch services. First, there is a positive and relatively strong linear relationship between the number of registered mobile money accounts per 1000 people and the number of bank branches

per 100,000 people. This relationship holds until around 2015, where we begin to see a decline in the number of bank branches, whereas the number of mobile money accounts still continues to rise. These trends are especially pronounced in the three aforementioned countries, but can still be seen within three other countries–Ghana, Tanzania, and Zimbabwe, as displayed below.



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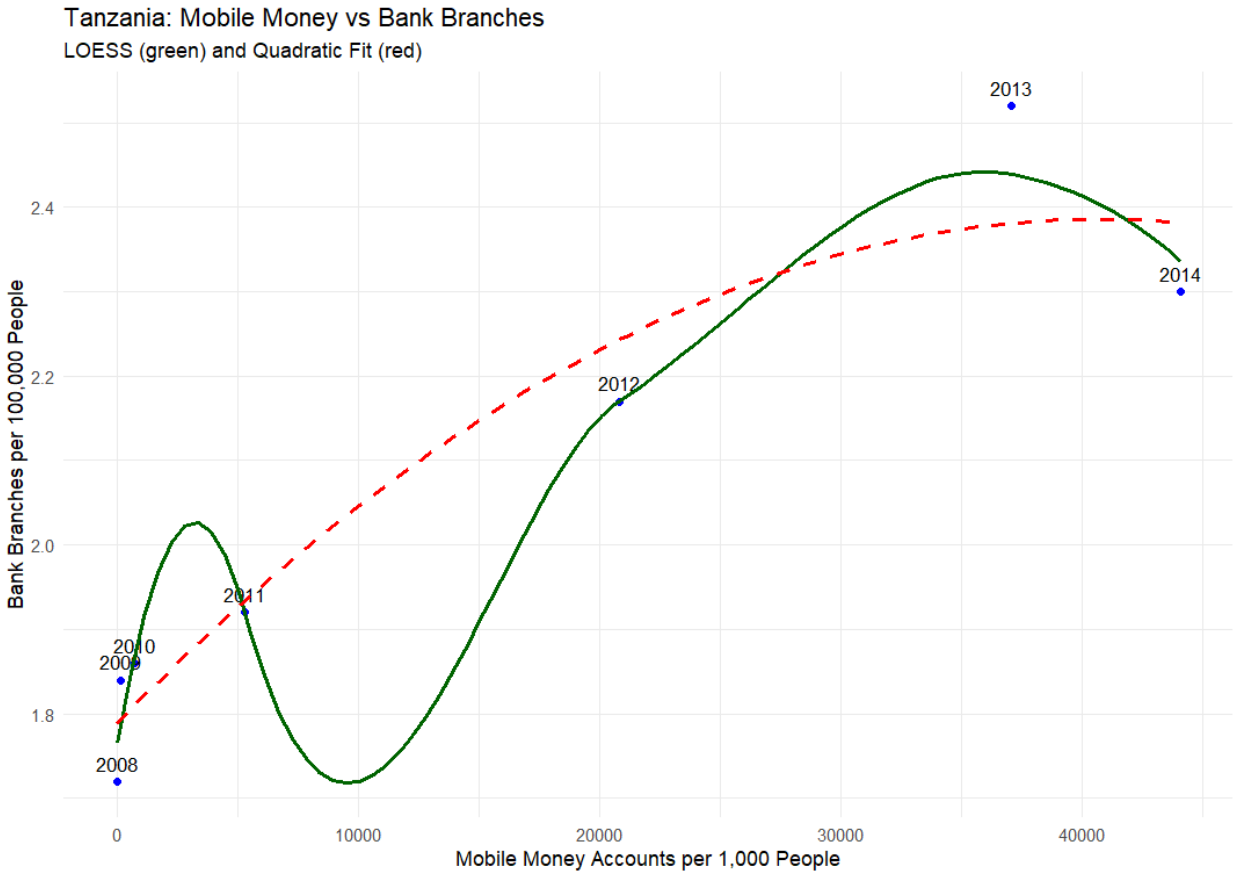

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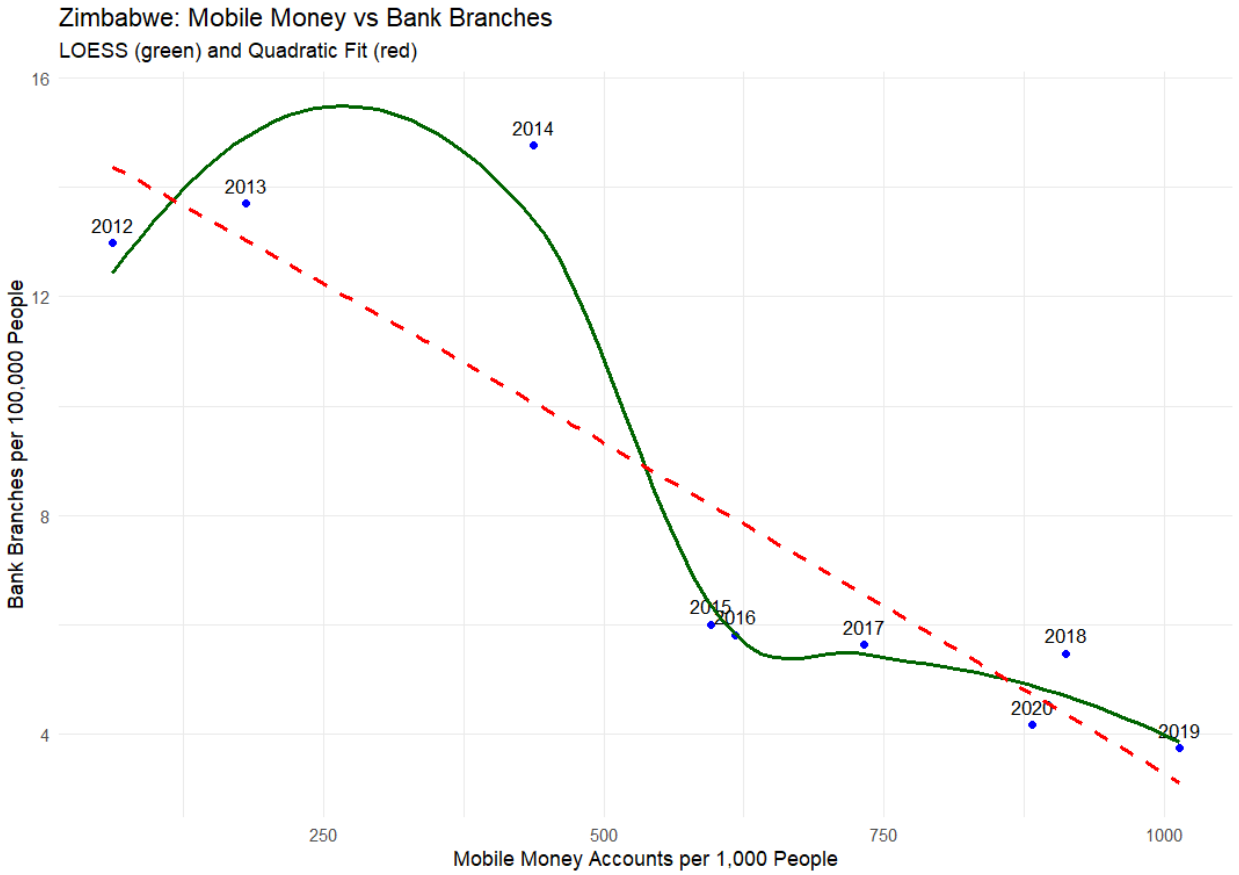

Within Ghana, the inverted U trend is not as pronounced, but rather seems to be skewed leftwards indicating a decline that happens later compared to other countries. Notably, it is intriguing to view these results in tandem with the findings from Kulu et. al, 2022, where they found that mobile money had a detrimental effect on banking efficiency. In our study, we investigate the prevalence of bank branches in general compared to mobile money, not efficiency–that is to say, both theories can be simultaneously true.

In Tanzania, analysis is limited by data availability. In the years with data available (2008-2014), we observe the beginning of the inverted U trend previously seen. Between 2013 and 2014, there

appears to be the first major dip in the number of bank branches, potentially leading to the same downward slope that we see within other countries.

Lastly, in Zimbabwe, analysis is similarly limited by data availability. In the years with data available (2012-2020), we observe a negative linear correlation between the two variables, similar in nature to the end part of the inverted U trend seen previously.. Between 2012-2013, there appears to be the last major section of a positive slope that could have continued from before 2012.

Furthermore, we create LOESS fitted graphs to capture the general essence of the trend between the two variables. They can be seen below.

We posit that there are two broad timeframes in which the relationship between mobile money and traditional banks can be separated into, 1–Emergence, and 2–Maturity. In the Emergence timeframe, mobile money generally complements traditional bank growth. This likely happens through meeting untapped markets and catering to the previously unbanked; these are customers mobile money is uniquely able to target. In the Maturity timeframe, mobile money begins to saturate out, and because of its ability to scale quickly, users begin switching out of in person bank branches.

5 Conclusion

5.1 General Comments

This paper investigated the longitudinal relationship between mobile money and traditional banking within Sub-Saharan Africa. Two methods of analysis–a two-way fixed effects panel regression as well as a correlation analysis–were employed to examine data collected between 2007 and 2021 of 7 Sub-Saharan African countries.

With the ever accelerating growth of financial technology and the digitalization of financial services, we sought to determine if mobile money and traditional banking complemented or substituted each other within the financial marketplace. The panel regression did not yield a

binary result, but was inconclusive as to determining the relationship between the two services. More interestingly, the regression revealed that general mobile connectivity in Sub-Saharan Africa had a positive relationship with overall banking presence in the physical form. The lack of a statistically significant result between mobile money presence and bank presence suggests that mobile money may not influence banking in a linear way across countries.

More significant findings resulted in the correlation analysis. Here, an inverted U trend was discovered clearly in 3 countries, and somewhat pronounced in 3 other countries. Essentially, mobile money and traditional banking seemed to have a positive relationship between ~2010 to ~2015, but then had a negative relationship from ~2015 to ~2020. This forwards a threshold hypothesis–during the initial development and expansion of mobile money, indicating that the two forms of financial services are complementary up until a certain point, where afterwards there seemed to be a substitute relationship, providing additional support for earlier findings by Meyer & Okoli, 2023.

5.2 Policy Recommendations & Proposals

With these findings, what are the implications and next steps for policy makers within Sub-Saharan Africa? Below are a series of recommendations that are drawn from findings above.

1. Localize Financial Strategy Based on Market Stage

The first recommendation is to tailor strategies based on the individual needs and contexts of a country. Given the statistically insignificant overall relationship between mobile money and banking infrastructure, blanket policies are deemed ineffective. Some countries may need infrastructure expansion, while others need regulatory guardrails.

2. Expand Mobile Network Infrastructure

The second recommendation is to invest in and expand mobile networks throughout Sub-Saharan Africa, in particular rural and underdeveloped regions. As shown in the fixed effects panel regression, there was a statistically significant positive relationship between mobile phone subscriptions and bank branches. Investing in mobile networks allows citizens to access digital

financial technology, but also generally makes transactions and the overall banking process far more efficient.

3. Enhance Financial Literacy

While the regression did not find a significant direct effect of mobile money accounts on bank branch prevalence, the correlation analysis suggests that user behavior changes over time. In the maturity phase, people may transition away from branches to mobile channels. This shift demands strong financial literacy to ensure consumers can manage digital accounts securely, avoid fraud, and integrate mobile and traditional services where possible. Policies could target rural areas, women, and older populations who often require more time to adjust to a changing financial environment.

4. Encourage Interoperability Between Mobile Money Services and Traditional Banks

The inverted-U relationship suggests a point where mobile money begins replacing physical banking rather than complementing it. Interoperability (e.g., shared wallets, linked accounts) can help reduce this substitution effect by allowing customers to fluidly use both systems. This supports financial inclusion without sacrificing physical infrastructure access, especially for populations who still rely on in-branch services for certain transactions.

5.3 Barriers and Final Implications

Notably, the aforementioned policy recommendations may face specific barriers. For instance, efforts to build interoperability may face hurdles such as regulatory fragmentation, lack of technical standards, and resistance from incumbent financial institutions. Moreover, these findings also point to similar emerging markets, and may hold relevance to other areas in the world that are experiencing rapid fintech growth.

We discover that digital financial ecosystems do not develop in a linear fashion, and that similar threshold dynamics may emerge in other rapidly digitizing economies, highlighting the need for adaptive, context-specific financial strategies globally.

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Spending for Smiles: How Government Investment Shapes National Happiness in ASEAN During COVID-19

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Doi: 10.5281/zenodo.16877874.

Abstract

This study examines the relationship between government spending and national happiness levels across ASEAN countries during the COVID-19 pandemic. Using comprehensive data from seven ASEAN member states, we analyse how different components of government expenditure influence subjective well-being indicators. Our regression analysis reveals that general government spending as a percentage of GDP demonstrates a significant positive correlation with national happiness scores ($\beta = 0.104$, $p < 0.001$). More specifically, government spending on health and education shows particularly strong associations with happiness levels, with coefficients of 0.393 and 0.497, respectively. Conversely, military expenditure as a share of government spending exhibits a significant negative relationship with happiness ($\beta = -0.081$, $p < 0.01$). These findings suggest that while overall government fiscal capacity enhances national well-being, the composition of spending matters significantly. Healthcare and education investments yield the highest happiness returns, while military spending may crowd out welfare-enhancing expenditures. The results provide valuable insights for policymakers seeking to optimise public spending allocation to maximise citizen well-being, particularly in developing economies navigating post-pandemic recovery. However, the study acknowledges limitations including sample size constraints and emphasises that happiness indicators should complement, rather than replace, traditional economic measures in policy decision-making.

Keywords: happiness economics; government spending; ASEAN; COVID-19; public policy; subjective well-being

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1. Introduction

Happiness is one of humanity's most pursued yet complex emotions. In academic research, it is widely conceptualised as a self-reported subjective indicator of well-being that encompasses both the temporary experience of joy and a sense of purpose in life (Tella & MacCulloch, 2006). When applied within an economic context, happiness is found to be a valuable multidimensional measure of well-being. It reflects not only access to tangible resources such as healthcare, education, and employment opportunities, but also incorporates less quantifiable dimensions, including emotional well-being and a sense of purpose (Jahan, 2025). Throughout history, the study of happiness economics has produced several seemingly paradoxical findings that challenge assumptions derived from conventional economic models. Most famously, Easterlin (1974), the first economist to make prominent use of the happiness data, concluded that “at a point in time, happiness varies directly with income, both among and within nations, but over time, the long-term growth rates of happiness and income are not significantly related.” This finding, now known as the Easterlin Paradox, challenges the conventional assumption that sustained income growth leads to lasting increases in happiness (Easterlin & O’Connor, 2021). In recent years, governments have placed increasing emphasis on the findings of happiness research, seeking to balance strong and sustainable economic growth with the happiness of their populations. Amid the rapid global spread of COVID-19, global happiness levels plunged to historical lows, marked by deaths, economic instability, and stress (Davidson, 2021). However, international studies indicate that the decline in happiness during the pandemic is more strongly associated with government interventions aimed at restoring societal functioning and mitigating the spread of the virus, rather than with the pandemic itself.

Since the emergence of the SARS-COV2 virus in December 2019, governments worldwide have implemented a range of strategies aimed at slowing the virus’s transmission, supporting vulnerable communities, and ensuring the capacity and resilience of the healthcare system. Existing research has specifically examined how lockdown measures affected happiness levels, using indicators such as the Gross National Happiness Index, consistently showing an overall

decline in happiness across all demographic groups during lockdowns. Other studies have questioned whether the costs of happiness from lockdowns outweigh the perceived benefits and well-being gains associated with reduced infection rates. Notably, several studies reveal that the primary determinants of happiness during this unprecedented crisis were not traditional macroeconomic indicators but rather elements directly related to the design and implementation of government policies. Furthermore, researchers have investigated how the determinants of happiness changed throughout the pandemic.

Against this backdrop, the current paper seeks to contribute to the existing literature by examining the relationship between government spending and national happiness levels through the COVID-19 pandemic. Through a comprehensive analysis of the ASEAN block (consisting of Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam), incorporating economies at various stages of economic maturity and prosperity, this paper aims to provide valuable insights into how divergent compositions of government influences happiness levels across varying developmental contexts. By utilising global indices of happiness and drawing on the most recent data, cross-country comparisons can be made effectively and meaningfully.

The paper is organised as follows: Section 2 outlines the data sources and methodological approach employed in the empirical analysis, along with a statistical summary of the dataset. Section 3 presents and discusses the empirical findings with country-specific examples. Finally, Section 4 presents concluding remarks and reflections on the study's implications.

2. Data and Methods

2.1 Data

Table 1: Descriptive Summary Statistics

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Statistic/ Variable	Happiness score	GDP per capita (current US$)	Unemployment, total (% of total labour force) (national estimate)	Inflation, consumer prices (annual %)	Life expectancy at birth, total (years)	General government final consumption expenditure (% of GDP)	Domestic general government health expenditure (% of GDP)	Government expenditure on education, total (% of GDP)	Military expenditure (% of general government expenditure)
Mean	5.42	14257.03	2.49	2.72	72.96	11.20	1.86	2.79	9.06
Median	5.38	4045.89	3.07	2.39	70.35	11.08	1.89	2.87	6.24
Std. Dev	0.72	24227.88	1.50	2.45	5.48	3.73	0.79	0.94	5.57
Minimum	3.91	1158.05	0.14	-1.61	65.29	4.81	0.58	0.86	3.56
Maximum	6.74	90674.07	4.64	9.45	83.60	18.24	3.89	4.70	22.21

The dataset used in this study is a panel dataset, comprising observations from 7 countries over the period 2015 to 2024. Each country is observed across multiple years, enabling the analysis to exploit both cross-sectional and time-series variation.

Table 1 above provides a descriptive summary of the variables under investigation alongside national happiness. A comparison of the mean and median values provides insights into the symmetry of data distributions. The mean happiness score is 5.42, while the median is 5.38. The

minimal difference of 0.04 indicates that the distribution of happiness scores across ASEAN countries is roughly symmetrical, strengthening the representativeness of the dataset. This trend holds for most variables. However, GDP per capita is a clear outlier, with a mean of USD 14,257.03 and a median of USD 4,045.89, reflecting a right-skewed distribution driven by high-income countries such as Singapore. Government spending directed towards the military is also an outlier, with a mean value of 9.06 percentage points and a median of 6.24 percentage points. The right-skewed distribution is driven by countries like Indonesia, which allocate a relatively larger share of their government budgets to defence due to ongoing territorial disputes and the need to maintain internal security across diverse and unstable regions. Therefore, correlations involving GDP per capita and government spending on military should be interpreted with caution, as they may reflect conclusions relevant only to specific economies and aren't representative of the ASEAN region.

These distributional patterns are further supported by the standard deviations of the variables. GDP per capita exhibits the highest standard deviation (USD 24,227.88), indicating substantial income inequality across the sample. Similarly, life expectancy shows a notable standard deviation of 5.48 years, likely reflecting disparities in healthcare access and quality among countries. Government spending for the military also displays a relatively high standard deviation, which may implicitly reflect varying national security priorities, perceived external threats, and differing fiscal capacities across ASEAN member countries. Interestingly, despite considerable variation in these key influencing factors, the standard deviation of happiness scores remains relatively low at 0.72. This observation will be examined further in the subsequent sections through a closer analysis of individual countries.

The wide range of values across all economic and social indicators examined, for instance, GDP per capita at US$89,516.02 and unemployment at 4.5 percentage points, provides substantial breadth for identifying correlations with national happiness across diverse economic development and economic growth contexts. Overall, the statistical analysis suggests that the ASEAN bloc offers a valuable and representative sample for examining the relationship between government spending and national happiness.

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2.2 Methods

The primary methodology involves conducting ordinary least squares regressions using cross-country panel data. The regression outputs will be presented in tabular format, incorporating different aspects of government expenditure alongside a range of control variables, including unemployment rates, inflation levels, life expectancy, and GDP per capita. All variables are sourced from the World Bank's Development Indicators Database, ensuring consistency and comparability across countries.

Throughout the analysis, a p-value less than 0.05 is interpreted as statistically significant. Multicollinearity was also checked prior to each regression and confirmed not to pose a statistical concern.

3.1 Results

Table 2: Impact of Overall Government Spending (% of GDP) on Happiness

Sample size: 48 countries/years

Variable	Coefficient	P-value	95% CI	Significant?
General gov. spending (% GDP)	0.104	0.000000021	[0.074, 0.135]	Yes ($p<0.001$)
Unemployment (% total labor force)	-0.078	0.020	[-0.144, -0.013]	Yes ($p<0.05$)
Inflation	0.020	0.384	[-0.026, 0.066]	No
Life expectancy (years)	0.036	0.108	[-0.008, 0.080]	No

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Variable	Coefficient	P-value	95% CI	Significant?
GDP per capita (current US$)	0.00001	0.034	[7.36e-07, 1.8e-05]	Yes (p<0.05)

Table 2 presents a significant positive correlation between government spending (as a percentage of GDP) and national happiness, while controlling for unemployment, inflation, life expectancy, and GDP per capita. Specifically, the correlation coefficient of 0.104 suggests that a one percentage point increase in overall government spending is associated with a 0.104-point increase in the happiness score. A government's spending capacity depends heavily on its economic status, with taxation serving as a key source of revenue. Rising unemployment shrinks the tax base, while economic growth boosts individual incomes and per capita tax collection, expanding fiscal capacity. Thus, GDP per capita show a positive correlation with government spending, whereas unemployment correlates negatively with both.

Table 3: Impact of Government Health Spending (% of GDP) on Happiness

Sample size: 49 countries/years

Variable	Coefficient	P-value	95% CI	Significant?
Gov. health spending (% GDP)	**0.393**	0.00022	[0.197, 0.590]	**Yes** (p<0.001)
Unemployment (% total labour force)	-0.130	0.0015	[-0.207, -0.053]	**Yes** (p<0.01)
Inflation	0.034	0.297	[-0.031, 0.098]	No
Life expectancy (years)	0.089	0.0016	[0.036, 0.142]	**Yes** (p<0.01)
GDP per capita (current US$)	-0.000006	0.239	[-1.6e-05, 4e-06]	No

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Table 3 isolates the impact of government health spending as a share of GDP, revealing that a one percentage point increase is associated with a 0.39-point rise in happiness, holding other variables constant. While unemployment remains a significant factor, GDP per capita no longer shows a statistically significant correlation with government health expenditure. This suggests that while health spending is positively associated with subjective well-being, it is not directly correlated with overall economic prosperity. In sum, economic growth does not necessarily translate into greater prioritisation of population well-being. Life expectancy is shown to be significantly correlated with health spending, as expected and intuitive. Notably, inflation is not significantly correlated with government spending in either model, examining overall government spending and government spending on health.

This trend is evident in Thailand, where government health spending reached 620.2 billion Thai baht in 2021, primarily allocated to the Universal Coverage Scheme (UCS) (Statista, 2021). Funded by general taxes, the UCS provides free healthcare at local clinics, mainly benefiting low-income and informal workers (ILO, 2024). Public satisfaction with this scheme is high, with 90% of beneficiaries reporting high satisfaction in 2015 (NHSO, 2016). Moreover, research indicates the UCS boosts perceived well-being by lessening health access anxiety (Mee-Udon, 2014). Since good health is rated by Thais as the top factor for life satisfaction, even above material wealth (Chandoevwit, 2016), Thailand's focus on universal healthcare has helped raise national happiness through better health outcomes and reduced health insecurity (World Bank, 2012).

Table 4: Regression: Happiness Score vs. Government Education Spending (% GDP)

Sample size: 49 countries/years

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Variable	Coefficient	Std. Error	t	p-value	95% CI	Significant?
Government expenditure on education (% GDP)	0.497	0.087	5.72	<0.00001	[0.323, 0.670]	**Yes**
Unemployment (% total labour force)	-0.043	0.021	-2.01	0.051	[-0.086, 0.000]	**Yes**
Inflation (annual %)	0.023	0.017	1.39	0.171	[-0.011, 0.057]	No
Life expectancy (years)	0.014	0.011	1.29	0.202	[-0.008, 0.037]	No
GDP per capita (current US$)	4.34e-06	2.93e-06	1.48	0.147	[-1.61e-06, 1.03e-05]	No

Government expenditure on education, as presented in Table 4**,** is found to be highly significant and positively associated with national happiness. Specifically, a one percentage point increase in education spending is associated with a 0.50-point increase in the happiness score. All other variables are statistically insignificant at the 5% level, with unemployment being borderline significant. Although education spending may boost happiness, its impact does not extend to other well-being indicators identified in Table 4. This suggests that the observed gain in happiness may stem more from social or perceived opportunity rather than measurable improvements in objective indicators.

Vietnam leads the ASEAN bloc in education spending, allocating 2.9% of its GDP, nearly 20% of its national budget in 2022 (Hatch & Phuong, 2025). Tuition-free public education through

high school and increased tertiary funding reflect Vietnam's strong commitment to educational equity (Vietnam News, 2025). These initiatives have led to near-universal primary enrolment and broader access to higher education, reinforcing perceptions of fairness (United Nations Viet Nam 2025). As a key driver of upward social mobility, educational initiatives foster optimism and confidence in future opportunities, particularly among youth and low-income groups. This optimism encourages active investment in human capital and sustained efforts to improve one's socioeconomic standing. As a result, Vietnam's education spending yielded high returns of happiness (VietNamNet Global, 2018; Huy Anh, 2024).

Table 5: Regression: Happiness Score vs. Military Spending (% of General Govt Expenditure)

Sample size: 49 countries/years

Variable	Coefficient	Std. Error	t	p-value	95% CI	Significant?
Military expenditure (% of govt exp)	-0.081	0.025	-3.28	0.002	[-0.132, -0.030]	**Yes**
Unemployment (% total labor force)	0.015	0.017	0.87	0.390	[-0.020, 0.049]	No
Inflation (annual %)	0.021	0.017	1.28	0.209	[-0.012, 0.054]	No
Life expectancy (years)	0.006	0.011	0.52	0.604	[-0.017, 0.029]	No
GDP per capita (current US$)	5.36e-06	2.98e-06	1.80	0.079	[-6.78e-07, 1.15e-05]	No

Unlike other subcomponents of government spending, which show consistently positive associations with national happiness, military spending is negatively and significantly associated, as shown in Table 5. A 1% increase in the military's share of government spending corresponds to a 0.08-point drop in national happiness. This may stem from the limited direct benefits military spending offers the general population during peacetime, as its impact is often perceived rather than experienced. Moreover, higher military expenditure may signal underlying geopolitical tensions, contributing to societal anxiety. It may also crowd out resources from welfare-enhancing areas, such as education and health, which have shown positive and significant links to happiness. As with education spending, all control variables remain statistically insignificant, except GDP per capita, which is borderline significant ($p = 0.079$), potentially reflecting its fundamental relationship with government expenditure in the GDP formula ($C + I + G + X – M$).

Following the 2021 coup, Myanmar ranks second lowest in ASEAN for happiness, allocating 14.24 per cent of its 2022 budget to defence, well above the global average of 6.44 per cent (TheGlobalEconomy, 2022). Consequently, only 6.6 per cent of government spending is allocated to education and just 2.5 per cent to health services (Nandar Linn, 2024), reflecting a significant opportunity cost. Moreover, much of the military spending has been directed toward internal control rather than national security, leading to a collapse in public trust, with confidence in the government falling by nearly 60 percentage points post-coup (Inc, 2022). Therefore, without an accountable government, heavy military expenditure also heightens the risk of corruption and the misuse of power. The resulting decline in public services and rise in societal stress have contributed to a continued drop in Myanmar's happiness score between 2021 and 2024.

5. Conclusion

This study investigates the relationship between government spending and national happiness across ASEAN countries, controlling for key macroeconomic and social variables such as

unemployment, inflation, life expectancy, and GDP per capita. The regression analysis revealed a positive relationship between overall government spending (as a percentage of GDP) and national happiness, with statistically significant effects across all three categories: health and education spending are positively associated, and military spending is negatively associated.

While beyond the scope of this paper, the findings support the idea that government spending on health and education can be effective tools for enhancing national happiness. Education investment yields particularly strong returns by fostering perceptions of opportunity and social mobility. The positive impact of such spending is especially pronounced among disadvantaged groups, as access to healthcare and education helps reduce fundamental stressors and insecurity. Given that vulnerable groups often exhibit the highest marginal gains in happiness from public spending, reducing happiness inequality may be a particularly effective strategy for enhancing overall national well-being in developing countries that have limited fiscal capacity.

Although the findings indicate a negative relationship between military spending and self-reported happiness, it is important to acknowledge that happiness is inherently subjective. In practice, improving societal well-being may involve trade-offs, with some groups facing short-term costs for long-term collective gains. Thus, while happiness provides authentic and nuanced insight into how economic factors shape well-being, it should not be the sole basis for policymaking. Rather, it should be considered alongside objective indicators to guide contextually appropriate and balanced public expenditure decisions.

Overall, the findings of this paper should be interpreted with caution due to the limited sample size and missing data across several indicators. As the analysis focuses solely on ASEAN countries, the results are not generalisable to broader global contexts. To strengthen the validity of future research, studies should incorporate a longer time frame and a wider range of countries. Additionally, more country-specific contextualisation of the interpreted trends is necessary, as

similar statistical patterns may arise from differing underlying causes that cannot be discerned from the data alone.

Building on this paper's identification of government spending areas that yield the greatest return on happiness, future research could explore how different sources and forms of government revenue collection influence the effectiveness of spending in boosting national happiness. For instance, such research could investigate how the unhappiness of being taxed interacts with the happiness gains derived from government services, particularly across different income groups. Doing so would help identify government revenue management regimes that minimise dissatisfaction at both the collection and expenditure ends, thereby maximising overall happiness outcomes.

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The Influence Emissions Fee: Should Viral Creators Pay for Climate Impact?

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Doi: 10.5281/zenodo.16877879

Abstract

The paper will theorise the concept of such an emissions tax directly on the creators of viruses and their roles in contributing to climate destruction. With the increase in digital materials consumption, the environmental effects associated with the character and distribution of the viral content have gained additional significance. As a conceptualised work, rather than a lengthy policy suggestion, it addresses the connection between online vitality and carbon emissions by discussing the patterns of energy consumption on online platforms and the role of creators in this setting. By focusing on various investigations into existing literature and previous cases, the paper will present the viewpoint on creating an emissions fee that would make viral creators pay attention to the consequences of their actions. The proposed contribution aims to promote sustainable activities in the digital content industry and contribute to more significant climate efforts. The current research aims to initiate a debate concerning the responsibility of online creators regarding the war on climate change and the opportunities behind regulatory measures to promote environmental responsibility in the online environment.

Keywords: Influencer Emission Fee, Climate Impact, Viral Creators, Digital Ecosystem

JEL Codes: Q 54, L 82, D 64

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1. Introduction

The environmental impact of online presence is becoming more evident in the modern era, marked by the widespread use of social networking sites that facilitate socialising and marketing mechanisms. The Influence Emissions Tax aims to ease the significant carbon emissions linked to the viral marketing methods, which tend to arouse the consumption patterns and life choices that increase climate change. Due to the promotion and growth of social media, the realisation of the environmental impact of a viral creator, a person or organisation capable of sparking a significant online conversation, has become increasingly important.

Climate change, sparked by increased greenhouse gas emissions, forms one of the most significant challenges to the environment's health and human existence. Therefore, it is crucial to study social media's role in exacerbating these emissions by supporting products and actions that may conflict with sustainability. The producers of the viral material are often hailed as adept in shaping the trends and changing the consumer behaviour, with a special place in this discussion, as their products may cause or result in massive increases in resource utilisation and waste generation.

The model of emissions tariffs has appeared as a possible solution to mitigate the ecological harm, placing monetary costs on activities that produce carbon products. The situations and events that led to the present investigation are quite different, as they allow a theoretical analysis of the Influence Emissions Fee rather than providing a good policy guide. It aims to evaluate the practicability and consequences of introducing an Influence Emissions Fee that is directed explicitly at viral creators, and study how such a policy would lead to a more sustainable approach in the digital marketing industry. This analysis aims to comprehend the significance and possible consequences of the Influence Emissions Fee for both the creators and the humongous social media infrastructure.

Key research questions will focus on the relationship between viral marketing and the creation of emissions, the effectiveness of emissions fees in promoting sustainable behaviour, and the ethical aspects of creating the accountability of digital influencers.

This analysis is significant since it aims to integrate environmental policy and digital marketing to provide observations that may influence future standards and approaches in social media. Through its exploration of the intersection of climate activism and the culture of influencers, the study sheds new insights into the existing discourse of sustainability as our world becomes increasingly connected.

This paper will be organised as follows: a review of the situation leading to climate change and emissions, a discussion on the role of social media and viral creators in this situation, a complete analysis of the emissions fees and a conclusion on findings and implications of the suggested Influence Emissions Fee. This analysis will underscore the creators' responsibility for viral media about climate change and the possible solutions that can be used to support a healthy online environment.

2. Literature Review

Influencer marketing and consumer behaviour

Social media influencers play a key role in shaping consumer behaviour, often without consumers realising it (Sokolova and Kefi, 2019; Liu and Zheng, 2024). Content created by influencers that highlights authenticity, expertise, and transparency is associated with increased brand credibility and a greater likelihood of purchase (Migkos, Giannakopoulos & Sakas, 2025; SSRN, 2025). Nabirasool et al. (2024) found that the parasocial relationships established by influencers enhance brand loyalty, particularly among younger audiences. A meta-analysis revealed substantial effect sizes for influencer credibility on buying decisions (IJRTI, 2024). Industry surveys further support these results—71% of consumers trust influencer content (Forbes, 2024), and many depend on social media for product suggestions (Axios, 2025).

Nevertheless, the "value–action gap" remains; consumers may voice environmental concerns yet persist in buying products marketed unsustainably (Pookulangara and Koesler, 2011). This highlights the contradiction of ethical intentions being compromised by the emotional and aspirational branding that influencers promote.

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Environmental impact of digital media

Digital media usage generates significant carbon emissions through data centres and network infrastructures. According to De Oliveira et al. (2024), digital content is responsible for approximately 40% of the per-capita carbon budget necessary for maintaining a 1.5 °C trajectory. Batmunkh (2022) assessed CO_2 emissions from platforms such as TikTok, Facebook, Netflix, and YouTube, revealing cumulative footprints that some estimates suggest may be comparable to those of long-haul flights. The Mozilla Foundation and Greenly indicate that social media activity contributes 0.6% of global CO_2 emissions (Mozilla Foundation, 2023; CloudZero, 2024), with TikTok's annual emissions reportedly approaching those of small nation-states (The Guardian, 2024)**.** Pachilakis et al. (2023) noted that web tracking adds 11 $MtCO_2e$ annually. Furthermore, the type of device used is significant: Greenly (2024) discovered that desktop usage produces more CO_2 than mobile for the same duration of use.

Policy tools for negative externalities

Emerging research suggests that traditional environmental policies—such as Pigovian taxes, levies on externalities, and Extended Producer Responsibility (EPR)—should be applied to digital media (Hickel et al., 2023; Fernandez, 2005). The IEA (2020) contends that regulatory measures remain essential, while streamlining efficiency has seen advancements. Academics advocate incorporating digital carbon externalities into current frameworks to account for concealed environmental costs (IEA, 2020; Eng, 2021).

Emerging ideas about indirect responsibility

There is an escalating discussion regarding the accountability of platforms and influencers that endorse high-emission consumption. Lameiras and Monteiro (2023) caution that “relatable” sustainability content might oversimplify more profound systemic challenges. Corner and Randall (2011) contend that relying solely on social marketing can mislead the audience and even obstruct more meaningful engagement. Advocates for reforms in platform design, carbon transparency, and digital moderation—such as steering clear of autoplay—are gaining momentum (The Ecologist, 2025; Wired, 2022). Simultaneously, the literature on the "value-

action gap" and greenwashing debates (Wikipedia, 2025) emphasise that sustainable messaging risks becoming superficial without accountability.

3. Background

Currently, the arrival of digital solutions and social media sites has considerably modified how individuals engage with merchandise, information, and one another. Platforms such as Instagram, TikTok, and YouTube have established new economic and cultural arenas where individuals—often called influencers—attain influence through content creation, molding millions of desires, aspirations, and actions (Abidin, 2016). Influencer marketing has transitioned into sector worth billions, with worldwide spending expected to rise above $30 billion by 2025 (Statista, 2024). While this transition has disrupted conventional advertising methods, it has also introduced new challenges—especially concerning sustainability.

Digital consumption is not without its environmental impact. Recent analyses underscore the environmental costs of viral digital media. For example, Greenly (2024) reports that a single hour of TikTok browsing emits roughly 2.6g of CO_2 on mobile and up to 8g on desktop. **While this may appear minimal in isolation, the cumulative emissions from viral videos can be significant.** If a single 30-second video reaches 100 million views, and each view emits 1g of CO_2 (accounting for autoplay, scrolling, and ad delivery), the cumulative emissions could exceed 100 metric tons—equivalent to more than 250,000 miles driven by a typical gasoline car (EPA, 2023). **This example gives a clear picture of how content that goes viral cause immense emission of large audiences, especially when a large number of people access such content. Moreover, these emissions might be augmented by the fact that viral content has a worldwide presence.**.

Although frequently regarded as "clean," the infrastructure that supports digital media—data centers, content delivery networks, and streaming services—significantly contributes to global greenhouse gas emissions (IEA, 2020; de Oliveira et al., 2024). In fact, it has been estimated that streaming an hour of high-definition video may require up to 400g of CO2 (Greenly, 2024). This number is even more considerable when transferred onto billions of views

that can be gathered by viral content. Within this framework, influencer marketing serves as a cultural phenomenon and an environmental catalyst, driving consumption habits that amplify digital and physical carbon footprints.

Additionally, as individuals become more aware of ecological problems, a noticeable inconsistency often arises between their principles and actions. This discrepancy is known as the 'attitude-behaviour gap' or 'value-action gap' (Johnstone and Tan, 2015). This difference is specifically observed when influencer posts glorify fast fashion, overconsumption, or constant travelling without awareness of their environmental consequences. This discrepancy is often ascribed to individuals, although recent debates suggest that the responsibility can be distributed between those who advance unsustainable activities (Lameiras and Monteiro, 2023). As an example, although consumers may feel a certain responsibility about the state of the environment, they continue to buy products that are endorsed by their influencers and that are in fact unsustainable. Therefore, it should not be the sole responsibility of consumers to promote sustainability but also of the influencers who build their purchasing behaviours.

Regulatory frameworks are yet to be fully established despite the relative increase in concerns about digital sustainability. Most environmental policies mainly focus on the tangible sectors: agriculture, manufacturing, and transportation (OECD, 2022). The impact of media, advertising, or consumption catalysed by such influencers is rarely considered concerning environmental degradation. This supervision is even more challenging as the digital economy continues to grow.

This study seeks to investigate how the culture of influencers and digital media has a backdoor impact on environmental degradation and determine whether adopting responsibility and regulation is adequate to address this new reality. The combination of concepts in environmental economics, media theory, and consumer behaviour allows filling a gap in knowledge about a generally overlooked but rapidly growing issue.

4. Conceptual / Theoretical Framework

This research work is based on the combination of different fields of knowledge, as this work integrates the concepts of environmental economics, media analysis, and consumer behaviour theories to explore the indirect effect of influencer marketing and digital media on the environment. Critical to this expedition is the concept of adverse externalities, particularly in environmental financial studies. The idea of externalities was initially introduced by Pigou (1920), who suggested that the activities of an individual or a corporation may inflict costs upon third parties that are not subject to market pricing. Such costs are usually addressed with Pigovian taxes, which are typically geared towards internalising the impacts by exacting taxes based on the perceived social damage caused (Oates, 1999). Although this concept has historically been linked to pollution or carbon-intensive industries, recent debates have led to the proposal to use such a framework within the digital sector, particularly the consumption and advertisement of content through influencers (Hickel, Dorninger, and Wieland, 2023).

Possible mechanisms similar to those of regulating digital emissions (carbon offsets, gradual digital taxation) are already considered in the existing climate literature. As an example, the IEA (2020) has developed a dedicated concept of the carbon offset scheme to apply it to streaming services, considering that they trigger and will intensively contribute to content delivery and consumption emissions. Moreover, the concept of progressive digital taxation (van Hooijdonk and Berbers, 2022) targets including digital platforms in calculating their environmental impact, which in this case is on the promotion of high-emission content. While none target influencers specifically, they reflect a growing recognition that digital behaviors carry real-world ecological costs.

Media and communication studies-wise, this inquiry engages with the agenda-setting theory that the media does not tell people what to think, but what to think about (McCombs and Shaw, 1972). The influencers can also serve as informal agenda-setters because most of them present consumption as desirable, and in many cases, downplay environmental effects associated with the product or platform they promote (Sokolova and Kefi, 2019).

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Besides, the theory of planned behaviour (TPB) is incorporated into the framework to explain the effects of intention and action as influenced by messages from leaders. The TPB proposes that individual behaviour is dictated by personal opinion, the perception of what is expected by others, and the opinion of being able to influence behaviour (Ajzen, 1991). By making unsustainable lifestyles desirable, influencers can shift social norms to create incongruence between values and actions, even among environmentally aware people (Pookulangara and Koesler, 2011.

Moreover, the key points are the digital carbon footprints (Greenly, 2024) and the principle of indirect responsibility. Although individuals may not produce significant emissions from a single video stream, the cumulative impact—exacerbated by influencers promoting ongoing consumption—can be considerable (Batmunkh, 2022; de Oliveira et al., 2024). Consequently, this study investigates whether those endorsing high-emission behaviours (such as influencers) should be held accountable through regulation or moral obligation (Lameiras and Monteiro, 2023).

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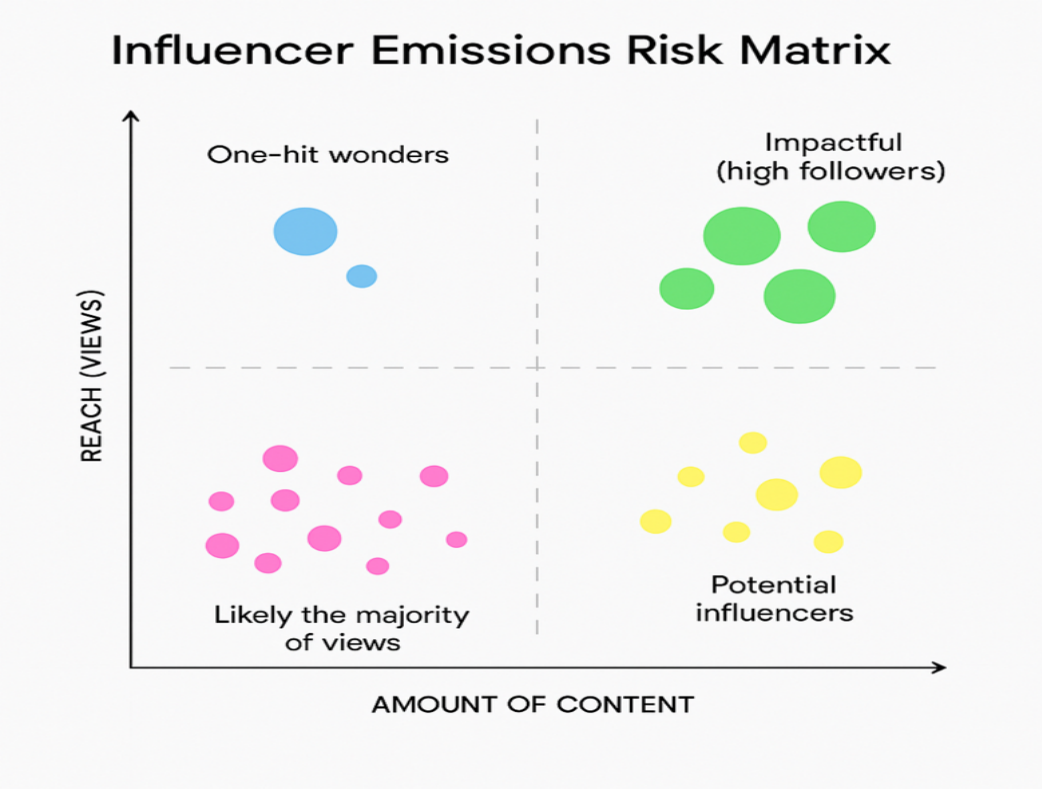

Figure 1: The Influencer Emissions Risk Matrix. This diagram categorises influencer types based on their content volume (x-axis) and reach (y-axis). Each bubble represents a creator, with size indicating potential emissions impact. The top right quadrant contains the most impactful influencers with high reach and consistent content output. These creators are likely to generate the most significant indirect environmental footprint and would be the primary targets of an Influence Emissions Fee.

To better understand which categories of content creators might have the most significant indirect environmental impact, this paper presents the "Influencer Emissions Risk Matrix" (refer to Figure 1). It classifies creators based on two key factors: the volume of content they generate and their overall reach (views). Creators positioned in the top-right quadrant—those who achieve extensive reach and high content production—are the most likely to generate excessive digital

emissions and encourage high-consumption behaviours. These individuals would likely be the most impacted by the proposed Influence Emissions Fee.

In contrast, 'one-hit wonders' (sitting in the top-left corner) can emit substantial amounts in intermittent blasts. Meanwhile, 'potential influencers' (present in the bottom-right corner) could gradually become key targets as their influence grows. This visual instrument is beneficial for differentiating varying levels of environmental responsibility among digital creators.

Overall, these theories allow the research to ask what influencers do and what larger systemic consequences result from what influencers promote.

5. Research Methodology (Qualitative)

A. Research Design

The study follows exploratory qualitative research since it is an advantageous approach to unravelling an intricate and new research matter where few past studies exist (Creswell and Poth, 2018). The aim is to analyse how society feels about it, some ethical concerns, and the feasibility of policy implementation known as the Influence Emissions Fee. This proposed policy change would impose fees on influencers or social platforms based on their unintended environmental impacts.

With the lack of research and the development of this topic, qualitative research allows a deeper and more flexible examination of opinions and meaning-making dynamics (Merriam and Tisdell, 2016). Rather than achieve statistical generalisation of findings, the work is intended to explore the individual experiences and theoretical orientations applied by persons considering the intersection between influencer marketing and environmental responsibility. This analysis is built on a perspective that argues that reality is socially constructed, and the most profound understanding may be gained by the subjective meanings that individuals attach to experience (Schwartz-Shea and Yanow, 2012). This approach acknowledges that perceptions of equity, viability and responsibility are based on social, cultural and digital norms.

For example, the notion of sustainability or responsibility in a media context might differ considerably depending on the platform engagement or age bracket. With this research as part of the interpretivist school, it becomes possible to display information about what the participants think about something, such as an Influence Emissions Fee, how the participants have come to believe this way, and how they operate. This is especially important in discussing ethics in indirect responsibility, a topic at the intersection of environmental justice, digital media and behavioural economics (Ajzen, 1991; Corner and Randall, 2011).

In light of the shifting environment of digital environmental accountability, this research design provides the flexibility required to capture a broad diversity of non-linear perspectives. This aspect renders it highly appropriate to the exploratory stages of policy inquiry.

B. Data Collection Methods

To explore the perceived feasibility, ethical implications, and anticipated outcomes of an Influence Emissions Fee, the study employs a combination of qualitative methods of data collection, namely continuing document analysis, semi-structured interviews, and content analysis over the online environment. Such a triangulation approach helps in a more profound and advanced understanding of the research problem (Bowen, 2009).

Document Analysis

The initial approach will involve an in-depth review of publicly available documents, including governmental reports, NGO research documents, corporate sustainability reports, codes of conduct of the influencers, and news articles. By studying such documents, researchers can discover explicit ideas and the inherent values embedded in policy discourse (Rapley, 2007). Through this kind of critical examination of such texts, the study uncovers the current language of environmental responsibility (or its absence) in the official discourse on the Internet. Also, the frameworks of organisations such as the ASA (Advertising Standards Authority) and the Federal Trade Commission (FTC) will be explored to understand their opinion on influencer responsibility.

Online Content Analysis

The study conducts an online qualitative content analysis of influencers' Instagram and TikTok posts. The posts will be selected based on hashtags (e.g., #sponsored, #sustainableliving, #haul), number of followers, and engagement rates. The aim is to compare how influencers describe sustainable and non-sustainable products and analyse disclaimers' language, imagery, and frequency. This method is based on the traditions of visual content analysis in media research (Krippendorff, 2018) and helps to find hidden persuasive strategies of digital consumer culture. The use of these three methodologies ensures that the research thoroughly investigates the topic and links the institutional narratives, the perspectives of the stakeholders, and the ways of communication in the real world.

C. Data Analysis Plan

The research will apply thematic analysis as the primary approach to study the qualitative data set, a flexible tool specifically conducive to identifying patterns and meanings in multiple data sources (Braun & Clarke, 2006). After compiling interview transcripts, document excerpts, and social media data, all data will be carefully reviewed and coded to arrive at essential statements and insights. The analysis will take place through various stages:

1. **Familiarisation**: All documents and transcripts will be thoroughly examined to understand the content comprehensively.
2. **Initial Coding**: Recurring phrases, viewpoints, and observations will be marked and given initial codes.
3. **Theme Developmen**t: Codes will be grouped into broader themes such as resistance to regulation, perceived fairness, platform accountability, and alternative incentives.
4. **Theme Categorisation**: These themes will be structured into overarching analytical categories—specifically:

- Perceived Responsibility (e.g., opinions on who bears accountability: creators, platforms, or consumers), Practical Barriers (e.g., technical enforcement challenges or financial issues),
- Public Acceptance (e.g., trust, backlash, or endorsement of proposed solutions).

5. **Interpretation**: Representative quotes or paraphrased statements will illustrate key insights, showcasing agreement and differences among participants.

This analytical framework will enable the study to reach nuanced conclusions that capture the subjective and context-dependent characteristics of the topic.

D. Ethical Considerations

As this research does not entail any direct engagement with human subjects, the main ethical concerns focus on the use of publicly accessible digital materials and documents.

- **Use of Public Posts**: All social media entries examined in the content analysis will be openly available and chosen based on hashtags and levels of engagement. Although usernames may be visible, precautions will be taken to prevent the disclosure of identifiable personal information. Should any posts be quoted, they will be paraphrased or anonymised unless they originate from verified public figures or brand accounts.
- **Document Sources**: Every policy report, sustainability framework, and media article utilised in the document analysis will be accurately cited using Harvard referencing. Any interpretative analysis will stay true to the context in which the original content was published.
- **Academic Integrity and Researcher Reflexivity**: The researcher will ensure that the interpretation of data remains impartial and rooted in the source material. Reflexive notes will be kept throughout the research process to track possible biases and promote transparency in the analysis. The research upholds ethical standards by following these guidelines while exclusively utilising secondary data.

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E. Limitations

While this study provides significant insights into the convergence of digital influence and environmental responsibility, it is essential to recognise several limitations.

Firstly, the research is mainly conceptual and qualitative, relying on secondary sources and publicly accessible content instead of empirical fieldwork. Consequently, the findings cannot be statistically generalised across all influencers or platforms; they aim to stimulate dialogue and serve as a basis for future exploration.

Secondly, the lack of primary interviews restricts the comprehensiveness of stakeholder perspectives—especially those of influencers, policymakers, or platform representatives. Although document and content analyses offer valuable contextual information, they may fall short of the nuanced insights from direct conversations.

Thirdly, interpretive bias presents a fundamental risk in qualitative research. Despite attempts to maintain reflexivity and methodological clarity, the selection and coding of themes are influenced by the researcher's viewpoint and prior beliefs.

Finally, the suggested Influence Emissions Fee is still a theoretical idea, and the study does not present a formal feasibility analysis or pilot implementation. For this reason, judgments about its conceivable effects ought to be perceived as initial rather than resolved. These boundaries stress the critical requirement for additional empirical and multi-faceted research to augment the early discoveries of this document.

6. Discussion

Interpret Findings

The analysis uncovers a notable disconnection between the swiftly growing impact of digital creators and the inadequate incorporation of environmental responsibility within current regulatory or platform structures. While numerous policy papers and sustainability reports highlight the need to decrease emissions (IEA, 2020; OECD, 2022), none consider the carbon

footprint associated with influencer-driven engagements, despite their rising significance (de Oliveira et al., 2024).

Document examination indicates that while entities such as the ASA and FTC prioritise honesty and transparency in influencer marketing, they do not possess any environmental obligations. Similarly, corporate sustainability reports focus on their product life cycles and production emissions, but hardly ever involve indirect digital promotion in their emissions analysis. This reveals that the influencer culture has mainly been shrouded in the existing environmental accountability systems.

Online content analysis is also used to explain the perpetuation of the celebrity tale, which persistently idealises the high-emission actions, including travelling by air regularly, buying fashion more than needed, and purchasing electronic devices, with little or no information about the climate consequences.

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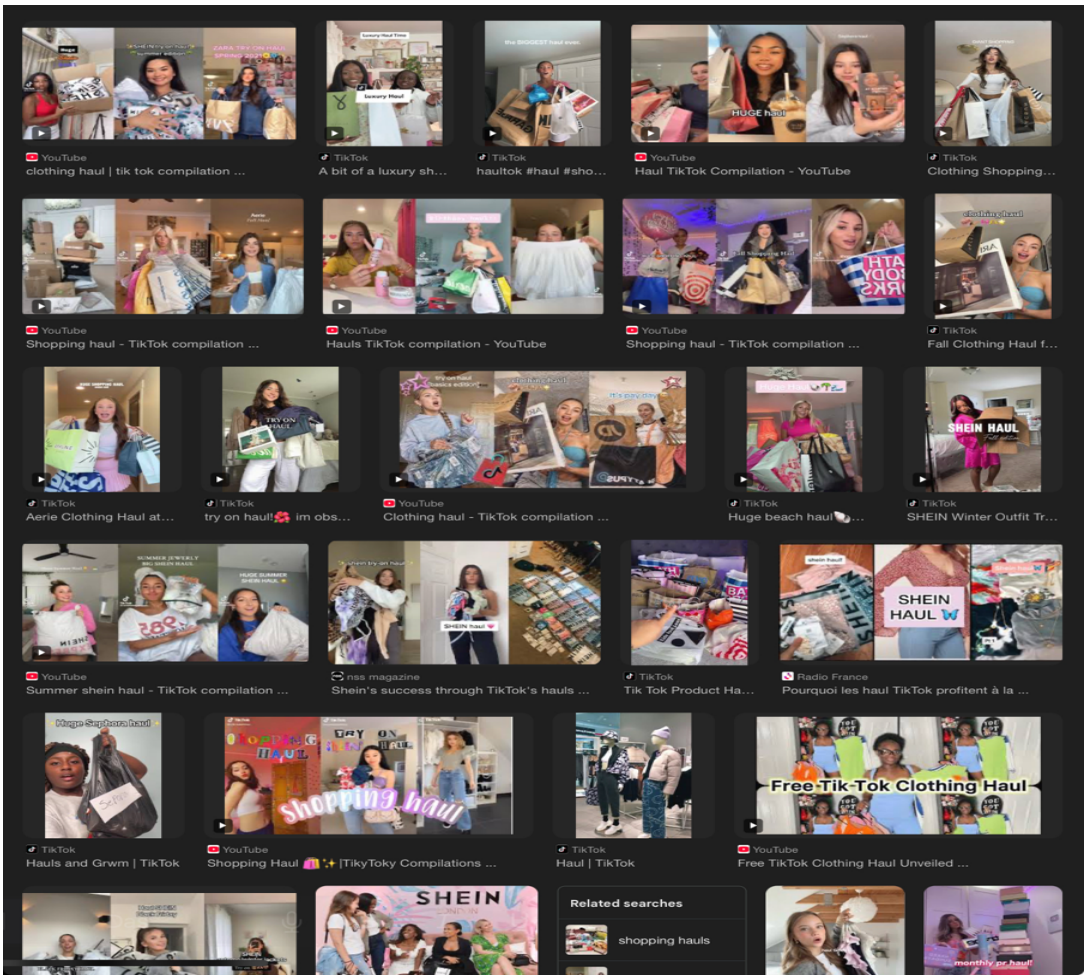

Figure 2: Screenshot of a standard "haul" presentation on platforms like TikTok and YouTube. The snapshot reveals different forms of influencers presenting considerable amounts of recently acquired products and often fast fashion stores. The videos always promote high

consumption behaviour without disclosing the environmental impacts involved. This material exemplifies how the trend-driven and aspiration-related stories discussed in the context of influencer-driven emissions are presented.

As one specific example, there was a post on YouTube mainly revolving around a so-called haul video, where a content creator was unboxing more than 30 new pieces of clothing bought at one of the fast fashion stores, emphasising affordability and current trends. The write-up featured appealing aesthetics and vibrant musical background, whereas it categorically paid no attention to references to the implications of production, emissions, etc whatsoever. The video has had an impressive number of views of more than two million, and the comments sections are full of expressions of excitement and imitations. As such, it demonstrates how such content can be used to normalise excessive consumer tendencies.

In posts even labelled as sustainable, Greenly (2024) and Lameiras & Monteiro (2023) note that the information posted often looks towards aesthetic minimalism rather than the measurable cutting back on carbon. This aligns with criticisms of the so-called relatable greenwashing in which branding or an individual story undermines the environmental message.

In addition, the results document an expansive transfer of responsibility on the consumer, as suggested by Pookulangara & Koesler (2011) and Corner & Randall (2011). This supports the theoretical assertion that influential digital behaviours remain unregulated externalities without incorporating environmental costs through mechanisms like Pigovian taxes (Pigou, 1920; Oates, 1999). Influencers, acting as agenda-setters (McCombs & Shaw, 1972), perpetuate overconsumption under the pretext of authenticity and aspiration—ultimately exacerbating the "value–action gap."

While most of the examined material promotes high-emission activities, it's critical that not every influencer's initiative contributes to environmental decline. A developing alliance of creators is zealously promoting eco-friendly behaviours—spotlighting the positive aspects of thrift store shopping, waste-free techniques, certified green brands, and travel routes that minimise emissions. These social media figures can contribute to making eco-friendly practices

commonplace and uplift the dialogue in the community. Nonetheless, their outreach and algorithmic visibility frequently remain constrained compared to high-consumption content that yields more substantial engagement metrics.

Importantly, the findings align well with the "Influencer Emissions Risk Matrix" (Figure 1), which visually classifies influencer types by content volume and reach. This framework helps translate abstract emissions risks into tangible categories of digital behaviour, reinforcing which creators might warrant policy intervention. Creators positioned within the upper-right quadrant—characterised by substantial output and broad audience engagement—are especially pertinent in this context, as they consistently manifest in the content analysis as advocates of unsustainable practices. Citing this matrix within the results augments interpretability and anchors abstract hazards within a comprehensible framework.

The findings affirm that viral content significantly contributes to unsustainable practices, yet policies, platforms, and creators function in isolation. Closing this gap would necessitate collaborative efforts: platforms integrating sustainability into algorithmic visibility, creators acknowledging their influence on climate culture, and policymakers developing digital-specific environmental tools such as the Influence Emissions Fee.

Connection to Theory

The findings of this study directly resonate with the idea of Pigovian taxation (External cost, such as pollution, should be reflected in the explicit financial policies) (Pigou, 1920). With the increasing number of influencer-driven content, there is still no precise analysis and control of the environmental effects of publishing content that promotes activities with higher emissions. This rationale is directly behind the Influence Emissions Fee, which offers a basis to take the position to address the market failure and hold those whose content unintentionally sparks overconsumption and carbon emissions responsible. Even though the existing measurement and enforcement gaps remain, internalising digital externalities through a specific fee has strong theoretical and empirical support.

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Implications

For Policy: The Influence Emissions Fee (IEF) allows governments to expand environmental laws into the virtual world. To create such a fee, legislators must develop specific metrics on digital carbon attributions, which may be based on content virality, user engagement, and projected downstream consumption. A differentiated approach might be implemented, with creators having earned a certain number of views or sponsored videos required to disclose environmental impact data and donate to a digital sustainability fund. Alternatively, the government can tax these platforms on the overall emissions of influencer-driven content and, in doing so, move the burden of responsibility to the parties who benefit most through algorithmic promotion.

For Influencers: An IEF would encourage content makers to reflect on their content strategy, particularly when they promote high-carbon lifestyles such as fast fashion hauls, regular long-distance travel, or irresponsible consumption aspects such as product promotions. Influencers can begin to practice self-regulation by adding sustainability disclaimers, promoting low-emission products, or partnering with environmentally friendly partners to appeal to a more environmentally acceptable audience. The fee might also lead to developing green creator certifications or scores that make ethical content more visible, urging the shift to values-based rather than volume-based influence.

For Platforms: The role of social media companies is crucial in mediating between other people and might play a key role in either facilitating or suppressing the integration of such a policy. Carbon transparency features include labelling the emission of a particular video, its carbon intensity index, or a sustainability icon, which is optional for creators. More prominently, algorithms could be changed to leave behind high-emission material or promote creators who meet the set standards regarding the environment. Since platforms control access to online engagement, they might also be compelled to publish data on the total emissions the employees contribute to offsetting programs in proportion to the leverage they might have in favouring unsustainable consumption patterns.

Limitations

This study contains certain notable limitations. To begin with, being a conceptual and exploratory study, the research does not include quantitative data, large-scale surveys and experimental assessments. Though the qualitative approach methodology supports in-depth observations and recognition of patterns, it cannot be used to make sweeping conclusions in the scope of the influencer landscape or global regulatory systems.

Secondly, the reliance on secondary data, such as documents and publicly available online sources, limits the range of opinions voiced. Without primary interviews, the study does not gather first-hand opinions of major stakeholders like the creators, policymakers or the representatives of the platforms.

Thirdly, the key activity of qualitative materials analysis requires subjective codification and topical classification. With all its attempts at reflexivity, it might carry the personal bias of the investigator. It could also be the case that the findings are not likely credible because of a lack of triangulation with quantitative or behavioural measurements.

Lastly, even the Influence Emissions Fee itself is theoretical. Whether it actually leads to behaviour change, content patterns, or a decrease in emissions cannot be proven without real-life policy experiments, simulations or implementation studies.

Future Research

The mentioned insights can be taken further in the future, with quantitative and experimental methods. For example, surveys may be used to determine people's level of approval of the responsibility of influencers for their impact on the environment or to test the creators' responsiveness and willingness to abide by emission-related rules. An Influence Emissions Fee prototype could be run with a social media platform to test the impact of engagement-based or estimated emission-based fees on content patterns. Alternatively, a voluntary carbon badge may

be tested, in which creators will have their visibility boosted when they endorse sustainable practices or brands.

In addition, the combination of environmental science, behavioural economics, and media studies may offer new ways of measuring the downstream consequences of internet-based information, such as buying patterns, shipping carbon footprints, and imitating lifestyles.

Finally, future efforts must focus on integrating digital consumption into the balance of environmental policies to ensure that the stakeholders' climate responsibility complies with the changes in the digital environment.

7. Conclusion

Conclusively, the Influence Emissions Fee effectively addresses the environmental problems caused by viral marketing in the modern online world. Due to the growing impact of social media on consumer behaviour and lifestyle choices, it is essential to recognise the high cost of carbon associated with the online material generated by the entity of viral content creators. This research explores the feasibility and consequences of any such fee, considering the twofold role of digital influencers as possible sources of climate change and advocates of sustainable living.

Nevertheless, fairness is paramount in the application of the Influence Emissions Fee. The Influence Emissions Fee must differentiate between casual users, emerging creators, and high-impact influencers, using metrics such as content volume and audience size (as introduced in the Influencer Emissions Risk Matrix). This risk-based classification would help avoid unjustly penalizing small creators or marginal voices while focusing regulatory attention on the most emissions-intensive.

Moreover, the fee mechanism should not exist in isolation. One possible model would be to reinvest revenues into climate justice initiatives—supporting communities disproportionately affected by climate change or funding green tech education and carbon literacy programs. This

redistributive element would align the policy with broader ethical goals and reinforce its legitimacy as more than a punitive measure.

By examining the interaction between influencer culture and environmental responsibility, the study will not only seek to add value to the policy debates that dominate contemporary discourse, but it will also endeavour to pave the way for a more environmentally friendly digital marketing practice. On the one hand, though millions of viral content creators might unwillingly promote overconsumption, there is an emerging group of successful sustainability advocates. Promoting and boosting the status of these opinions could result in more powerful regulatory measures and a more climate-conscious digital ethos.

Ultimately, this paper does not propose immediate legislative efforts but aims to trigger critical dialouge into the links between sustainability and the impact of digital influence. With the increasing digitization of the society the borders between virtual and real actions are eroding. It is imperative that digital creators—alongside platforms and regulators—begin to see themselves as stakeholders in environmental futures.

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