REPUBLIC OF TÜRKİYE
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS
ECONOMICS IN ENGLISH PROGRAM

PhD DISSERTATION

ESSAYS ON THE ECONOMICS OF AUTOMATION

HÜSEYİN CAN HACIBEBEKOĞLU
19729012

THESIS ADVISOR
PROF. DR. BURAK ÜNVEREN

2025

REPUBLIC OF TÜRKİYE
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS
ECONOMICS IN ENGLISH PROGRAM

PhD DISSERTATION

ESSAYS ON THE ECONOMICS OF AUTOMATION

HÜSEYİN CAN HACIBEBEKOĞLU
19729012
ORCID NO: 0000-0001-6910-1035

THESIS ADVISOR
PROF. DR. BURAK ÜNVEREN

JULY 2025

Hüseyin Can HACIBEBEKOĞLU tarafından hazırlanan “Essays on The Economics of Automation” başlıklı çalışma, **07/07/2025** tarihinde yapılan savunma sınavı sonucunda oybirliği ile başarılı bulunmuş ve jürimiz tarafından İktisat Ana Bilim Dalı İngilizce İktisat Programında **DOKTORA** tezi olarak kabul edilmiştir.

Danışman	**İmza**
Prof. Dr. Burak Ünveren	……

Jüri Üyeleri	**İmza**
Doç Dr. Seçkin Sunal	……
Doç Dr. Aykut Attar	……
Prof. Dr. M. Anıl Mercan	……
Prof. Dr. Serdar Sayan	……

ABSTRACT

ESSAY ON THE ECONOMICS OF AUTOMATION

This thesis is structured as a three-essay format. The first essay investigates whether political competition leads to the taxation or subsidization of robots in a general equilibrium setup. Our primary assumption is that while automation substitutes for routine labor, it enhances the productivity of non-routine labor, thereby creating a political conflict of interest within society. This conflict gives rise to electoral competition between two political parties, each representing different labor groups, and engaging in a game-theoretic rivalry to win elections and maximize the expected welfare of their electorates. In this political competition framework known as the Wittman model, both income tax and a robot tax serve as policy instruments. Our theoretical and quantitative analyses demonstrate that, given the currently high cost of robots, both parties support subsidies for robot usage. However, as technological progress drives down robot prices over time, the model suggests that robot tax may become inevitable in the long run. The second essay examines how the robot tax is endogenously determined in an overlapping generations (OLG) model featuring young routine and non-routine workers, as well as old routine and non-routine retirees. By incorporating generational differences and accounting for both income and wealth inequality, the model analyzes how two political parties—each representing distinct groups—maximize the expected indirect utility of their electorates under Wittman political competition. The party representing young and old non-routine individuals favors a moderate robot subsidy in the steady state, while the party representing routine workers proposes a high robot tax. Compared to the laissez-faire and social planner solutions, the analysis reveals that there are probabilistic shifts in election outcomes that alter the levels of income and wealth inequality, reminiscent of political business cycles. The third essay explores whether redistribution can be a driver of automation. Using a general equilibrium model with automation, both analytical and numerical results show that redistribution increases the level of automation. This theoretical insight is supported by an empirical analysis based on panel data. Applying the GMM-IV estimation method, the study finds that redistribution has a statistically significant and positive causal effect on automation.

Keywords: Robot taxation, political economy of automation, OLG, redistribution and technological change

ÖZET

OTOMASYONUN EKONOMİSİ ÜZERİNE MAKALELER

Bu tez üç makale formatındadır. İlk makale, siyasal rekabetin robotların vergilendirilmesine mi yoksa sübvanse edilmesine mi yol açtığını genel denge çerçevesinde incelemektedir. Temel varsayımımız, otomasyonun rutin emeğin yerini alırken aynı zamanda rutin olmayan emeğin verimliliğini artırdığıdır. Bu durum toplum içinde siyasi çıkar çatışmasına neden olmakta ve her biri farklı emek gruplarını temsil eden iki siyasi partinin, seçmenlerinin beklenen refahını maksimize etmeye çalıştıkları oyun kuramsal bir seçim rekabetine yol açmaktadır. "Wittman modeli" olarak bilinen bu siyasal rekabet çerçevesinde hem gelir vergisi hem de robot vergisi birer politika aracı olarak kullanılmaktadır. Teorik ve nicel analizlerimiz, robotların mevcut yüksek maliyeti göz önüne alındığında, her iki partinin de robot kullanımına yönelik sübvansiyonu desteklediğini göstermektedir. Ancak teknolojik ilerleme ile robot fiyatlarının zamanla düşmesi sonucunda model, uzun vadede robot vergisinin kaçınılmaz hale geleceğini öngörmektedir. İkinci makale, robot vergisinin nasıl endojen olarak belirlendiğini genç rutin ve rutin olmayan işçiler ile yaşlı rutin ve rutin olmayan emeklileri içeren örtüşen nesiller (OLG) modelinde incelemektedir. Bu model, nesiller arası farklılıkları içselleştirerek hem gelir hem de servet eşitsizliğini dikkate almakta ve her biri farklı grupları temsil eden iki siyasi partinin, seçmenlerinin dolaylı faydasını maksimize etmeye çalıştığı Wittman tipi siyasal rekabet içinde nasıl bir politika önerdiğini analiz etmektedir. Rutin olmayan genç ve yaşlıları temsil eden parti durağan durumda ılımlı bir robot sübvansiyonunu savunurken, rutin işçileri temsil eden parti yüksek oranlı bir robot vergisi önermektedir. Laissez-faire ve sosyal planlayıcı çözümleriyle karşılaştırıldığında, analiz seçim sonuçlarında olasılıksal kaymaların meydana geldiğini ve bunların gelir ve servet eşitsiliği seviyelerini değiştirdiğini ortaya koymakta, bu durum siyasal konjonktür döngülerine benzerlik taşımaktadır. Üçüncü makale, yeniden dağıtımın otomasyonun bir belirleyicisi olup olmadığını araştırmaktadır. Otomasyonu içeren bir genel denge modelinde yapılan analitik ve sayısal analizler, yeniden dağıtımın otomasyon düzeyini artırdığını göstermektedir. Bu teorik bulgu, panel veri seti ile yapılan ampirik analizle de desteklenmektedir. GMM-IV tahmin yöntemi kullanılarak yapılan analiz, yeniden dağıtımın otomasyon üzerinde istatistiksel olarak anlamlı ve pozitif yönlü nedensel bir etkisi olduğunu ortaya koymaktadır.

Anahtar Kelimeler: Robot vergilendirmesi, otomasyonun politik ekonomisi, OLG, yeniden dağıtım ve teknolojik dönüşüm

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to everyone who contributed to the completion of this dissertation.

First and foremost, I am deeply grateful to my advisor, Prof. Dr. Burak Ünveren, for his invaluable support and guidance throughout this journey. If this work has been completed, it is largely thanks to his dedication and commitment to working with me every step of the way. I have always admired his devotion to his profession. His commitment to the discipline of economics and his immeasurable support cannot be overstated. His integrity as a person and excellence as a scholar have been a constant source of inspiration to me.

I would also like to thank Assoc. Prof. Dr. Aykut Attar, a member of my thesis committee, for his insightful suggestions and valuable feedback during each review. I am equally grateful to Assoc. Prof. Dr. Seçkin Sunal, whose warm and calm demeanor, along with his constructive comments, have been greatly appreciated.

I would like to thank Prof. Dr. Serdar Sayan, a member of my thesis defense committee, for his thoughtful remarks and recommendations. I also thank Prof. Dr. Anıl Mercan for his kindness and valuable feedback during the defense.

I extend my heartfelt thanks to my beloved family—my mother Sevinç and my father Tahir Hacıbebekoğlu—who have supported me both emotionally and financially throughout my life. Without their unwavering belief in me, I would not be the person I am today.

Finally, I would like to express my deepest appreciation to my dear wife, Aycan. I am truly indebted to her for providing me with a peaceful and loving home, for her constant patience and understanding, and most importantly, for always believing in me.

.

Hüseyin Can HACIBEBEKOĞLU

July 2025; İstanbul

CONTENTS

ABSTRACT iii
ÖZET iv
ACKNOWLEDGMENTS v
CONTENTS vi
LIST OF TABLES viii
LIST OF FIGURES ix
ABBREVIATIONS x

1. INTRODUCTION 1

2. ON THE POLITICAL ECONOMY OF AUTOMATION 5
2.1. Introduction 5
2.2. The Benchmark Model 8
2.2.1. Economic environment 8
2.2.2. Political competition 11
2.3. Unidimensional theoretical analysis 14
2.4. Multidimensional quantitative analysis 16
2.5. Conclusion 19

3. ENDOGENOUS ROBOT POLICY: AN OLG APPROACH 20
3.1. Introduction 20
3.2. Economic Environment of The Model 27
3.2.1. Household Problem 27
3.2.2. Firm's Problem 29
3.2.3. Government 31
3.2.4. Skill-Wealth Nexus 31
3.2.5. Political Parties 32
3.3. Numerical Analysis 36
3.3.1. Wittman Equilibrium 40
3.3.2. An Optimal Solution 48
3.3.3. Sensitivity Analysis 52
3.4. Discussion 55
3.5. Conclusion 57

4. REDUCING INEQUALITY ACCELERATES AUTOMATION: THEORY AND EVIDENCE 59
4.1. Introduction 59
4.2. A Simple Model 63
4.3. Empirical Analysis 67
4.3.1. Overview 68
4.3.2. Data and Methodology 68
4.4. Endogeneity 71

4.5. Descriptive Statistics and Plots 73
4.6. Result 75
4.7. Discussion 81
4.8. Conclusion 82

REFERENCES 84
APPENDIX 91

LIST OF TABLES

Table 1. Wittman Equilibrium 17
Table 2. The Results of Wittman Equilibrium for the First Period..... 41
Table 4. Wittman Results under the Different Initial Capital Level for the First Period 53
Table 3. The Results of Weighted Wittman Equilibrium for the First Period 55
Table 5. Level-Level (Automation Rate(R/R+L), Redistribution/GDP) 76
Table 6. Level-Log Automation Rate(R/R+L), Redistribution..... 77
Table 7. Level-Level Automation Rate(R/R+L), Before Tax- After Tax Gini..... 78
Table 8. Level-Log Automation Rate(R/R+L), Before Tax- After Tax Gini 79
Table 9. Level-Level Automation Rate(R/R+L), After- Before Tax Bottom %50 Share of Income Instruments: Homophobia and Democracy 80

LIST OF FIGURES

Figure 1. Wittman Equilibrium 16
Figure 2. The impact of robot prices on political equilibrium in a competitive 18
Figure 3. An Example of the Winning Probability for the Party P 35
Figure 4. The Shape of the PDF Under Different Intervals 36
Figure 5. Utility of Non-Routine Old 38
Figure 6. Utility of Routine Old 38
Figure 7. Utility of Non-Routine Young 39
Figure 8. Utility of Routine Young 39
Figure 9. Total Welfare in Equal Weights 40
Figure 10. Output in Time Wittman vs Laissez-Faire 42
Figure 11. Putty Capital in Time Wittman vs Laissez-Faire 43
Figure 12. Wage Premium Wittman vs Laissez-Faire 44
Figure 13. Total Factor Productivity (TFP) Wittman vs Laissez-Faire 45
Figure 14. Traditional and Robot Capital Wittman vs Laissez-Faire 46
Figure 15. Consumtions of Agents 47
Figure 16. Output in Time Optimal Solution 49
Figure 17. Putty Capital in Time Optimal Solution 50
Figure 18. Wage Premium Optimal Solution 50
Figure 19. TFP Optimal Solution 51
Figure 20. Traditional and Robot Capital 51
Figure 21. Consumtions of Agents Optimal Solution 52
Figure 22. Redistribution vs Automation 66
Figure 23. Wage Premium 66
Figure 24. Correlation Between Automation and Redistribution Using Alternative Redistribution Indicators 74
Figure 25. First-Stage Correlation: Religiosity vs. Redistribution Indicators 75

ABBREVIATIONS

AKP	: Justice and Development Party
CDF	: Cumulative Distribution Function
CDFs	: Cumulative Distribution Functions
CES	: Constant Elasticity of Substitution
CHP	: The Republican People's Party
GDP	: Gross Domestic Product
GMM	: Generalized Method of Moments
IFR	: International Federation of Robotics
IV	: Instrumental Variable
OLG	: Overlapping Generations Model
PDF	: Probability Density Function
PWT	: Penn World Table
TFP	: Total Factor Productivity
UBI	: Universal Basic Income
U.S.	: United State
V-Dem	: Varieties of Democracy
WVS	: World Values Survey

1. INTRODUCTION

Automation and robotics are rapidly spreading globally, sharply affecting production processes and the labor market. According to the International Federation of Robotics (IFR, 2023), in 2022, there were 151 robots per 10,000 employees in the manufacturing sector worldwide. This figure was only around 65 in 2015. In other words, robot density has more than doubled in seven years. During this period, the annual growth rate of robot density was 15% for Asian countries, 8% in Europe, and 7% in the Americas. Notably, China alone has been responsible for 52% of global robotization in recent years. As evidenced by the IFR data, the exceptionally high levels of robotization in recent years clearly demonstrate the technological transformation taking place in production processes. These developments have begun to be discussed in literature in terms of the impact of robotization and AI use on productivity and labor market (Koch et al., 2019; Acemoglu & Restrepo, 2020; Graetz & Michaels, 2018; Dauth et al., 2021; Bessen et al., 2023; Acemoglu et al., 2021; Brynjolfsson et al., 2023, Babina et al., 2024). These discussions have also revealed that the impact of automation on labor market is not homogeneous, and that the effects differ across labor groups. For example, the literature emphasizes that automation and robotics tend to be substitutive for routine and low-skilled jobs, while being complementary to non-routine and high-skilled jobs (Autor et al., 2003; Goos et al., 2009; Arntz et al., 2016; Acemoglu & Restrepo, 2018; Graetz & Michaels, 2018). Additionally, the impact of automation on the labor market is also analyzed in terms of blue-collar and white-collar occupations (Staffing Industry analysis, 2023). Regardless of the terminology or how the categories are defined, it is clear that automation affects different groups of workers in various ways. Due to the unequal impact of automation across occupational groups, particularly in terms of income effects—the taxation of robots has become a relevant subject of economic policy discussion (Guerreiro et al., 2023; Gasteiger and Prettner, 2022; Guerreiro et al., 2022; Thuemmel, 2023). The core of these discussions centers on the idea that automation tends to benefit capital owners and high-skilled workers, while raising concerns for other groups—particularly low- and middle-income earners. As a result, redistribution

policies based on robot taxation are proposed as a means to mitigate income inequality. Since automation affects each worker group differently, their preferences about robot taxes also differ. To understand how this divergence is resolved under political competition, the first essay looks at a model where robot tax is decided through elections.

The first essay examines a robot tax determined by election in a static general equilibrium model involving robotization. In the model, there are two groups of workers performing different tasks. One is perfectly substituted by robots, while the other is complementary with robots. The public good financed by the robot tax provides benefits to both groups. Two political parties represent the interests of these two different groups. Each party seeks to maximize the expected utility of its own voter group. The probability of winning the election depends on the robot tax proposed by each party. This creates a game-theoretic structure. This is called the Wittman model of political competition. The revenue from the robot tax is used to provide public goods. If robots are subsidized instead, the amount of public goods decreases. All economic agents optimize their objectives under the policy of the winning party. While the existing literature focuses either on optimal robot taxation (e.g., Ales et al., 2015; Costinot & Werning, 2023) or on how automation influences electoral outcomes (e.g., Caselli et al., 2020), this study is the first to endogenize robot taxation through political competition in a general equilibrium framework. In a model where automation has asymmetric effects on different groups of workers, both theoretical and simulation results show that current robot prices are still high, leading all political parties to prefer subsidizing robots. However, as robot prices gradually decline over time due to technological development, the model predicts that all parties advocate for taxing robots. Nevertheless, unlike the first essay, the second essay shows how the income inequality between the two worker groups turns into a wealth inequality over time. By using a dynamic model, it allows us to examine both income and wealth inequality together.

The second essay uses a dynamic OLG model. This allows for the examination of wealth inequality in addition to income inequality. Again, there are two types of labor performing different tasks. One is substitutable with robots (routine labor), while the other is complementary (non-routine). These two groups, who work when young, consume their savings when old. In other words, the income difference in the first

period leads to a wealth difference. This time, the revenue from robot taxes is distributed as a universal basic income. The two political parties again represent the interests of these two different groups. Under Wittman political competition, the robot tax rate is determined, and accordingly, the income and wealth inequality in the current period is shaped. Unlike previous studies on optimal robot taxation (e.g., Gasteiger & Prettner, 2020; Prettner & Strulik, 2020; Guerreiro et al., 2022; Thuemmel, 2022), we endogenize the robot tax through political competition. Our results show that political rivalry leads to persistent deviations in real economic indicators (such as output, wage premium, the wealth of old routine and non-routine workers, total factor productivity, and consumption levels), even after the economy reaches its steady state. Since the election outcome is determined probabilistically based on the tax proposals of both parties, the winning party—and thus the robot policy applied—varies across periods. This leads to ongoing fluctuations in the economy.

In the first two essays, we examined how robot taxation is shaped by political competition and how it affects income and wealth inequality in both static and dynamic general equilibrium settings. However, another important aspect deserves attention. While robot taxes and redistribution aim to reduce inequality, they may unintentionally accelerate automation by increasing the relative cost of labor and making robots more attractive to firms. This suggests the possibility of a feedback loop between redistribution and automation. The third and final essay adopts an approach contrary to the existing literature by establishing a causal direction from redistribution to automation, rather than from automation to redistribution. A general equilibrium model is developed to reflect this direction. Moreover, this causality is empirically tested using panel data analysis. Thus, the direction of causality found in the theoretical model is empirically valid as well. Unlike Acemoglu et al. (2020), who analyze the effect of automation on employment and labor share, Moll et al. (2022), who focus on wealth and income inequality, and Gilfoyle (2023), who examines how automation impacts income inequality across countries depending on labor market institutions, this essay reverses the direction of causality by showing that redistribution itself can act as a driver of automation. While Süssmuth et al. (2020) also analyze the effect of taxation on automation, they use a dynamic neoclassical model with homogeneous labor and U.S.-specific time series data via cointegration and VECM methods. In contrast, our study employs a static general equilibrium framework with

heterogeneous labor and tests the theoretical mechanism using panel data and GMM-IV estimations across multiple countries. The theoretical model shows that, as income is redistributed from skilled to unskilled workers, the resulting rise in unskilled wages reduces their labor supply and increases firms' demand for robots. This relative increase in labor costs makes automation more attractive. The mechanism is supported both analytically and via calibrated simulations. Empirically, GMM-IV results consistently reveal a significant positive relationship between redistribution and automation, even after addressing endogeneity using instrumental variables such as religiosity and homophobia. These findings provide evidence that the causality between redistribution and automation is bidirectional.

In conclusion, this study contributes to the literature by examining the political economy of robot taxation in both a static model—where robot taxes finance public goods—and a dynamic model where robot taxes fund UBI, revealing how these policies shape the economy. Finally, it uncovers the causal link from redistribution to automation, highlighting how redistribution can steer technological change.

2. ON THE POLITICAL ECONOMY OF AUTOMATION

2.1. Introduction

As a result of the 21st-century automation revolution, there is a growing literature on whether it is efficient and socially optimal to tax robots (see Prettner and Strulik 2020, Gasteiger and Prettner 2022, Thuemmel 2023, Guerreiro et al. 2022, Ünveren et al. 2023). This is a crucial issue because there is virtually no economy with robot taxes despite the ubiquity of taxes on labor income (McKinsey Global Institute 2020, The Economist 2023). Arguably, this creates unfair competition between tax-paying humans against robots that do not. So, it stands to reason that robot taxes could enhance efficiency by preventing lower tax revenues, and help finance valuable public services such as infrastructure, basic research, and education provided by the government (Rubin 2020, Korinek et al. 2021, Shome 2022).

The literature, however, overlooks another fundamental question: Would politicians find crafting industrial policies taxing robots in their best interest to win the elections or further their ideological positions? To put it more succinctly, can robot taxes be politically viable? The fact that robots typically substitute for blue-collar jobs and reduce their wages lies at the crux of the matter (see Autor and Dorn 2013, Acemoglu and Restrepo 2018, Graetz and Michaels 2018, Acemoglu et al. 2023). This mechanism suggests a large voter base for taxing robots. But automation also has a positive impact on the productivity of white-collar professionals who potentially constitute a voter base for robot subsidies. Therefore, there is a potential political conflict of interest between white- and blue-collar workers regarding whether robots should be taxed or subsidized.

To contribute to this discussion, we develop the first theoretical model in the literature where electoral competition determines robot policies within a general equilibrium automation framework. In our model, there are two types of labor, each performing one of two distinct tasks: routine and non-routine. Robots substitute for workers performing routine tasks and enhance the productivity of those involved in non-routine

tasks. Two political parties exist, each representing the interests of either routine or non-routine workers. To maximize the expected utility of its voter base (either routine or non-routine workers), each party campaigns for an automation policy (taxing or subsidizing robots) that also determines the odds of electoral victory. Robot taxes finance the provision of a pure public good while robot subsidies reduce the amount of public goods. Following the election results, all economic agents optimize their objectives under the winning party's policy within competitive markets.

The first contribution of this analysis is the characterization of how automation impacts political competition. We go beyond merely considering the social efficiency of robot taxes designed by a benevolent planner by incorporating the political economy dimension into the automation debate. In contrast, previous studies have primarily focused on the impact of automation on social welfare (e.g., Eden and Gaggl, 2020; Aum & Shin, 2024; Bezell et al., 2015) or have analyzed robot and income taxes crafted by a benevolent social planner (e.g., Ales et al., 2015; Adachi, 2024) to mitigate the adverse effects of automation (e.g., Hémous and Olsen, 2022; Schulz et al., 2022). Likewise, in their recent and notable contributions, both Costinot and Werning (2023) and Guerreiro et al. (2022) have analyzed optimal tax systems to address the economic challenges of automation.

Having said that, we also note that social efficiency and electoral competition are closely related. For example, Atolia et al. (2024) analyze optimal capital taxation and UBI with the objective of maximizing the welfare of a homogeneous group of workers (as opposed to entrepreneurs). They interpret this optimal taxation problem as majority voting, which, by assumption, reflects only the preferences of the homogeneous working class. In a similar vein, Persson and Tabellini (1994), Farhi and Werning (2008), Acemoglu et al. (2010), and Farhi et al. (2012) also explore the political economy of capital taxation. However, these studies are predicated on a traditional notion of capital which has an unambigously positive impact on all workers. In other words, capital accumulation is beneficial to the productivity of everyone in these models. In contrast, we posit that robots create an asymmetric impact on routine and non-routine workers by replacing the former while enchaning the efficiency of the latter. So, the political economy of capital taxation literature cannot provide adequate

insights into the interaction between automation (robots, AI, etc.) and political parties[1]. According to our results, we theoretically find that all rival parties would advocate for taxing robots if the prices of robots are sufficiently low and subsidizing them when prices are high. Given the secular decline in robot prices over time, this finding can be interpreted as that robots will eventually be subjected to taxation. This has significant implications for the future of political competition and economic policy.

Nonetheless, these results do not answer whether current robot prices are low enough to lead robot taxation or subsidies as political outcomes in free market economies. To address this question, we calibrate our model targeting certain empirical value. Morover, we extended the model by assuming that the strategy space of political parties also includes income taxes in our calibrations. The quantitative results show that robots are still relatively expensive, thereby inducing all political parties to choose robot subsidies as their equilibrium strategy. That is to say, the real-world robot prices are still relatively high enough to protect blue-collar jobs from automation making robot subsidies a viable political strategy. As we reduce the price of robots in our numerical experiments, however, we observe that all parties propose robot taxes in equilibrium only when the robot market is sufficiently competitive.

The impact of automation on electoral outcomes is also analyzed by Im et al. (2019), Caselli et al. (2020), and Anelli et al. (2021). All three argue that robot adoption and automation are driving forces for those who are exposed to voting populist parties. However, these studies use purely empirical techniques focusing on voter preferences and ignoring the strategic interaction between political parties.

In contrast, we rigorously formalize political competition assuming each political party represents a certain segment of the society, either routine or non-routine workers. More specifically, the objective of each party is the expected utility of the electorate that they represent. So, both pragmatism (i.e., odds of electoral victory) and ideology (i.e., interests of certain voters) enter the objectives of each political party. This is called the Wittman model. A standard alternative could be the Downs model where political parties are only pragmatically motivated by taking office without any ideological concerns. However, the Downsian equilibrium generically does not exist when

[1] After extensively analyzing capital taxation, Atolia et al. (2024) touch upon robotization. But their analysis on automation is fairly brief, presumably because robots do not change optimal tax rates, which they interpret as “no robot taxes in equilibrium”.

political parties have multi-dimensional strategies which we assume in our quantitative analysis where political parties choose their income tax and robot policy strategies.

This brings us to another contribution of our analysis. We have theoretically demonstrated the existence of equilibrium in our benchmark model, where the strategy space of political parties is unidimensional. This is the first proof in the literature for the existence of Wittman equilibrium within a truly general equilibrium model, setting our work apart from existing research (cf. Llavador and Solano-García 2011, De Donder & Jean Hindriks 2007, Smirnov and Fowler (2007), Lee 2011, Öztürk Göktuna 2019). We find this interesting because the Downs equilibrium—the natural reference point—exists under quite general conditions assuming unidimensional strategy spaces while there is generically no Downsian equilibrium if strategy spaces are multidimensional. The Wittman equilibrium does not possess similarly crystal-clear features: there is no general existence or non-existence result that applies to the Wittman model.

The paper is organized as follows. The next section introduces a simple general equilibrium model of automation with policymaking. In Section 3, we introduce political competition to endogenize the automation policy. The quantitative analysis is presented in Section 4. We conclude after discussing potential future research in Section 6.

2.2. The Benchmark Model

In this section, we incorporate political competition into a concise general equilibrium analysis of robots. Assuming perfectly competitive markets, we begin by describing the economic environment to analyze automation under given robot taxes.

2.2.1. Economic environment

Assume that competitive firms supply robots using simple linear robot production technology to maximize profits:

$$\max(\rho R - \phi R), \tag{1}$$

where ρ is the price, R is the supply, and ϕ is unit final good to produce a robot (Guerreiro et al., p.9, 2022). In other words, producing one robot requires ϕ units of output. Therefore, producing R robots entail a total cost of ϕR. Under perfect

competition, robot producers maximize profits, which leads the price of robots to equal their marginal cost, that is ϕ (Auray and Eyquem, p.5, 2018).

Following Autor et al. (2003), the final good production technology is:

$$Y = A(L_r + R)^{1-a} L_n^{\alpha}, \tag{2}$$

where L_r and L_n are routine and non-routine labor employment while R is the number of robots used in production. This production function is the Cobb-Douglas form, which implies an elasticity of substitution equal to one between robots and routine labor. In fact, in a CES (Constant Elasticity of Substitution) production function, if robots and routine workers have equal productivity and the production technology is defined at the limit where the elasticity of substitution approaches one, the CES function reduces to the Cobb-Douglas form. Therefore, the representative competitive firm producing the final good solves:

$$\max(Y - w_r L_r - w_n L_n - \rho(1+\tau)R), \tag{3}$$

subject to Eq (2) by optimally choosing (Y, L_r, L_n, R) where τ is the tax on robots if $\tau > 0$. Of course, $-1 \leq \tau \leq 0$ is also admissible which simply corresponds to subsidizing robots. There are deep task-based roots of this technological specification as shown by Guerreiro et al. (2022) according to the approach developed by Acemoglu and Restrepo (2018) which has become the standard in the field.[2] Assume $a > 1/2$, lest non-routine workers supply routine labor.

Turning to consumers, each worker is endowed with either routine or non-routine labor. The population ratios of the routine and non-routine labors are n_r and n_n (routine and non-routine respectively) with $n_r > n_n$. The individual's utility function is:

$$u(c_i, l_i, G) = c_i(1 - l_i)^v G^{\eta}, \tag{4}$$

where i denotes the labor types r and n, routine and non-routine respectively. Each individual gets utility from consumption (c) of the final good and public good (G) and

[2] More specifically, assuming $Y = A\left(\int_0^m r_j^{\sigma} dj + \int_m^1 l_j^{\sigma} dj\right)^{\frac{1-\alpha}{\sigma}} (L_n)^{\alpha}$ yields exactly the same aggregate production function where m denotes the upper-bound of the tasks that each robot, r_j, can perform replacing routine workers, l_j, given $j \in [0, m]$.

disutility from working hours (l). We assume $\eta \in (0,1)$ $and\, v > 0$ are fixed preference parameters.

Each i maximizes their utility under the budget constraint:

$$c_i \leq (1-t)w_i l_i\,, \tag{5}$$

where w_i is the wage rate of type i worker and t is a flat income tax rate. The utility maximization gives:

$$l^* = l_i = 1/(1+v). \tag{6}$$

as the supply of both non-routine and routine labor.

The government obtains taxes to spend for public good under the following financial constraint:

$$G \leq n_r t w_r l_r + n_n t w_n l_n + \tau \phi R. \tag{7}$$

Therefore, the government revenues come from taxing both robots and the incomes of all workers. Market clearing condition prescribes the household's problem, firms' problem, and the government budget constraint to be feasible. In particular, the real GDP in this economy is:

$$Y = n_r c_r + n_n c_n + G + \phi R. \tag{8}$$

Likewise, the market clearing condition for labor is:

$$L_i = n_i l_i, \tag{9}$$

for each $i = r, n$.

Under these hypotheses, we can compute the market equilibrium in closed form as a function of the policy tuple $\theta \coloneqq (\tau, t)$ by simultaneously solving Eq (1-9) above. The results can be found in Appendix 1. Therfore, under the definition of Walrasian general equilibrium, allocations and prices simultaneously satisfy the following conditions: (i) profit maximization by firms producing robots and the final good, (ii) utility maximization by households subject to their budget constraints, (iii) government budget balance, and (iv) market clearing for all inputs and the final good. Thus,

$$v_i(\theta) = v_i\big(c_i{}^*(\theta), l_i{}^*(\theta), G^*(\theta)\big), \tag{10}$$

where $(c_i{}^*, l_i{}^*, G^*)$, the equilibrium defined in the Appendix 1, represent the indirect utility of individual $i = r, n$ as a function of the policy tuple θ.

This completes the economic stage where firms and consumers make their decisions by taking the election outcome as given. So, we move to the political competition stage to endogenize the election results that determine the policy tuple (τ, t).

2.2.2. Political competition

We have hitherto treated the focus of our analysis—robot policy, τ—as exogenously given. To endogenize τ, we shall use the Wittman model of political competition. More formally, there are two political parties, R and N. The party R represents the interests of routine workers while the party N represents non-routine workers. Given the policy space $T \subset \mathbb{R}^2_+$, let:

$$\theta^J \coloneqq (\tau^J, t^J) \in T,$$

be the policy choice of the Party J where $J = N, R$.

We postpone specifying $T \subset \mathbb{R}^2_+$ to the next section. At the time being, simply take T as an arbitrary subset of $\mathbb{R}^2_+$. This allows us to accommodate different modelling strategies where t—the income tax rate—may be fixed or not. In the next section, where we derive our analytical results, we assume t is fixed, implying a unidimensional strategy space.[3] When we move to our quantitative analysis, we will assume that the income tax rate is also a choice variable for political parties, implying that T is a multidimensional space. From a quantitative point of view, however, the results are quite insensitive to whether the policy space is multi-dimensional or not as we shall explain in Section 4.

According to the Wittman model of political competition, the von Neumann–Morgenstern utility functions representing the preferences of party R and N are:

$$V^R(\theta^R, \theta^N) = \Pi(\theta^R, \theta^N) v^r(\theta^R) + \big(1 - \Pi(\theta^R, \theta^N)\big) v^r(\theta^N)\,, \tag{11}$$

[3] $T \subset \mathbb{R}^2_+$ does not necessarily imply that that the dimension of T is 2, e.g., the horizontal axis on a plane is a subset of $\mathbb{R}^2_+$ but it is unidimensional.

$$V^N(\theta^R, \theta^N) = \Pi(\theta^R, \theta^N)v^n(\theta^R) + \big(1 - \Pi(\theta^R, \theta^N)\big)v^n(\theta^N)\,, \qquad (12)$$

where Π is the probability of winning the election for the Party R and $v^r and\ v^n$ are the indirect utilities of the represented voters as we compute in closed form in the previous section. Note that these objectives are precisely the expected payoff of the voter that each party $J = R, N$ represents. Thus, each party $J = R, N$ is assumed to choose θ^J to maximize $V^J(\theta^R, \theta^N)$ while taking its rival's policy as given (i.e., Nash hypothesis) in Wittman's model. Morover, the model includes a commitment assumption: if a party wins the election, it fully implements the policy it previously announced. In other words, the party is bound by its pre-election promises and does not deviate from them after taking office. Formally:

Definition 1: A Wittmann equilibrium is a tuple $\theta^{*J} = (\tau^{*J}, t^{*J})$ for each $J = N, R$ such that:

$$V^R(\theta^{*R}, \theta^{*N}) \geq V^R(\theta^R, \theta^{*N}) \text{ for all } \theta^R \in T,$$

$$V^N(\theta^{*R}, \theta^{*N}) \geq V^R(\theta^{*R}, \theta^N) \text{ for all } \theta^N \in T,$$

where V^J is defined in Eq (11) and (12).

In lieu of the Wittman model, a classic alternative for political competition is the Downs model where two political parties or candidates try to maximize only the probability of winning the election without any ideological disposition. However, multi-dimensional problems (generically) prevent the existence of a Downsian equilibrium. So, the Downs model would inherently be inapplicable in the present setup when we move to our quantitative analysis where the policy space is multidimensional.

Moreover, even under unidimensional strategy space, we find the fundamental Downsian hypothesis (i.e., parties only aim at winning the office) quite unrealistic as political parties in real world are clearly incentivized by ideological motives too. In Wittman's model, both motives—ideology and pragmatism—enter into the objectives of the political parties. The political parties under Wittman's competition are partially pragmatic, akin to the Downs model, as the probability of electoral victory, Π, directly enters into their objectives. The ideology is represented by the indirect utilities of the voters that they represent.

Another merit of the Wittman model is that political parties do not choose identical strategies in equilibrium. We find this feature of the Wittman model, known as policy divergence, more realistic in comparison to the median voter result of the Downsian equilibrium (if it exists). However, the Wittman model possesses this appealing feature only under the hypothesis of electoral uncertainty. So, we incorporate uncertainty into the Wittman model to ensure policy divergence.

The uncertainty hypothesis also crucially captures the idea that there are other issues relevant to elections outside our model (see Roemer, p.50, 2001). So, uncertainty in elections can be deemed a first order approximation to the impacts of other relevant issues (e.g., immigration, race, religion, etc.) that are not modelled here.

Now we illustrate the probability function, Π, which creates uncertainty in the model. We use the finite-type of uncertainty. To be specific, we posit that:

$$\Pi(\theta^R, \theta^N) = \Pr\left(\sum\nolimits_{i=r,n} \epsilon^i a^i > 0\right), \tag{13}$$

where (ϵ^1, ϵ^2) is a vector-valued random variable uniformly distributed on the positive orthant of the unit circle and a^i denotes the weighted preference of voter type i for party N over party R, depending on the relative indirect utility from each party's proposed policy:

$$a^i = n_i f\left(\frac{v^i(\theta^N)}{v^i(\theta^R)}\right), \tag{14}$$

given that n_i is the weight of the $i = r, n$ type labor in the population and $v^i(\theta^J)$ is the indirect utility of type i under Party J proposed policy. The function $f(b)$ capture relative utility:

$$f(b) = \frac{1-b}{1+b}. \tag{15}$$

The function $f(b)$ exhibits the following properties:

- If $b < 1$, then the voter type i prefers Party R and, $f(b) > 0$.
- If $b > 1$, then the voter type i prefers Party N and, $f(b) < 0$.
- If $b = 1$, the electorates are indifferent between the two parties, and $f(b) = 0$.

This function captures the intensity of electorate preferences under two different policy proposals, exhibiting continuity, differentiability, and monotonic decreasing properties, as defined by Roemer (2001, p. 47), where the virtues and theoretical foundations of this specification are explained in detail. The next section discusses our theoretical findings.

2.3. Unidimensional theoretical analysis

As discussed above, the objective of political party $J = N, R$ is is the expected utility of its representative voter denoted by:

$$V^J: T \times T \to \mathcal{R}.$$

The strategy space $T \subset \mathcal{R}^2$ identifies the restrictions and constraints that the political parties should comply with. No policy can violate non-negativity and feasibility constraints. Formally, any $\theta^J \in T$ should satisfy $R^* \geq 0$. Furthermore, we assume $\tau \geq -1$ to prevent robots from being a free good. And $t \geq 0$ ensures that the government taxes income.

Our primary focus is the robot policy, τ. So, if we treat the income tax rate, t, parametrically, then T would be equal to:

$$T^U \coloneqq \{(\tau, t) \in \mathcal{R}^2 : R^* \geq 0 \text{ and } t > 0 \text{ is fixed and } \tau \geq -1\},$$

which is a unidimensional set. If, however, the income tax rate is also a choice variable for political parties, then we obtain the following multidimensional strategy space:

$$T^M \coloneqq \{(\tau, t) \in \mathcal{R}^2 : R^* \geq 0 \text{ and } t \geq 0 \text{ and } \tau \geq -1\}.$$

Our first theoretical result shows that Wittman equilibrium exists if the strategy space is unidimensional, $T = T^U$. All proofs are in the appendix.

Theorem 1: A Wittmann equilibrium exists if $T = T^U$.

But what if the strategy space is multidimensional, i.e., $T = T^M$? Although we cannot theoretically prove the existence of equilibrium, we invoke the multidimensional case in our quantitative analysis. The numerical results show that the distinction between T^M and T^U is not very crucial for the equilibrium behavior from a quantitative perspective. We elaborate this issue in the next section.

Returning to Theorem 1, we use the classic game-theoretical approach to establish the existence of equilibrium[4]. If the objective function of each player is quasi-concave in its own strategy over a convex and compact strategy set, then a Nash equilibrium exists. Nevertheless, this is a rather difficult result to show due to the endogeneity of the indirect utility functions and Π that make up the objectives of the political parties. The endogeneity of the objective functions prevents us from applying the standard approach in equilibrium existence techniques: directly hypothesizing that V^J is quasi-concave in τ^J. Nor could we make the necessary assumptions on Π or indirect utility functions to yield this result. Whether the model has these nice properties to guarantee the equilibrium's existence is already *set in stone*, so to speak. And Theorem 1 deciphers the writings on stone.

Our next result is our primary finding: sufficiently cheap robots ensure that both parties would campaign for taxing robots.

Theorem 2: If ϕ is sufficiently low, then $\tau^{*J} > 0$ for all $J = N, R$ at any Witmann equilibrium[5].

Due to the secular decline in robot prices, we argue that this result can be interpreted as that robot taxes will be eventually taxed. That is because, robot taxes would be unanimously supported and there would be no opposition to taxing automation if robots are cheap enough according to Theorem 2. Of course, this does not mean that both parties would campaign for identical robot policies. The precise tax rate on automation that each party would prefer would almost certainly differ.

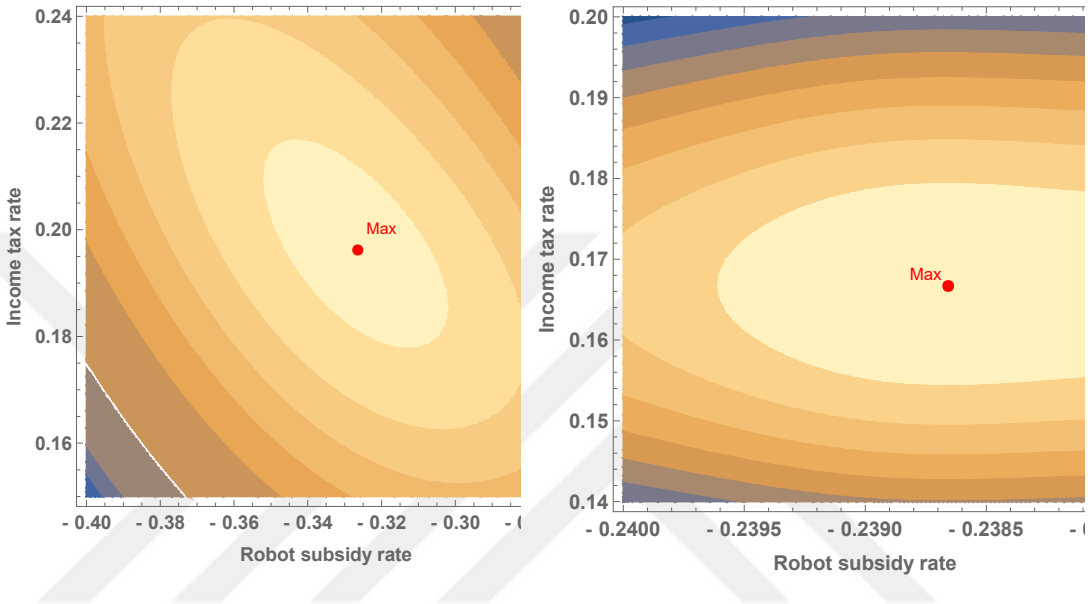
Note that this is a somewhat puzzling result. It is, of course, clear why routine workers would vote for robot taxes: to avoid being replaced by robots. But why would the party representing the non-routine workers campaign for robot taxes given the fact that robots increase the productivity of its primary voter base—non-routine workers? The explanation is that cheap robots increase demand for robots which would provide substantial tax revenues—if taxed—to produce the public good. Hence, even non-routine workers could embrace moderate robot taxes to enjoy higher levels of public goods and services. As an immediate corollary of Theorem 2, we obtain the following:

[4] See Appendix 2.
[5] See Appendix 3.

Corollary 1. If ϕ is sufficiently high, then $\tau^{*J} < 0$ for all $J = N, R$ at any Wittman equilibrium. So, sufficiently expensive robots induce unanimous support for robot subsidies. But why would routine workers vote for a policy that would encourage automation replacing them? The answer is

Figure 1. Wittman Equilibrium

Party N's objective Party R's objective



Notes. The Wittman equilibrium over the indifference curves of each political party's objective function. See Table 1 for the numerical values.

that robot subsidies would enhance the productivity of non-routine workers and the tax revenues that come from taxing their incomes. Hence, routine workers could benefit from robot subsidies to enjoy higher levels of public goods. However, this positive effect would overwhelm the threat of being replaced by robots only if the risk is already low—when robots are expensive. Thus, our model makes a very clear prediction: robot prices directly shape whether robots will be taxed or subsidized.

But are robots expensive or cheap in real life with regards to their role in affecting taxes and subsidies? This is clearly an empirical question. So, we calibrate our model to address this question by matching widely used empirical targets.

2.4. Multidimensional quantitative analysis

In this section, we calibrate our model. Our objective is to see whether robots are indeed sufficiently expensive (cheap) to support robot subsidies (taxes) as the

equilibrium strategies of both parties. To this end, we extend and enrich our model towards certain directions. We first begin by assuming that the strategy space is multidimensional, i.e., $T = T^M$. This means we assume that both parties use the income tax rates as a part of their campaigning strategies. In the next section,

Table 1. Wittman Equilibrium

	Robot policy		Income tax	
Policy	τ^R	τ^N	t^R	t^N
Equilibrium	-23.87%	-32.64%	16.66%	19.62%

Notes. The Wittman equilibrium (see Definition 1) in a competitive economy computed at the baseline parameter values in Eq (16). See Figure 1 for a visualization.

to quantify our model, we choose the baseline values for the parameters as:

$$(A, n_r, n_n, \phi, \eta, \nu, a) = (1, 0.56, 0.44, 0.43, 0.2, 2, 0.62). \quad (16)$$

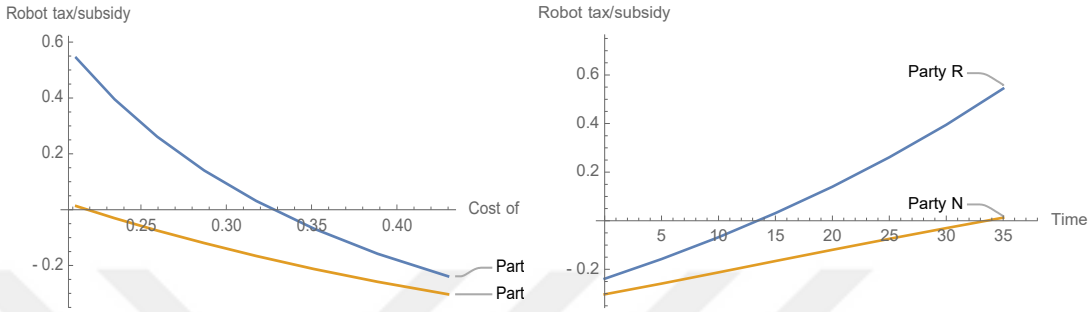
Note that $A = 1$ is a benign normalization. We follow Guerreiro et al. (2022) for choosing the demographic variables as $(n_r, n_n) = (0.56, 0.44)$. The production cost of robots, $\phi = 0.43$, also comes from Guerreiro et al. (2022). We set $\eta = 0.2$ to ensure that the optimal income-tax-to-GDP ratio is around 16%. As is standard in calibration exercises, we target labor supply to be 1/3 which means $\nu = 2$. The target of setting $a = 0.62$ is to obtain a 2:1 ratio between the wages of non- routine and routine workers. This target comes from the empirically observed relative wages of workers with a college education and others (high-school or less) in the US.

The results are reported in Table 1. These results imply that both political parties would campaign for substantial robot subsidies (i.e., negative taxes). Therefore, regardless of who wins the elections, robots would be subsidized at a rate between 20-35%. Figure 1 visualizes this equilibrium over political parties' indifference curves. So, the robot price studied by Guerreiro et al. (2022) is sufficiently expensive to induce all political parties to support subsidizing automation

in our model. But what if Guerreiro et al. (2022) is wrong about robot prices—the most crucial parameter? However, the equilibrium subsidies are quite substantial implying that this result is very robust with respect to even quite large perturbations in parameters.

Nevertheless, we still maintain that subsidizing automation can only be a transitory state. The reason is that sufficiently cheap robots support only automation taxes in equilibrium (see Theorem 2). And robot prices are constantly decreasing in real life. Therefore, there must be a threshold robot price (and a certain point in time) where all parties choose taxing robots in Wittman equilibrium.

Figure 2. The impact of robot prices on political equilibrium in a competitive



Notes. The Wittman equilibrium as a function of robot production cost (left). Assuming robot prices decline 2% per annum, equilibrium policies as a function time (right).

This can be visually seen in Figure 2 (left-hand side) where we map the equilibrium robot policies by both parties as a function of robot prices. There is a monotonic negative relationship between robot price and robot taxes. Consequently, robot prices should, more or less, halve to induce both parties choose taxing robots as their equilibrium strategies.

Given the robust and consistent decline in robot prices, Guerreiro et al. (2022) assume that robot prices decrease 2% per annum and map equilibrium behavior as a function of time. This means that, over the years, technology will develop that allows robots to be produced using less output. As a result, we see that both political parties would leave behind automation subsidies as their electoral strategies and instead endorse robot taxes after 35 years. Note also that there is an interim period where two political parties choose strategies in opposite directions with regards to the choice between subsidizing and taxing robots.

As noted earlier, we use the multi-dimensional policy space by assuming that the income tax rate, t, is a choice variable. Nonetheless, the equilibrium income tax rates are quite insensitive to robot prices and remain relatively close to each other. For all values of ϕ, the cost of robot production, t^{*R} is a constant at 16.66%. In a similar fashion, $t^{*N} = 19.62\%$ for $\phi = 0.43$ and $t^{*N} = 16.42\%$ for $\phi = 0.21$. This

observation suggests that the unidimensional analysis in Section 3 where t is fixed may be less restrictive than it first looks.

2.5. Conclusion

This study analyzes whether democratic political competition in free-market economies would entail robot taxes or subsidies as electoral outcomes. For this purpose, we develop a general equilibrium model under political competition. The model assumes that there is a conflict of interest between routine and non-routine workers with regard to robotization because automation replaces routine workers while increasing the efficiency of the non-routine workers.

Assuming that there are two political parties representing either routine or non-routine workers, we conduct both analytical and quantitative analyses. The quantitative results suggest that the robot prices are currently high enough to ensure that all political parties should campaign for robot subsidies. Nevertheless, we analytically find that sufficiently low robot prices would only support robot taxes by both parties as an equilibrium. These results suggest that robot taxation may be inexorable due to a secular decline in the cost of automation, although robots are currently too expensive to yield such a result. We also extend our model to multi-dimensional policy space. The results show that multi-dimensionality of the policy space is not very crucial for our findings.

3. ENDOGENOUS ROBOT POLICY: AN OLG APPROACH

3.1. Introduction

The increasing adoption of robotics, particularly in the manufacturing sector, is transforming the production process (Jurkat et al., 2022). This transformation affects economic dynamics and has become a growing topic of debate among literature and public discourse. In particular, the impact of automation on productivity and the labor market has been extensively studied in the literature (Koch et al., 2019; Acemoglu & Restrepo, 2020; Graetz & Michaels, 2018; Dauth et al., 2021; Bessen et al., 2023; Acemoglu et al., 2021; Brynjolfsson et al., 2023; Babina et al., 2024). Automation's impact on the structure of production and the distribution of income has prompted further debate in the literature. At the center of this debate lies the issue of taxing robots. Hence, numerous studies have examined whether a potential robot tax would affect innovation (Prettner and Strulik, 2020), lead to economic stagnation (Gasteiger and Prettner, 2022), or impact wage inequality (Thuemmel, 2022; Guerreiro et al., 2022).

Despite the growing number of studies on this topic in literature, there has not been a comprehensive analysis of the political feasibility of a robot tax, nor of policymakers' willingness to implement such a tax. From a political perspective, the stance of political parties on a robot tax will depend on the interests of the groups they represent. For example, a left-leaning party would be expected to support a robot tax in response to rising wage inequality, whereas a right-leaning party would likely be reluctant to adopt such a policy. Considering the potential for political conflict and the possible polarization of different income groups, the feasibility of implementing a robot tax emerges as a significant issue.

The impact of automation on labor markets lies at the core of this issue. Robots particularly replace blue-collar jobs, leading to wage declines in these sectors (Autor & Dorn, 2013; Acemoglu & Restrepo, 2018; Graetz & Michaels, 2018; Acemoglu et al., 2023). Autor and Dorn (2013), in their study covering the period from 1980 to 2005, find that automation led to a decline in middle-skill occupations, a rise in both

low-skill service jobs and high-skill jobs, and a polarization of wages. Acemoglu and Restrepo (2018) find that, in the United States, adding one industrial robot per 1,000 workers reduces the employment rate by 0.2 percentage points and average wages by 0.42%. Graetz and Michaels (2018), in their panel data study covering 17 countries from 1993 to 2007, find that the use of industrial robots increased labor productivity by 0.36%, raised total factor productivity, and reduced output prices. Despite these gains, they find that robot adoption did not reduce overall employment but did lead to a decline in the employment share of low-skilled workers. Acemoglu et al. (2023), in their study on Dutch firms, find that firms adopting robots experience higher value added compared to non-adopting firms. At the worker level, they show that blue-collar workers face declines in earnings and employment, while other workers benefit from robot adoption. More recently on the theoretical front, Bloom et al. (2024), focusing on workers with different skill levels, proposed that if AI can more easily replace high-skilled workers than low-skilled ones, it may reduce the skill premium offering novel interpretation. Wang and Wong (2025) analyze the impact of artificial intelligence on the labor market. Their model generates three distinct equilibria: one with no AI adoption, one with limited AI accompanied by rising unemployment, and one with unbounded AI that boosts productivity without reducing employment. Calibrated to U.S. data, the model suggests that providing targeted subsidies to jobs at risk of displacement by AI could increase welfare by 26% in the short run and over 50% in the long run. The theoretical relationship between automation and inequality has also been empirically observed. Frey and Osborne (2017) found that 47% of U.S. jobs were at high risk of automation, with routine occupations being more vulnerable, while creative and skill-intensive jobs were less susceptible to computerization. Acemoglu and Restrepo (2019) showed that the rise in automation, particularly the use of industrial robots, increased employment and wages for high-skilled workers while reducing them for routine workers. Moreover, the geographical concentration of job losses caused by automation has exacerbated regional income inequality, leading to local economic downturns (Acemoglu & Restrepo, 2020; Autor, Dorn & Hanson, 2013).

Acemoglu and Restrepo (2022) stated that in the United States, 50% to 70% of the wage losses among workers in routine jobs over the past 40 years can be attributed to automation. Another study conducted for the United States, Webb (2020) found that

between 1980 and 2010, robotization led to a 20% decline in employment and a 15% decline in wages in blue-collar occupations. In white-collar occupations, he identified a 7–15% decline in employment and a 2–6.5% decline in wages due to increased exposure to software technologies. In another study, Boustan et al. (2022) examined the effects of CNC machines on productivity, labor share, and employment in the U.S. between 1970 and 2010. They found that in sectors where these machines were adopted, the labor share declined by 1.6%, while output per worker increased by 20%. Additionally, employment decreased by 4%, and workers exposed to this technological shift either moved to less automation-affected sectors, returned to education, or, if unionized, benefited from union protections. If the classification of CNC machines as automation were to be questioned, it is stated in OECD (2017) that CNC machines are a form of automation technology. Hémous et al. (2025) developed a new method to measure automation in the United States by using keywords in patent texts and found that an increase in low-skill wages raises automation innovation by 2–5 percent. Firm-level studies, on the other hand, suggest that robotization increases sales and employment, but leads to a decline in wages (Humlum, 2021; Koach et al., 2021; Acemoglu et al., 2023b; Bongiflioli et al., 2023). Other studies have shown that capital investment incentives increase firms' output but do not lead to a decline in the labor share (Curtis et al., 2021; Hirvonen et al., 2022). Restrepo (2024) cites these studies as evidence that, in his task-based model, the effects of automation investments on the workforce are fundamentally different from those of other types of capital investment. These examples suggest that such divergent economic interests may cause a political conflict between white and blue collar workers regarding whether robots should be taxed or subsidized.

Beyond labor markets, automation also affects wealth inequality and other economic dynamics. By altering income distribution, it is plausible to expect that automation would benefit capital owners disproportionately, worsening the distribution of wealth. Research shows that returns from technological progress and rising automation have outpaced wage growth, disproportionately benefiting owners of physical and financial capital. Moll et al. (2022) argued within a theoretical model framework that automation benefits not only skilled workers but also capital owners through rising returns to capital, thereby contributing to both income and wealth inequality. Koru (2024) employs a dynamic model to explain the role of automation in deepening

wealth inequality. The model is calibrated based on U.S. economic data. The study emphasizes that automation accelerates capital accumulation, thereby increasing the incomes of capital owners and widening wealth inequality. Liu and Liang (2025) argue, using a continuous-time dynamic general equilibrium model with heterogeneous agents, that artificial intelligence (AI) increases wealth inequality in the short term, but this effect may diminish in the long run as AI becomes more widely adopted. As a policy recommendation for China, they suggest increasing the use of AI to promote economic growth while addressing inequality. As a result, many workers experience stagnant or declining wages (Piketty, 2014; Acemoglu & Restrepo, 2018). The top 1% of the wealth distribution has increasingly captured a larger share of total wealth due to technological advances and automation. As discussed by Acemoglu and Johnson (2023) in Power and Progress, when technological advances are controlled by those with market power, inequality can worsen. While wages stagnate for most workers, those with access to technology reap significantly higher benefits.

Therefore, it stands to reason that automation can have significant political and economic consequences, as groups harmed by automation disproportionately suffer from stagnant wages and shrinking job opportunities. In other words, disadvantaged groups may face growing exclusion. One policy to address this disadvantage could be to provide training programs aimed at helping displaced workers develop new skills (OECD, 2018). Another policy is the taxation of automation, which, by increasing the relative cost of automated technologies, can make disadvantaged groups more competitive against automation (Guerreiro et al., 2022). Or another important option, they are likely to exert political pressure on redistributive policies such as Universal Basic Income (UBI) to compensate for their losses (Cabrales et al., 2020; Kirkpatrick & Hmielowski 2025). On the other hand, advantaged groups benefiting from higher profits and capital gains are more likely to support automation-enhancing policies that protect their economic interests. Hence, the resulting conflict of interest stemming from capital distribution may place robot taxation at the center of broader debates about wealth redistribution and economic justice.

These policy proposals raise an important question: To what extent are automation and redistribution policies effective or practically implementable? Therefore, let us examine this debate through empirical and theoretical examples to assess whether

these policies are politically viable and whether they involve economic trade-offs—such as potentially adverse effects on innovation.

Empirical studies show that in societies with high levels of inequality, political movements supporting redistribution tend to gain public support (Bartels, 2016). However, in cases where political power is influenced by capital owners, it is well known that the policies adopted tend to serve the interests of these groups rather than the broader society (Stiglitz, 2012). In other words, if policymakers are under the influence of groups that benefit from automation, the policies demanded by disadvantaged groups may not be implemented or prioritized. Also, another point of debate is that a tax policy affecting the production process could negatively impact innovation and economic growth in the long run. In the literature, it is generally believed that any form of capital taxation hinders production, thereby hampering innovation and growth (Judd, 1985; Chamley, 1986). Some emprical research; Dimitrova and Eswar (2018), using data on venture capital-backed startups, found that increases in tax rates reduce patent production. They also showed that entrepreneurs respond by shifting toward less risky forms of innovation. Akcigit et al. (2022) investigated the effects of personal and corporate income taxes on the quantity, quality, and geographic distribution of innovation in the United States during the twentieth century. For this study, they constructed a panel dataset by combining personal and corporate data with economic indicators starting from the year 1920. As a result of the study, it was found that higher tax rates negatively affect the quantity and geographic location of innovation, while having no significant impact on the average quality of innovation. Differences in tax rates at the state level influence individual innovation output and interstate mobility. Corporate taxes, in particular, affect both the amount of innovation produced by inventors working within firms and their movement across states. However, these studies do not conclusively imply that capital taxation is inherently harmful. In contrast to the conventional view the theoretical study by Prettner and Strulik (2020) shows that a well-calibrated robot tax can both enhance innovation and reduce inequality. Gasteiger and Prettner (2022) find that a robot tax increases output and welfare in the steady state; however, it does not lead to long-term economic growth.

This study discusses an overlapping generations model (OLG) composed of agents who live for two periods. Each individual, in their first period—youth—works and

receives both labor income and a government transfer. In the second period, they retire and consume using the savings from their youth along with the government transfer, and then die without leaving any bequests. There are two different skill groups in this economy: routine and non-routine workers. While routine workers are substituted by robots, non-routine workers are complementary to them, thereby earning higher income compared to the former. Consequently, since non-routine workers earn more income during their youth than routine workers, they enter old age with higher levels of capital. This situation brings about not only skill-based income inequality but also wealth inequality over time. The transfer expenditures provided by the government are financed by the tax imposed on robots used in the production process. This tax rate changes in each OLG period. The reason is that the tax rate is determined as a result of Wittman-type political competition between two political parties and the voter groups they represent. In each election period, there are four different voter groups in the economy: the young routine workers and young non-routine workers of that period, and the routine and non-routine workers of the previous period who are now in the old age stage of their lives. The robot tax rate that emerges after the election affects both production and transfer expenditures, constantly altering the equilibrium in the economy.

This study addresses a gap in the literature by examining how political competition over robot taxation influences key economic outcomes—particularly income and wealth inequality—an aspect that has been largely overlooked in existing research focused on normative or centralized policy frameworks. This study makes two contributions to literature. First, instead of determining the optimal robot tax through a social planner approach (Gasteiger & Prettner (2022), Prettner & Strulik (2020), Guerreiro et al. (2022) and Thuemmel (2022)), it is determined through electoral competition between political parties. In this way, rather than relying on a normatively chosen robot tax, economic outcomes are determined through a method that we consider to be more realistic. The second contribution is that the model incorporates not only income inequality but also wealth inequality. The skill heterogeneity among workers leads not only to income disparities but also to wealth inequality in the subsequent period. In this way, the substitution or complementarity of workers to automation results in long-term differences in wealth, allowing the model to analyze inequality both within the same generation and across generations. The universal basic

income (UBI) incorporated into the model is financed through robot taxation and distributed equally. Its determination through electoral competition highlights the uniqueness of this redistribution policy. Overall, our approach integrates an overlapping generations model with the dynamics of electoral competition. Automation policy arises because of political bargaining rather than centralized decision making.

Our results show that political competition leads to a robot tax being proposed by the group negatively affected by automation, while the group that benefits from automation proposes a subsidy, reflecting their respective voter bases. Unlike the social planner approach in studies (Gasteiger & Prettner (2020), Prettner & Strulik (2020), Guerreiro et al. (2022) and Thuemmel (2022), the robot tax is revealed as an outcome of electoral competition between two political parties representing different electorates. In this model with four voters, one of the parties represents young routine labor and old routine (capital poor). Accordingly, it seeks to compensate for their automation-induced losses through broad-based redistribution via lump-sum transfers. The other party represents young non-routine labor and old non-routine (capital-rich) group, and therefore pursues pro-automation policies. The equilibrium robot tax is endogenously determined as the Nash equilibrium between these two parties. After reaching the steady state, output begins to fluctuate due to electoral uncertainty as the robot tax rate is endogenously determined by the outcome of each election. These fluctuations affect the wage premium and wealth inequality both tend to decline(rise) when the elected party implements a robot tax(subsidy). The production function includes both traditional and robot capital, solving the model under a laissez-faire scenario—without political competition—shows that both output and traditional capital accumulation increase under a robot tax regime, consistent with Gasteiger and Prettner (2020, p. 26). Additionally, while Gasteiger & Prettner (2022) identify the optimal robot tax rate that maximizes total welfare in the steady state to be around 0.5, our model—based on equal weighting across four voter groups—yields a higher optimal rate of approximately 0.79. In the Wittman political competition equilibrium, after the steady state is reached, the robot tax fluctuates between 0.66 and 0.68 depending on the winning party, while the subsidy ranges between 0.02 and 0.04. As a result, economic indicators fluctuate as agents adjust their decisions in response to the prevailing tax or subsidy levels.

The remainder of the paper is organized as follows. Section 2 introduces the overlapping generations (OLG) model with automation and heterogeneous agents—routine and non-routine workers—who, depending on their previous occupations, become capital-poor or capital-rich retirees. This section also presents the political competition model à la Wittman, where two parties represent different voter bases. In Section 3, we conduct a numerical analysis of the Wittman equilibrium and compare its outcomes with two benchmark scenarios: a laissez-faire economy with no robot tax, and a social planner solution maximizing total welfare under equal weights. Section 4 discusses and compares the macroeconomic and distributional outcomes across these different scenarios. Finally, Section 5 summarizes the main findings and concludes the study.

3.2. Economic Environment of The Model

In this section, we integrate political competition into an OLG framework to analyze the role of robots in the economy. In the model, the first stage proceeds through the backward induction method, where routine and non-routine workers—belonging to two distinct skill groups—maximize their utility under budget constraints, taking the robot tax as exogenously given. The representative firm that produces the final good solves a profit maximization problem. The government collects revenue by taxing the use of robots in final goods production and redistributes it as a universal basic income. In the second stage, two political parties—each representing different households—engage in electoral competition and reach a Nash equilibrium, where each party chooses a robot tax policy that maximizes the expected value of the indirect utility of the households they represent.

3.2.1. Household Problem

Consider an overlapping generation model where households live two periods where they supply labor in their young and live with their saving when they are old. Each household is either routine or non-routine denoted by $i = n, r$ maximize their utility function,

$$u(c_{i,t}, c_{i,t+1}) = \ln c_{i,t} + \frac{1}{1+\rho} E[\ln c_{i,t+1}], \qquad \rho \in (0,1), \tag{17}$$

where $c_{i,t}$ is the consumption level of agent i when he is young and work and $c_{i,t+1}$ is the consumption level when he is old and retire, ρ is the discount rate. The expectation operator reflects the uncertainty regarding which political party wins the election as we shall explain soon. Each individual gets utility today and discounted future consumption.

During the first period of their lives (young), households allocate their wage income and any government transfers toward consumption and savings for that period,

$$s_{i,t} = w_{i,t} - c_{i,t} + g_t, \tag{18}$$

where g is universal basic income (UBI) and distributed equally among all agents.

Old households consume all their savings and the UBI, whose level depends on which party is in power. Therefore, the second period of their lifes, budget constraint is

$$c_{i,t+1} = (1 + r_{t+1})s_{i,t} + g_{t+1}, \tag{19}$$

where r_{t+1} and g_{t+1} are the future rental rate and UBI.

Substituting the budget constraint into the utility function and taking derivatives with respect to $c_{i,t}$ gives the Euler equation,

$$\frac{1}{c_{i,t}} = \frac{1}{1+\rho} E\left[\frac{1 + r_{t+1}}{c_{i,t+1}}\right]. \tag{20}$$

Also, the total saving of an individual can be expressed as

$$s_{i,t} = k_{i,t+1} + x_{i,t+1}, \tag{21}$$

where savings are comprised of both traditional capital ($k_{i,t+1}$) and robot capital ($x_{i,t+1}$). This total saving can be conceptualized as a "*putty capital*", which firms allocate between traditional and robot capital to produce the final good. As an important note, the amount saved in eq. (18) constitutes the total capital stock eq. (21) to be used in the next period, the *putty capital*. Both types of capital—traditional and robot—are fully depreciated at the end of each OLG period. Thus, the entire capital stock must be rebuilt by the next generation through new savings. How much of the total capital saved will be tradinional capital and how much robot capital will be depends on the tax rate to be applied in the next period. In other words, while the

current tax rate determines the future total capital level, the future tax rate determines the composition of this capital, i.e. what type of capital it will be transformed into. Now let us explain the firm in the model.

3.2.2. Firm's Problem

Imagine an economy that produces a single output good,

$$Y_t = Z\, {K_t}^{\alpha} {H_t}^{\beta} (L_t + X_t)^{1-\alpha-\beta}, \qquad \alpha, \beta \in (0,1), \tag{22}$$

where K is traditional capital, X is robot capital and H_t and L_t are labor supplies of non-routine and routine workers respectively (Autor, 2003, Guerreiro et al., 2022; Gasteiger and Prettner, 2022). Note that we distinguish between two different forms of capital: traditional and robotic. The production function is of the Cobb-Douglas form and exhibits constant returns to scale, with Z representing total factor productivity.

The firm's objective is maximaxing

$$\Pi = Z\, {K_t}^{\alpha} {H_t}^{\beta} (L_t + X_t)^{1-\alpha-\beta} - w_r L_t - w_n H_t - r_t K_t - (1+\tau_t) p_t X_t, \tag{23}$$

where the firm face wage bills ($w_r L_t + w_n H_t$), the expense of traditional and robot capital respectively ($r_t K_t$ and$(1+\tau_t) p_t X_t$). The robot tax rate denoted by τ is imposed by government and all the tax revenues are redistributed to the households equally as a lump-sum transfer($G_t \leq \tau_t p_t X_t$).

The first order conditions of the firm's profit maximization problem are,

$$w_r = (1+\tau_t) p_t = (1-\alpha-\beta) \frac{Y_t}{L_t + X_t}, \tag{24}$$

$$r_t = \alpha \frac{Y_t}{K_t}, \tag{25}$$

$$w_n = \beta \frac{Y_t}{H_t}. \tag{26}$$

The first-order conditions (24)-(26) show how the firm optimizes the factors of production. Eq. (24) states that when choosing between routine labor and robots, the firm equates the cost of the robot, including tax, with the wage of the routine worker,

which is due to the fact that these two factors of production are perfectly substitutable. Eq. (25) states that the return to traditional capital r_t equals its marginal product, which depends on its share in production α. Lastly, eq. (26) indicates that the wage of non-routine labor equals its marginal product, determined by its output share β.

In the long run, equilibrium requires that both types of capital yield the same return. That is because, if the return on robot capital exceeds the return on traditional capital, all investment will flow into robot capital, therefore no investment will be made in traditional capital and there will be no yield in the next period due to the structure of the production function. Conversely, if the return on traditional capital is higher, investment will go only to traditional capital, reducing the production function to a standard Cobb-Douglas form. This dynamic is governed by a no-arbitrage condition, where the return on traditional capital equals the return on robot capital $r_t = p_t$. Therefore, from equations (24) and (26), we can deduce

$$\frac{1-\alpha-\beta}{1+\tau_t}\frac{Y_t}{L_t+X_t} = \alpha\frac{Y_t}{K_t}, \tag{27}$$

so, we can write the level of robots as:

$$X_t = \frac{1-\alpha-\beta}{\alpha(1+\tau_t)}K_t - L_t. \tag{28}$$

Now plug robot employment into the production function which gives:

$$Y_t = Z\,{K_t}^{\alpha}{H_t}^{\beta}\left(L_t + \frac{1-\alpha-\beta}{\alpha(1+\tau_t)}K_t - L_t\right)^{1-\alpha-\beta}. \tag{29}$$

So, the production function simplifies to

$$Y_t = A(\tau_t)\,{K_t}^{1-\beta}{H_t}^{\beta}, \tag{30}$$

where

$$A(\tau_t) = Z\left(\frac{1-\alpha-\beta}{\alpha(1+\tau_t)}\right). \tag{31}$$

The special that studied by Gasteiger and Prettner (2022) arises when $\beta = 0$, in which case the production function reduces to an AK- type form. Here we refer to $A(\tau_t)$ as pseudo-TFP which represents the overall productivity of K_t (traditional capital) and H_t (high skill labor). Note that, in comparison to the actual TFP denoted by Z, pseudo-TFP is not a purely technological constant and it depends on the policy variables. Thus, pseudo-TFP is negatively related to the robot tax. In other words, taxing robots reduces their adoption, which in turn lowers the productivity of traditional capital and non-routine workers, given their complementary relationship.

Market clearing conditions ensure that the household's optimization problem, the firm's production decisions, and the government's budget constraint are all solved and mutually consistent. This concludes the economic stage, where firm and consumers make decisions based on the given election outcomes (policy variable (τ)). Following the backward induction method, we move on to the political competition stage to endogenize the election results that determine policy (τ).

3.2.3. Government

The government obtains taxes to transfer UBI under the following financial constraint:

$$G_t \leq \tau_t p_t X_t. \tag{32}$$

where τ is the tax rate on robots if $\tau > 0$ or it is subsidy. p_t is the rental price of robot. Therefore, the government revenues only come from taxing robots for simplicity.

Before turning to the political competition, we first explain how initial skill differences in youth (routine vs. non-routine workers) not only generate income inequality but also evolve into wealth inequality in old age.

3.2.4. Skill-Wealth Nexus

Within the OLG framework, distinguishing between routine and non-routine workers during youth not only leads to income differences but also results in wealth inequality in old age. At time t, a non-routine worker earns a higher wage compared to a routine worker due to comlementarity with robot capital. This wage premium allows them to save more for old age. As a result, when they retire and exit the labor market at time $t + 1$, their total capital accumulation—driven by relatively higher savings in youth—is greater than that of a routine worker. This reflects how the initial difference in labor

type during youth leads to a divergence in capital ownership in old age. Huggett et al. (2011) argue that much of the lifetime income and wealth inequality across individuals is driven by the level of human capital they possess in their early 20s, that is, by the initial conditions established early in life. This directly supports our OLG model, in which income and wealth inequality arise through differences in initial skill types. Thus, today's non-routine worker becomes tomorrow's capital-rich agents, while routine worker becomes capital-poor.

3.2.5. Political Parties

So far, we have considered the robot tax policy τ as exogenously given as the focus of our analysis. To endogenize τ, we adopt Wittman's model of political competition. In this framework, there are two political parties, the Rich Party and the Poor Party. The Rich Party represents the interests of non-routine worker and capital-rich(old non-routine) representatives, while the Poor Party defends the interests of routine worker and capital-poor (old routine).

In the production side of the model, only young routine and non-routine workers participate as active labor. However, in the political domain, there are four distinct voter groups: young routine, young non-routine, old routine (capital-poor), and old non-routine (capital-rich) individuals. Retired agents live off their capital income (past savings), and all agents receive the same amount of UBI regardless of age or type. Accordingly, Party *P* represents the interests of routine individuals—both the young and the old. In contrast, Party *R* represents non-routine individuals—both young the old. This classification allows us to analyze how both income and wealth heterogeneity influence political preferences and outcomes.

The policy space $T = (-1, \infty)$ is unidimensional, defined solely by robot tax rate τ. Let:

$$\theta^J \coloneqq (\tau^J) \in T,$$

represent the policy choice of Party *J*, where $J \in \{R, P\}$.

The equilibrium τ* is determined by the political competition between these two parties and reflects the economic and political interests of their respective electorates.

In the Wittman model of political competition, the von Neumann–Morgenstern utility functions reflect the preferences of the *R* and the *P* over robot tax policies.

Let $v^j(\tau)$ denote the indirect utility of voter group $j \in \{n, r, no, ro\}$, which depends on the robot tax rate τ. Specifically:

$$v^r: young\ routine$$

$$v^n: young\ non-routine$$

$$v^{ro}: old\ routine\ (capital\ poor)$$

$$v^{no}: old\ non-routine\ (capital\ rich).$$

Young agents' utility depends on both current and expected future consumption. In contrast, old agents only derive utility from current consumption, as they no longer work or save and do not live beyond the current period.

Since the election outcome is uncertain, and the probability of winning the election depends on the policies proposed by the parties—each aiming to maximize the expected utility of their respective voter groups—the utility functions of the parties are defined as follows:

$$V^P(\tau^P, \tau^R) = \Pi(\tau^P, \tau^R)(v^r(\tau^P) + v^{ro}(\tau^P)) + \big(1 - \Pi(\tau^P, \tau^R)\big)(v^r(\tau^R) + v^{ro}(\tau^R)), \quad (33)$$

$$V^R(\tau^P, \tau^R) = \Pi(\tau^P, \tau^R)(v^n(\tau^P) + v^{no}(\tau^P) + \big(1 - \Pi(\tau^P, \tau^R)\big)(v^n(\tau^R) + v^{no}(\tau^R)). \quad (34)$$

Here $\Pi(\tau^P, \tau^R)$ denotes the probability that Party P wins the election and the probability of winning the election is a function of the robot tax policies proposed by both parties. The term $v^j(\tau)$ is the indirect utility functions. In the Wittman model of political competition, each party $J = P, R$ choose τ^J to maximize $V^J(\tau^P, \tau^R)$ by taking the policy of the opponent $J = P, R$ as given. Before defining the probability function, it should be noted that if parties had no opponents and could freely maximize the utility of their electorates, they would propose the highest possible tax (or subsidy) rate $\overline{x}$ (or $\overline{x}$). In other words, under the Wittman equilibrium, no higher tax rate (or lower subsidy rate) than this can emerge. After specifying the highest and lowest robot tax rates that would be implemented in the absence of a political opponent, we can then proceed to define the probability function.

To model the election probabilities, we use a probability density function (PDF) defined between the lowest and highest possible values of tax rates. This function is as follows:

$$f(x) = c(x - \underline{x})^2(x - \overline{x})^2, x \in [\underline{x}, \overline{x}], \tag{35}$$

where c is a normalization coefficient that guaranteet the total area of the function is 1(so, $\int_{\underline{x}}^{\overline{x}} f(x)\, dx = 1$). This quadratic structure ensures that the density is zero at the extreme values (lower and upper bounds) and highest near the midpoint. This reflects that voters do not prefer very extreme tax rates, but rather support policies with more moderate, average values. The cumulative distribution function (CDF) corresponding to this density function shows voter support up to a tax rate.

$$F(x) = \int_{\underline{x}}^{x} f(t)\, dt, \qquad x \in [\underline{x}, \overline{x}]. \tag{36}$$

Using this framework, we define the probability of the poor party winning as:

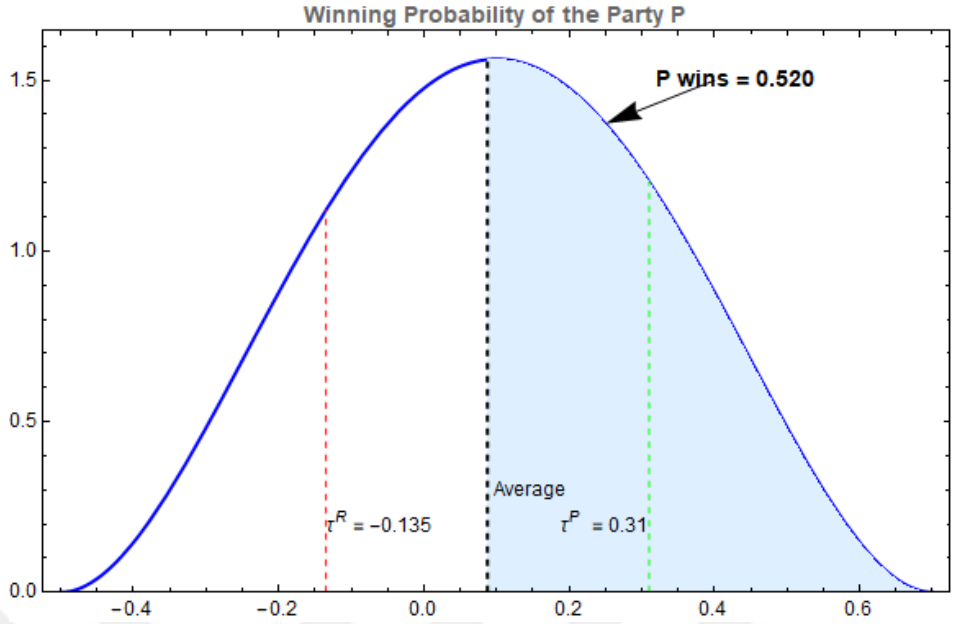
$$\Pi(\tau^P, \tau^R) = 1 - \int_{\underline{x}}^{\tau^A} f(x)\, dx = 1 - F(\tau^A), \tag{37}$$

where:

$$\tau^A := \frac{\tau^P + \tau^R}{2},$$

is the average of the tax rates proposed by the two parties and represents the threshold point that voters use to make their decision.

Figure 3. An Example of the Winning Probability for the Party P



Let us illustrate the previously defined PDF and CDF with a geometric example based on a specific election outcome. In Figure 3, the blue curve represents the probability density function $f(x)$, with the defined interval set as an example $[-0.5,0.7]$. The shaded area to the right of the average represents the probability that Party P wins the election, given the proposed tax rates. In this example, the lower and upper bounds of the tax rate interval are set based on the solution to the Wittman competition. The resulting proposed tax rates are $\tau^P = 0.31$, $\tau^R = -0.135$ and the winning probability of Party P is approximately 0.52.

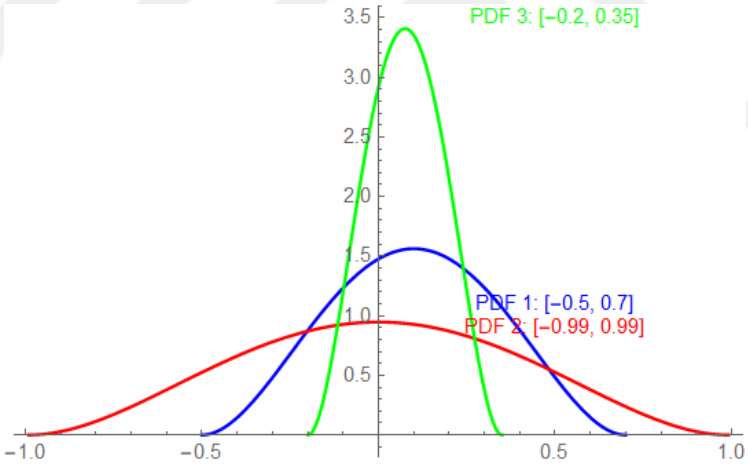
The structure of the function is consistent both mathematically and economically: For example, if the tax rate proposed by the poor party increases while the party *R* remains constant, the threshold point shifts upwards so, the proportion of voters supporting the party *R* increases and the probability of the party *P* winning decreases. This is because the proposed higher tax rate discourages voters in the electorate who may vote for the poor party but whose economic interests prefer more moderate rates. Similarly, if the party *R* lowers the tax rate proposed, the threshold point is lowered; in this case, the area supporting the party *R* narrows and the probability of the poor party winning increases. This mechanism can be visually seen in Figure 3.

In addition, since the density approaches zero towards the ends of the range in which the function is defined, very low or very high tax rates reduce the probability of winning the election. The main reason for using such a probability function is that it is

economically reasonable to avoid extreme values for the robot tax or subsidy, which are determined by election outcomes. Moreover, the function is bounded and does not diverge to positive or negative infinity. Its bell-shaped concentration around the mean also provides a plausible distributional assumption. Alternatively, for example, a uniform distribution would imply that all outcomes are equally likely which we find quite implausible. The proposed probability function is consistent with Öztürk-Göktuna (2019) and Laslier and Öztürk-Göktuna (2016). Both studies model cumulative distribution functions (CDFs) to model voter preferences and election outcomes, based on the logic of the nature of voter behavior. Another critical point of the probability function is that its bounds.

In addition, Figure 4 illustrates the geometric shapes of the probability density function (PDF) under different interval settings. These visualizations demonstrate how changes in the interval boundaries lead to different election outcomes, highlighting the sensitivity of the results to the defined policy space.

Figure 4. The Shape of the PDF Under Different Intervals



After explaining the probability function, we now proceed to present the numerical results of the model.

3.3. Numerical Analysis

After presenting the theoretical framework, this section conducts a numerical analysis to compute the equilibrium outcome. The parameters of the model are as follows:

$$\left(\alpha, \beta, \rho, L, H, Z, S_R, S_P, \underline{x}, \overline{x}\right) = \left(\frac{1}{3}, \frac{1}{3}, \frac{2}{3}, 0.6, 0.4, 5, 0.8, 0.2, -0.62, 1.32\right).$$

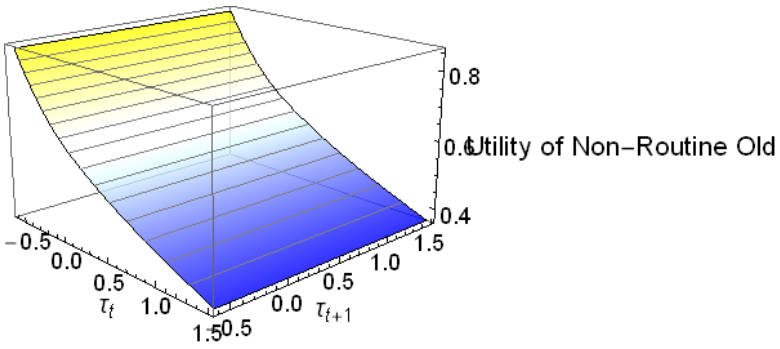
We assign values to the parameters that are commonly used in economics literature. The shares of traditional capital (α) and non-routine labor (β) in output are both set 1/3. The discount factor, which indicates time preference, is determined as 0.6. This corresponds to a discount rate (ρ=2/3), implying that individuals are moderately patient between current and future consumption (Gasteiger and Prettner, 2022).

The shares of routine (L) and non-routine (H) labors are set to 0.6 and 0.4, respectively, in line with Guerreiro et al. (2022). In the model, the value of Z is calibrated as a percentage. This value leads to approximately 12% growth over the first 20-year OLG period. This growth corresponds to the cumulative productivity increase implied by the average annual TFP growth rate of 0.6% reported for the 2007–2019 period by the U.S. Bureau of Labor Statistics (2025). We normalized the initial capital stock to $S_R + S_P = 1$ by setting the initial capital distribution such that the capital-poor group holds one-fourth of the total capital. This allocation is consistent with global trends in wealth inequality.

We endogenously determine the lower and upper bounds of the probability density function, denoted by $\underline{x}, \overline{x}$ respectively as explained above. Specifically, we define $\underline{x}$ as the robot tax (or subsidy) rate that maximizes the sum of the indirect utility functions of the group (young and old non-rotine) represented by Party R, and $\overline{x}$ as the rate that maximizes the sum of the indirect utility functions of the group (young and old routine) represented by Party P. In doing so, we ensure that tax rates outside this range are economically irrelevant or unattainable, thereby endogenizing the boundaries of the tax policy space within the model. Lastly, the initial value of π is a starting probability. The iterative process converges after the very first step.

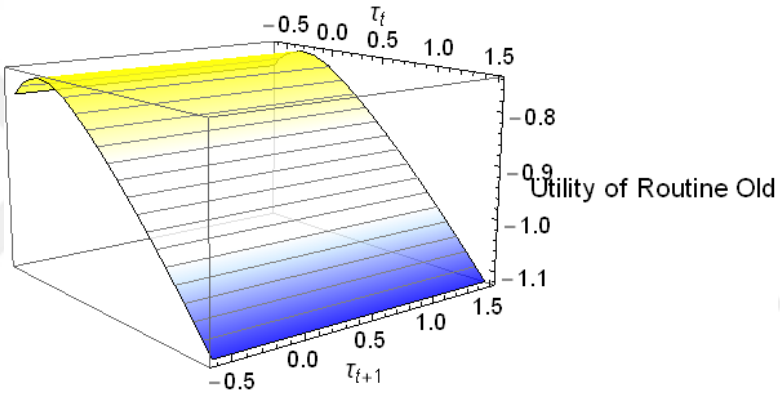
Before presenting the results of the Wittman equilibrium, we first outline the structure of the agents' utility functions. These utility levels depend on both the robot tax rate in the current period (τ_t) and the robot tax rate in the next period (τ_{t+1}). Analyzing these functions would help to understand better the welfare effects of different tax policies on each group.

Figure 5. Utility of Non-Routine Old



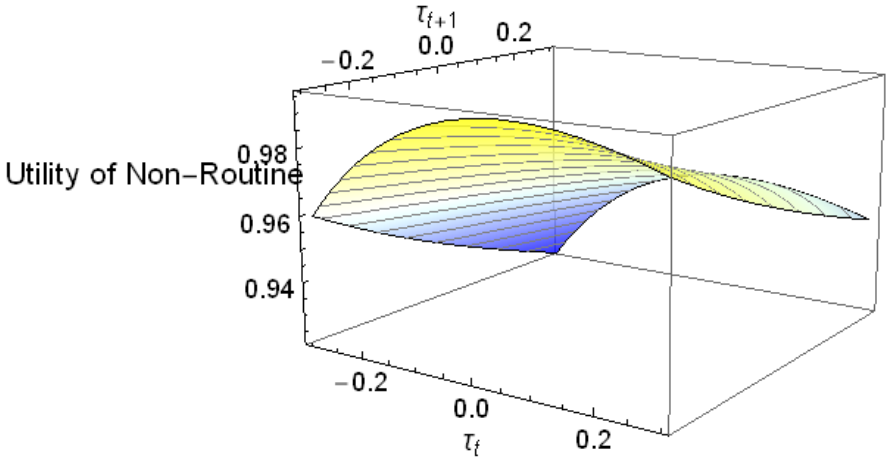
Since the capital rich agent is old in this period and will not live to the next, the robot tax rate in the next period (τ_{t+1}) does not directly influence his/her utility. Also, its utility decreases with an increase in today's robot tax rate (τ_t) .

Figure 6. Utility of Routine Old



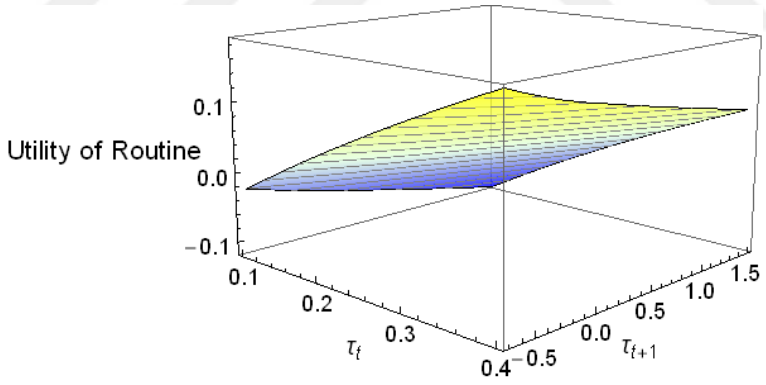
The routine worker (capital poor agent) who is old in the current period and not alive in the next period is not affected by the future robot tax rate (τ_{t+1}). As can be seen in the graph, this agent's utility initially increases with the robot subsidy (negative tax), but starts to decrease when the robot tax (τ_t) increases above a certain level. This indicates the existence of a subsidy level that maximizes his utility.

Figure 7. Utility of Non-Routine Young



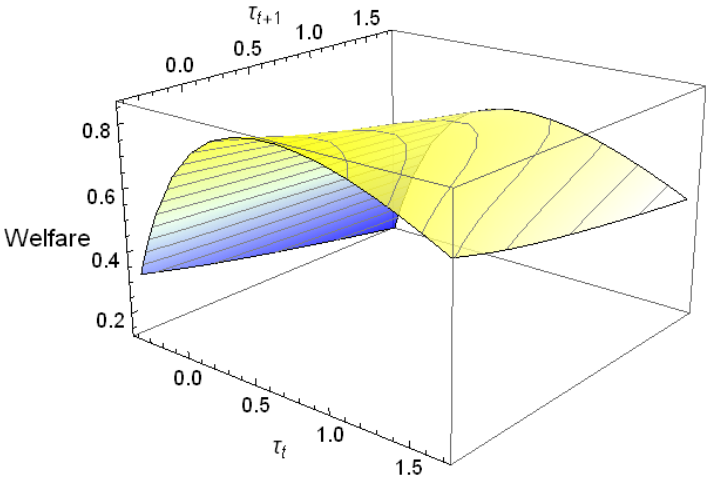
The utility of non-routine young labor depends on both the current (τ_t) and the next period (τ_{t+1}) robot tax rates, reflecting their forward-looking nature. The graph shows a peak utility at specific combinations of (τ_t) and (τ_{t+1}), indicating an optimal balance between current subsidies or taxes and future policies. This highlights the trade-offs in policy design, as excessive subsidies or taxes in either period can lower their overall utility.

Figure 8. Utility of Routine Young



The utility of routine young labor is influenced by both the current (τ_t) and next period (τ_{t+1}) robot tax rates. The graph shows that utility increases with higher (τ_t), as routine labor benefits more from redistributive effects and subsidies funded by the robot tax. However, the impact of (τ_{t+1}) is relatively low, indicating a lower dependence on future policies.

Figure 9. Total Welfare in Equal Weights



This graph illustrates the total welfare of the population as a function of the current (τ_t) and future (τ_{t+1}) robot tax rates, summing the utilities of all four groups in equal weight: the current capital-rich, current capital-poor, non-routine, and routine workers. A social planner aiming to maximize overall welfare would take into account the conflicting preferences of these groups.

The utility graphs reveal the diverse preferences of the four agents regarding the current and future robot tax rates. While the capital-rich and capital-poor agents, being in the final period of their lives, focus solely on the current tax rate, the young non-routine and routine workers, who will become the capital-rich and capital-poor of the next period, consider both current and future tax rates. These differences shape the electorate composition of the competing political parties. The party representing the current capital-rich and non-routine workers (next generation's capital-rich) is likely to favor lower robot taxes or subsidies, as both groups benefit from capital accumulation and innovation incentives. Conversely, the party of the current capital-poor and routine workers (next period capital-poor) advocates for higher robot taxes to redistribute income and protect routine labor.

3.3.1. Wittman Equilibrium

According to the model results for the first period, the probability of the poor party winning the election is calculated as 0.59, which shows that the robot tax policy it proposes is supported by the majority. While the poor party adopts an approach that prioritizes redistribution by proposing a robot tax of 59%, the rich party aims to encourage capital accumulation and limit redistribution by proposing a robot subsidy

of −9%. An important point is that these election outcomes are temporary; specifically, as the model converges to a steady state, the proposed tax policies and the probability of winning the election will change.

Table 2. The Results of Wittman Equilibrium for the First Period

Party	Winning Probability	Proposed Robot Tax
Poor	0.59	0.59
Rich	0.41	-0.09

In addition, the planning solution that maximizes social welfare proposes a robot tax of 28%, which is not suprisingly close to the average of the proposed tax rates by each party. In this analysis, the resulting equilibrium reflects the behavior of political parties that do not differentiate among the groups they represent. Specifically, both the party P and the party R aim to maximize aggregate welfare without prioritizing specific segments of their constituencies. To illustrate the dynamic results of the political competition model over subsequent time periods, we present the evolution of robot tax rates proposed by competing parties under Wittman model. Before presenting the outcomes for real economic indicators, we first provide a possible scenario that includes the winning party, its probability of winning the election, and the corresponding robot tax policy it implements.

Table 3. Probabilistic Political Equilibrium

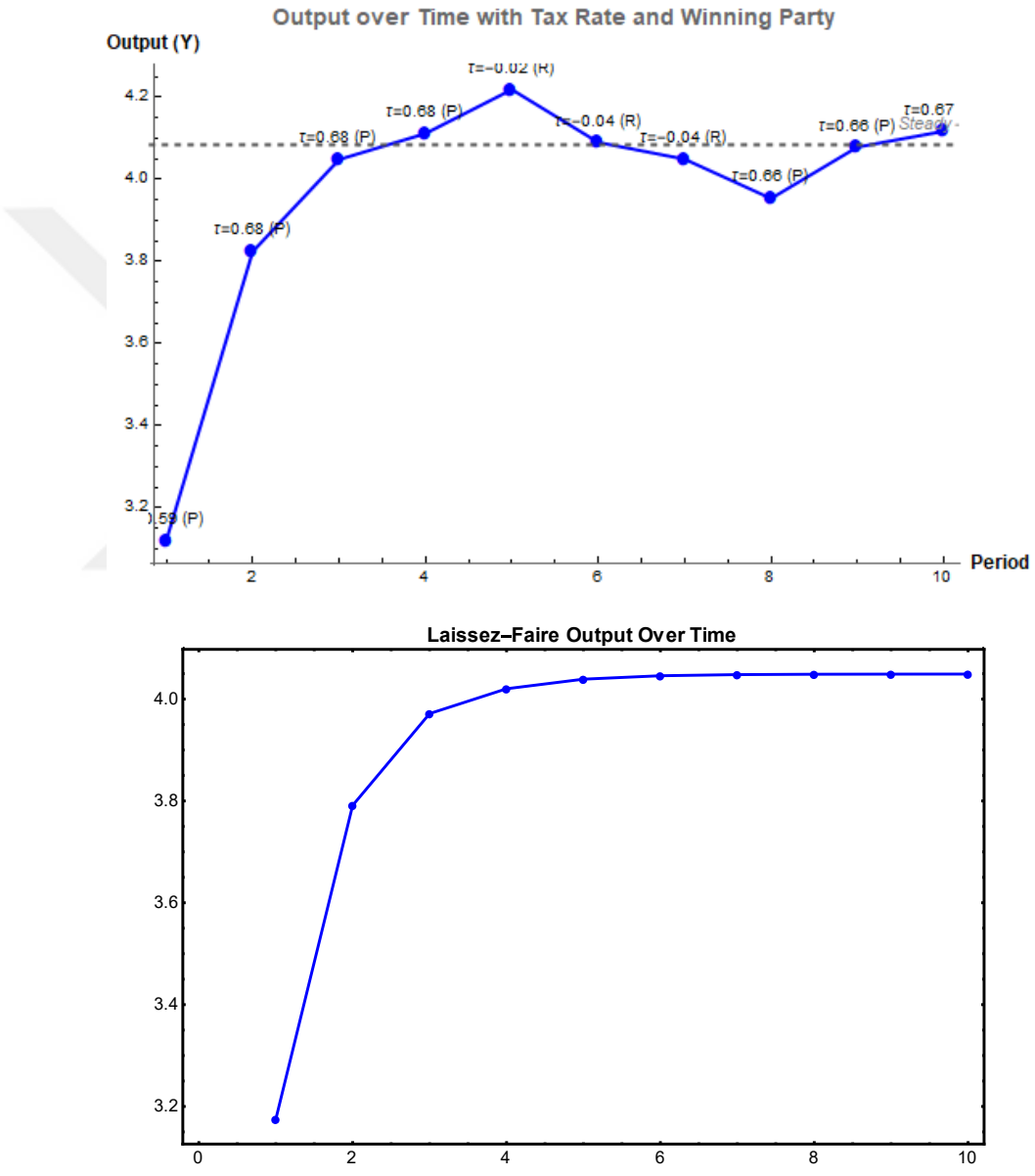
Period	Tax Rate	Probability	Winning Party
1	0.59	0.59	P
2	0.68	0.52	P
3	0.678	0.52	P
4	0.676	0.52	P
5	-0.022	0.48	R
6	-0.037	0.46	R
7	-0.037	0.46	R
8	0.66	0.537	P
9	0.66	0.537	P
10	0.67	0.52	P

In the table, we present a ten-period OLG scenario where election outcomes are randomly determined based on winning probabilities. The table shows the implemented policy (tax rate), the winning party, and the corresponding probability of victory. An important point to note is that elections are repeated in each OLG period.

Based on this simulated political path, we now examine how real economic variables evolve in response.

This comparison will include both the outcome under Wittman political competition and the laissez-faire scenario. In this way, we can evaluate how the economy shaped by political competition differs from a scenario with no policy intervention.

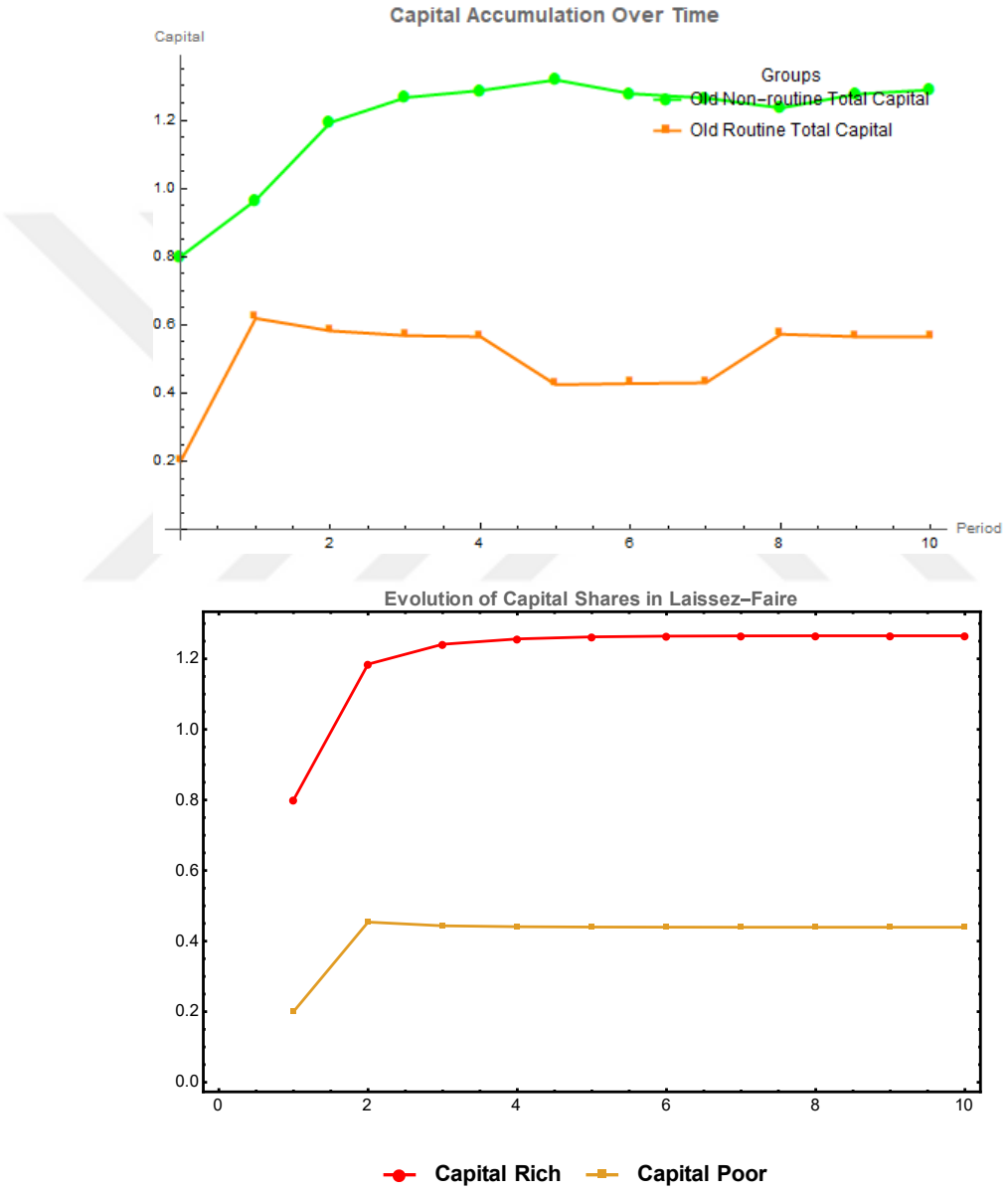
Figure 10. Output in Time Wittman vs Laissez-Faire



The dashed line represents the steady-state output,. Since the election outcome changes in each economic period, the output exhibits a zigzag pattern. This indicates that fluctuations in election results and thus in the implemented tax policies introduce volatility into the economy. In the Laissez-Faire graph, output gradually reaches a

steady state and remains stable over time, unlike in the Wittman equilibrium. However, in the Wittman case, even after reaching a stationary level, fluctuations arise due to changes in tax policy driven by electoral outcomes. These fluctuations cause output to swing both above and below its potential level observed under Laissez-Faire. This highlights how political uncertainty and shifts in policy can cause the economy to deviate from its potential path in the real world.

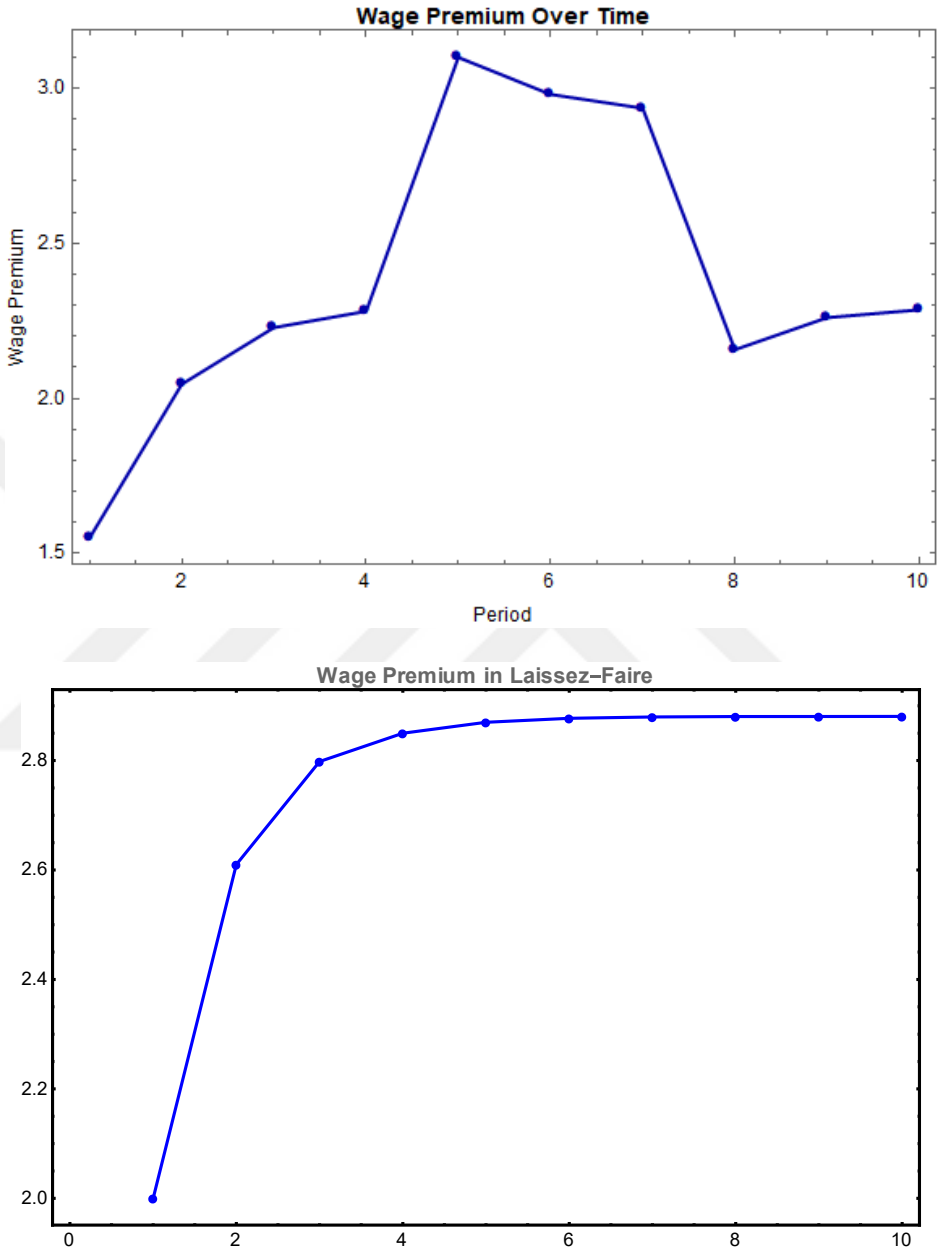
Figure 11. Putty Capital in Time Wittman vs Laissez-Faire



In this graph, we observe the evolution of aggregate capital. It shows that the old non-routine (capital-rich) group is relatively less affected by policy changes, while the old routine (capital-poor) group experiences significantly larger fluctuations. In the Laissez-Faire scenario, wealth distribution remains stable after reaching a steady state.

However, this is not the case under the Wittman equilibrium. It is evident that wealth inequality increases or decreases across periods depending on the policies implemented by the party that wins the election.

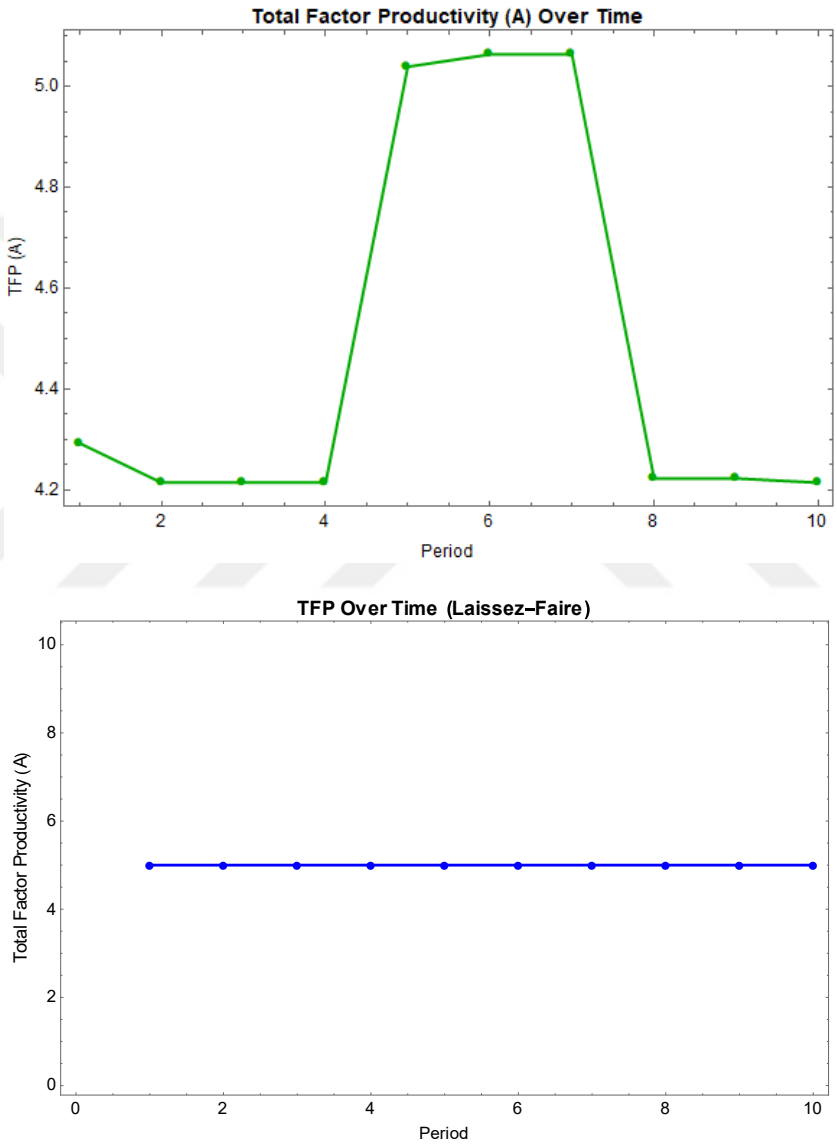
Figure 12. Wage Premium Wittman vs Laissez-Faire



This graph vividly illustrates the striking impact of policy changes. The wage premium declines when there is a robot tax, but deteriorates rapidly when subsidies are in place. When the poor party implements a moderate robot tax, routine labor wages rise due to reduced robot adoption, which leads to a sharp decline in the wage premium. This pattern highlights the significant role of political outcomes in shaping labor market dynamics and wage inequality between routine and non-routine workers. In the

Laissez-Faire scenario, the wage premium remains stable around 2.9 once the steady state is reached. However, when compared to the outcome under political competition, this situation changes dramatically. Due to high robot taxes implemented by the winning party, the wage premium drops as low as 2.2, while in periods of robot subsidies, it rises to as high as 3.1. This demonstrates that political competition significantly influences not only wealth inequality but also wage inequality.

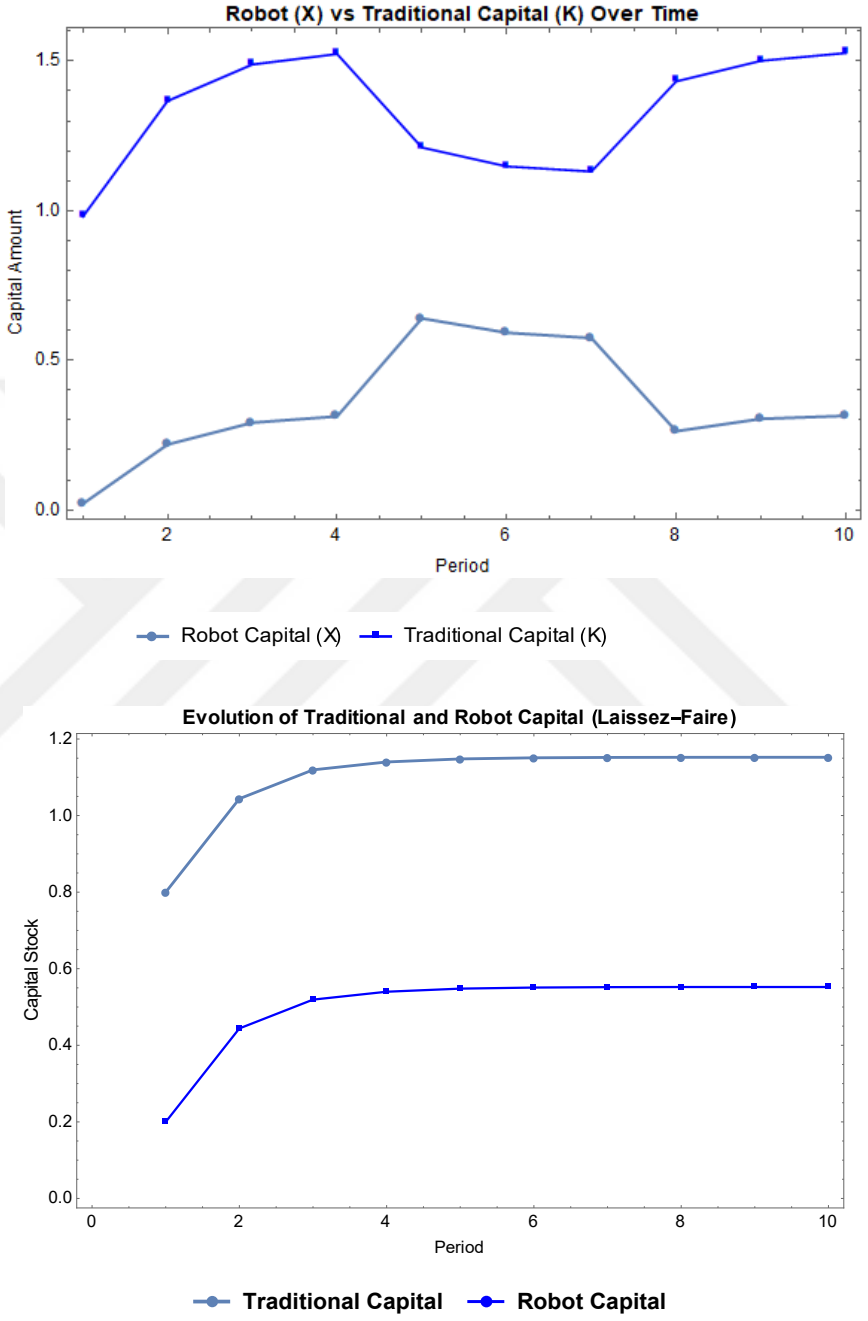
Figure 13. Total Factor Productivity (TFP) Wittman vs Laissez-Faire



TFP declines due to the increase in the robot tax. The mathematical reason for this can be seen in eq.(31). Economically, an increase in the robot tax rate reduces TFP because it raises the cost of robot capital, leading firms to use fewer robots and thereby lowering technological efficiency in production. This fluctuating structure in TFP points to changes in election results and the differentiation of policies implemented

accordingly, which reveals how political competition shapes efficiency dynamics. Since TFP in the model is inversely related to the robot tax, it remains constant in the Laissez-Faire scenario where the robot tax is zero.

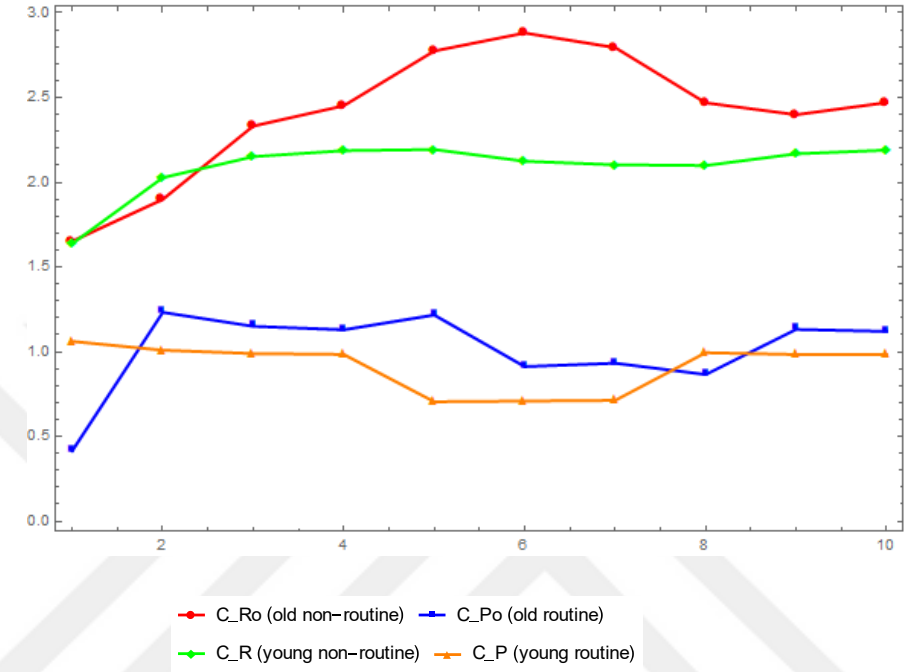
Figure 14. Traditional and Robot Capital Wittman vs Laissez-Faire

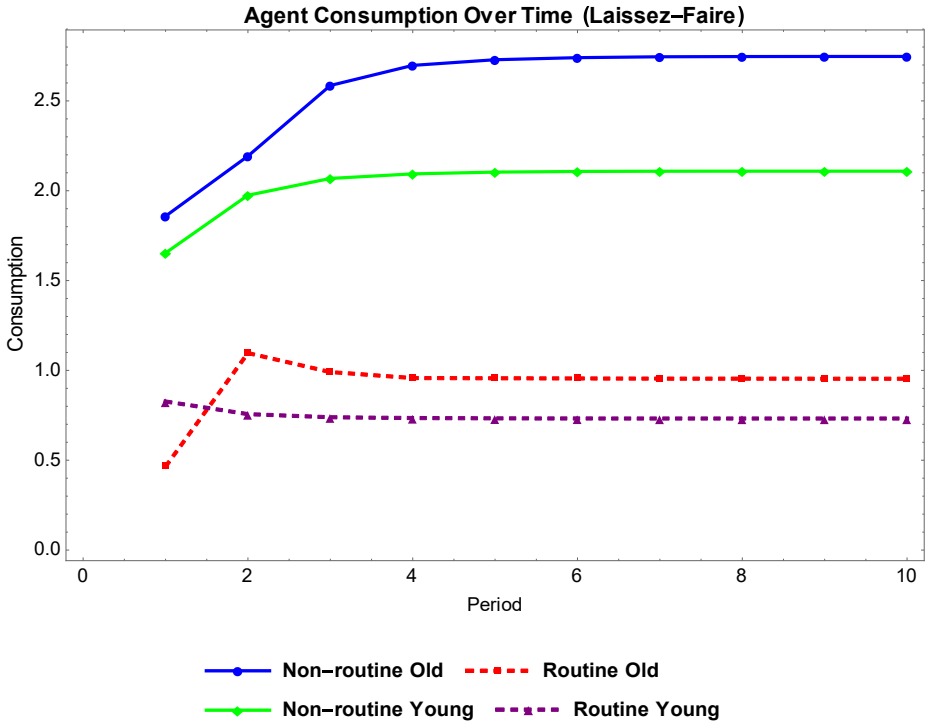


The graph demonstrates that both traditional capital K and robot capital X fluctuate over time in response to changes in robot tax policies. However, the magnitude of increases and decreases is greater for robot capital. The graph underscores how political cycles influence the allocation of resources, with robot capital showing more dramatic reactions to policy shifts. In the Laissez-Faire scenario, both traditional and

robot capital increase until they reach their steady states and then remain stable. However, under Wittman political competition, during periods when Party R (P) wins, the implemented subsidy (tax) increases (decreases) robot capital while decreasing (increasing) traditional capital.

Figure 15. Consumtions of Agents





The graph above shows the consumption patterns of the four agents participating in the elections, as they evolve over time in response to changing policies. The non-routine worker is the least affected by policy changes. This is primarily due to the structure of their utility function: since future policies matter to them as much as today's, this results in a much smoother consumption path over time. In the Laissez-Faire scenario, all voter groups (young and old, routine and non-routine) gradually converge to a stable consumption equilibrium over time. In contrast, under Wittman political competition, consumption levels fluctuate depending on the policies implemented. In both cases, old non-routine individuals are the highest consumers, followed by young non-routine individuals. However, when Party P wins the election, the consumption of young routine individuals surpasses that of the elderly, while the opposite occurs when Party R wins—old routine individuals consume more than the young routine ones. This is because the return on capital is inversely related to the robot tax: when the tax increases, the return on capital declines, thereby reducing the income of capital owners.

We have demonstrated how the equilibrium values evolve over time under a potential scenario shaped by Wittman-style political competition. However, comparing these results with a laissez-faire scenario—where no robot tax exists and no electoral competition over robot tax policy occurs—allows us to see how political competition truly alters the economic equilibrium.

After presenting Wittman vs Laissez-Faire results, we will also provide the outcomes of the optimal solution to highlight how the Wittman equilibrium differs from the social optimum. It is obtained by maximizing the indirect utility function, giving equal weight to each individual—that is, young and old routine, and young and old non-routine agents. Of course, this represents only one possible optimal solution. Different optimal outcomes would emerge if the utilities were weighted differently across agents.

3.3.2. An Optimal Solution

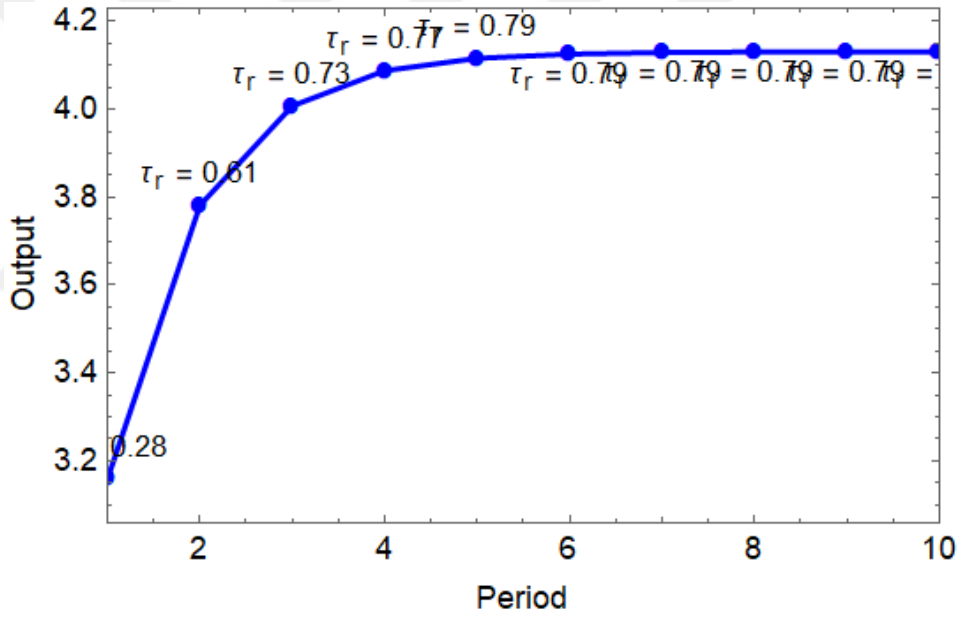
In this section, we present and discuss an example of an optimal solution that assigns equal weight to each group. The motivation for including this case, as previously mentioned, is to illustrate how the outcome under Wittman-style political competition differs from the standard solution commonly used in the literature—namely, that of a

benevolent social planner. Of course, this optimal solution is not unique; it depends on which group the planner prioritizes. In that sense, there are infinitely many possible optimal outcomes. However, in this study, we focus on a particular case where the planner assigns equal weight to all groups, allowing us to benchmark the effects of political competition against an egalitarian normative standard. The total indirect utility function that maximizes social welfare is given by:

$$W(\tau) = v^{r}(\tau^{*}) + v^{ro}(\tau^{*}) + v^{n}(\tau^{*}) + v^{no}(\tau^{*}), \tag{38}$$

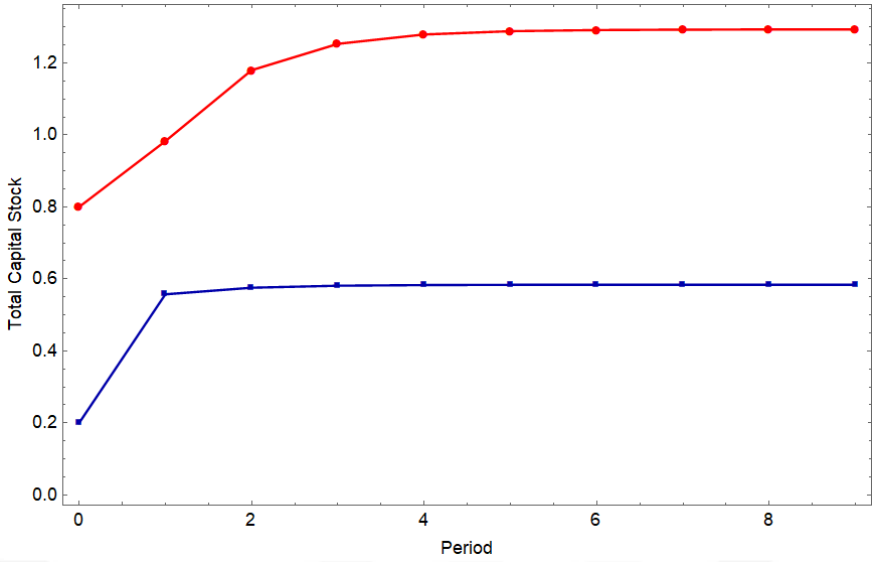
where each term represents the indirect utility of routine young $v^{r}(\tau^{*})$, routine old $v^{ro}(\tau^{*})$, non-routine young $v^{n}(\tau^{*})$, and non-routine old $v^{no}(\tau^{*})$ individuals, respectively.

Figure 16. Output in Time Optimal Solution



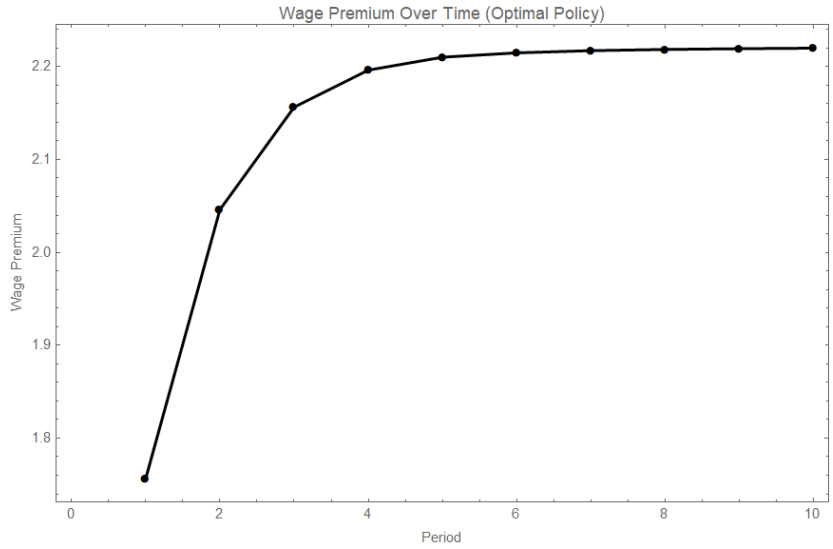
Despite the robot tax increasing from 28% to 77% over time, output reaches a steady state after the fifth period. In this optimal policy scenario—where all voter groups are weighted equally—the resulting steady-state output is higher than under laissez-faire. This outcome arises because, although a high robot tax reduces both TFP and robot capital usage, it simultaneously increases the use of traditional capital. As a result, total output rises as Gasteiger and Prettner (2022) suggested. However, the Wittman equilibrium reaches an output level of 4.22, which the social planner solution can never attain. The highest level it can reach is the steady-state value of 4.13.

Figure 17. Putty Capital in Time Optimal Solution



As expected, the lowest level of wealth inequality occurs under the optimal solution scenario. The capital-rich and capital-poor agents maintain a nearly constant capital gap at a ratio of approximately 1:2. In the Wittman equilibrium, the wealth of the old non-routine, which can rise as high as 1.32, falls to around 1.235 due to the implemented policies. In contrast, under the social planner solution, it stabilizes at a steady-state value of 1.29. Similarly, while the old routine group accumulates wealth between 0.42 and 0.57 in the Wittman case, their steady-state wealth under the social planner is 0.58.

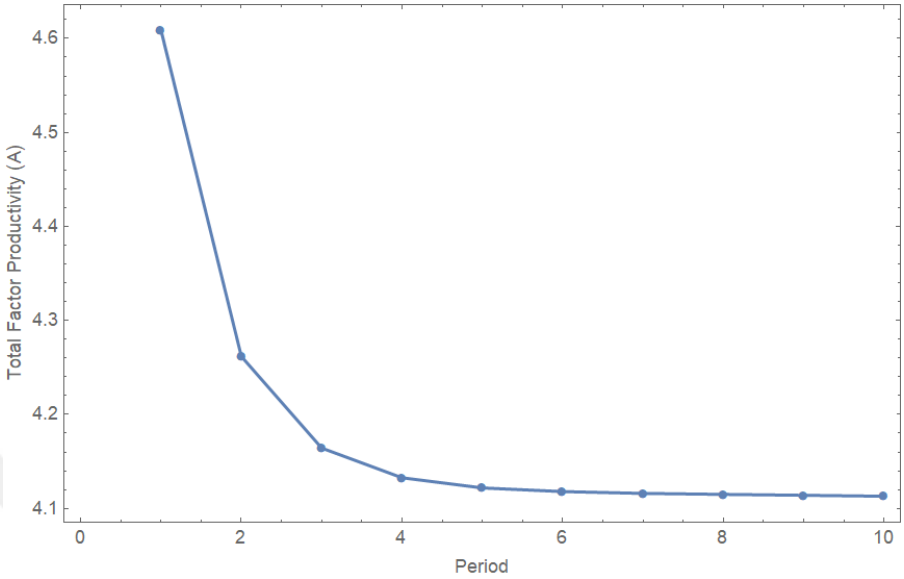
Figure 18. Wage Premium Optimal Solution



As expected, in the optimal tax scenario, the wage ratio remains around 2.2 in favor of non-routine workers, reflecting a more equitable distribution compared to Laissez-

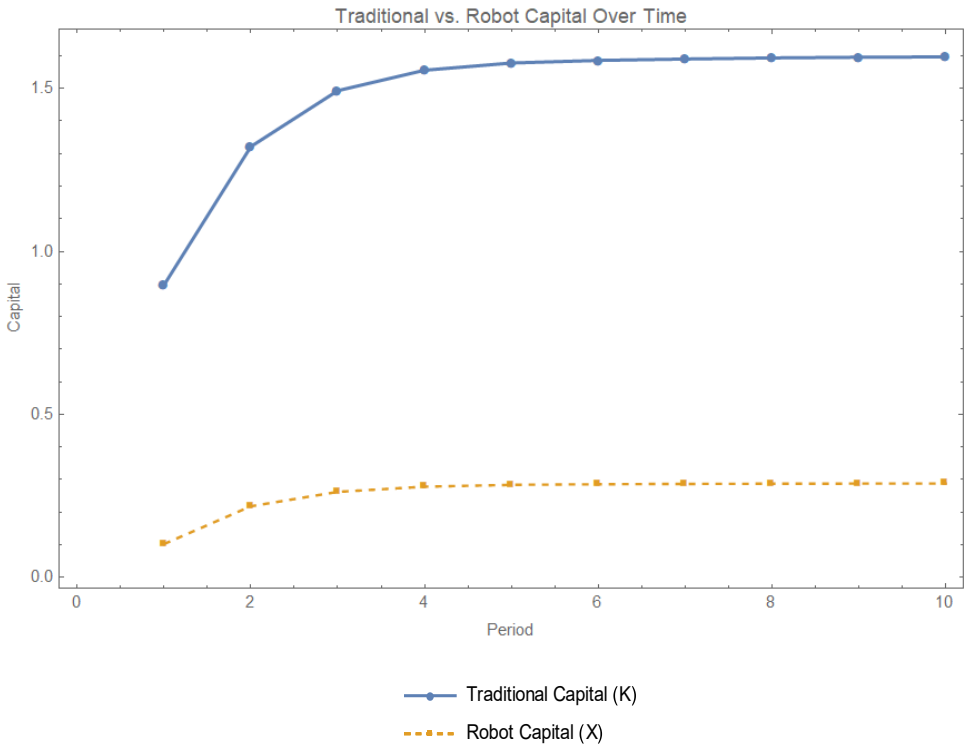
Faire, where it reaches approximately 2.8. In contrast, under the Wittman political competition, this ratio fluctuates significantly depending on the winning party—rising up to three times higher or dropping close to the optimal scenario level of 2.2.

Figure 19. TFP Optimal Solution



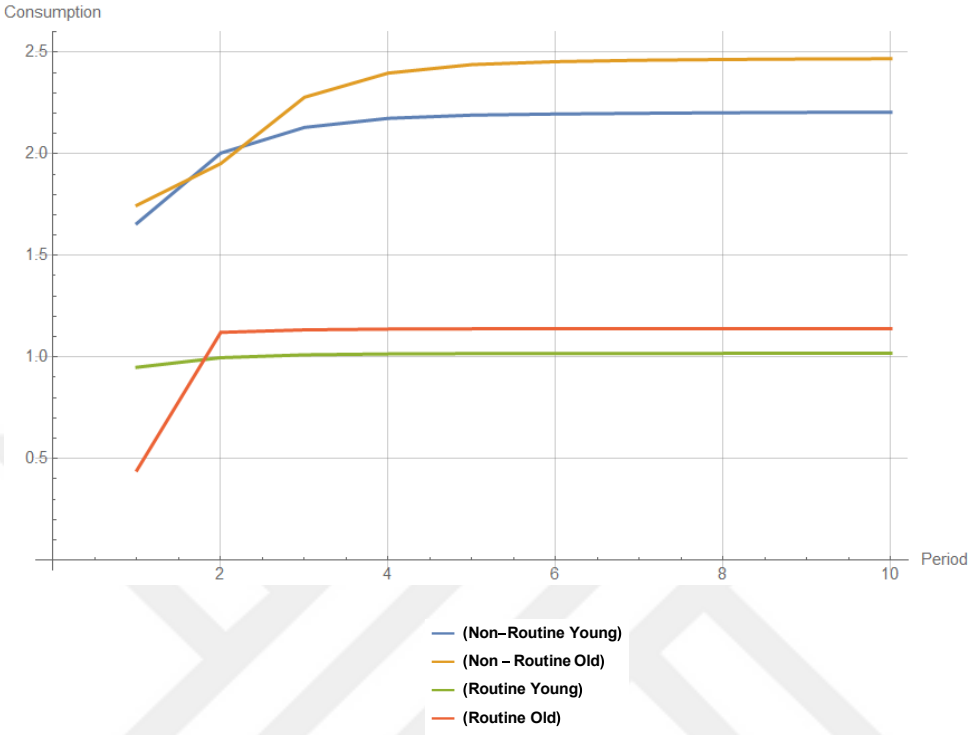
The TFP continuously declines and stabilizes in the steady state. This results from the inverse relationship between robot taxes and TFP: as the optimal tax policy increases the robot tax to curb income and wealth inequality, TFP is consequently suppressed.

Figure 20. Traditional and Robot Capital



Due to the high robot tax policy implemented to reduce inequality, this scenario results in the lowest level of robot capital among all solutions.

Figure 21. Consumtions of Agents Optimal Solution



Finally, consumption levels are most equitable under the optimal robot tax scenario. While the highest consumption still belongs to old non-routine individuals, the gap between them and other groups is minimized. In the Wittman equilibrium, the consumption of old non-routine peaks at 2.88 but later declines to 2.40, whereas under the optimal (social planner) solution, it reaches a steady state level of 2.47. The young non-routine group is relatively more stable in the Wittman case, with consumption ranging from 2.10 to 2.19, while in the optimal solution, they consume around 2.20. In contrast, both old and young routine individuals experience significant fluctuations in the Wittman setting, with consumption varying between 0.87–1.22 and 0.70–0.99, respectively. Under the optimal solution, however, their consumption stabilizes at 1.14 and 1.02 respectively.

3.3.3. Sensitivity Analysis

In this section, we examine how equilibrium outcomes respond to changes in the initial capital distribution between capital-rich and capital-poor actors. In addition, we aim

to demonstrate how assigning different weights to voter groups by political parties affects the initial equilibrium.

When we change capital distribution ratios to examine the sensitivity to initial capital inequality, we observe significant differences in the political equilibrium results. When the capital rich own 90% of the total capital, the P party's proposed robot tax decreases to 49.6%, while the rich party proposes a more aggressive robot subsidy of −11.6%. In this case, the P party's probability of winning the election increases to 65%. On the other hand, when inequality decreases so that the capital distribution is 70%-30%, the P party proposes a higher tax (64%), the R party's subsidy decreases to −9%, and the election probability reaches equilibrium at 56%. These findings show that as initial inequality increases, the poor party's proposed policy becomes more moderate, while the R party turns to more aggressive subsidies. At the same time, it is observed that as social inequality increases, the election result shifts in favor of the P party.

Table 3. Wittman Results under the Different Initial Capital Level for the First Period

Capital Distribution (Rich : Poor)	Poor Party Tax Proposal	Rich Party Tax Proposal	Poor Party Win Prob.
0.9 : 0.1	0.496	-0.116	0.65
0.8 : 0.2 (baseline)	0.59	-0.09	0.59
0.7 : 0.3	0.64	-0.073	0.56

In a more comprehensive robustness analysis, basic parameters such as productivity (Z) and intertemporal discount factor (ρ) are also tested. No significant change is observed in the robot tax rates and the election winning probability of the parties, when these parameters change within reasonable ranges. These results show that political balance is determined more by wealth inequality and voter structure rather than technology level or time preferences.

Political parties may give value to different voter groups differently, which is important to consider when analyzing political competition. Empirical evidence shows that parties often give priority to specific demographic segments. For example, in Turkey, the Justice and Development Party (AKP) receives strong support from economically disadvantaged, elderly, and rural segments; this support is associated

with the party's populist and clientelist practices and the hegemony it has built in line with the neoliberal economy (Özbudun, 2014; Tuğal, 2009). In contrast, the Republican People's Party (CHP) receives support mostly from young, urban, and white-collar voters; this is consistent with the party's emphasis on secularism (Carnegie Endowment for International Peace, 2024). A similar pattern is observed in Europe, where left-wing parties tend to receive support from the working class and secular groups, while right-leaning parties are backed by middle- and upper-income groups as well as religious voters (Klüver, 2020). In the United States, the Democratic Party tends to receive support from younger people, minorities, and highly educated groups, while the Republican Party draws more support from older individuals, less-educated voters, and predominantly white populations (Pew Research Center, 2024). These examples show that different economic and demographic groups can support different political parties. But can't political parties favor some groups within their electorate over others? Or, to put it another way, wouldn't such favoritism help them win elections? For our model, the Poor party may prioritize policies that benefit elderly voters (capital-poor). In contrast, the Rich party may prefer policies that appeal to urban and professional voters (non-routine labor). To test this, we assign distinct weights to voter groups based on their relative importance to each party's electoral objectives. The poor party prioritizes the capital-poor agent, assigning them a weight of 0.8, while giving a lesser weight of 0.2 to routine labor. Conversely, the rich party emphasizes the interests of non-routine labor with a weight of 0.8 and assigns a weight of 0.2 to the capital rich. The von Neumann–Morgenstern utility functions are expressed as:

$$V^P(\tau^P,\tau^R) = \Pi(\tau^P,\tau^R)(a\, v^r(\tau^P) + (1-a)v^{ro}(\tau^P)) + \big(1-\Pi(\tau^P,\tau^R)\big)(a\, v^r(\tau^R) + (1-a)v^{ro}(\tau^R))\,, \tag{39}$$

$$V^R(\tau^P,\tau^R) = \Pi(\tau^P,\tau^R)((1-a)v^n(\tau^P) + a\, v^{no}(\tau^P) + \big(1-\Pi(\tau^P,\tau^R)\big)((1-a)v^n(\tau^R) + a\, v^{no}(\tau^R))\,, \tag{40}$$

where $a = 0.2$ representing prioritization.

Table 4. The Results of Weighted Wittman Equilibrium for the First Period

Party	Winning Probability	Proposed Robot Tax
Poor	0.77	0.15
Rich	0.23	-0.045

These results diverge notably from the unweighted findings (Table 1). The poor party proposes a moderate robot tax of 0.15, giving 80% weight to the capital poor group and 20% to routine worker. This tax rate observes a two-way balance: the capital poor are negatively affected by the decreasing returns to capital (rent) as the robot tax increases, while routine worker benefit from the increasing prices of robots. The increase in the cost of robots leads firms to reduce the use of robots, thus increasing the wage of routine worker who replaces robots. On the other hand, the rich party proposes a negative tax of −0.045, which means subsidizing robots by considering 80% of non-routine worker. This policy reflects the complementary relationship of non-routine workers with traditional and robot capital; subsidizing robots increases productivity by increasing the use of robots

3.4. Discussion

In this section, we compare the key steady-state outcomes of the model under Wittman-style political competition and the laissez-faire scenario. This comparison focuses on the effects of robot taxation on income distribution, wealth accumulation, and the consumption levels of different demographic groups.

The Wittman equilibrium illustrates how real economic outcomes diverge from both the laissez-faire benchmark and a socially optimal solution in which all four demographic groups are weighted equally. Moreover, since the model is an overlapping generations (OLG) framework, it also reveals how intergenerational conflict may arise. When young, a high robot tax directly increases the income of routine workers. For non-routine workers, the reduced demand for robots due to the tax indirectly boosts the accumulation of traditional capital, which in turn enhances their productivity and wages. Therefore, in the short term, a high robot tax is beneficial for young worker , whereas a zero or moderate subsidy is more beneficial for young non-routine worker. However, for their discounted future consumption, they prefer a lower robot tax in the future, as they will no longer work and instead rely on the returns from the capital they accumulated. Since capital income is negatively affected by the

robot tax, this now-elderly group—previously the young routine and non-routine workers—will support robot subsidies to maintain higher returns on their savings.

It is important to note that the robot tax collected in the model is redistributed equally to all groups as a form of Universal Basic Income (UBI). While UBI is more appealing to capital-poor individuals (elderly routine workers), it still cannot fully offset the loss of capital income resulting from the tax. In contrast, for young routine workers, the robot tax provides dual benefits: both an increase in labor income and an additional income stream via UBI. Meanwhile, young non-routine workers tend to favor mild subsidies—approaching the laissez-faire scenario—because they attempt to balance the TFP loss caused by the robot tax with gains from higher traditional capital accumulation and UBI redistribution. After outlining the economic logic behind the preferences of different social groups, we presented the economic implications of a possible Wittman-type political competition, illustrated through election outcomes and their effects on real macroeconomic variables. For comparative purposes, we also analyzed the laissez-faire scenario, which assumes no robot taxation at all. Both cases represent realistic and plausible paths: on the one hand, robot taxation is already being discussed in legislative bodies across various countries; on the other hand, some nations may continue to refrain from adopting any form of robot tax, effectively resembling the laissez-faire setting. We also reported an optimal taxation scenario for reference. The optimal solution, though theoretically informative, requires assigning equal or alternative weights to social groups, a level of centralized social planning rarely attainable outside a socialist economy. For this reason, a comparison between political competition and laissez-faire conditions is not only more feasible but also more reflective of the real-world institutional constraints.

In the laissez-faire scenario, where no robot tax is implemented, the economy reaches a steady state after four periods. In contrast, under the Wittman scenario, the high robot tax increases demand for traditional capital, which offsets the decline in TFP. As a result, the economy exhibits faster short-term growth and reaches a steady state in just three periods. However, in subsequent periods, changes in election outcomes—such as the alternation between a subsidy-supporting party (Party R) and a tax-supporting party (Party P)—lead to persistent deviations from the steady state. These shifts generate fluctuations in the economy, causing key economic indicators to oscillate above and below the steady-state path. Naturally, such volatility does not occur under

the laissez-faire scenario, where, once the economy settles on the steady-state path, all economic variables remain stable. While the capital level of the capital-rich (old non-routine individual) remains constant around 1.2 under the laissez-faire scenario, it fluctuates above 1.2 under the Wittman equilibrium. The most notable change, however, is observed among the capital-poor (old routine workers). In the laissez-faire case, their capital level stabilizes around 0.4, whereas under the Wittman scenario, it increases significantly—reaching up to 0.6. The wage premium under the Wittman scenario can rise up to a factor of 3 in favor of young non-routine workers, especially when the subsidy-supporting Party R wins. However, it drops to around 2.2 when Party P wins and imposes a high robot tax. In contrast, under the laissez-faire case—where no tax intervention occurs—the premium remains slightly above 2.8, resulting in a persistent and stable income inequality over time. In terms of consumption, both under the Wittman scenario and the laissez-faire equilibrium, the highest levels are consistently observed among the old non-routine and young non-routine individuals, respectively. However, due to shifting policies in the Wittman framework, the consumption rankings among routine cohorts fluctuate over time. In contrast, under the laissez-faire regime, routine old individuals consistently consume slightly more than their younger counterparts in the steady state. Thus, we have thoroughly discussed how the outcomes of robot policy under political competition (through taxation) differ from those in a laissez-faire scenario within the framework of our automation-based overlapping generations model, which features income inequality, wealth disparity, and generational conflict.

3.5. Conclusion

This study investigates a robot tax determined through political competition within a dynamic general equilibrium model. The model features two types of workers: those engaged in routine tasks and those performing non-routine tasks. Since the model has an overlapping generations (OLG) structure, each individual goes through two distinct life stages. Initially, based on an exogenously given talent endowment, the individual enters the labor market and works in either a routine or non-routine job. This occupational assignment determines their income and savings during the working period. In the next stage, they retire from the labor force and consume the capital they accumulated while young. Because non-routine workers earn higher incomes and save

more, they become capital-rich in old age, whereas routine workers remain capital-poor. This life-cycle structure introduces both income and wealth inequality into the model, generating conflict along both dimensions during political competition.

The result of Wittman-style political competition, significant differences in real economic indicators are observed between the years when robots are taxed and the years when they are subsidized. The fact behind this, political parties care only the interest of their electorates and win the office. The most striking fluctuations are observed in the wage premium and total factor productivity (TFP). In periods when a robot tax is implemented, both the wage premium and TFP decline significantly. Another visible outcome under the Wittman scenario is that the policies implemented by the winning party lead to substantial variations in consumption levels across demographic groups—except for the young non-routine individuals, whose consumption remains relatively stable. In particular, the consumption of young routine, old routine, and old non-routine agents fluctuates significantly depending on which party holds office. Additionally, the wealth of old routine individuals exhibits dramatic changes over time, reflecting their heightened sensitivity to shifts in robot tax policy. Overall, unlike previous models that emphasize central planner solutions, this analysis better captures the political feasibility of implementing a robot tax in a democratic setting.

4. REDUCING INEQUALITY ACCELERATES AUTOMATION: THEORY AND EVIDENCE

4.1. Introduction

The rapid adoption of automation, robotics, and artificial intelligence (AI) is a sign of a structural transformation in current labor markets (Frey and Osborne, 2017). As firms increasingly introduce technologies that can replace routine labor, the impacts of this trend on wages, inequality have become central to both academic and political debates. In parallel, when considered from a fiscal policy perspective, this rise of automation also poses a threat to existing tax systems (Kovacev, 2020). Furthermore, the situation of skilled workers, not just those who perform routine work, is uncertain because of new automation systems which threaten the skilled workers (Bloom et al., 2025). However, in the literature, the threat of automation is generally more pronounced for low-skilled workers engaged in routine tasks.

The economic challenges reshaped by automation have been the subject of extensive research, particularly in the areas of employment, productivity, inequality and redistribution. For example, Acemoglu and Restrepo (2020) showed that robotization reduces employment in the United States and negatively affects low-skilled workers using robot data provided by the IFR. Graetz and Michaels (2018) found that robots increase productivity but have a limited impact on employment in a study covering 17 countries. Theoretical models address the impact of automation on the workforce in a task-based framework. Acemoglu and Restrepo (2018) explain how technological change replaces certain tasks and creates new jobs, while Autor et al. (2003) show how middle-skilled jobs have eroded over time. Guerreiro et al. (2023) analyzes the effects of automation on productivity and income distribution by expanding task-based models.

For inequality debate, there is a wide range of debates in literature concerning this issue. How robotization shapes labor markets and how this transformation affects inequality is widely discussed (Graetz and Michaels, 2018; Acemoglu and Restrepo,

2019, 2020; De Vries et al., 2020; Battisti and Gravina, 2021; Acemoglu and Restrepo, 2022). Also, the interaction between redistribution policies and automation has attracted attention, demonstrating the need to navigate the trade-off between the goal of reducing inequality and encouraging innovation. Hötte et al. (2024), who investigated the public finance implications of automation, analyzed its impact on public revenues in 19 EU countries between 1995 and 2016. They found that automation led to a decline in total tax revenues until 2008, but this effect weakened in the years that followed.

Additionally, micro-level studies have also been conducted on the effect of robots on firm value, production such as Li et al. (2024) and Humlum (2021).

The increase in robotization, which has led to rising unemployment and declining wages, has also brought the idea of a robot tax to the forefront of policy discussions. For these reasons, the taxation of robots has been widely debated in numerous studies (Guerreiro et al., 2022; Korinek & Stiglitz, 2021; Gasteiger & Prettner, 2022; Thummel, 2019). However, robot taxation is also viewed as a rejection of economic progress, with concerns that it could reduce productivity; instead, it has been argued that automation should be encouraged through subsidies (Atkinson, 2019; Ünveren et al., 2023). Despite these debates, no concrete policy action has been taken so far, and robotization and automation continue to integrate rapidly into the economy.

An accepted explanation for this technological transformation is primarily attributed to the relative price between labor and capital, a factor widely emphasized in economic history and theory. (Allen, 2009; Acemoglu, 2002). Labor costs have an important role among the factors that determine the direction of technological change. The view that high wages lead technological change is accepted in literature both historically and theoretically. For example, Allen (2009) explains why the Industrial Revolution began in England, arguing that this country's high wages and cheap energy made the development of machines that replaced labor attractive. Similarly, Habakkuk (1962) argues that high labor costs in 19th-century America encouraged capital-intensive production methods. Studies such as Blanchard (1997) and Caballero and Hammour (1998) also provided empirical findings supporting this historical process. These historical and theoretical foundations inform current discussions about how labor market dynamics shape technology. Extending this idea, Acemoglu (2002) shows in his directed technical change model that differences in factor prices, particularly

between labor and capital, lead firms to adopt technologies biased toward the relatively cheaper factor. It has been theoretically demonstrated that firms turned to capital-biased technologies and reduced labor demand in the long run, especially after the "wage push" shocks experienced in continental Europe in the 1970s (pp. 796–797). In Acemoglu's framework, the "price effect" encourages technological substitution of high-wage factors (i.e., labor), while the "market size effect" promotes innovation toward more abundant (pp. 783–786). Hémous et al. (2025) found that in the United States, an increase in low-skill wages raises automation innovation by 2–5 percent, based on an analysis of keywords in patent texts. These historical and theoretical foundations inform current discussions about how labor market dynamics and relative input prices shape firms' automation strategies and broader technological transformation.

To sum up, studies on the determinants of automation generally show that high labor costs lead firms to automation. However, by the same token, income distribution should affect the direction of technological change. This has been surprisingly a relatively neglected subject which opens a door to the role of government. Does redistribution cause high labor cost and indirectly lead automation?

This study aims to fill this gap in literature by focusing on this question. We have a theoretical model explaining this mechanism. In other words, rather than viewing increases in inequality because of automation, we examine whether inequality affects automation decisions through redistributive mechanisms. We developed a simple general equilibrium model of automation and show that redistribution increases automation. We also test this mechanism via panel data analysis. The effect of redistribution on automation is estimated with Generalized Method of Moments (GMM) covering 25 countries between 1993 and 2019. In the econometric analysis, the dependent variable is the level of automation, measured as the ratio of each country's robot stock to the sum of total employment and robot stock. This ratio reflects the share of tasks performed by robots, capturing the intensity of automation within the labor market. The key explanatory variable is redistribution, for which multiple measures are used across different regression specifications. By incorporating various indicators of redistribution, the analysis tests the robustness of the results regarding the impact of redistribution on automation. The control variables include average hourly wages, total factor productivity (TFP), and investment levels.

Additional other control variables are also included in subsequent specifications to further test the robustness of the model.

However, due to potential endogeneity concerns—particularly the possibility of reverse causality where automation may influence redistribution policies (see Guerreiro et al., 2022; Korinek & Stiglitz, 2021; Gasteiger & Prettner, 2022; Thummel, 2019)—an instrumental variable (IV) approach is adopted. To address this, religiosity is employed as the main instrument. The literature discusses the relationship between religiosity and redistribution preferences (e.g., Arıkan & Ben-Nun Bloom, 2019; Basedau et al., 2018), but religiosity is not expected to have a direct effect on automation. Therefore, it serves as a valid instrument by satisfying both the relevance condition in the first stage and the exclusion restriction in the second stage.

The results confirm the theoretical expectations. Our findings reveal a positive causal relationship between redistribution and automation, indicating that redistribution alters the structure of incentives for innovation and capital accumulation. These results suggest that while redistribution serves as a tool for promoting economic equality, it also acts as a driver of long-term technological transformation.

This study contributes to the literature on automation, inequality, and redistribution in three ways. First, unlike the existing literature which predominantly examines the causal link from automation to inequality and subsequently to redistribution, this study investigates the reverse causality: whether redistribution, by increasing the relative cost of labor, induces firms to adopt automation technologies. Second, the relationship between redistribution and automation is analyzed both theoretically—through a general equilibrium model—and empirically using a robust panel data methodology with an instrumental variable approach. This dual strategy strengthens the causal interpretation of the link between redistribution and automation. There are studies similar to this one, such as Acemoglu et al. (2020) and Süssmuth et al. (2020), but there are important differences. In the model by Acemoglu et al. (2020), there is a single type of labor, but both automation and traditional capital are included. They examine how taxes on labor and capital affect the level of automation. Additionally, their study does not include an econometric analysis. In contrast to our model, in Süssmuth et al. (2020), households benefit from government consumption rather than redistribution. The model is dynamic and includes a production function with a single type of worker, robots, and physical capital. Taxes are collected from consumption,

labor income, and capital income. They use US time-series data with cointegration and VECM methods, not panel data. Although both studies find that the existing tax system increases automation, they do not directly link this outcome to redistribution as our study does. Third, this study contributes to ongoing policy debates on redistribution during a period of rapidly advancing automation. It highlights a potential paradox: while redistribution aims to promote equity, it may inadvertently accelerate automation, which could in turn exacerbate the very inequality it seeks to reduce. The study helps bridge the gap between redistribution policies and the dynamics of technological change.

The paper is organized as follows. First we present a simple general equilibrium model with automation and show analytically and numerically that redistribution increases automation. Then we explain the empirical approach and introduce the dataset. Then we discusses the endogeneity between automation and redistribution and introduces the instrumental variable. After that we present the correlations between automation and redistribution, as well as the first-stage relationship between religiosity and redistribution. The reports and discusses the GMM-IV regression results. Lastly, we present the theoretical and empirical findings, and lastly we concludes with a summary and final remarks.

4.2. A Simple Model

In this section we develop a simple general equilibrium model to demonstrate the effects of redistribution on the level of automation in a competitive economy. Only robot capital is included in the model, not traditional capital. This choice is not only for analytical simplicity, but also to isolate the labor substitution effect of automation. This approach is a technique adopted in task-based models such as Acemoglu and Restrepo (2018), Acemoglu et al. (2020) and Guerreiro et al. (2022).

We construct a static general equilibrium model to analyze the effect of income taxation on automation. In this model, competitive firms produce a single final good using two types of labor (skilled vs unskilled) and robots, which are substitutes for unskilled labor. Households derive utility from their consumption of the final good and leisure. The government distributes equal lump-sum transfers by taxing labor income.

Firm produces output with the following production function

$$Y = A\, L_s^{1-\gamma}(L_u + \rho\, R)^{\gamma}\,, \tag{41}$$

where Y is the total output. L_s, L_u are skilled and unskilled labor hours respectively. We write R for the number of robots, given the efficiency coefficient of robots with respect to labor is $\rho > 0$. Production technology treats robots and unskilled labor as substitutable inputs while skilled labor is complementary to the robots and unskilled labor.

Firm maximizes the following profit function:

$$\Pi = Y - w_u L_u - w_s L_s - \phi R\,, \tag{42}$$

where w_i is the wage for laborers, ϕ is the unit cost of the robot. The first-order conditions (FOC) for profit maximization are as follows.

$$\frac{\partial Y}{\partial L_u} = w_u\,, \frac{\partial Y}{\partial L_s} = w_s \text{ and } \frac{\partial Y}{\partial R} = \phi. \tag{43}$$

These conditions above determine the equilibrium wage and robot demand.

There are two individuals in the economy, denoted by i. Each individual i is either skilled (s) or unskilled (u). The utility function of individual i's utility function is defined as

$$U_i = \log(c_i) + \beta \log(l_i), \tag{44}$$

where c is consumption, l is leisure time, and $\beta > 0$ is a preference parameter that captures the value of leisure time.

The time constraint is

$$l_i + L_i = 1, \tag{45}$$

which implies that the budget constraint is

$$c_i \leq (1-t)w_i\, L_i + \frac{T}{2}, \tag{46}$$

where t is the income tax rate and $\frac{T}{2}$ is the lump-sum transfer that is distributed equally among workers. The households maximize their utilities under this constraint.

The government obtains tax from laborers and transfers equally as lump sum under the budget constraint:

$$T = t(w_u L_u + w_s L_s). \tag{47}$$

The market clearing solves the household's utility problem, the firm's profit problem and the government budget constraint. Therefore, the real GDP is

$$Y = c_u + c_s + \phi R. \tag{48}$$

Under these conditions we can compute the market equilibrium simultaneously, denoting the equilibrium robot level as $R^*(T)$, which is a function of T (See Appendix 1).

Proposition 1. Robot demand is increasing with Transfers $\frac{\partial R^*}{\partial T} > 0$ if $\gamma < 0.5$.[6]

Next, we demonstrate a numerical analysis to show the effect of redistribution on automation and a socially optimal income tax rate. We analyze our simple model numerically and calibrate the parameters to illustrate how transfers (redistribution) affect automation. We set the parameters as

$$(A, \gamma, \rho, \phi, \beta) = (1, 0.3, 4, 1, 0.6).$$

A and ϕ are normalized to 1 while γ is 0.3 to ensure that that the ratio of skilled to unskilled workers' hourly wages exceeds 2.5, consistent with the U.S. data. Also ρ is set at 4 to reflect that although robots are relatively expensive compared to unskilled labor, their efficiency is sufficiently high to ensure automation occurs in production.

[6] The proof of Proposition 1 is in the Appendix 4.

Figure 22. Redistribution vs Automation

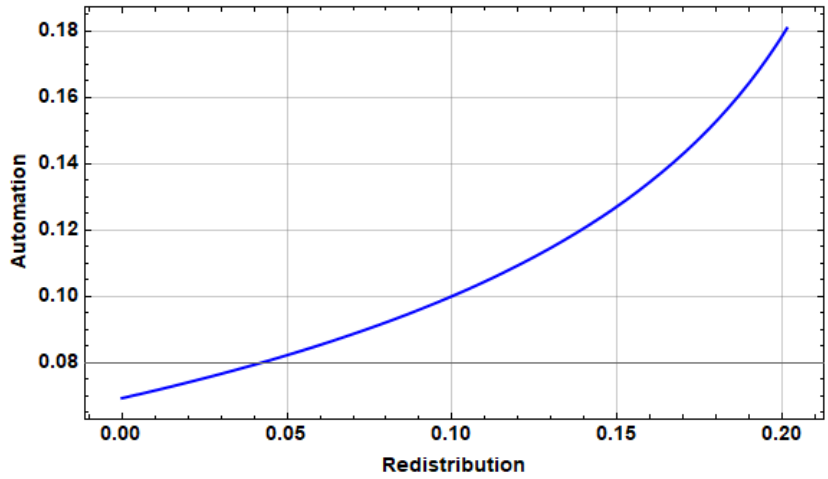


Figure 22 illustrates the positive relationship between redistribution and automation. As shown in the graph, higher levels of redistribution are associated with increased automation. The underlying mechanism driving this relationship is further explained in Figure 23.

Figure 23. Wage Premium

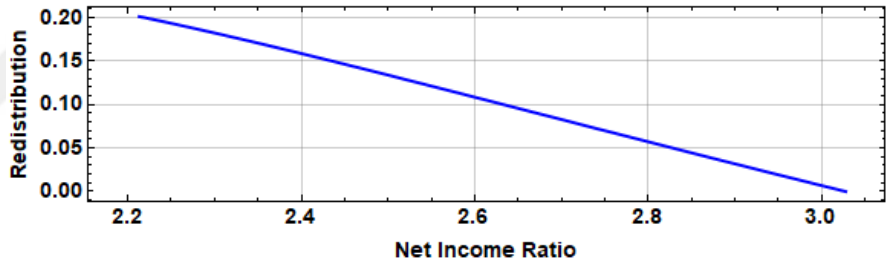


Figure 23 shows that as redistribution rises due to higher income taxation it raises the net wage of unskilled labor, so the net income ratio of skilled-unskilled labor diminishes. This increase in net wage leads to a decline in the supply of unskilled labor, which is then offset by greater adoption of robots in production. Thus, we can interpret that redistribution is indirectly raising the effective cost of unskilled labor and inducing firms to automate more. Therefore, we analytically demonstrate that redistribution has a positive effect on automation.

What about an optimal tax rate to maximize social welfare. An optimal income tax rate is determined to maximize social welfare, defined as $W = \sum_{i \in (u,s)} U_i$ where a benevolent social planner maximizes equally weighted indirect utilities of skilled and unskilled labors. We estimated that the optimal tax rate that maximizes W is 33.4%, which already falls within the range of US labor income tax rate. Further, the optimal

rate implies %15 automation representing the extent to which robots are involved in a given task.

Acemoglu et al. (2020) investigate that the U.S. tax code is labor-biased and favors automation under the current labor income tax rate, which ranges between 25.5% and 33.5%. Their model incorporates both a two-period framework and an infinite-horizon setup, allowing them to analyze capital taxation as well—unlike our model. They estimate that the optimal labor income tax rate is 18.22% and the optimal capital tax rate is 26.65%. However, when these optimal rates are applied, the changes in the real economy are minimal: the labor share increases by only 0.78%, employment rises by 4.02%, and the share of automated tasks decreases by 4.02%. These results suggest that the current tax system is already very close to optimal. The model is also robust, as the wage premium at the optimal tax rate is 2.32 in favor of skilled labor consistent with the findings of Bloom et al. (2025). Another important study by Süssmuth et al. (2020) empirically finds that changes in capital and labor income taxation have a permanent impact on the level of robotization. Moreover, their neoclassical model shows that income taxation reduces labor supply and wages, thereby triggering automation. However, Süssmuth et al. (2020) do not incorporate worker heterogeneity in their dynamic growth models. Moreover, since traditional capital is included in their model, capital taxation is also considered. In their empirical analysis, they examine the effect of income and capital taxes on automation per worker in the U.S. using time series methods. In contrast, our empirical study is based on panel data and focuses directly on the relationship between redistribution and automation, rather than tax rates. In the next section, we develop an econometric model to empirically examine this relationship using real-world data.

4.3. Empirical Analysis

In this section, the main objective is to examine the effect of redistribution on automation. To achieve this, we conduct a panel data analysis using a combination of multiple datasets. The panel regression is based on a GMM-IV estimation strategy to address potential endogeneity issues.

4.3.1. Overview

This study investigates the causal relationship between redistribution and automation using panel data analysis for 25 countries over the period 1993–2019. The analysis employs cultural and institutional instrumental variables, along with automation-related control variables, to examine the effect of redistribution on automation.

4.3.2. Data and Methodology

The sample data used in this study is extracted from the Penn World Table (PWT), Fisher-Gethin Redistribution Dataset, The Standardized World Income Inequality Database, International Federation of Robotics (IFR), Varieties of Democracy (V-Dem), and the World Values Survey (WVS). However, the dataset has two main limitations. First, the World Values Survey covers only a limited number of countries and is conducted in 5-year intervals. Second, the IFR dataset also includes fewer countries than the PWT and begins in 1993, as automation is a relatively recent phenomenon. Additionally, the time frame is constrained by the PWT version 10.01, which we use to maximize the number of countries and years included in our sample. Another challenge arises from the WVS data, as each 5-year interval provides only a single data point. To address this issue, we interpolate the data to fill the gaps within these intervals. However, some missing values remain, resulting in an unbalanced panel dataset.

The dependent variable in our empirical analysis is:

$$Automation_{it} = \frac{R_{it}}{R_{it} + L_{it}}$$

where R_{it} is the total stock of robot deployment and L_{it} is the total number of employed people. Therefore, automation according to our definition measures the density or penetration of robotic technologies into the labor force in relative terms.

Robot density, the main measurement method in literature, focuses only on the amount and density of robots used in certain sectors (the number of robots per worker), rather than directly reflecting the overall level of automation in the labor market.

Although task-based theoretical models help determine which jobs are more prone to automation, they do not directly measure the share of automation in the total employee. In this context, our proposed measurement method aims to directly measure the real

share of automation in the employee, which is compatible with task-based theoretical models. The measurement method we propose is calculated by comparing the total stock of robots used in the sector with the total employee to determine the real share of automation in the workforce. Thus, it allows us to directly measure not only the numerical density of robots but also the prevalence of automation compared to workers. This approach is consistent with the theoretical framework provided by task-based models (Acemoglu & Restrepo, 2018; Autor et al., 2003) and provides a new and complementary metric for measuring the prevalence of automation in the labor market. The regressors were chosen to capture the effects of the 5 categories which are redistribution average hourly wage, investment, total factor productivity and trend. Thus, the baseline model on which our empirical analysis relies can be expressed as follows:

$$Automation_{it} = \beta_0 + \beta_1 Redistribution_{it} + \beta_2\, Hourly\, Wage_{it} + \beta_3 Investment_{\ it} + \beta_4 TFP_{it} + Trend + u_{it} \quad (49)$$

where u_{it} is idiosyncratic error term.

4.3.2.1. Redistribution

There are several diffirent measuresment techniques to quantify the amount of redistribution in any given economy. One of the measurements is the difference between pre-tax national income and post-tax disposable income. This method allows us to evaluate the level and impact of redistribution by measuring the change between the income individuals receive from the market and the income after government intervention. The data for this absolute approach to measuring redistribution of income can be found in the Fischer-Gethin dataset (Gethin, 2023). Another measure of redistribution is its share in Gross Domestic Product (GDP), which allows us to capture the relative level of redistribution. In this specification, redistribution is also defined as the difference between pre-tax national income and post-tax disposable income but relative to total output. The other measurement technique is the difference between pre-tax and post-tax Gini (Solt, 2019). According to this measurement, redistribution is the reduction in income inequality. Finally, we also consider the share of the bottom 50% income group in total income after redistribution (Gethin, 2023). Thus, we employ four different measures to test our hypotheses.

4.3.2.2. Hourly Wage

The hourly wage variable is calculated using data from the Penn World Table (PWT 10.01). The variable is obtained by multiplying the labor share of GDP (*Labsh*) by real GDP (*Rgdp*), divided by average working hours (*Avh*) and total employment (*Emp*):

$$Hourly\ wage_{it} = \frac{Labsh_{it} * Rgdp_{it}}{Avh_{it} * Emp_{it}} \tag{50}$$

This calculation represents the actual hourly labor costs, considering the share of labor in the production process. Thus, we will examine the effect of the average hourly wage on automation and analyze whether labor cost leads firms to automation.

4.3.2.3. Investment

The investment variable is calculated using PWT 10.01 data which provides both the capital stock and the depreciation rate of capital data. Hence, the investment amount is derived by considering the change in capital stock and the depreciation rate (δ_t) with the following formula:

$$Investment = capital_{it} - (1 - \delta_{it})\ capital_{i,t-1} \tag{51}$$

This calculation helps determine the level of real investment in the economy. In the analysis process, the effect of investment on automation will be examined using the logarithmic transformation of the variable. The investment variable essentially reflects its inverse relationship with the rental rate. Therefore, it serves as an indirect measure to capture the relationship between the rental rate and automation.

4.3.2.4. Productivity

The total factor productivity (TFP) variable is used to measure the impact of technological progress on automation. As in the study of Ünveren, et al. (2023), the TFP variable obtained from PWT is an important component in the model to evaluate long-term growth dynamics and productivity increases.

In this context, the study conducted by Ünveren et al. (2023) analyzed the interaction between artificial intelligence investments, income distribution and wages, and demonstrated the operation of automation through multiple equilibrium mechanisms. The findings of the study show that the effects of automation on income distribution

and wages can lead to different equilibria in different countries. Within the framework of this model, the role of TFP and investment variables on automation was examined in detail.

4.3.2.5. Other Control Variables

We include a set of control variables to account for the main economic and labor market factors that may influence redistribution. GDP per capita captures the level of economic development, which may affect redistribution preferences and capacity. Capital per employee is included as a proxy for economic development and structural capital intensity, which may influence a country's capacity and need for redistribution. Human capital represents the skill level of the labor force and may influence both labor market outcomes and redistributive policies. Including these controls helps reduce the risk of omitted variable bias. As confirmed by the Durbin-Wu-Hausman test, redistribution is endogenous. Therefore, we apply GMM-IV estimation and use cultural and political variables as instruments.

4.4. Endogeneity

In this econometric model, the effect of redistribution on automation will be examined. However, to address the endogeneity problem arising from reverse causality and omitted variable bias, the instrumental variable (IV) method will be employed. To overcome potential endogeneity problems in the model, religiosity and homophobia indices were used as instrumental variables.

To qualify as a valid IV, a variable should have a strong first stage and satisfy the exclusion restriction. In the present context, the former condition (i.e, strong first stage) is equivelant to a statistically significant correlation between religiosity and income redistribution. According to our dataset, the correlation between these two variables is negative when redistribution is defined as redistribution as a share of GDP. If redistribution is defined in logarithmic form, then the correlation is also negative. Similarly, we obtain a negative correlation when redistribution is defined as the difference between pre-tax and post-tax Gini coefficients (i.e., pre-tax minus post-tax Gini), and when it is defined as the bottom 50% redistribution share, respectively. Likewise, the literature clearly shows the close negative link between religiosity and

income redistribution (see Arıkan and Ben-Nun Bloom, 2019; Stegmueller et al., 2012; Stegmueller, 2013).

As for the exclusion restriction, we strongly maintain that there is no obvious reason to suspect that religiosity would impact automation investments. Investment in automation is a purely economic variable while religiosity is a cultural phenomenon. Of course, one could argue religiosity is strongly associated with low economic development which would hinder automation technologies. However, we control the level of economic development via GDP per capita. We also control for key economic factors that may influence automation, including human capital, capital per employee, average hourly wage, total factor productivity (TFP), and capital investment.

Similarly, homophobia is used as a cultural variable, and naturally, it cannot have a direct effect on automation. One might argue that it reflects underlying institutional structures, which could, in turn, influence economic outcomes. However, as with religiosity, we address this concern by including a comprehensive set of control variables, as previously mentioned.

The effect of religiosity on redistribution preferences was previously demonstrated by Arıkan and Ben-Nun Bloom (2019) and Jordan (2014), who showed that religious beliefs can support redistribution through prosocial values, but at the same time, strengthening conservative identity formation can lead to opposition to redistribution. This bidirectional effect supports the assumption that religiosity cannot be directly related to automation, but is indirectly related to it through redistribution preferences, and suggests that it is plausible to use as an instrumental variable. Similarly, in their study examining the effects of religion on economic development, Basedau et al. (2018) show that religion creates multidimensional effects and is a determinant in individuals' savings, education and institutional preferences. This supports the idea that religiosity may affect redistributive policies but will not have a direct effect on technological investment decisions.

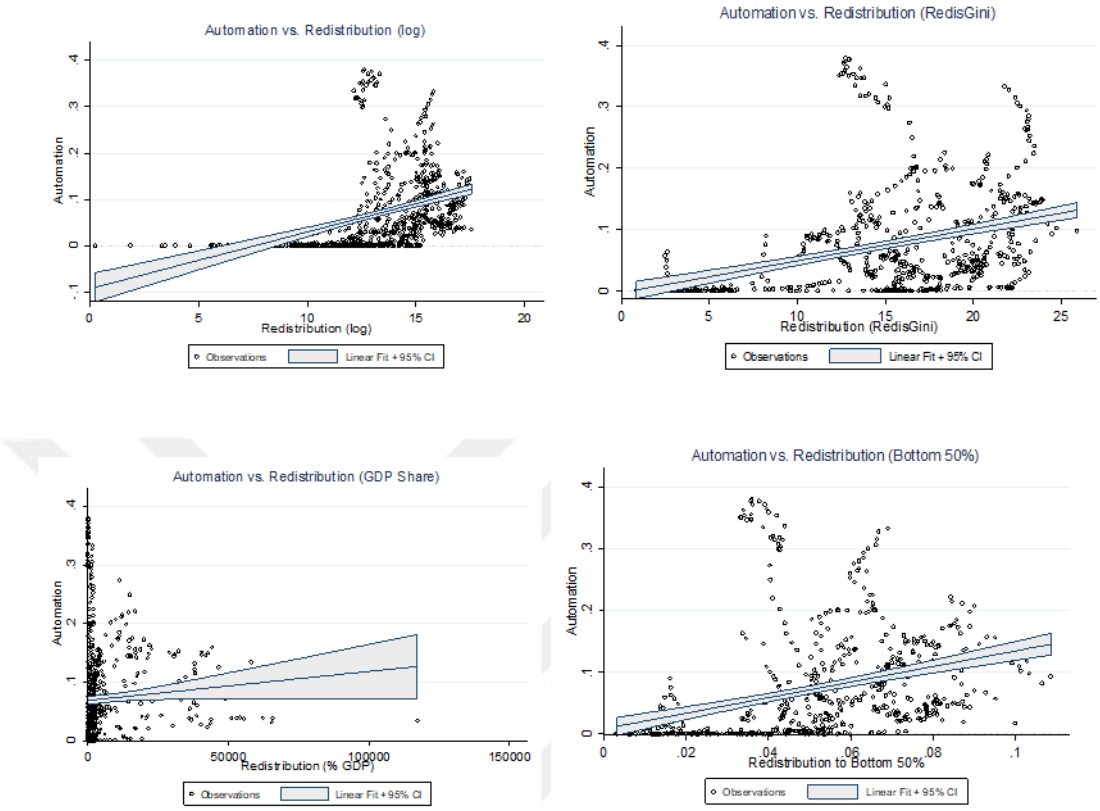
The homophobia index is a broad cultural variable that reflects the general structure of social values and institutional environment. The level of inclusiveness of societies may have an impact on the structure of labor markets and the state's response to redistributive policies. It is thought that both variables contribute to isolating the possible endogenous effect of redistribution on automation by providing exogeneity.

In addition, another instrumental variable included in the model is the democracy level of countries. The democracy variable is taken from the Varieties of Democracy (V-Dem) dataset and is assumed to affect automation decisions through the institutional structures and the policy-making processes. In more democratic countries, the protection of workers' rights, the strength of unions, and the effectiveness of social policies may limit firms' automation decisions or, conversely, encourage firms to automate due to better protected labor market structures. Basihos (2024) highlights the relationship between democracy and economic power, emphasizing the regulatory influence of democratic institutions on economic decisions. In addition, Acemoglu's evaluations on artificial intelligence and democracy suggest that artificial intelligence may threaten democratic institutions and authoritarian political structures in the long term. However, in this study, the focus is turned to the opposite direction of causality: the effect of democratic structures on technological transformation is analyzed. Thus, the indirect role of political institutions on technological change is evaluated.

4.5. Descriptive Statistics and Plots

This section visualizes the relationships between the main variables used in the analysis. First, the relationship between automation and redistribution is presented using different redistribution measurement methods. Then, the relationship between religiosity, which is used as an instrumental variable in the model, and redistribution is examined. These visuals are presented both to show the main trends among the variables and to support the background of the subsequent econometric analysis.

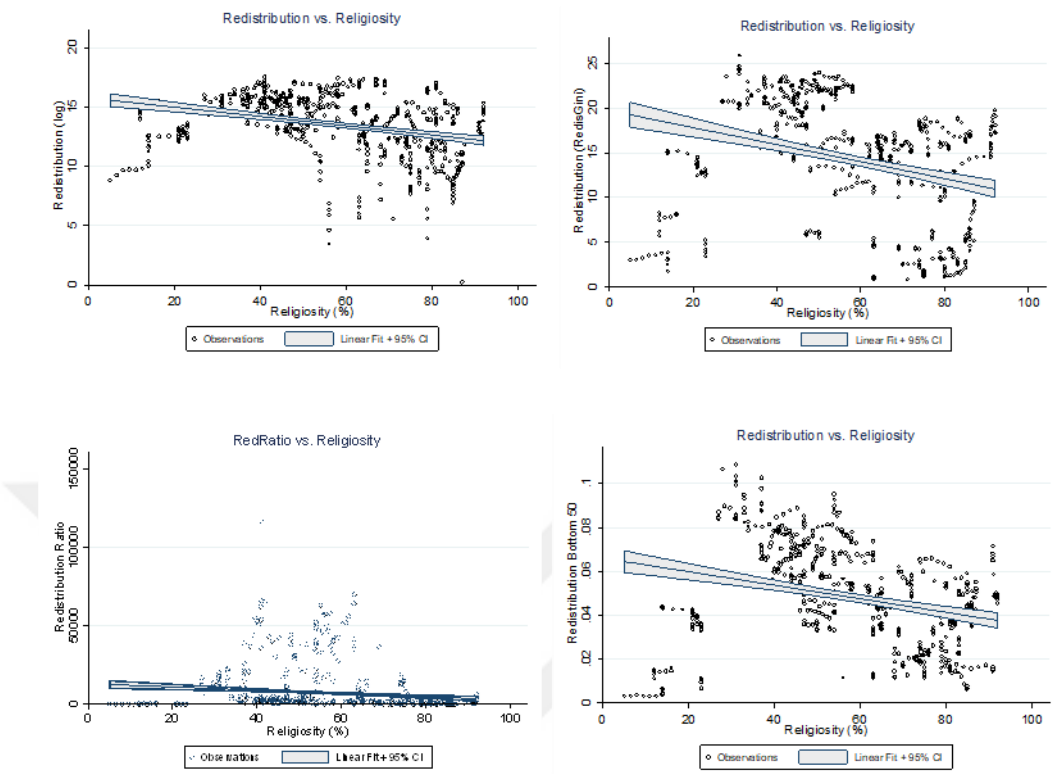
Figure 24. Correlation Between Automation and Redistribution Using Alternative Redistribution Indicators



Sources: International Federation of Robotics, Amory Gethin Dataset, Standardized World Income Inequality Database

In all four measurement methods used to capture redistribution, a positive relationship with automation is observed. However, the strength of this relationship varies across the different measures. It is important to emphasize that correlation does not imply causation. To identify the causal effect, the instrumental variable (IV) method is employed. Religiosity is used as the main instrument. The correlation between religiosity and the various measures of redistribution is presented below, representing the first stage of the IV estimation.

Figure 25. First-Stage Correlation: Religiosity vs. Redistribution Indicators



Sources: World Values Survey, Amory Gethin Dataset, Standardized World Income Inequality Database

The correlation between religiosity and the various measures of redistribution used in the first stage is shown above. Religiosity is negatively associated with all four redistribution indicators. This suggests that in societies with higher levels of religiosity, there is a lower tendency toward income equalization. Overall, the graphs support the validity of religiosity as a strong and consistent instrument for the first stage regression.

4.6. Result

In this section, the results of the econometric estimations are presented. The impact on automation is investigated using five different regressions. Firstly, for each redistribution data set, the baseline model is calculated and then the results are examined by adding control variables. All regressions were calculated with the GMM method. The reason for this is the existence of endogeneity as well as the autocorrelation and heteroscedasticity problem.

Table 5. Level-Level (Automation Rate(R/R+L), Redistribution/GDP)

	(1)	(2)	(3)	(4)
Redistribution Rate	0.1***	0.078***	0.074***	0.135***
	(0.02)	(0.018)	(0.017)	(0.03)
Hourly Wage	-0.03	-0.14***	-0.16***	0.094**
	(0.02)	(0.029)	(0.03)	(0.04)
Capital Investment	0.05***	0.05***	0.05***	0.09***
	(0.01)	(0.009)	(0.008)	(0.018)
Productivity	-0.24***	-0.35***	-0.27***	-0.04
	(0.05)	(0.06)	(0.05)	(0.07)
Year	0.003***	0.003***	0.003***	0.006***
	(0.00)	(0.00)	(0.00)	(0.001)
Capital per Emp.		0.14***	0.14**	0.26***
		(0.02)	(0.02)	(0.04)
Human Capital			0.14***	0.75***
			(0.05)	(0.17)
GDP per Capita				
				-0.62***
				(0.14)
Constant	-7.91***	-9.81***	-8.61***	-12.39***
	(1.71)	(1.66)	(1.64)	(2.72)
N	577	577	577	577
Hansen J	0.31	0.17	0.13	0.69

Note: Stars represent significant levels: * 0.1, ** 0.05, *** 0.01.

Table 5 shows the GMM estimation. All variables except the dependent variable and Redistribution Rate are in level. Religiosity and Homophobia are used as instruments. In all specified models (1-4), redistribution demonstrates statistically positive and significant effect on automation. Investment has consistently positive significant effect on automation. This indicates that as the rental rate decreases, investment in automation increases. Therefore, the result is consistent with fundamental economic theory which is represented by our simple general equilibrium model. Recall.that we theoretically demonstrate the positive impact of redisitribution on automation technologies in Section 2. The positive relationship between capital per worker and automation is also highly consistent with neoclassical models that incorporate automation. This is because capital is typically modeled as a complement to both labor and robots in these frameworks (Stegium, 2011; Prettner, 2017; Süssmuth et al., 2020).

Also, Hansen J statistics indicate that in all four models there is no overidentification problem. So, the instruments are strong.

Table 6. Level-Log Automation Rate(R/R+L), Redistribution

	(1)	(2)	(3)	(4)
Redistribution	0.036*** (0.007)	0.037*** (0.006)	0.037*** (0.006)	0.045*** (0.008)
Hourly Wage	0.023*** (0.007)	-0.1*** (0.02)	-0.1*** (0.02)	0.02 (0.03)
Capital Investment	0.21*** (0.004)	0.028*** (0.004)	0.027** (0.03)	0.035** (0.004)
Productivity	-0.2*** (0.046)	-0.3*** (0.05)	-0.31*** (0.06)	-0.24*** (0.07)
Year	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0015* (0.00)
Capital per Emp.		0.13*** (0.016)	0.13*** (0.017)	0.16*** (0.022)
Human Capital			-0.014 (0.05)	0.17** (0.08)
GDP per Capita				-0.23* (0.06)
Constant	-1.36 (1.4)	-4.2*** (1.35)	-4.29*** (1.37)	-4.5*** (1.47)
N	577	577	577	577
Hansen J	0.14	0.45	0.46	0.86

Note: Stars represent significant levels: * 0.1, ** 0.05, *** 0.01.

The only difference between Table 6 from Table 5 is the measurement method of redistribution. In this model redistribution is at a log level and still positive and significant. Hansen J test statistics show there is no overidentification for religiosity and homophobia.

Table 7. Level-Level Automation Rate(R/R+L), Before Tax- After Tax Gini

	(1)	(2)	(3)	(4)
Before Tax- After Tax Gini	0.027***	0.028***	0.028***	0.019***
	(0.007)	(0.007)	(0.006)	(0.003)
Hourly Wage	-0.13***	-0.24***	-0.27***	-0.32***
	(0.05)	(0.06)	(0.06)	(0.06)
Capital Investment	0.033***	0.04***	0.04***	0.027***
	(0.007)	(0.007)	(0.008)	(0.006)
Productivity	0.45***	0.37***	0.44***	0.13*
	(0.16)	(0.13)	(0.14)	(0.068)
Year	0.00	0.00	0.00	0.00
	(0.001)	(0.00)	(0.00)	(0.00)
Capital per Emp.		0.12***	0.12***	0.078***
		(0.02)	(0.02)	(0.012)
Human Capital			0.13*	-0.13**
			(0.078)	(0.065)
GDP per Capita				
Constant	-0.91	-2.99*	-1.85	-3.43***
	(1.99)	(1.63)	(1.76)	(1.18)
N	577	577	577	577
Hansen J	0.02	0.23	0.32	0.01

Note: Stars represent significant levels: * 0.1, ** 0.05, *** 0.01.

For the robustness of the model, we change the redistribution as Gini index. The results do not change significantly compared to the first two estimations. Redistribution is positive and significant. Also, we use democracy as an instrument instead of homophobia and the result is still robust

Table 8. Level-Log Automation Rate(R/R+L), Before Tax- After Tax Gini

	(1)	(2)	(3)	(4)
Before Tax- After Tax Gini	0.48***	0.35***	0.37***	0.29***
	(0.14)	(0.09)	(0.1)	(0.057)
Hourly Wage	-0.3***	-0.35**	-0.35***	-0.58***
	(0.1)	(0.088)	(0.09)	(0.11)
Capital Investment	0.034**	0.035***	0.036***	0.022***
	(0.009)	(0.007)	(0.007)	(0.004)
Productivity	1.12***	0.67***	0.65***	0.22**
	(0.37)	(0.21)	(0.22)	(0.1)
Year	-0.002	0.00	0.00	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Capital per Emp.		0.16***	0.15***	0.09***
		(0.03)	(0.03)	(0.02)
Human Capital			-0.12	-0.54***
			(0.09)	(0.13)
GDP per Capita				0.52***
				(0.11)
Constant	3.1	-2.1	-2.8	-2.87*
	(3.5)	(2.04)	(2.05)	(1.56)
N	577	577	577	577
Hansen J	0.67	0.13	0.17	0.75

Note: Stars represent significant levels: * 0.1, ** 0.05, *** 0.01.

Table 8 differs from Table 7 only in that the redistribution variable is used in logarithmic form. In this model, the log of the before–after-tax Gini is positive and statistically significant. Additionally, there is no overidentification problem in this specification.

Table 9. Level-Level Automation Rate(R/R+L), After- Before Tax Bottom %50 Share of Income Instruments: Homophobia and Democracy

	(1)	(2)	(3)	(4)
After- Before Tax Bottom %50 Share of Income	2.13*** (0.13)	0.42** (0.21)	0.35 (0.22)	0.56** (0.28)
Capital Investment	0.02** (0.003)	0.022*** (0.002)	0.022*** (0.002)	0.024*** (0.003)
Productivity	-0.13*** (0.02)	-0.15*** (0.016)	-0.13*** (0.017)	-0.11*** (0.017)
Year	0.0025*** (0.00)	0.002*** (0.00)	0.0016*** (0.00)	0.0018*** (0.00)
Capital per Emp.		0.05*** (0.005)	0046*** (0.005)	0.06*** (0.006)
Human Capital			0.036 (0.028)	0.085** (0.04)
GDP per Capita				-0.03** (0.015)
Constant	-5.67*** (0.94)	-4.94*** (0.87)	-4.45*** (1.01)	-4.74*** (1.05)
N	591	591	591	591
Hansen J	0.24	0.14	0.15	0.18

Note: Stars represent significant levels: * 0.1, ** 0.05, *** 0.01.

Lastly, we also use a different redistribution variable which is the after-before tax income share of bottom %50. Also, this model demonstrates that redistribution has a positive and significant effect on automation. In all five models, we consistently observe a positive and significant effect of investment. This highlights the inverse relationship between investment and its price, indicating that as the rental rate decreases, automation investment increases. Therefore, all 5 models prove that redistribution has a positive impact on automation.

4.7. Discussion

This study examines the effect of redistribution on automation through both theoretical and empirical approaches. The theoretical model employs a simple production framework that incorporates automation. In the model, the factors of production are skilled labor, unskilled labor, and robots. Robots are assumed to be substitutes for unskilled labor and complements to skilled labor. Both types of workers derive utility from consumption and leisure. The government collects income tax on post-production earnings and redistributes the revenue equally between the two types of workers. When robots are modeled as a function of redistribution, the analysis shows that redistribution increases the level of automation. This result is demonstrated analytically and further supported by a numerical simulation using calibrated parameter values. The mechanism of the model operates as follows: Redistribution increases the wage of unskilled workers, leading them to reduce their labor supply. To compensate for the reduced availability of unskilled labor, the demand for robots increases. In other words, as income is transferred from skilled to unskilled workers, the wage premium declines. This reduction in relative wage differences makes unskilled labor more expensive compared to robots, thereby encouraging greater adoption of automation.

Similarly, Süssmuth et al. (2020) theoretically and empirically show that increases in income and capital taxation lead to greater automation in the U.S. context, using a model that includes both traditional capital and robots but again assumes homogeneous labor. Our model differs in several respects: it is static rather than dynamic, features heterogeneous labor, and is supported by a panel data analysis rather than a time-series study focused solely on the U.S. Süssmuth et al. use cointegration and VECM techniques on U.S. time-series data, we apply GMM-IV estimations on a cross-country panel dataset and employ cultural instruments such as religiosity and homophobia to address endogeneity. These distinctions mark important differences in methodology and scope.

In the empirical part of the study, the effect of redistribution on automation is examined after measuring redistribution using various indicators. In the empirical analysis, redistribution is measured in two ways: as a share of GDP and as the logarithm of redistribution following Gethin (2023), calculated as the difference

between post-tax disposable income and pre-tax national income. Using these two measures separately, GMM-IV regressions are estimated, revealing that redistribution has a positive and statistically significant effect on automation. To address concerns of endogeneity and omitted variable bias, religiosity and homophobia are employed as instrumental variables in the first stage. The correlation between religiosity—our main instrument—and redistribution is demonstrated in correlation tables and supported by the existing literature. For robustness, an alternative measure of redistribution—defined as the difference between the pre-tax and post-tax Gini coefficients—is also used. This alternative specification confirms the main result, showing a positive and significant effect of redistribution on automation.

In summary, while much of the literature examines the causal relationship from automation to redistribution (Guerreiro et al., 2022; Korinek & Stiglitz, 2021; Gasteiger & Prettner, 2022; Thummel, 2019), this study approaches the question from the opposite direction. Both the theoretical and empirical findings indicate that the causality is bidirectional: redistribution, by increasing the relative price of labor, can trigger greater automation.

4.8. Conclusion

This study provides both theoretical and empirical evidence that redistribution can accelerate automation. While much of the existing literature focuses on the causal relationship from automation to redistribution, this paper highlights the possibility of reverse causality. The theoretical model illustrates how redistribution policies, by increasing the income of unskilled workers, raise their wages and reduce their labor supply. In response, firms are incentivized to replace labor with robots, leading to higher levels of automation. This mechanism is supported both analytically and through calibrated simulations. Also, we use GMM-IV panel data approach—that redistribution can raise effective labor costs, prompting firms to adopt labor-substituting technologies such as automation. To ensure robustness, multiple measures of redistribution are employed, and endogeneity concerns are addressed using religiosity as an instrumental variable. The results suggest that modern economies may be undergoing a transformation like the First Industrial Revolution, with the rapid rise of automation likely to continue. In this context, redistribution policies may inadvertently foster long-term innovation that is biased toward labor-saving

technologies. However, from another perspective, this situation can be seen as a win-win outcome. Although automation may initially seem detrimental to unskilled labor, this is not necessarily the case. Because the automation driven by rising wages increases both productivity and output, the resulting wage and employment losses for unskilled workers will not pose a long-term problem as long as redistribution continues. In this way, the technological progress initially triggered by redistribution—and the potential economic costs it imposes on certain groups—can ultimately be resolved through redistribution itself.

REFERENCES

Acemoglu, D. (2002). Directed technical change. *Review of Economic Studies*, *69*(4), 781–809. https://doi.org/10.1111/1467-937X.00226

Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. In O. Ashenfelter & D. Card (Eds.), Handbook of Labor Economics (Vol. 4B, pp. 1043–1171). Elsevier.

Acemoglu, D., & Johnson, S. (2023). *Power and progress: Our thousand-year struggle over technology and prosperity*. PublicAffairs.

Acemoglu, D., Manera, A., & Restrepo, P. (2020). *Does the US tax code favor automation?* (NBER Working Paper No. 27052). https://doi.org/10.3386/w27052

Acemoglu, D., & Restrepo, P. (2018). Modeling automation. *American Economic Review: Papers & Proceedings*, *108*, 48–53.

Acemoglu, D., & Restrepo, P. (2018). The race between man and machine: Implications of technology for growth, factor shares, and employment. *American Economic Review*, *108*(6), 1488–1542.

Acemoglu, D., & Restrepo, P. (2019). Automation and new tasks: How technology displaces and reinstates labor. *Journal of Economic Perspectives*, *33*(2), 3–30. https://doi.org/10.1257/jep.33.2.3

Acemoglu, D., & Restrepo, P. (2020). Robots and jobs: Evidence from US labor markets. *Journal of Political Economy*, *128*(6), 2188–2244. https://doi.org/10.1086/705716

Acemoglu, D., & Restrepo, P. (2022). Demographics and automation. *Review of Economic Studies*, *89*(1), 1–44.

Acemoglu, D., & Restrepo, P. (2022). Tasks, automation, and the rise in U.S. wage inequality. *Econometrica*, *90*(5), 1973–2016.

Acemoglu, D., Autor, D., Hazell, J., & Restrepo, P. (2021). *AI and jobs: Evidence from online vacancies* (NBER Working Paper No. 28257). https://doi.org/10.3386/w28257

Acemoglu, D., Golosov, M., & Tsyvinski, A. (2010). Dynamic Mirrlees taxation under political economy constraints. *Review of Economic Studies*, *77*(3), 841–881.

Acemoglu, D., Koster, H. R. A., & Ozgen, C. (2023). *Robots and workers: Evidence from the Netherlands* (NBER Working Paper No. 31009). https://doi.org/10.3386/w31009

Akcigit, U., Grigsby, J., Nicholas, T., & Stantcheva, S. (2022). Taxation and innovation in the twentieth century. *Quarterly Journal of Economics*, *137*(1),

329–385. https://doi.org/10.1093/qje/qjab022stantcheva.scholars.harvard.edu+2

Ales, L., Kurnaz, M., & Sleet, C. (2015). Technical change, wage inequality, and taxes. *American Economic Review*, *105*(10), 3061–3101.

Allen, R. C. (2009). *The British Industrial Revolution in global perspective*. Cambridge University Press.

Anelli, M., Colantone, I., & Stanig, P. (2021). Individual vulnerability to industrial robot adoption increases support for the radical right. *Proceedings of the National Academy of Sciences*, *118*(47).

Arıkan, G., & Ben-Nun Bloom, P. (2019). Religion and support for redistribution: The mediating role of values. *Political Psychology*, *40*(5), 1095–1114.

Atkinson, R. D. (2019). *The case against taxing robots (ITIF Report)*. Information Technology and Innovation Foundation.

Atolia, M., Holland, M., & Kreamer, J. (2024). Optimal taxes and basic income during an episode of automation: A worker's perspective. *Macroeconomic Dynamics*, 1–27. https://doi.org/10.1017/S1365100524000361

Aum, S., & Shin, Y. (2024). *Is software eating the world?* (NBER Working Paper No. 32591). https://doi.org/10.3386/w32591

Auray, S., & Eyquem, A. (2018). *Robots in a small open economy (Working Paper No. 2018-17)*. Center for Research in Economics and Statistics (CREST). https://crest.science/RePEc/wpstorage/2018-17.pdf

Autor, D. H., & Dorn, D. (2013). The growth of low-skill service jobs and the polarization of the US labor market. *American Economic Review*, *103*(5), 1553–1597.

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *Quarterly Journal of Economics*, *118*(4), 1279–1333. https://doi.org/10.1162/003355303322552801

Autor, D., Dorn, D., & Hanson, G. H. (2013). The China Syndrome: Local labor market effects of import competition in the United States. *American Economic Review*, *103*(6), 2121–2168.

Babina, T., Bernstein, S., De Haas, R., & Tang, H. (2024). Artificial intelligence, firm growth, and product innovation. *Journal of Financial Economics*, *152*(1), 1–30.

Bartels, L. M. (2016). *Unequal democracy: The political economy of the new gilded age*. Princeton University Press.

Basedau, M., Gobien, S., & Prediger, S. (2018). The multidimensional effects of religion on socioeconomic development: A review of the empirical literature. *Journal of Economic Surveys*, *32*(4), 1106–1133. https://doi.org/10.1111/joes.12250

Basihos, S. (2024). *Market power is political power! The pressure of declining competition on democracy* (Working Paper). University of Cambridge.

Battisti, M., & Gravina, A. F. (2021). Do robots complement or substitute for older workers? *Economics Letters*, *208*, 110064.

Benzell, S. G., Kotlikoff, L. J., LaGarda, G., & Sachs, J. D. (2015). *Robots are us: Some economics of human replacement* (NBER Working Paper No. 20941). https://doi.org/10.3386/w20941

Bessen, J. E., Goos, M., Salomons, A., & Van den Berge, W. (2023). Automatic reaction: What happens to workers at firms that automate? *Review of Economics and Statistics*, *105*(1), 1–16.

Blanchard, O. (1997). The medium run. *Brookings Papers on Economic Activity*, *1997*(2), 89–158.

Bloom, D. E., Prettner, K., Saadaoui, J., & Veruete, M. (2024). *Artificial intelligence and the skill premium* (NBER Working Paper No. 32430). https://doi.org/10.57938/e950e0b9-4702-46c6-b76a-d187a6737540

Bonfiglioli, A., Crinò, R., Fadinger, H., & Gancia, G. (2020). *Robot imports and firm-level outcomes* (CEPR Discussion Paper No. 14593). Centre for Economic Policy Research.

Brynjolfsson, E., Li, D., & Raymond, L. (2023). *Generative AI at work* (NBER Working Paper No. 31161). https://doi.org/10.3386/w31161

Caballero, R. J., & Hammour, M. L. (1998). Jobless growth: Appropriability, factor substitution, and unemployment. *Carnegie-Rochester Conference Series on Public Policy*, *48*(1), 51–94.

Cabrales, A., Hernández, P., & Sánchez, A. (2020). Robots, labor markets, and universal basic income. *PLOS ONE*, *15*(12), e0243850.

Carnegie Endowment for International Peace. (2024). *Turkey's electoral map explained: Actors, dynamics, and future prospects*. Retrieved from https://carnegieendowment.org

Caselli, M., Fracasso, A., & Traverso, S. (2020). Globalization, robotization, and electoral outcomes: Evidence from spatial regressions for Italy. *Journal of Regional Science*, *61*(1), 86–111.

Coppedge, M., Gerring, J., Knutsen, C. H., Lindberg, S. I., Teorell, J., & V-Dem Team. (2023). *Varieties of Democracy (V-Dem) Dataset – Version 13*. University of Gothenburg. https://www.v-dem.net

Costinot, A., & Werning, I. (2023). Robots, trade, and Luddism: A sufficient statistic approach to optimal technology regulation. *The Review of Economic Studies*, *90*(5), 2261–2291.

Curtis, E. M., Eden, B., & Glover, A. (2021). Do capital investment tax incentives work? Evidence from the bonus depreciation policy. *American Economic Journal: Economic Policy*, *13*(4), 263–291.

Dauth, W., Findeisen, S., Südekum, J., & Woessner, N. (2021). The adjustment of labor markets to robots. *Journal of the European Economic Association*, *19*(6), 3104–3153. https://doi.org/10.1093/jeea/jvab012

De Donder, P., & Hindriks, J. (2007). Equilibrium social insurance with policy-motivated parties. *European Journal of Political Economy*, *23*(3), 624–640.

De Vries, G. J., Gentile, E., Miroudot, S., & Wacker, K. M. (2020). The rise of robots and the fall of routine jobs. *Labour Economics*, *66*, 101885.

Dimitrova, L., & Eswar, S. K. (2018). Capital gains tax and innovation. *Northwestern Law & Economics Research Paper No. 18-09*.

Durlauf, S. N., Kourtellos, A., & Tan, C. M. (2022). The Great Gatsby Curve. *Annual Review of Economics*, *14*(1), 571–605.

Eden, M., & Gaggl, P. (2020). On the welfare implications of automation. *Review of Economic Dynamics*, *37*(1), 135–157.

Farhi, E., & Werning, I. (2008). The political economy of nonlinear capital taxation. *mimeo*.

Farhi, E., Sleet, C., Werning, I., & Yeltekin, S. (2012). Non-linear capital taxation without commitment. *The Review of Economic Studies*, *79*(4), 1469–1493.

Feenstra, R. C., Inklaar, R., & Timmer, M. P. (2015). The next generation of the Penn World Table. *American Economic Review*, *105*(10), 3150–3182.

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, *114*, 254–280. https://doi.org/10.1016/j.techfore.2016.08.019

Gasteiger, E., & Prettner, K. (2022). Automation, stagnation, and the implications of a robot tax. *Macroeconomic Dynamics*, *26*(1), 218–249.

Gethin, A. (2023). *Government redistribution and development dataset*. https://amory-gethin.fr/data.html

Gilfoyle, A. (2023). *The impact of automation on income inequality: A cross-country analysis (arXiv Working Paper No. 2304.07835)*. arXiv.

Graetz, G., & Michaels, G. (2018). Robots at work. *Review of Economics and Statistics*, *100*(5), 753–768. https://doi.org/10.1162/rest_a_00754

Guerreiro, J., Rebelo, S., & Teles, P. (2023). Should robots be taxed? *Journal of Political Economy*, *131*(1), 71–121.

Habakkuk, H. J. (1962). *American and British technology in the nineteenth century: The search for labour-saving inventions*. Cambridge University Press.

Hémous, D., & Olsen, M. (2022). The rise of the machines: Automation, horizontal innovation, and income inequality. *American Economic Journal: Macroeconomics*, *14*(1), 179–223.

Hémous, D., Olsen, M., Zanella, C., & Dechezleprêtre, A. (2025). Induced automation innovation: Evidence from firm-level patent data. *Journal of Political Economy, 133*(6), 1975–2028. https://doih.org/10.1086/734778

Hirvonen, T., Leino, T., & Mankinen, R. (2022). Investment subsidies and firm outcomes: Evidence from Finland. *VATT Institute for Economic Research*.

Hötte, K., Theodorakopoulos, A., & Koutroumpis, P. (2024). Automation and taxation. *Oxford Economic Papers*, *76*(4), 945–969. https://doi.org/10.1093/oep/gpae006

Huggett, M., Ventura, G., & Yaron, A. (2011). Sources of lifetime inequality. *American Economic Review*, *101*(7), 2923–2954. https://doi.org/10.1257/aer.101.7.2923

Humlum, A. (2021, November 28). *Robot adoption and labor market dynamics* [Unpublished job market paper]. University of Chicago.

Im, Z., Mayer, N., Palier, B., & Rovny, J. (2019). The "losers of automation": A reservoir of votes for the radical right? *Research and Politics*, January–March, 1–7.

International Federation of Robotics (IFR). (2022). *World Robotics Report 2022*. https://ifr.org/worldrobotics

Jerrim, J., & Macmillan, L. (2015). Income inequality, intergenerational mobility, and the Great Gatsby Curve: Is education the key? *Social Forces*, *94*(2), 505–533. https://doi.org/10.1093/sf/sov075

Jordan, J. (2014). Religious belief, religious denomination, and preferences for redistribution: A comparison across 13 countries. *European Journal of Political Research*, *53*(2), 279–297. https://doi.org/10.6084/m9.figshare.1609730.v2

Jurkat, A., Klump, R., & Schneider, F. (2022). Tracking the rise of robots: The IFR database. *Jahrbücher für Nationalökonomie und Statistik*, *242*(5–6), 669–689.

Kirkpatrick, A. W., & Hmielowski, J. D. (2025). Automation and support for a universal basic income: Awareness, anxiety and the moderating role of income and education. *Basic Income Studies*. Advance online publication. https://doi.org/10.1515/bis-2023-0016

Klüver, H. (2020). Setting the party agenda: Interest groups, voters and issue attention. *British Journal of Political Science*, *50*(3), 979–1000.

Koch, M., Manuylov, I., & Smolka, M. (2021). Robots and firms. *The Economic Journal*, *131*(638), 2553–2584.

Korinek, A., & Stiglitz, J. E. (2021). Artificial intelligence and its implications for income distribution and unemployment. In A. Agrawal, J. Gans, & A. Goldfarb (Eds.), *The economics of artificial intelligence: An agenda* (pp. 349–390). University of Chicago Press.

Koru, Ö. F. (2024). *Automation and top wealth inequality*. University of Pennsylvania.

Kovacev, R. (2020). A taxing dilemma: Robot taxes and the challenges of effective taxation of AI, automation and robotics in the Fourth Industrial Revolution. *The Ohio State Technology Law Journal*, *16*(1), 183–217.

Laslier, J.-F., & Öztürk-Göktuna, B. (2016). Opportunist politicians and the evolution of electoral competition. *Journal of Evolutionary Economics*, *26*(2), 381–406. https://doi.org/10.1007/s00191-016-0444-x

Lee, W. (2011). Bandwagon, underdog, and political competition: The uni-dimensional case. *Social Choice and Welfare*, *36*(3–4), 423–449.

Li, J., Wu, Z., Yu, K., & Zhao, W. (2024). The effect of industrial robot adoption on firm value: Evidence from China. *Finance Research Letters*, *60*, 104907. https://doi.org/10.1016/j.frl.2023.104907

Liu, F., & Liang, C. (2025). Analyzing wealth distribution effects of artificial intelligence: A dynamic stochastic general equilibrium approach. *Heliyon*, *11*(2), e41943. https://doi.org/10.1016/j.heliyon.2025.e41943

Llavador, H., & Solano-García, Á. (2011). Immigration policy with partisan parties. *Journal of Public Economics*, *95*(1–2), 134–142.

McKinsey Global Institute. (2020). *The automation age: Implications for employment and income inequality*. https://www.mckinsey.com/featured-insights/artificial-intelligence/five-fifty-fear-fear-not

Moll, B., Rachel, L., & Restrepo, P. (2022). Uneven growth: Automation's impact on income and wealth inequality. *Econometrica, 90*(6), 2645–2683. https://doi.org/10.3982/ECTA19417

OECD. (2017). *The next production revolution: Implications for governments and business*. OECD Publishing.

OECD. (2018). *OECD employment outlook 2018*. OECD Publishing. https://doi.org/10.1787/empl_outlook-2018-en

Özbudun, E. (2014). AKP at the crossroads: Erdoğan's majoritarian drift. *South European Society and Politics*, *19*(2), 155–167. https://doi.org/10.1080/13608746.2014.920571

Öztürk-Göktuna, B. (2019). A dynamic model of party membership and ideologies. *Journal of Theoretical Politics*, *31*(2), 209–243. https://doi.org/10.1177/0951629819833185

Persson, T., & Tabellini, G. (1994). Representative democracy and capital taxation. *Journal of Public Economics*, *55*(1), 53–70.

Pew Research Center. (2024). *Partisanship by race, ethnicity, and education*. Retrieved from https://www.pewresearch.org

Piketty, T. (2014). *Capital in the twenty-first century*. Harvard University Press.

Prettner, K. (2017). The implications of automation for economy growth and the labor share. *Macroeconomic Dynamics*, *12*, 1–8.

Prettner, K., & Strulik, H. (2020). Innovation, automation, and inequality: Policy challenges in the race against the machine. *Journal of Monetary Economics*, *116*, 249–265.

Restrepo, P. (2024). Automation: Theory, evidence, and outlook. *Annual Review of Economics, 16*(1), 1–25. https://doi.org/10.1146/annurev-economics-090523-113355

Roemer, J. E. (2001). *Political competition: Theory and applications*. Harvard University Press.

Rubin, R. (2020, January 20). The 'robot tax' debate heats up. *Wall Street Journal*.

Schulz, K., Tsyvinski, A., & Werquin, N. (2022, May). *Generalized compensation principle* (Working Paper No. 2022-18). Federal Reserve Bank of Chicago. https://doi.org/10.21033/wp-2022-18

Shome, P. (2022). Taxation of robots. *The Governance Brief*, (44).

Smirnov, O., & Fowler, J. H. (2007). Policy-motivated parties in dynamic political competition. *Journal of Theoretical Politics*, *19*(1), 9–31.

Solt, F. (2019). *The Standardized World Income Inequality Database*. Harvard Dataverse.

Stegmueller, D. (2013). Religion and redistributive voting in Western Europe. *The Journal of Politics*, *75*(4), 1064–1076.

Stegmueller, D., Scheepers, P., Roßteutscher, S., & de Jong, E. (2012). Support for redistribution in Western Europe: Assessing the role of religion. *European Sociological Review*, *28*(4), 482–497. https://doi.org/10.1093/esr/jcr011

Steigum, E. (2011). Robotics and growth. In O. de la Grandville (Ed.), Frontiers of economics and globalization: Economic growth and development (Vol. 11, pp. 543–555). Emerald Group Publishing. https://doi.org/10.1108/S1574-8715(2011)0000011026

Stiglitz, J. E. (2012). *The price of inequality: How today's divided society endangers our future*. W.W. Norton & Company.

Süssmuth, B., Irmen, A., & Heer, B. (2020). Taxation, automation capital, and the functional income distribution. In *Beiträge zur Jahrestagung des Vereins für Socialpolitik 2020: Gender Economics*. ZBW – Leibniz Information Centre for Economics.

The Economist. (2023, February 25). Why there's no robot tax yet. *The Economist*. https://www.economist.com/finance-and-economics/2017/02/25/why-taxing-robots-is-not-a-good-idea

Thuemmel, U. (2023). Optimal taxation of robots. *Journal of the European Economic Association*, *21*(3), 1154–1190.

Thumel, M. (2019). Taxation of robots: Recommendations for policymakers. *Intereconomics*, *54*(6), 358–364.

Tuğal, C. (2009). *Passive revolution: Absorbing the Islamic challenge to capitalism*. Stanford University Press.

U.S. Bureau of Labor Statistics. (2025). *Total factor productivity trends in the private nonfarm business sector, 2024 (USDL-24-0450)*. https://www.bls.gov/news.release/pdf/prod3.pdf

Ünveren, B., Durmaz, T., & Sunal, S. (2023). AI revolution and coordination failure: Theory and evidence. *Journal of Macroeconomics*, *78*, 103561. https://doi.org/10.1016/j.jmacro.2023.103561

Wang, P., & Wong, T.-N. (2025, May). *Artificial Intelligence and Technological Unemployment* (NBER Working Paper No. 33867). National Bureau of Economic Research. https://doi.org/10.3386/w33867

Wittman, D. (1973). Parties as utility maximizers. *American Political Science Review*, *67*(2), 490–498.

World Values Survey Association. (2022). *World Values Survey: Wave 7 (2017–2022) [Data set]*. https://www.worldvaluessurvey.org/WVSDocumentationWV7.jsp

APPENDIX

Appendix 1.

This appendix presents the equilibrium levels of wages, consumption, labor supply, robot deployment, and provision of the public good as a function of the policy variables. We focus on the interior equilibrium, but the results can be easily generalized to the boundary cases.

Given the production technology in Eq (2), the profit maximization problem in Eq (3) implies that the market equilibrium wages as a function of policy variables is:

$$w_r^* = \phi(1+\tau) \text{ and } w_n^* = \alpha A \beta^{\frac{1}{\alpha}-1}, \tag{52}$$

where:

$$\beta \coloneqq \frac{(1-\alpha)A}{(1+\tau)\phi}. \tag{53}$$

Recall that the preferences are given in Eq (4). Therefore, the utility maximizing consumption and labor supply decisions by individual $i = n, r$ are:

$$c_i^* = \frac{1-t}{1+v} w_i^* \text{ and } l_i^* = \frac{1}{1+v}. \tag{54}$$

Given the robot price $\rho^* = \phi$ due to Eq (1), the profit maximization yields:

$$R^* = \frac{n_n \beta^{\frac{1}{\alpha}} - n_r}{1+v} \text{ and } L_i^* = \frac{n_i}{1+v} \text{ for } i = n, r. \tag{55}$$

So, due to Eq (7), the level of public good provision is:

$$G^* = \frac{n_r t w_r^*}{1+v} + \frac{n_n t w_n^*}{1+v} + \tau \phi R^*. \tag{56}$$

Appendix 2.

This appendix proves Theorem 1: the existence of a Wittman equilibrium, which is the Nash equilibrium of the game where two political parties choose the robot tax policies to maximize the expected utilities of the workers that they represent.

Following Roemer (2001, p.63), we define the *sets of decent responses by party R and N* as:

$$\nabla_R(\tau^N) \coloneqq \{\tau^R \in T^U : v^r(\tau^R, t) > v^r(\tau^N, t)\},$$

and:

$$\nabla_N(\tau^R) \coloneqq \{\tau^N \in T^U : v^r(\tau^N, t) > v^r(\tau^R, t)\},$$

respectively. According to Theorem 3.3 of Roemer (2001, p.65), a Wittman equilibrium exists if V^J is quasi-concave in τ^J on $\nabla_J(\cdot)$. In other words, to prove the existence of equilibrium, we need to show:

$$\frac{dV^J}{d\tau^J} = 0 \text{ implies } \frac{d^2V^J}{d\tau^J d\tau^J} \leq 0 \text{ for all } J = N, R, \tag{57}$$

over the sets of decent responses.

A set of sufficient conditions for the second order derivatives of V^J to be non-positive is the concavity of $v^j, j = n, r$ (indirect utility functions) and the log-concavity of Π (see Corollary 3.2, p.68 in Roemer (2001))[7]. To show the concavity of indirect utility functions, the first step is proving the concavity of the public good with respect to automation policy.

Lemma 2. G^* is concave in τ.

Proof. First, write:

$$\frac{dG^*}{d\tau} \coloneqq G^*_\tau \text{ and } \frac{d^2G^*}{d\tau^2} \coloneqq G^*_{\tau\tau}.$$

Due to (52), (55), and (56), we have:

$$G^* = \frac{n_r t(1+\tau)\phi - n_r\tau\phi}{1+\nu} + \frac{n_n t\alpha A\beta^{\frac{1}{\alpha}-1}}{1+\nu} + \frac{\tau\phi n_n\beta^{1/\alpha}}{1+\nu}$$

[7] An alternative but equivalent proof is available upon request from the authors.

Therefore, G_τ^* satisfies:

$$(1+\nu)G_\tau^* = -(1-t)n_r\phi + n_n tA(1-\alpha)\beta^{\frac{1}{\alpha}-2}\beta' + \phi n_n\beta^{\frac{1}{\alpha}} + \phi n_n\beta^{\frac{1}{\alpha}-1}\left(\frac{1}{\alpha}\right)\beta'\tau \tag{58}$$

where β' is the derivative of β with respect to τ. However, (53) implies:

$$\frac{\beta'}{\beta} = -\frac{1}{(1+\tau)}.$$

Therefore, (58) simplifies to:

$$(1+\nu)G_\tau^* = -(1-t)n_r\phi - n_n t\phi\beta^{\frac{1}{\alpha}} + \phi n_n\beta^{\frac{1}{\alpha}} - \left(\frac{1}{\alpha}\right)\frac{\phi n_n\tau\beta^{\frac{1}{\alpha}}}{1+\tau}.$$

Deduce that:

$$(1+\nu)G_{\tau\tau}^* = -\frac{\left(-t+1-\left(\frac{1}{\alpha}\right)\frac{\tau}{1+\tau}\right)\frac{1}{\alpha}\phi n_n\beta^{\frac{1}{\alpha}}}{1+\tau} - \left(1+\left(\frac{1}{\alpha}\right)\frac{\tau}{(1+\tau)^2}\right)\phi n_n\beta^{\frac{1}{\alpha}} < 0.$$

This gives the desired result. ■

The following lemma establishes that the indirect utility functions are indeed concave.

Lemma 3. If G^* is concave in τ, then:

$$\frac{d^2v^r}{d\tau^R d\tau^R} < 0 \; and \; \frac{d^2v^n}{d\tau^N d\tau^N} < 0.$$

Proof. Recall that $v^i = c_i^*(1-l_i^*)^\nu(G^*)^\theta$. Therefore,

$$\frac{dv^i}{d\tau} = (1-l_i^*)^\nu(G^*)^\theta\left(\frac{dc_i^*}{d\tau}\right) + \theta c_i^*(1-l_i^*)^\nu(G^*)^{\theta-1}\left(\frac{dG^*}{d\tau}\right)$$

implies:

$$\frac{d^2v^i}{d\tau^2} = (1-l_i^*)^\nu(G^*)^\theta\left(\frac{d^2c_i^*}{d\tau^2}\right) + 2(1-l_i^*)^\nu(G^*)^{\theta-1}\theta\left(\frac{dc_i^*}{d\tau}\right)\left(\frac{dG^*}{d\tau}\right) + \theta(\theta-1)c_i^*(1-l_i^*)^\nu(G^*)^{\theta-2}\left(\frac{dG^*}{d\tau}\right)^2 + \theta c_i^*(1-l_i^*)^\nu(G^*)^{\theta-1}\left(\frac{d^2G^*}{d\tau^2}\right).$$

If $i = r$, then c_r^* is linear in τ. This ensures:

$$\frac{d^2 u_r^*}{d\tau^2} < 0,$$

assuming G^* is concave in τ. If $i = n$, then:

$$\begin{aligned}\frac{d^2 u_i^*}{d\tau^2} &= (1 - l_i^*)^{\nu}(G^*)^{\theta}\left(\frac{d^2 c_i^*}{d\tau^2}\right) + 2(1 - l_i^*)^{\nu}(G^*)^{\theta-1}\theta\left(\frac{dc_i^*}{d\tau}\right)\left(\frac{dG^*}{d\tau}\right) \\ &\quad + \theta(\theta - 1)c_i^*(1 - l_i^*)^{\nu}(G^*)^{\theta-2}\left(\frac{dG^*}{d\tau}\right)^2 \\ &\quad + \theta c_i^*(1 - l_i^*)^{\nu}(G^*)^{\theta-1}\left(\frac{d^2 G^*}{d\tau^2}\right) \\ &= -(1 - l_i^*)^{\nu}(G^*)^{\theta}\frac{1}{(1+\tau)}\left(\frac{1}{\alpha}\right)\frac{dc_i^*}{d\tau} \\ &\quad - 2(1 - l_i^*)^{\nu}(G^*)^{\theta-1}\theta\frac{c_i^*}{(1+\tau)}\left(\frac{1}{\alpha} - 1\right)\left(\frac{dG^*}{d\tau}\right) \\ &\quad + \theta(\theta - 1)c_i^*(1 - l_i^*)^{\nu}(G^*)^{\theta-2}\left(\frac{dG^*}{d\tau}\right)^2 \\ &\quad + \theta c_i^*(1 - l_i^*)^{\nu}(G^*)^{\theta-1}\left(\frac{d^2 G^*}{d\tau^2}\right).\end{aligned}$$

because:

$$\frac{dc_i^*}{d\tau} = \frac{(1-t)}{(1+v)(1+\tau)}\alpha A\beta^{\frac{1}{\alpha}-1}\left(\frac{1}{\alpha} - 1\right) = -\frac{c_i^*}{(1+\tau)}\left(\frac{1}{\alpha} - 1\right)$$

$$\frac{d^2 c_i^*}{d\tau^2} = -\frac{1}{(1+\tau)}\left(\frac{1}{\alpha} - 1\right)\frac{dc_i^*}{d\tau} - \frac{1}{(1+\tau)}\frac{dc_i^*}{d\tau} = -\frac{1}{(1+\tau)}\left(\frac{1}{\alpha}\right)\frac{dc_i^*}{d\tau}.$$

Hence,

$$\begin{aligned}\frac{d^2 u_i^*}{d\tau^2} &< -(1 - l_i^*)^{\nu}(G^*)^{\theta}\frac{1}{(1+\tau)}\left(\frac{1}{\alpha}\right)\frac{dc_i^*}{d\tau} - \theta c_i^*(1 - l_i^*)^{\nu}(G^*)^{\theta-1}\frac{G_\tau^*}{(1+\tau)\alpha} \\ &= -\frac{1}{(1+\tau)\alpha}\frac{du_i^*}{d\tau} \leq 0. \blacksquare\end{aligned}$$

The only remaining step is proving the log-concavity of Π. This means:

$$(\ln \Pi)'' = \frac{\Pi''}{\Pi} - \left(\frac{\Pi'}{\Pi}\right)^2 \leq 0,$$

where:

$$\Pi' \coloneqq \frac{d\Pi}{d\tau^R} \text{ and } \Pi'' \coloneqq \frac{d^2\Pi}{d\tau^R d\tau^R}.$$

To achieve this, we need to define:

$$\Delta v^r \coloneqq v^r(\tau^R, t) - v^r(\tau^N, t),$$

and:

$$\Delta v^n \coloneqq v^n(\tau^N, t) - v^n(\tau^R, t).$$

So, we have the following result:

Lemma 1: If $\Delta v^j > 0$ and v^j is concave for all $j = n, r$, and then:

$$\Pi''\Pi - (\Pi')^2 \leq 0 \tag{59}$$

Proof. We start with noting that, under the hypotheses of our model, the probability of the winning the election for Party R is:

$$\Pi = 1 - \frac{2}{Pi}\arctan\left(-\frac{a^n}{a^r}\right), \; where \; Pi \approx 3{,}14 \ldots \tag{60}$$

according to Roemer, p. 253 (2001). The trigonometric expressions appear here because the compact interval for the univariate random variable is extended to a two-dimensional compact disc.

Now define:

$$a \coloneqq -\frac{\Delta v^n}{\Delta v^r}\frac{v^r}{v^n}.$$

Therefore, by definition, we can re-express the success probability as:

$$\Pi \coloneqq 1 - \frac{2}{Pi}\arctan(-a).$$

We write:

$$a' \coloneqq \frac{da}{d\tau^R} \text{ and } \Pi' \coloneqq \frac{d\Pi}{\mathrm{d}\tau^R}.$$

Note that:

$$\Pi' = \frac{2}{Pi}\,\frac{1}{1+a^2}\,a',$$

according to the calculus rules of trigonometric functions. This implies:

$$\Pi'' = \frac{2}{Pi}\left(\left(\frac{1}{1+a^2}\right)\, a'' - \frac{2a}{(1+a^2)^2}(a')^2\right).$$

Now let us plug these derivatives into (59) to obtain:

$$\begin{aligned}\Pi''\Pi - (\Pi')^2 &= \frac{2}{Pi}\Pi\left(\left(\frac{1}{1+a^2}\right)\, a'' - \frac{2a}{(1+a^2)^2}(a')^2\right) - \left(\frac{2}{Pi}\,\frac{1}{1+a^2}\, a'\right)^2 \\ &= \frac{2}{Pi}\Pi\left(\left(\frac{1}{1+a^2}\right)\, a'' - \frac{2a}{(1+a^2)^2}(a')^2 - \frac{2}{Pi\Pi}\,\frac{1}{(1+a^2)^2}(\, a')^2\right) \\ &= \frac{2}{Pi}\Pi\left(\left(\frac{1}{1+a^2}\right)\, a'' - \left(1+\frac{1}{aPi\Pi}\right)\frac{2a}{(1+a^2)^2}(a')^2\right) \\ &< \frac{2}{Pi}\Pi\left(\left(\frac{1}{1+a^2}\right)\, a'' - \frac{a}{(1+a^2)^2}(a')^2\right).\end{aligned}$$

Note that the last inequality follows from:

$$\left(1+\frac{1}{aPi\Pi}\right) \leq \frac{1}{2},$$

which is a direct consequence of the definition of Π. Now we shall see that:

$$\left(\frac{1}{1+a^2}\right)a'' - \frac{a}{(1+a^2)^2}(a')^2 < 0.$$

To see this, take the derivative of a to obtain:

$$a' = \left(v_n'\frac{v^r}{v^n}\frac{1}{\Delta v^r}\right) + \left(v_r'\frac{v^r}{(v^n)^2}\frac{\Delta v^n}{\Delta v^r}\right) - \left(v_r'\frac{\Delta v^n}{v^n}\frac{1}{\Delta v^r}\right) + \left(v_r'\frac{v^r}{v^n}\frac{\Delta v^n}{(\Delta v^r)^2}\right),$$

where:

$$v_i' \coloneqq \frac{dv^i(\tau^R)}{d\tau^R}.$$

for $i = r, n$. Re-arranging terms simplifies the result as follows:

$$a' = a\left(v_r'\left(\frac{1}{v^r} - \frac{1}{\Delta v^r}\right) - v_n'\left(\frac{1}{v^n} + \frac{1}{\Delta v^n}\right)\right).$$

Now use this result to take the second order derivative to see:

$$\begin{aligned}a'' = \frac{a'\cdot a'}{a} + a\Bigg(&v_r''\left(\frac{1}{v^r} - \frac{1}{\Delta v^r}\right) - v_n''\left(\frac{1}{v^n} + \frac{1}{\Delta v^n}\right) - (v_r')^2\left(\frac{1}{v^r} - \frac{1}{\Delta v^r}\right) \\ &+ (v_n')^2\left(\frac{1}{v^n} + \frac{1}{\Delta v^n}\right)\Bigg).\end{aligned}$$

Deduce that:

$$a'' < \frac{a' \cdot a'}{a},$$

due to $\Delta v^j > 0$ and v^j is concave for all $j = n, r$ (by hypothesis).

Now plug these results into:

$$(1 + a^2) \cdot a'' - a \cdot a' \cdot a' < \frac{(1 + a^2) \cdot a' \cdot a'}{a} - a \cdot a' \cdot a'$$
$$= \frac{1}{a}((1 + a^2) \cdot a' \cdot a' - a^2 \cdot a' \cdot a') = \frac{a^2}{a} < 0,$$

which gives the desired result. ■

Now let us complete the proof of Theorem 1. Lemma 1, 2, and 3 above establish that:

$$\frac{dV^J}{d\tau^J} = 0 \text{ for all } J = N, R,$$

implies $v^j, j = n, r$ (indirect utility functions) are concave and Π is log-concave, which is sufficient for the quasi-concavity of V^J, thereby ensuring the existence of equilibrium. So, the proof for the existence of equilibrium is now complete.

Appendix 3.

This appendix proves Theorem 2: sufficiently low robot prices ensure that both parties would choose robot taxes, i.e., $\tau^{*J} > 0$ for all $J = N, R$.

Proof. The proof consists of two steps. We separately prove each step as Claim 1 and Claim 2 below:

Claim 1. If ϕ is sufficiently low, then $\tau^{*J} \leq 0$ implies $J = N$.

Note that $\tau^{*R} \leq 0$ at any arbitrarily small ϕ would imply:

$$w_r^* = \phi(1 + \tau^{*R}) \to 0$$

at θ^{*R}. Therefore, $v^r(\theta^{*R})$ would also converge to 0. But $v^r(\theta^{*R}) \geq v^r(\theta^{*N})$. So, $v^r(\theta^{*N})$ would also converge to zero. This would ensure:

$$v^r(\theta^{*R}) - v^r(\theta^{*N}) = \Delta v^r \to v^r(\theta^{*R}) + v^r(\theta^{*N}) = V^r.$$

Deduce sufficiently low ϕ guarantees:

$$a = -\frac{\Delta v^n}{\Delta v^r}\frac{V^r}{V^n} \to -\frac{\Delta v^n}{V^n} \geq -1.$$

By definition, this would imply $\Pi \geq 1/2$. However, this contradicts the fact that Π must converge to 0 due to:

$$\Delta v^r \to 0,$$

$$\frac{dV^R}{d\tau^R} = \Pi\frac{dv^r}{d\tau^R} + \frac{d\Pi}{d\tau^R}\Delta v^r = 0.$$

This completes the proof of the first step, Claim 1.

Now we move to the second step, Claim 2:

Claim 2. If ϕ is sufficiently low, then $\tau^{*N} > 0$.

Suppose not. Note that $\tau^{*N} \leq 0$ at any arbitrarily small ϕ would imply:

$$\beta \coloneqq \frac{(1-\alpha)A}{(1+\tau^{*N})\phi} \to \infty.$$

Therefore, $R^* \to \infty$ and $G^* \to \infty$ and $w_n^* \to \infty$ and $w_r^* \to 0$ at $\theta = (\tau^{*N}, t^{*N})$. Therefore:

$$\Delta v^n \to \infty,$$

$$\Delta v^r \to v^r(\theta^{*R}),$$

$$V^r \to v^r(\theta^{*R}).$$

Deduce:

$$\frac{d\Pi}{d\tau_n} = -\frac{2}{Pi}\,\frac{1}{1+a^2}\;a' \to 0,$$

$$a = -\frac{\Delta v^2}{\Delta v^1}\frac{V^1}{V^2} \to -1,$$

$$\Pi \to \frac{1}{2},$$

due to:

$$\frac{dV^n}{d\tau_n} = (1-\Pi)\frac{dv^n}{d\tau_n} - \frac{d\Pi}{d\tau_n}\Delta v^n = 0.$$

Hence .

$$a' = a\left(v_1'\left(\frac{1}{V^1} - \frac{1}{\Delta v^1}\right) - v_2'\left(\frac{1}{V^2} + \frac{1}{\Delta v^2}\right)\right) \to 0.$$

We have already established that $V^J \to \Delta v^J$ for all $J = N, R$. Conclude:

$$\left(v_2'\left(\frac{1}{V^2} + \frac{1}{\Delta v^2}\right)\right) \to 0.$$

This implies (again, due to $V^J \to \Delta v^J$ for all $J = N, R$):

$$v_2'\left(\frac{1}{V^2} + \frac{1}{\Delta v^2}\right) \to 2\frac{v_2'}{V^2} = -\frac{1}{(1+\tau)}\left(\frac{1}{\alpha} - 1\right) + \theta\frac{\frac{dG^*}{d\tau}}{G^*} \to 0.$$

However,

$$\frac{\frac{dG^*}{d\tau}}{G^*} = \frac{n_r t(1+\tau)\phi - n_r\tau\phi + n_n t\alpha A\beta^{\frac{1}{\alpha}-1} + \tau\phi n_n\beta^{\frac{1}{\alpha}}}{-(1-t)n_r\phi - n_n t\phi\beta^{\frac{1}{\alpha}} + \phi n_n\beta^{\frac{1}{\alpha}} - \left(\frac{1}{\alpha}\right)\frac{\phi n_n\tau\beta^{\frac{1}{\alpha}}}{1+\tau}} = \frac{t\alpha A\beta^{-1} + \tau\phi}{-t\phi + \phi - \left(\frac{1}{\alpha}\right)\frac{\phi\tau}{1+\tau}}$$

$$= \frac{\frac{t\alpha A(1+\tau)\phi}{(1-\alpha)A} + \tau\phi}{-t\phi + \phi - \left(\frac{1}{\alpha}\right)\frac{\phi\tau}{1+\tau}} = \frac{\frac{t\alpha(1+\tau)}{(1-\alpha)} + \tau}{-t - \left(\frac{1}{\alpha}\right)\frac{\tau}{1+\tau}} \leq 0.$$

Conclude:

$$-\frac{1}{(1+\tau)}\left(\frac{1}{\alpha} - 1\right) + \theta\frac{\frac{dG^*}{d\tau}}{G^*} \geq -\left(\frac{1}{\alpha} - 1\right).$$

This ensures that a' cannot converge to zero. This established the desired contradiction and proves the result. ■

Appendix 4.

This appendix proves Proposition 1: Robot demand is increasing with Transfers $\frac{\partial R^*}{\partial T} > 0$ if $\gamma < 0.5$.

Proof.

First from the firm's FOC, we write robot demand as

$$R = \frac{1}{\rho}\left[\left(\frac{\rho A\gamma}{\phi}\right)^{\frac{1}{1-\gamma}} L_s - L_u\right]. \tag{61}$$

Also, from the FOC of utility maximization (see Appendix 2) we can write L_s and L_u

$$L_s = 1 - \frac{1 + \frac{T}{2(1-t)w_s}}{\frac{1}{\beta}+1}, L_u = 1 - \frac{1 + \frac{T}{2(1-t)w_u}}{\frac{1}{\beta}+1}. \tag{62}$$

The wages are $w_s = (1-\gamma)A\left(\frac{\rho A\gamma}{\phi}\right)^{\frac{\gamma}{1-\gamma}}, w_u = \frac{\phi}{\rho}$ from profit maximization. We plug the labor supplies and wages into the government budget constraint and solve for tax rate (t), we get closed form of income tax rate (t).

$$\frac{(-T\rho - A\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} + A\gamma\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} - \phi - \sqrt{-4(-T\rho - T\beta\rho)(-A\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} + A\gamma\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} - \phi) + (T\rho + A\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} - A\gamma\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} + \phi)^2)}}{(2(-A\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} + A\gamma\rho(\frac{A\gamma\rho}{\phi})^{\frac{\gamma}{1-\gamma}} - \phi))}.$$

After this, we can take derivatives of robot R with respect to transfer T because we already know the closed form of labor supplies, wages and income tax rate. So, $\frac{\partial R}{\partial T}$ is equal to

$$\frac{\left(\beta(-1+2\gamma)(-X)^2\left(T(\rho+2\beta\rho) + X + \sqrt{4T(1+\beta)\rho(X) + (T\rho - X)^2}\right)\right)}{(1+\beta)(-1+\gamma)\phi\sqrt{4T(1+\beta)\rho(X) + (T\rho - X)^2}\left(T\rho + X + \sqrt{4T(1+\beta)\rho(X) + (T\rho - X)^2}\right)^2},$$

where $X = A(-1+\gamma)\rho\left(\frac{A\gamma\rho}{\phi}\right)^{\frac{\gamma}{1-\gamma}} - \phi < 0$. Since the $\gamma < 1$ by definition. For the result to be a real number, the value inside the square root $\left(\sqrt{4T(1+\beta)\rho(X) + (T\rho - X)^2}\right)$ must be positive. Also, $(-1+\gamma) < 0$. So, the denominator is negative. In the numerator part, $\left(T(\rho+2\beta\rho) + X + \sqrt{4T(1+\beta)\rho(X) + (T\rho - X)^2}\right)$ is confusing but, even if T is close to zero, the absolute value coming from the square root of $(-X)^2$ will cancel out the X term outside the square root, and the remaining terms will be strictly positive. Therefore if $\gamma < 0.5$, $(-1+2\gamma) < 0$ and the $\frac{\partial R}{\partial T} > 0$.

Corollary. Since γ<0.5 is the structural assumption of the model, reflecting the elasticity of skilled labor (which is $1-\gamma$) must be greater than that of unskilled labor. Thus, we proved our proposition.

Appendix 5.

The first-order conditions of household's utility function are

$$\frac{\partial U}{\partial l_i} = -\lambda_i w_i (1-t)\,, \frac{\partial U}{\partial c_i} = \lambda_i. \tag{63}$$

The equilibrium values obtained from these conditions determine labor, leisure time and consumption. From the first order conditions we can show that

$$\frac{l_i(1-t)w_i}{\beta} = c_i. \tag{64}$$

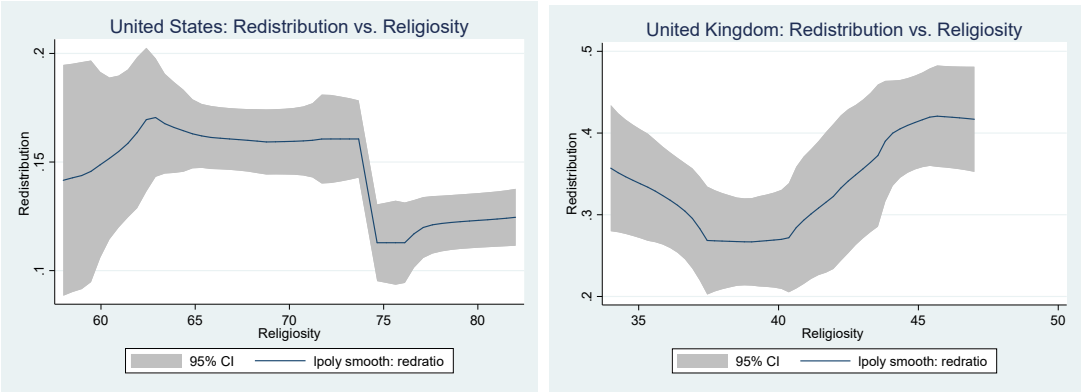
If we write this equation to the budget constraint we can get

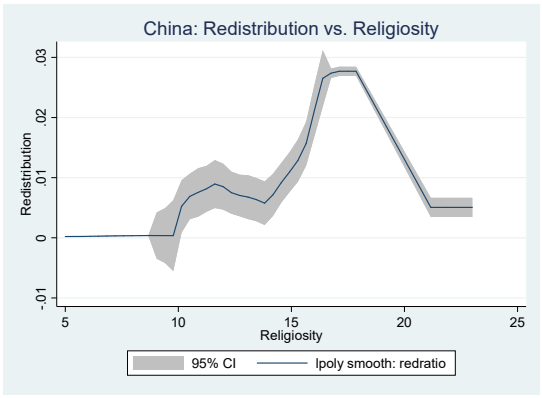
$$l_i = \frac{1 + \frac{T}{2(1-t)w_i}}{\frac{1}{\beta} + 1}. \tag{65}$$

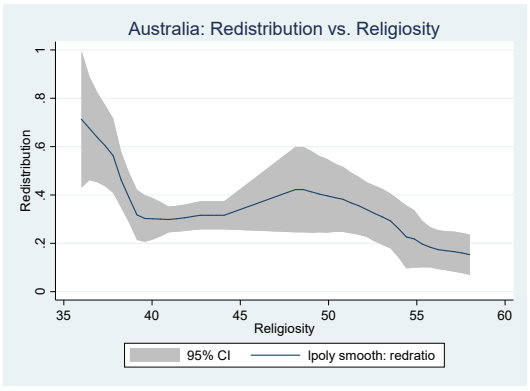
So, the leisure time is increasing function of transfer (T) and decreasing function of net hourly wage income ($(1-t)w_i$).

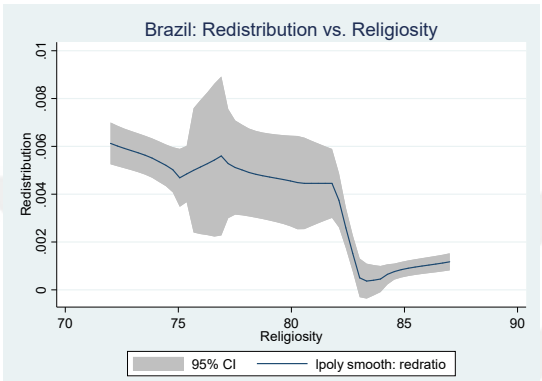
Appendix 6.

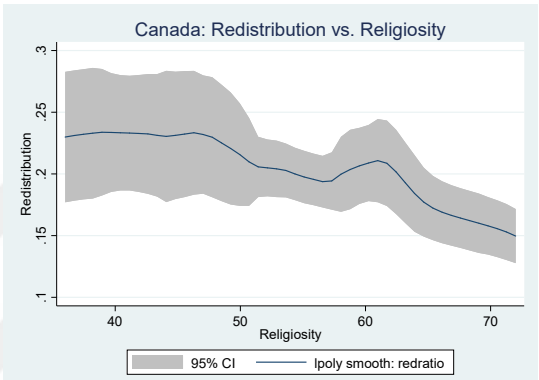
This appendix demonstrates Redistribution/GDP – Religiosity by country plots.

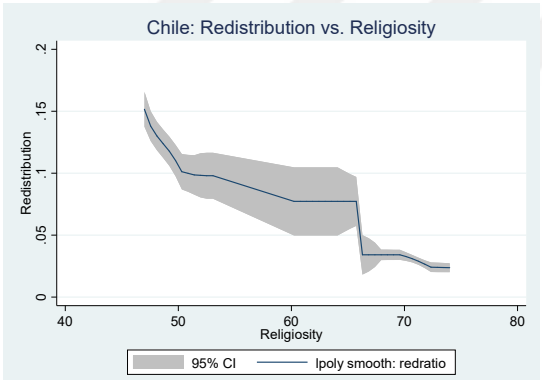


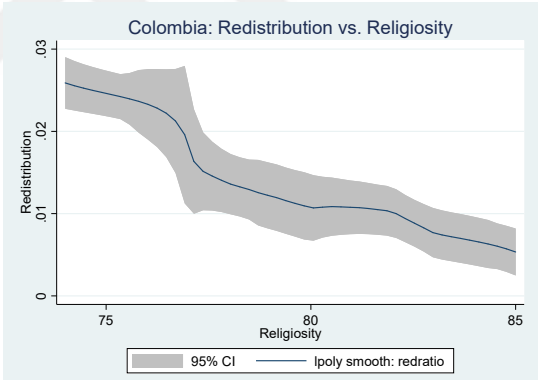

China: Redistribution vs. Religiosity
Redistribution
-.01
0
.01
.02
.03
5
10
15
20
25
Religiosity
95% CI
lpoly smooth: redratio

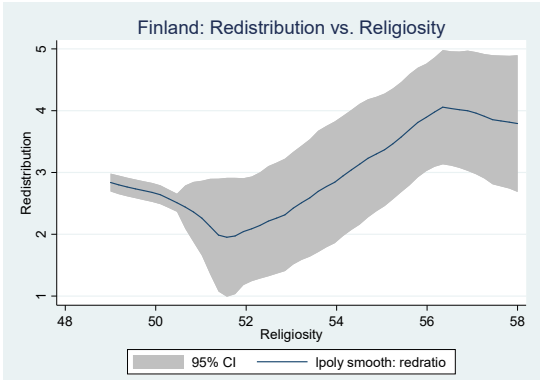

Australia: Redistribution vs. Religiosity
Redistribution
0
.2
.4
.6
.8
1
35
40
45
50
55
60
Religiosity
95% CI
lpoly smooth: redratio

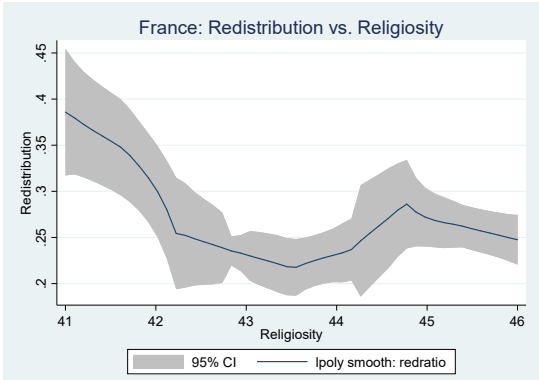

Brazil: Redistribution vs. Religiosity
Redistribution
0
.002
.004
.006
.008
.01
70
75
80
85
90
Religiosity
95% CI
lpoly smooth: redratio

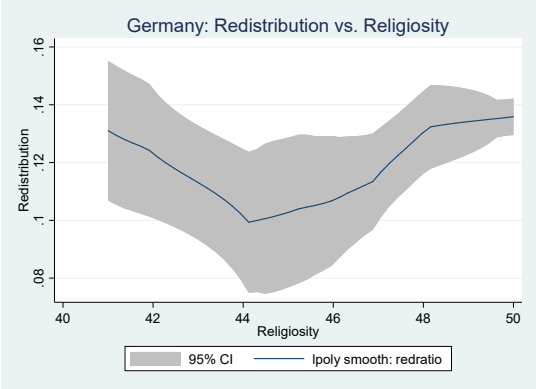

Canada: Redistribution vs. Religiosity
Redistribution
.1
.15
.2
.25
.3
40
50
60
70
Religiosity
95% CI
lpoly smooth: redratio

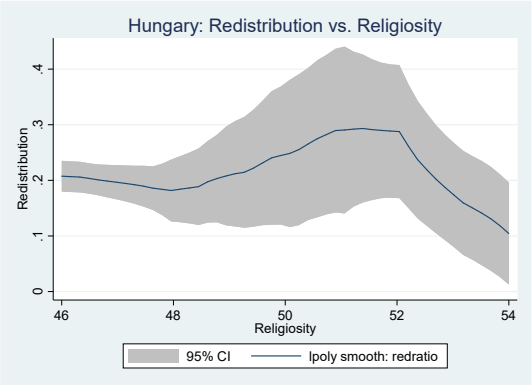

Chile: Redistribution vs. Religiosity
Redistribution
0
.05
.1
.15
.2
40
50
60
70
80
Religiosity
95% CI
lpoly smooth: redratio

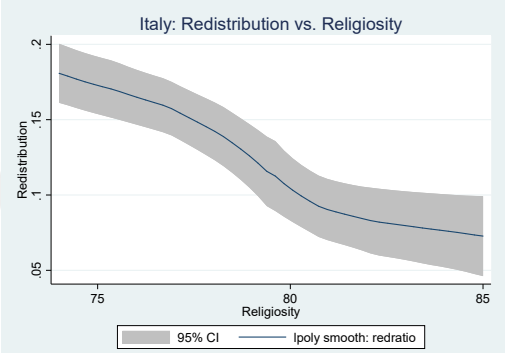

Colombia: Redistribution vs. Religiosity
Redistribution
0
.01
.02
.03
75
80
85
Religiosity
95% CI
lpoly smooth: redratio

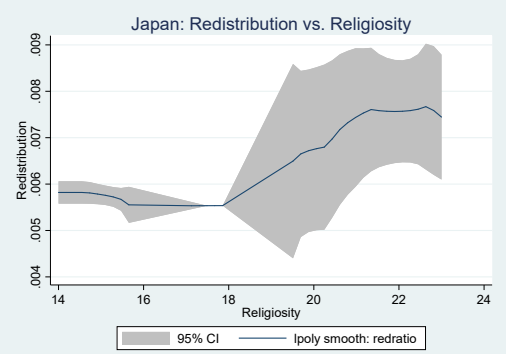

Finland: Redistribution vs. Religiosity
Redistribution
1
2
3
4
5
48
50
52
54
56
58
Religiosity
95% CI
lpoly smooth: redratio

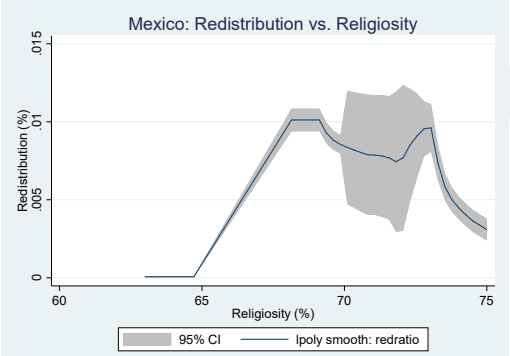

France: Redistribution vs. Religiosity
Redistribution
.2
.25
.3
.35
.4
.45
41
42
43
44
45
46
Religiosity
95% CI
lpoly smooth: redratio

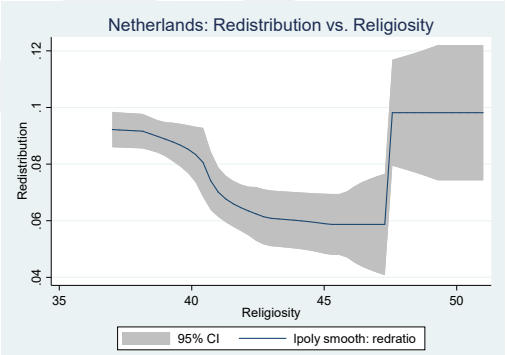

Germany: Redistribution vs. Religiosity
Redistribution
.08
.1
.12
.14
.16
40
42
44
46
48
50
Religiosity
95% CI
lpoly smooth: redratio

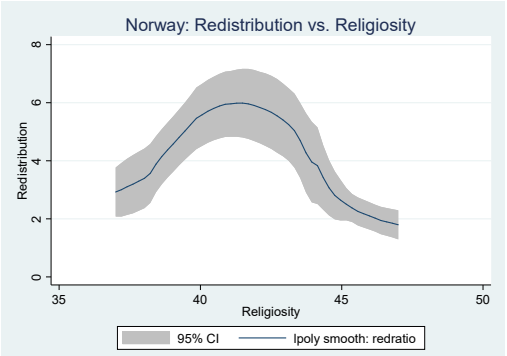

Hungary: Redistribution vs. Religiosity
Redistribution
0
.1
.2
.3
.4
46
48
50
52
54
Religiosity
95% CI
lpoly smooth: redratio

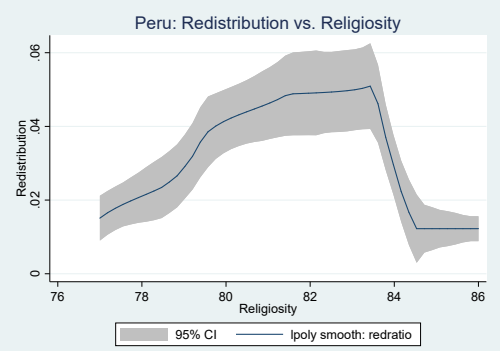

Italy: Redistribution vs. Religiosity
Redistribution
.05
.1
.15
.2
75
80
85
Religiosity
95% CI
lpoly smooth: redratio

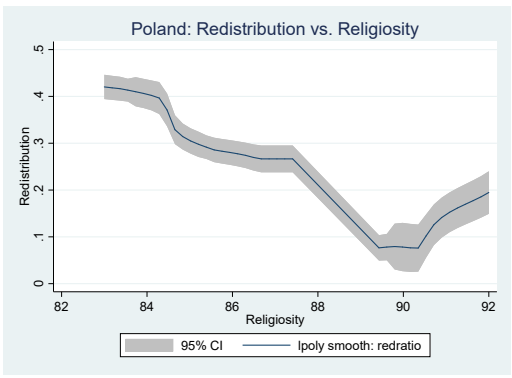

Japan: Redistribution vs. Religiosity
Redistribution
.004
.005
.006
.007
.008
.009
14
16
18
20
22
24
Religiosity
95% CI
lpoly smooth: redratio

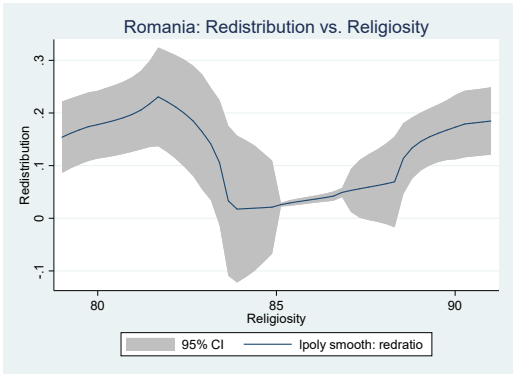

Mexico: Redistribution vs. Religiosity
Redistribution (%)
0
.005
.01
.015
60
65
70
75
Religiosity (%)
95% CI
lpoly smooth: redratio

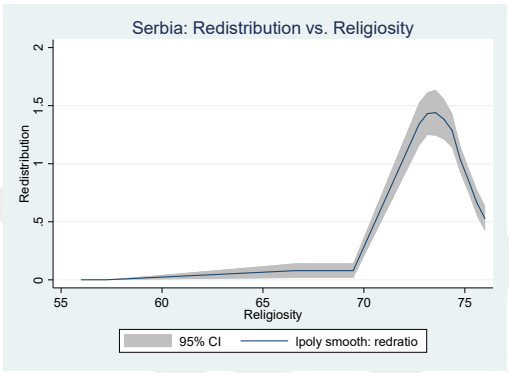

Netherlands: Redistribution vs. Religiosity
Redistribution
.04
.06
.08
.1
.12
35
40
45
50
Religiosity
95% CI
lpoly smooth: redratio

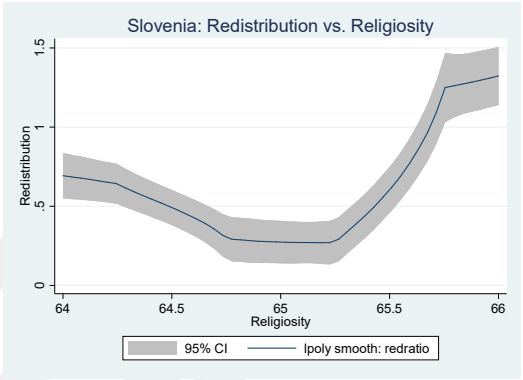

Norway: Redistribution vs. Religiosity
Redistribution
0
2
4
6
8
35
40
45
50
Religiosity
95% CI
lpoly smooth: redratio

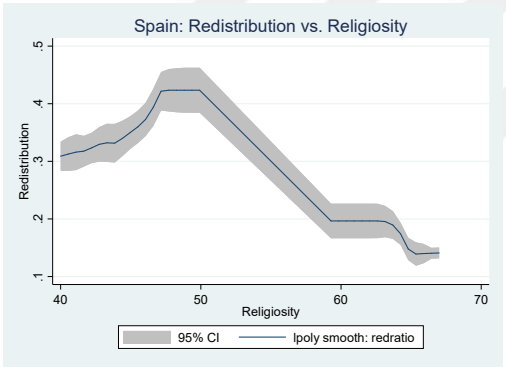

Peru: Redistribution vs. Religiosity
Redistribution
0
.02
.04
.06
76
78
80
82
84
86
Religiosity
95% CI
lpoly smooth: redratio

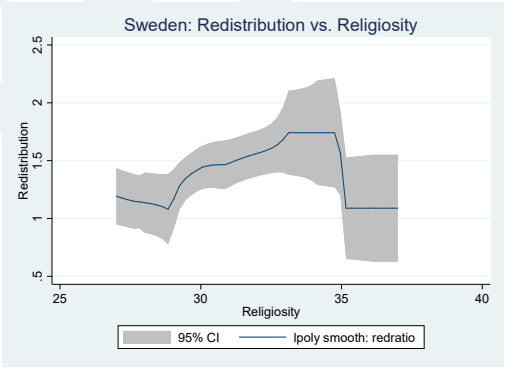


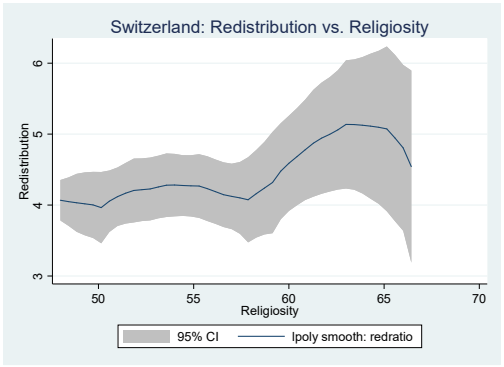






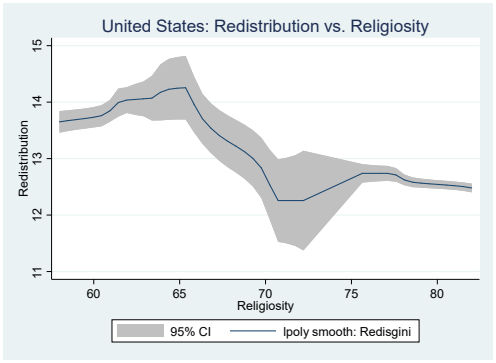


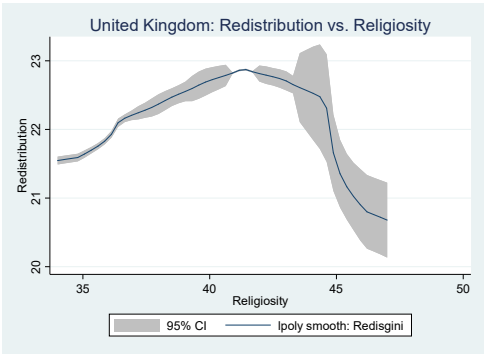


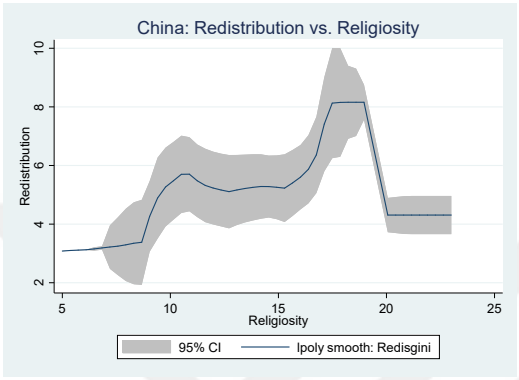


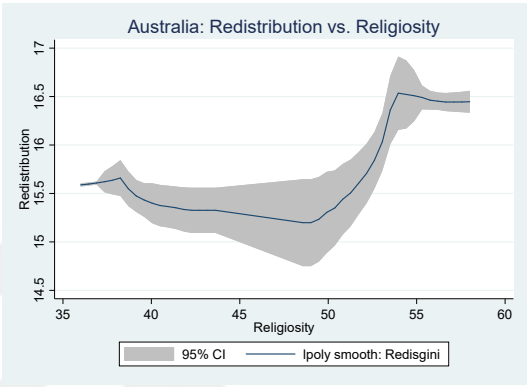
Appendix 7.

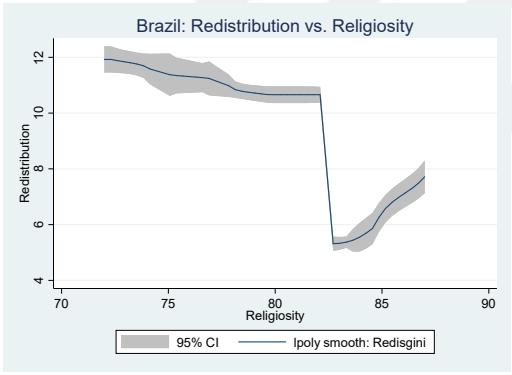
This appendix shows the Redistribution (Gini) -Religiosity by country plots.

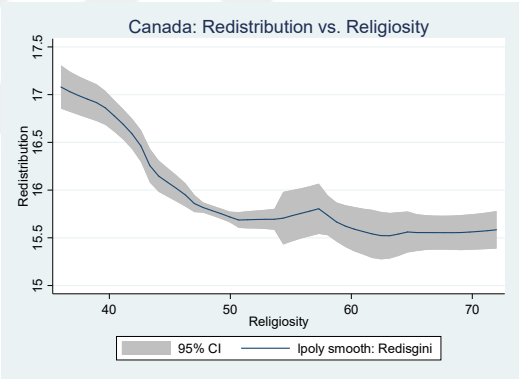

United States: Redistribution vs. Religiosity
Redistribution
11
12
13
14
15
60
65
70
75
80
Religiosity
95% CI
lpoly smooth: Redisgini

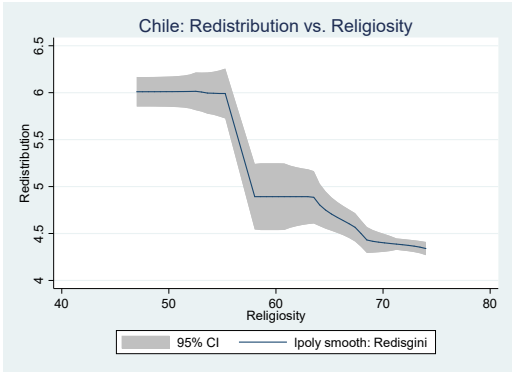

United Kingdom: Redistribution vs. Religiosity
Redistribution
20
21
22
23
35
40
45
50
Religiosity
95% CI
lpoly smooth: Redisgini

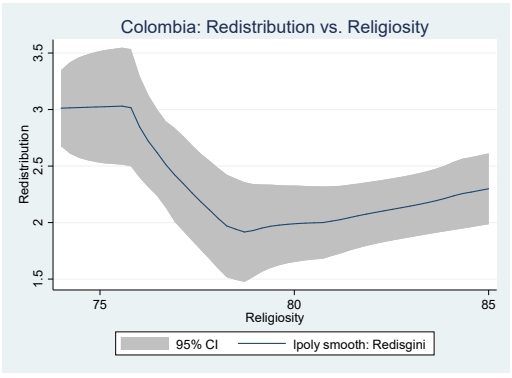

China: Redistribution vs. Religiosity
Redistribution
2
4
6
8
10
5
10
15
20
25
Religiosity
95% CI
lpoly smooth: Redisgini

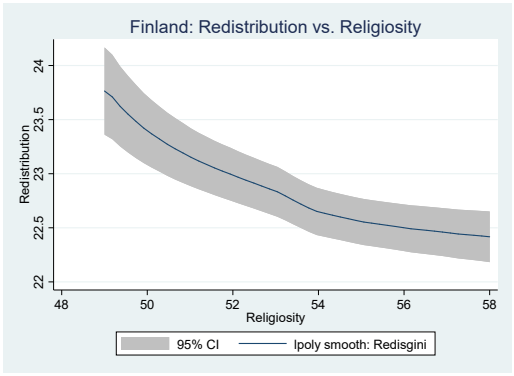

Australia: Redistribution vs. Religiosity
Redistribution
14.5
15
15.5
16
16.5
17
35
40
45
50
55
60
Religiosity
95% CI
lpoly smooth: Redisgini

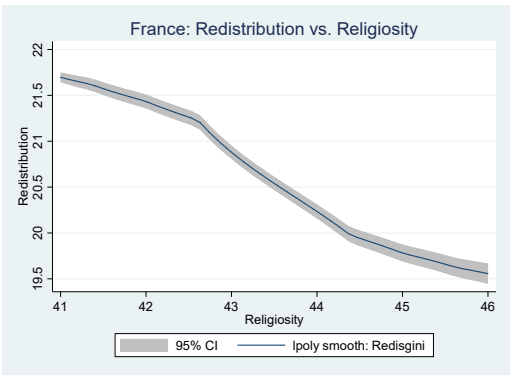

Brazil: Redistribution vs. Religiosity
Redistribution
4
6
8
10
12
70
75
80
85
90
Religiosity
95% CI
lpoly smooth: Redisgini

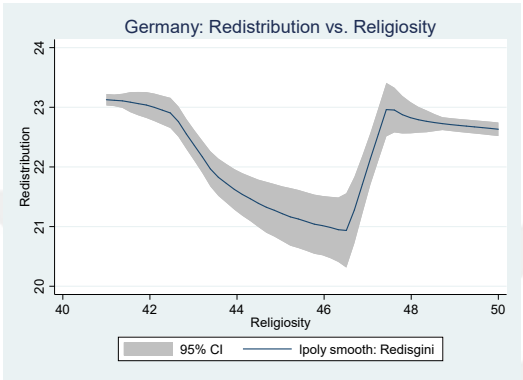

Canada: Redistribution vs. Religiosity
Redistribution
15
15.5
16
16.5
17
17.5
40
50
60
70
Religiosity
95% CI
lpoly smooth: Redisgini

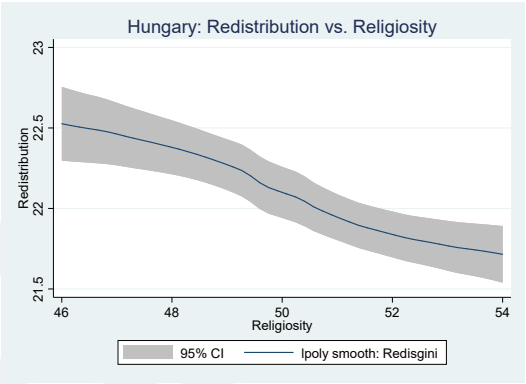

Chile: Redistribution vs. Religiosity
Redistribution
4
4.5
5
5.5
6
6.5
40
50
60
70
80
Religiosity
95% CI
lpoly smooth: Redisgini

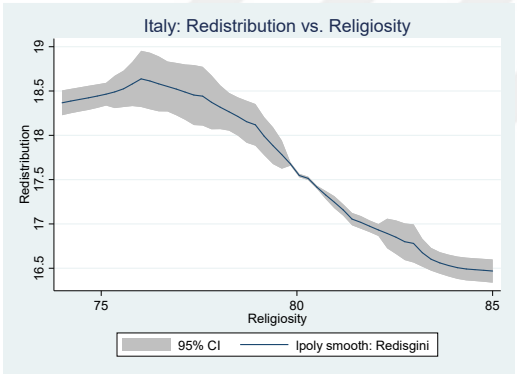

Colombia: Redistribution vs. Religiosity
Redistribution
1.5
2
2.5
3
3.5
75
80
85
Religiosity
95% CI
lpoly smooth: Redisgini

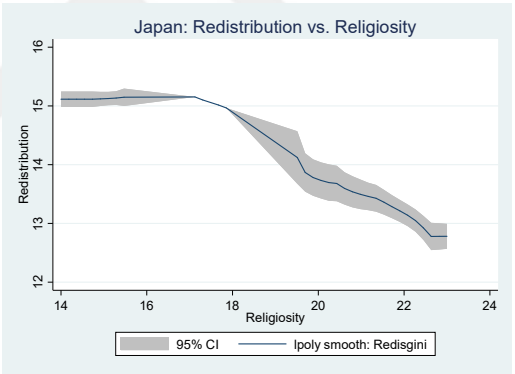

Finland: Redistribution vs. Religiosity
Redistribution
22
22.5
23
23.5
24
48
50
52
54
56
58
Religiosity
95% CI
lpoly smooth: Redisgini

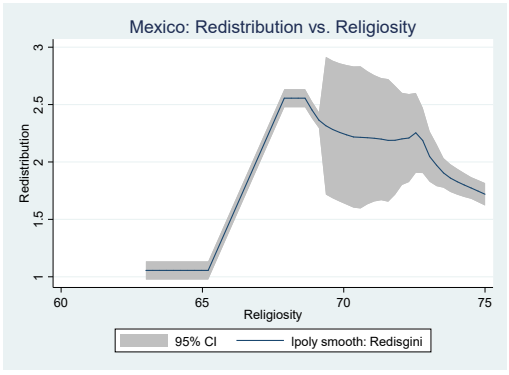

France: Redistribution vs. Religiosity
Redistribution
19.5
20
20.5
21
21.5
22
41
42
43
44
45
46
Religiosity
95% CI
lpoly smooth: Redisgini

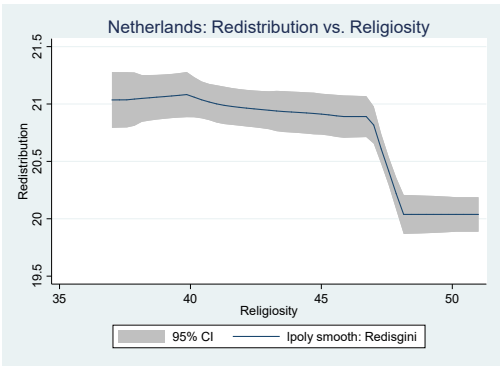

Germany: Redistribution vs. Religiosity
Redistribution
20
21
22
23
24
40
42
44
46
48
50
Religiosity
95% CI
lpoly smooth: Redisgini

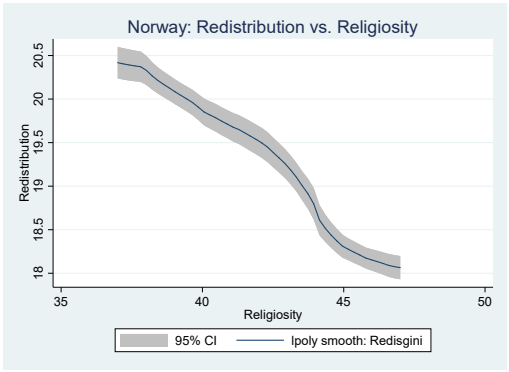

Hungary: Redistribution vs. Religiosity
Redistribution
21.5
22
22.5
23
46
48
50
52
54
Religiosity
95% CI
lpoly smooth: Redisgini

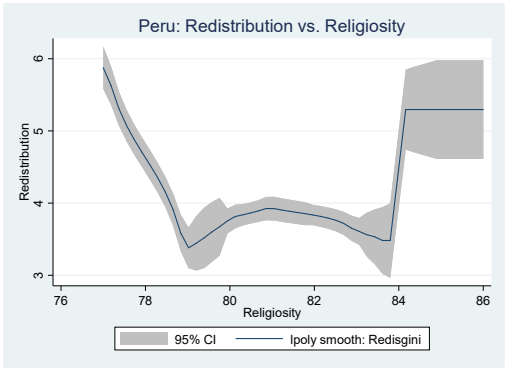

Italy: Redistribution vs. Religiosity
Redistribution
16.5
17
17.5
18
18.5
19
75
80
85
Religiosity
95% CI
lpoly smooth: Redisgini

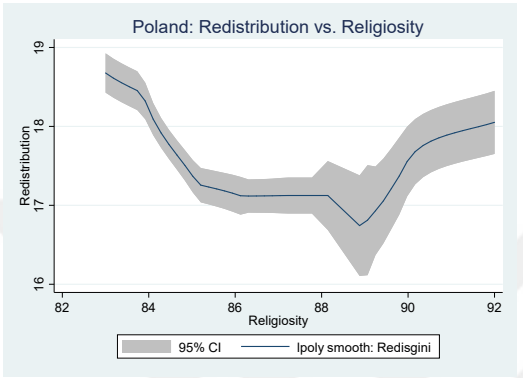

Japan: Redistribution vs. Religiosity
Redistribution
12
13
14
15
16
14
16
18
20
22
24
Religiosity
95% CI
lpoly smooth: Redisgini

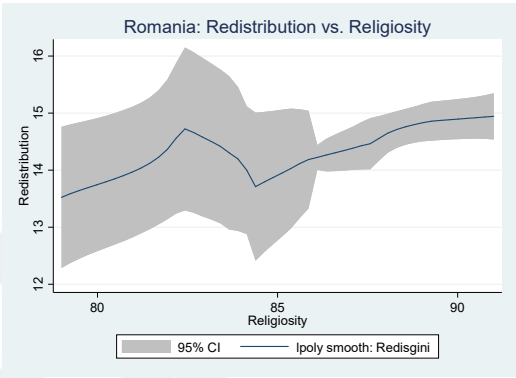

Mexico: Redistribution vs. Religiosity
Redistribution
1
1.5
2
2.5
3
60
65
70
75
Religiosity
95% CI
lpoly smooth: Redisgini

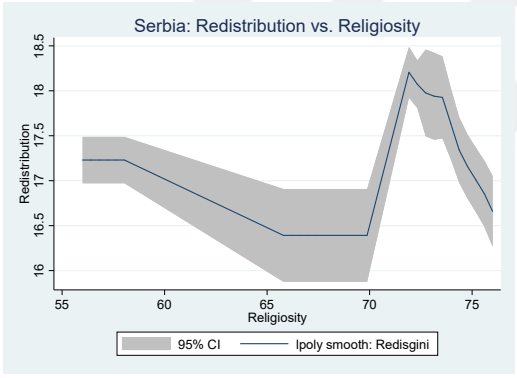

Netherlands: Redistribution vs. Religiosity
Redistribution
19.5
20
20.5
21
21.5
35
40
45
50
Religiosity
95% CI
lpoly smooth: Redisgini

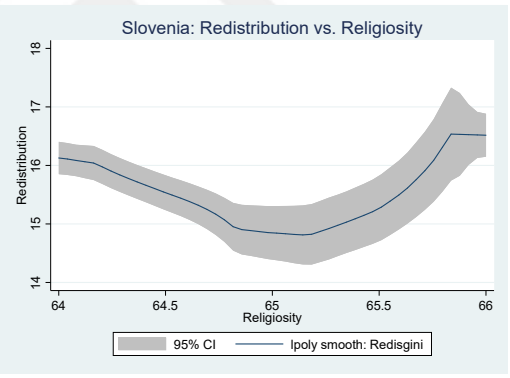

Norway: Redistribution vs. Religiosity
Redistribution
18
18.5
19
19.5
20
20.5
35
40
45
50
Religiosity
95% CI
lpoly smooth: Redisgini

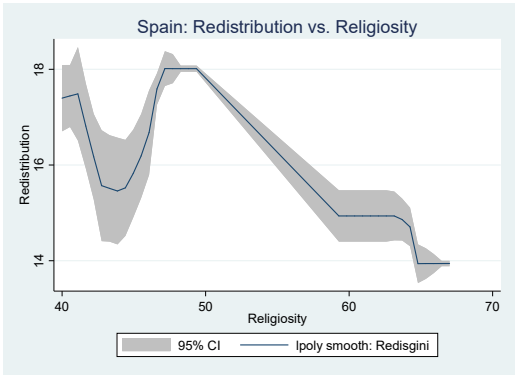

Peru: Redistribution vs. Religiosity
Redistribution
3
4
5
6
76
78
80
82
84
86
Religiosity
95% CI
lpoly smooth: Redisgini

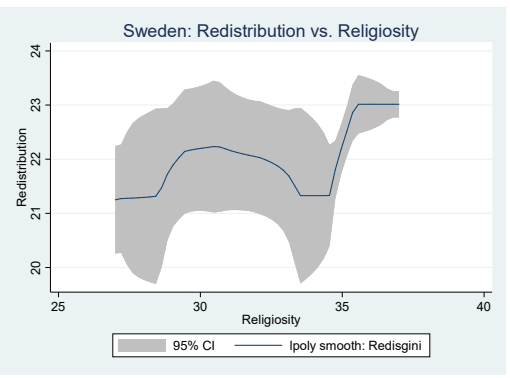

Poland: Redistribution vs. Religiosity
Redistribution
16
17
18
19
82
84
86
88
90
92
Religiosity
95% CI
lpoly smooth: Redisgini

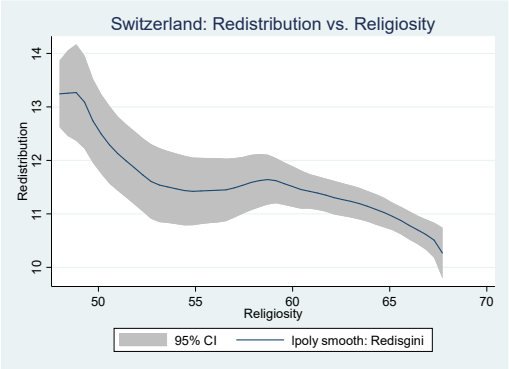

Romania: Redistribution vs. Religiosity
Redistribution
12
13
14
15
16
80
85
90
Religiosity
95% CI
lpoly smooth: Redisgini


Serbia: Redistribution vs. Religiosity
Redistribution
16
16.5
17
17.5
18
18.5
55
60
65
70
75
Religiosity
95% CI
lpoly smooth: Redisgini


Slovenia: Redistribution vs. Religiosity
Redistribution
14
15
16
17
18
64
64.5
65
65.5
66
Religiosity
95% CI
lpoly smooth: Redisgini

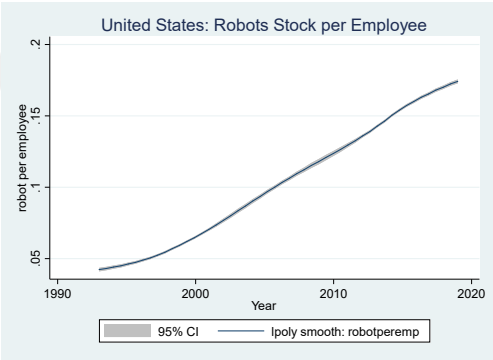

Spain: Redistribution vs. Religiosity
Redistribution
14
16
18
40
50
60
70
Religiosity
95% CI
lpoly smooth: Redisgini

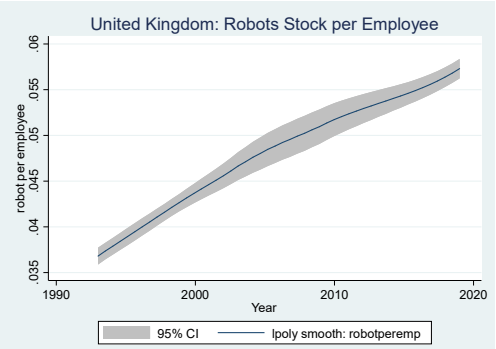

Sweden: Redistribution vs. Religiosity
Redistribution
20
21
22
23
24
25
30
35
40
Religiosity
95% CI
lpoly smooth: Redisgini

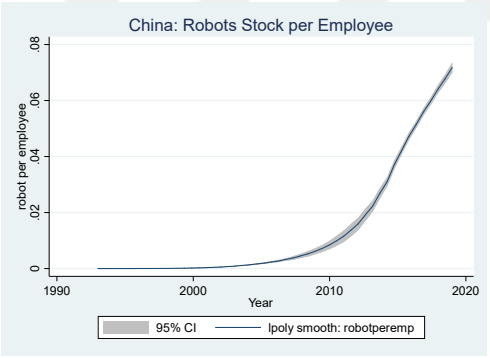


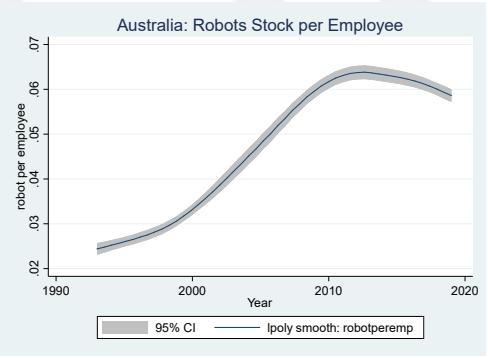
Appendix 8.

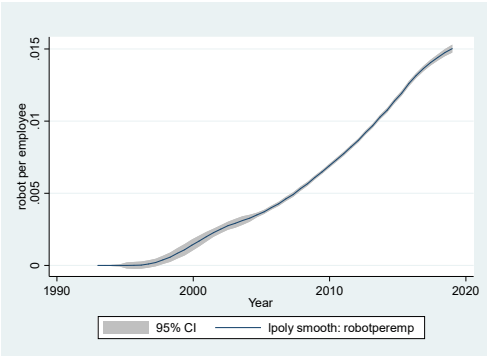
This appendix presents the Robot Stock Per Employee by country per years.

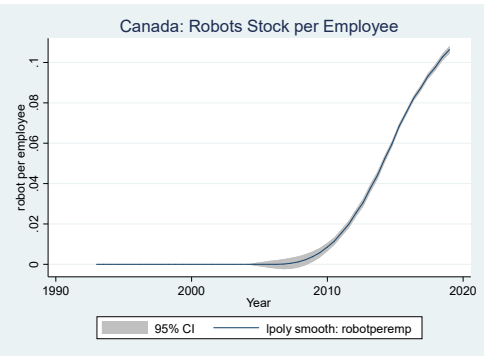


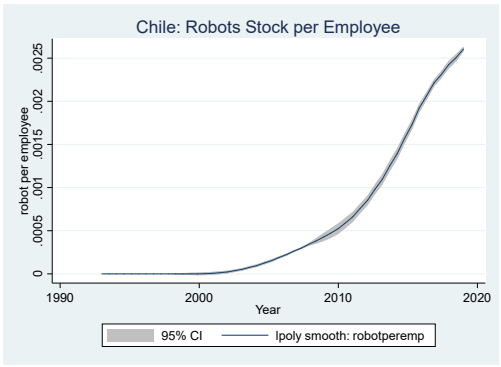


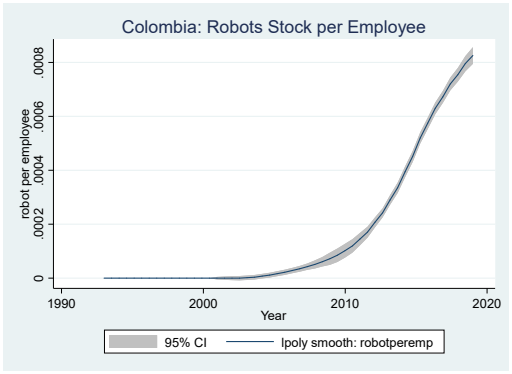


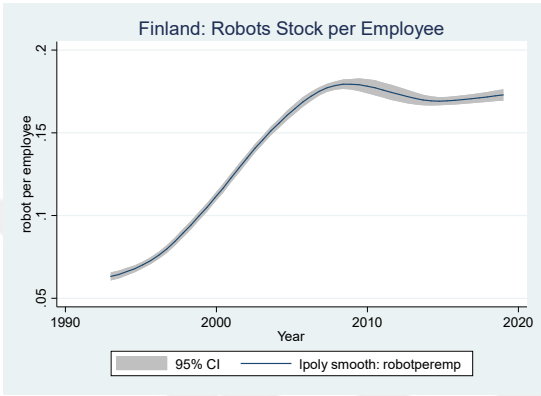


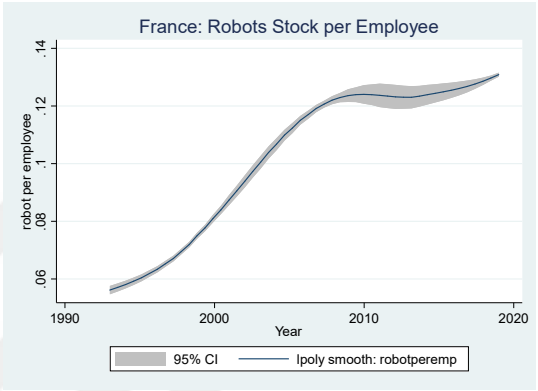


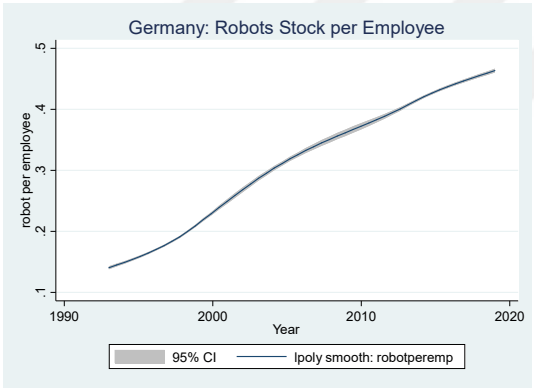


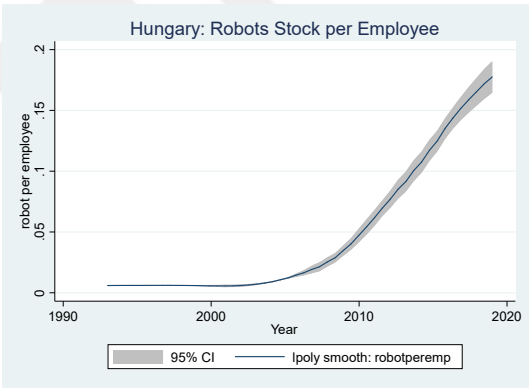

Chile: Robots Stock per Employee
robot per employee
0
.0005
.001
.0015
.002
.0025
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

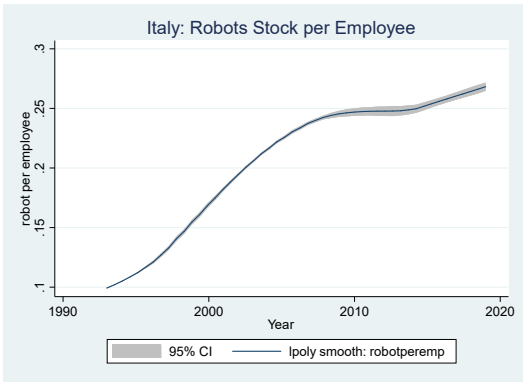

Colombia: Robots Stock per Employee
robot per employee
0
.0002
.0004
.0006
.0008
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

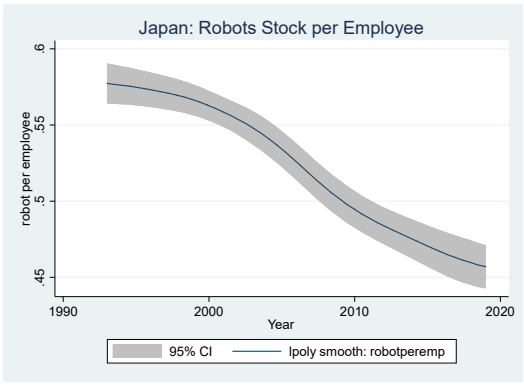

Finland: Robots Stock per Employee
robot per employee
.05
.1
.15
.2
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

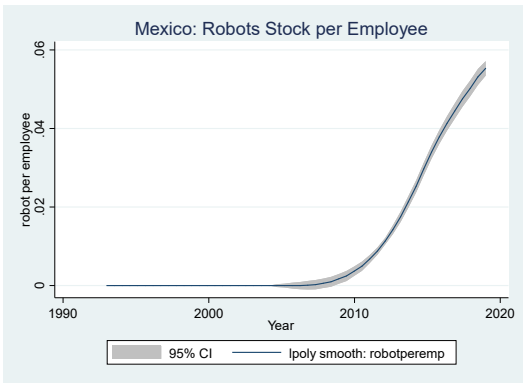

France: Robots Stock per Employee
robot per employee
.06
.08
.1
.12
.14
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

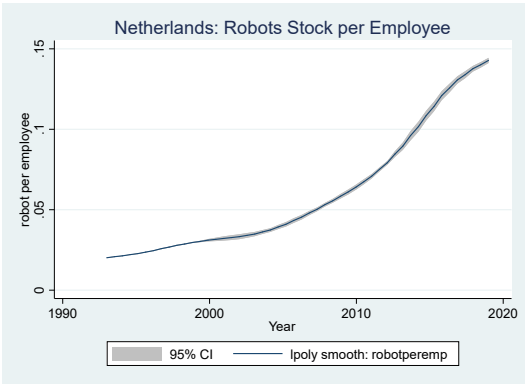

Germany: Robots Stock per Employee
robot per employee
.1
.2
.3
.4
.5
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

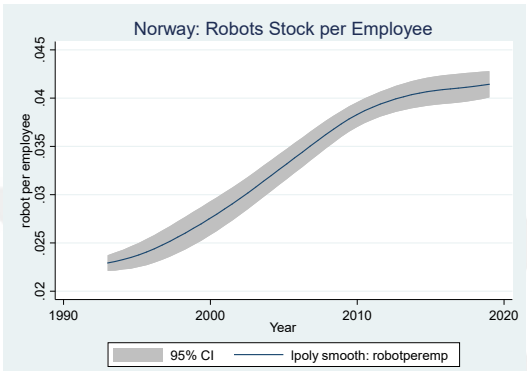

Hungary: Robots Stock per Employee
robot per employee
0
.05
.1
.15
.2
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

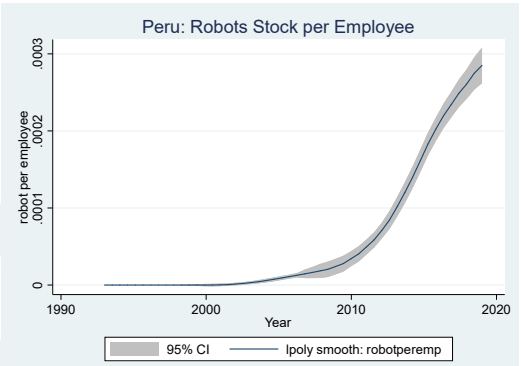

Italy: Robots Stock per Employee
robot per employee
.1
.15
.2
.25
.3
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

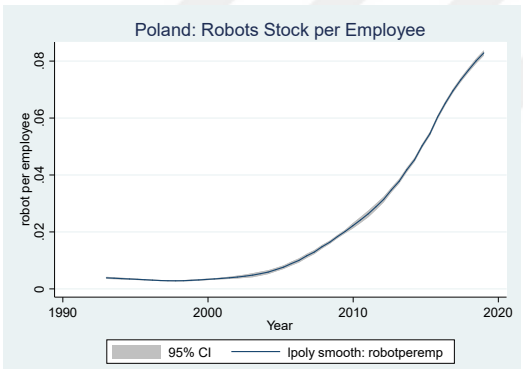

Japan: Robots Stock per Employee
robot per employee
.45
.5
.55
.6
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

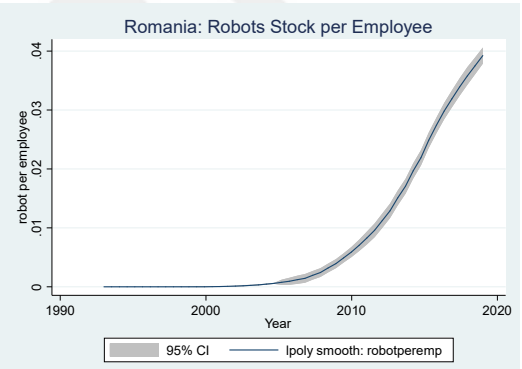

Mexico: Robots Stock per Employee
robot per employee
0
.02
.04
.06
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

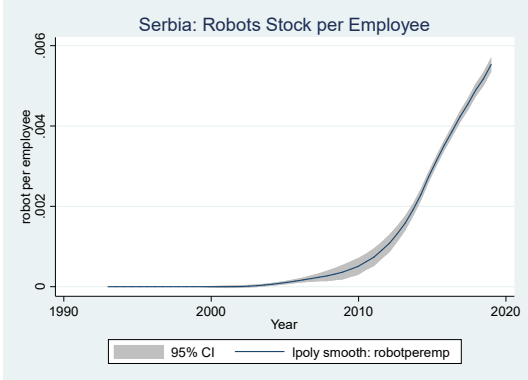

Netherlands: Robots Stock per Employee
robot per employee
0
.05
.1
.15
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

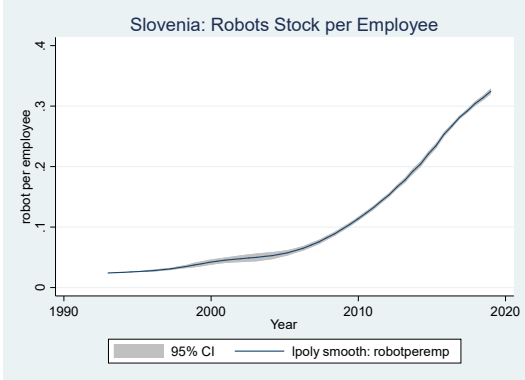

Norway: Robots Stock per Employee
robot per employee
.02
.025
.03
.035
.04
.045
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

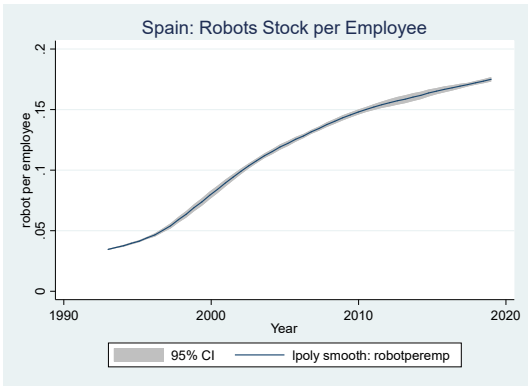

Peru: Robots Stock per Employee
robot per employee
0
.0001
.0002
.0003
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

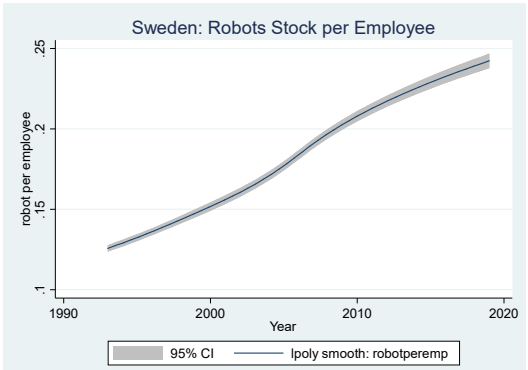

Poland: Robots Stock per Employee
robot per employee
0
.02
.04
.06
.08
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp

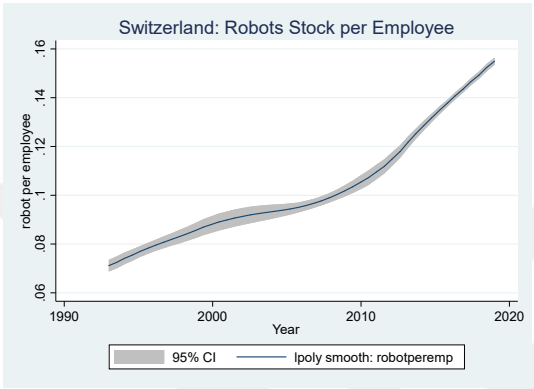

Romania: Robots Stock per Employee
robot per employee
0
.01
.02
.03
.04
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp


Serbia: Robots Stock per Employee
robot per employee
0
.002
.004
.006
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp


Slovenia: Robots Stock per Employee
robot per employee
0
.1
.2
.3
.4
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp


Spain: Robots Stock per Employee
robot per employee
0
.05
.1
.15
.2
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp


Sweden: Robots Stock per Employee
robot per employee
.1
.15
.2
.25
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp


Switzerland: Robots Stock per Employee
robot per employee
.06
.08
.1
.12
.14
.16
1990
2000
2010
2020
Year
95% CI
lpoly smooth: robotperemp