Corporate Tax Cuts and Structural Change

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Abstract

The paper shows, both theoretically and empirically, how corporate tax cuts contributed to structural change. For nearly a century, the United States has consistently reduced corporate taxes while maintaining the labor income tax. This shift in tax structure has an uneven impact on goods and services production, contributing to the divergence of sectoral value-added. Indeed, the factor intensity of the goods-producing sector and the service-producing sector differs, thus, changes in corporate taxes affect them differently. A 1% increase in the corporate tax retention rate raises the value-added of the services sector by 0.27 percentage points relative to the value-added of the goods sector.

Keywords: Structural change, Corporate tax

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Introduction

The paper shows, both theoretically and empirically, how corporate tax cuts contributed to structural change.

I consider a partial equilibrium model with two sectors, one that produces goods and the other that produces services, each with a different production function. I demonstrate how a higher corporate tax rate affects the sectoral value-added ratio. Indeed, because factor intensities differ across sectors, raising corporate taxes raises the marginal cost of the capital-intensive sector relative to the labor-intensive sector. As a result, the relative value added is impacted.

The difference in factor intensities across sectors is the primary mechanism by which corporate tax cuts affect structural change. I also examine the evolution of the labor share in the goods and services sectors and find that factor intensities differ structurally across sectors.

I evaluate empirically the causal effect of the change in the corporate tax and structural change using the Box-Jenkins model, which shows that a 1% increase in the corporate tax retention rate raises the value-added of the services sector by 0.27% relative to the value-added of the goods sector.

Three scenarios explain how the corporate tax cut influences the decline in the goods value-added share relative to the services value-added share.

The first scenario assumes that the sectors are gross substitutes, with the services sector more capital-intensive. In this case, the lower corporate tax raises the goods sector's marginal cost relative to the services sector. As a result, the optimal output in services relative to goods increases. Because the sectors are gross substitute, the decrease in service prices caused by increased supply is minimal. Thus, the value-added share of the goods sector decreases.

The second scenario is when the goods sector is capital-intensive, the services sector is labor-intensive, and the two sectors are complement. Because the goods sector is capital intensive, lowering the corporate tax rate reduces the goods sector's marginal cost relative to the services sector. This has the effect of lowering the optimal output of services relative to goods. However, because goods and services are complement, the price of services soars sharply relative to the price of goods, causing the value-added of services to rise relative to the value-added of goods.

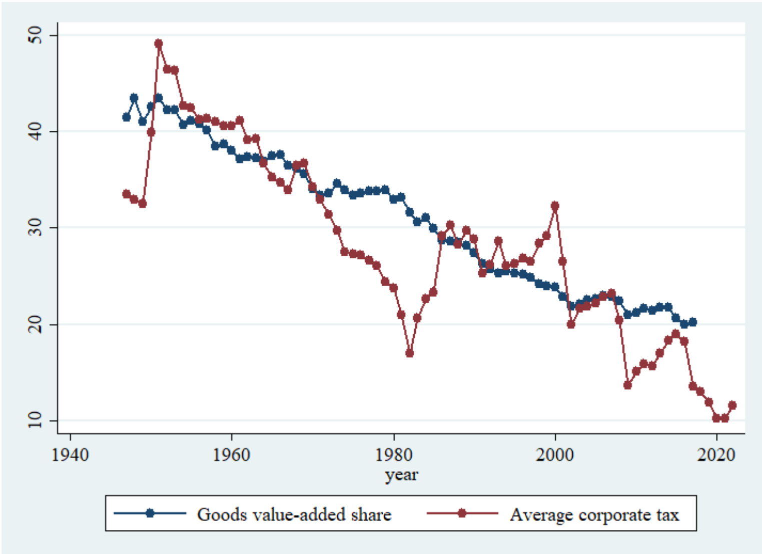
The third scenario is based on three assumptions consistent with Herrendorf et al. (2021) and Alvarez-Cuadrado et al. (2018) estimates. First, the services sector is capital-intensive, whereas the goods sector is labor-intensive. Second, goods and services are complement. Finally, the difference in factor intensities is narrowing over time. In this case, the reduction in corporate tax reduces the value-added divergence between goods and services. However, the contribution of the decline in corporate tax to reducing the divergence of value-added between goods and services weakens over time.

For nearly a century, the United States has consistently reduced corporate taxes while maintaining the labor income tax. This shift in tax structure has an uneven impact on goods and services production, contributing to the divergence of sectoral value-added. Indeed, since 1950, the value-added of the goods sector has been declining relative to the value-added of the services sector, in the United States. This decline is referred to as structural change since the economy shifts from a good-intensive to a service-intensive mode.

Figure 1 depicts the decline of the corporate tax rate in the United States from 1947 to 2022 and the decline of the goods value-added share in the United States from 1947 to 2017. The blue line represents the latter. Its value in 1947 was 41.4%, but it has since dropped to 20% in 2017.

The average corporate tax is depicted by the red line. In 1947, the average corporate tax rate was 33.4%; by 2022, it had dropped to 11.5%. The average corporate tax rate has experienced brief episodes of sharp increases. Most of these episodes are related to the business cycle, with profit increasing at a slower rate than tax receipts during and after a crisis. However, the 1994 increase is related to the Omnibus Budget Reconciliation Act,

Figure 1: Secular decline in the corporate tax rate, and the goods sector value-added share



Note: The data source of goods value-added share is Herrendorf et al. (2021)). It contrasts the services value-added share which increasing. The average corporate tax is computed using FRED data.

which was signed in 1993 to raise corporate tax rates. Besides these short episodes, the corporate tax rate has declined for almost a century. This decline aims to boost firms production, employment, and competitiveness.

The paper is related to the literature on structural change. In this line of the literature, several papers have documented the diverse sources of structural change. According to Kongsamut et al. (2001), Boppart (2014), and Foellmi and Zweimüller (2008), among others[1], structural change is driven by non-homothetic preferences, which result in differences in the income elasticity of demand across goods. Increases in capital stock or income increase demand for goods with high income elasticity, such as services and luxury goods, while decreasing demand for goods with low income elasticity, such as foods and other necessities.

Herrendorf et al. (2021), Ngai and Pissarides (2007) contend that structural change is sourced from technological differences across sectors. Changes in relative TFP have an im-

[1] See also Echevarria (1997), Laitner (2000), Caselli and Coleman (2001), Gollin et al. (2007), Duarte and Diego (2010)

pact on both relative output and relative prices. Acemoglu and Guerrieri (2008) find that differences in the elasticity of output with respect to capital across sectors drive structural change when capital accumulates. Indeed, capital accumulation changes the factor allocations, which in turn changes the relative prices of goods and services sectors. According to Alvarez-Cuadrado et al. (2018), sectoral differences in capital and labor elasticity of substitution have also contributed to structural change. Indeed, as a factor becomes readily available and thus relatively cheaper, as a result of capital accumulation, the more flexible sector uses it more.

This paper main contribution is to demonstrate another possible cause of structural change, which is institutional. I contend that corporate tax cuts in the United States have also resulted in structural change. The fall in corporate tax has an uneven effect on marginal cost across sectors. Indeed, for equal profit before tax, the sector that employs more labor pays less tax and is thus less adversely affected.

The paper is also related to Kaymak and Schott (2019), who documented the corporate tax cuts in the United States. However, their focus is on the relationship between corporate tax and labor share, whereas this paper focuses on structural change.

The following is how this paper is organized: the first section introduces the model. The second section investigates the theoretical effects of corporate tax cuts on structural change. The third section empirically assesses the contribution of corporate tax cuts to structural change. The last section concludes.

1. Model

In this section, I present a simple motivating model of corporate taxation's effect on structural change. The model is a partial equilibrium with heterogeneous firms. The model also includes a government that levies a corporate tax to fund exogenous government spending.

1.1. Firms

The economy is made up of one firm that produces goods, denoted by Q_1, and another that produces services, denoted by Q_2. In addition, the economy has an aggregate producer who uses goods and services to produce the gross output denoted by Q. To produce goods and services, both capital and labor are required.

$$Q_s = A_s K_s^{\alpha_s} N_s^{\gamma-\alpha_s}, \qquad s \in \{1, 2\} \tag{1}$$

where A_s denotes total factor productivity (TFP) and α_s the capital intensity of firm s, respectively. The return to scale of the good-producing firm, and the service-producing firm is decreasing ($\gamma < 1$). However, as in Sandwidi (2023), the results are extended to the constant return to scale case. The amounts of capital and labor used by the firm s are represented by K_s and N_s, respectively.

Let r and w be the interest rate and the wage rate, respectively. Firms are price takers. They produce and sell their products in order to maximize profits after taxes. The taxable firm income is the revenue less labor expenses (Kaymak and Schott (2019)). Their respective problems are formalized as follows:

$$\pi_s^b = P_s A_s K_s^{\alpha_s} N_s^{\gamma-\alpha_s} - w N_s \tag{2}$$

$$\max_{N_s, K_s} (1-\tau)\pi_s^b - r K_s, \qquad s \in \{1, 2\} \tag{3}$$

where P_s denotes the price of the output of the firm s, π_s^b, the revenue less labor expenses, and τ the corporate tax.

To produce the aggregate output Q, the aggregate producer uses Q_1 and Q_2, the value-added in the goods and services sectors, respectively. Her production function is as follows:

$$Q = (\psi Q_1^\rho + (1-\psi) Q_2^\rho)^{\frac{1}{\rho}} \tag{4}$$

In the production of aggregate output, ψ is the weight of goods and $1-\psi$ is the weight of services. The substitution parameter ρ is such that the elasticity of substitution between goods and services equals $\frac{1}{1-\rho}$. If $\rho < 0$, goods and services are gross complement, otherwise gross substitute. The aggregate producer maximizes her profit by taking the input and output prices as given.

$$\max_{Q_1,Q_2} (\psi Q_1^\rho + (1-\psi)Q_2^\rho)^{\frac{1}{\rho}} - P_1Q_1 - P_2Q_2 \tag{5}$$

1.2. Government

The government has an exogenous expenditure G, and levies corporate tax to finance it. τ is therefore considered exogenous, and is such that:

$$\tau(\pi_1^b + \pi_2^b) = G$$

2. Model Analysis

In this section, I describe the evolution of the factors and examine the theoretical implications of the corporate tax changes. Let us denote by $r_\tau = \frac{r}{1-\tau}$. The capital and labor demand formulated by good-producing and service-producing firms is given by:

$$r_\tau K_s = \alpha_s P_s^{\frac{1}{1-\gamma}} A_s^{\frac{1}{1-\gamma}} \left(\frac{\alpha_s}{r_\tau}\right)^{\frac{\alpha_s}{1-\gamma}} \left(\frac{\gamma-\alpha_s}{w}\right)^{\frac{\gamma-\alpha_s}{1-\gamma}}; \tag{6}$$

$$wN_s = (\gamma-\alpha_s) P_s^{\frac{1}{1-\gamma}} A_s^{\frac{1}{1-\gamma}} \left(\frac{\alpha_s}{r_\tau}\right)^{\frac{\alpha_s}{1-\gamma}} \left(\frac{\gamma-\alpha_s}{w}\right)^{\frac{\gamma-\alpha_s}{1-\gamma}} \tag{7}$$

The solution to the maximization problem 3 is the demand for factors given in (6), and (7). Factor demands are decreasing in both costs, namely the interest rate and the wage rate. However, the cost of each factor has a greater impact on its demand. Increased taxation reduces the demand for capital and labor. Moreover, the impact on capital is greater than on labor.

The corporate tax rate has an uneven impact on factor demand across sectors. Increases in the corporate tax rate reduce capital in the capital-intensive sector more than in the labor-intensive sector. As it will become clear later, the main mechanism by which the corporate tax influences structural change is its uneven impact across sectors.

The optimal value-added is determined by evaluating the value-added at the optimal level of the factor demands. The optimal value added of goods and services is given in formal terms by equation (8).

$$P_s Q_s = P_s^{\frac{1}{1-\gamma}} A_s^{\frac{1}{1-\gamma}} \left(\frac{\alpha_s}{r_\tau}\right)^{\frac{\alpha_s}{1-\gamma}} \left(\frac{\gamma-\alpha_s}{w}\right)^{\frac{\gamma-\alpha_s}{1-\gamma}} \tag{8}$$

The cost of factors has a negative impact on sectoral optimal value-added. Increased corporate taxes reduce value-added in the goods and services sectors, but most dramatically in the capital-intensive sector. Let us denote by $\theta = \frac{\alpha_1^{\alpha_1}(\gamma-\alpha_1)^{\gamma-\alpha_1}}{\alpha_2^{\alpha_2}(\gamma-\alpha_2)^{\gamma-\alpha_2}}$. The following is the price ratio of goods to services:

$$\frac{P_1}{P_2} = \left(\frac{\psi}{1-\psi}\right)^{\frac{1-\gamma}{1-\gamma\rho}} \left[\theta \frac{A_1}{A_2} \left(\frac{w}{r_\tau}\right)^{\alpha_1-\alpha_2}\right]^{-\frac{1-\rho}{1-\gamma\rho}} \tag{9}$$

The price ratio is determined by three major drivers. The first is the TFP ratio. TFP relative increases tend to lower relative prices. Indeed, a relative increase in TFP results in a relative decrease in the marginal cost of production.

The second driver is the relative cost of factors: the wage rate and the interest rate ratio. The effect of the relative cost of factors depends on the distribution of the factors' intensities across sectors. The relative increase in the cost of a given factor raises the relative price of the sector that is more intensive in this factor. In other words, if labor becomes more expensive than capital, the price of the labor-intensive sector rises in relative terms. Similarly, as capital becomes more expensive, the price of the capital-intensive sector rises in relative terms.

The third driver is the corporate tax rate. Increased corporate taxes raise the relative price of the capital-intensive sector. The corporate tax, indeed, raises the marginal cost of production. Because the corporate tax is levied on revenue after deducting labor expenses, an increase in corporate tax is comparable to an increase in the cost of capital. In this sense, when the corporate tax is raised, the marginal cost of the capital-intensive sector rises faster than that of the labor-intensive sector. As a result, the capital-intensive sector's relative price rises.

Let us denote the ratio of the value-added of services to goods sectors by Δ_γ. The expression for Δ_γ is as follows:

$$\Delta_\gamma = \left(\frac{1-\psi}{\psi}\right)^{\frac{1}{1-\gamma\rho}} \left(\frac{1}{\theta}\frac{A_2}{A_1}\left(\frac{w}{r_\tau}\right)^{\alpha_2-\alpha_1}\right)^{\frac{\rho}{1-\gamma\rho}} \tag{10}$$

Δ_γ is the value-added ratio of services to goods in an economy with a decreasing return to scale γ within sectors. Similarly, Δ_1 is the value-added ratio of services to goods in a constant return to scale economy.

The ratio of value-added, like the ratio of prices, is affected by the ratio of TFP, the ratio of factor costs, and the level of corporate taxes.

These effects are determined by whether the sectors are complement or substitute. If the sectors are substitute, the relative value-added increases in the sector with the fastest TFP growth. In the sector that is intensive in the factor with falling relative costs, the relative value-added also rises. The increase in corporate tax reduces the relative value-added of the capital-intensive sector. The value-added ratio and the price ratio both move in the same direction in this case.

Conversely, if goods and services are complement, the sector with the fastest TFP growth experiences a decrease in its relative value-added, as does the sector intensive in the factor with the lowest relative cost. The increased corporate tax raises the relative value-added of the capital-intensive sector. In that case, the value-added ratio and the price ratio move in opposite directions.

The following equations give the value-added shares of the goods and services sectors, denoted by S_1 and S_2, respectively.

$$S_1 = \frac{1}{1+\Delta_\gamma}; \qquad S_2 = \frac{1}{1+\Delta_\gamma^{-1}} \tag{11}$$

Continuous changes in S_1, and S_2 characterize structural change as defined in Herrendorf et al. (2021).

Definition 1. *Structural change implies that the value-added share or similarly the employment share increases in one sector and decreases in another sector*[2].

The US economy is undergoing structural change as it transitions from a goods-intensive to a services-intensive mode of production. Indeed, the value-added and employment shares rise in the services sector while falling in the goods sector. Proposition 1 gives the marginal effect of corporate tax on the value-added shares of the goods and the services sector.

Proposition 1. *The corporate tax has the following effect on the sectoral value-added share:*

$$\frac{\partial S_1}{\partial \tau} = -\frac{\partial S_2}{\partial \tau} = \frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}\frac{\Delta_\gamma}{1-\tau}S_1^2 \tag{12}$$

Proof 1. *see Appendix A*

The proposition 1 demonstrates how the corporate tax affects the sectoral value-added share. If the factor intensities in the two sectors are the same, corporate tax has no effect on structural change. However, the effect only exists if one sector is capital-intensive and the other is labor-intensive. Hence, the source of the corporate tax causal effect on structural change is the dispersion of factor intensities.

In the case of a homogeneous distribution of factor intensities, changes in corporate tax affect the marginal cost sectors equally. Thus, the relative marginal cost remains the same. However, when the intensity of factors is not distributed uniformly, the corporate tax has

[2] See Sandwidi (2023), Herrendorf et al. (2021), Kongsamut et al. (2001)

an uneven impact on the marginal cost of sectors. The marginal cost rises faster in the capital-intensive sector. Changes in relative marginal cost affect the relative value added as well. The greater the dispersion of factor intensities, the more significant the impact of corporate tax on relative value-added. The dispersion in this simple framework with two sectors is measured by the difference in the factor intensities. According to equation (13), a 1% change in the retention rate changes the value-added ratio by a number of percentage points, which is positively affected by the difference in factor intensities between the two sectors.

In light of Figure 1, I will present scenarios that demonstrate a positive relationship between corporate tax cuts and structural change. A positive relationship implies that a decrease in corporate tax contributes to a relative increase in services sector value-added or, similarly, a relative decrease in goods sector value-added. A negative relationship means the opposite. Because structural change is characterized by faster growth in the value-added of the services sector, a positive relationship implies that corporate tax cuts contribute to the divergence of the sectoral value-added, whereas a negative relationship implies that corporate tax cuts contribute to its reduction. Based on Proposition 1, three scenarios explain the observed positive relationship of the corporate tax cuts and structural change.

Scenario 1 (goods and services are substitute): This scenario assumes that the sectors are gross substitutes, with the services sector more capital-intensive. In this case, the lower corporate tax raises the marginal cost of the goods sector compared to the services sector. This has the effect of increasing the optimal output in services relative to goods. Because the sectors are gross substitutes, the decrease in service prices as a result of increased supply is relatively small. Therefore, the goods sector value-added share decreases.

Scenario 2 (goods and services are complement): In this scenario, the goods sector is capital-intensive and the services sector is labor-intensive, and the two sectors are complement. In this case, the falling corporate tax reduces the share of goods sector value-added.

Because the goods sector is capital intensive, lowering the corporate tax rate lowers the marginal cost of the goods sector relative to the services sector. This tends to reduce the optimal output of services relative to goods. However, because goods and services are gross complements, the services sector's price soars sharply relative to the goods sector, such that the value-added of the services rises relative to the goods.

Scenario 3 (Herrendorf et al. (2021) and Alvarez-Cuadrado et al. (2018)): The third scenario relies on three assumptions based on Herrendorf et al. (2021) and Alvarez-Cuadrado et al. (2018)[3]. First, goods and services sectors are complement. Second, the goods sector is labor-intensive and the services sector is capital-intensive. Third, the discrepancy between factor intensities across sectors narrows over time. In this case, Proposition 1 demonstrates that lowering corporate tax raises the value-added share of the goods sector while decreasing the value-added share of the services sector. In this scenario, the corporate tax contributes to the reduction of structural change by reducing the divergence of goods and services value-added[4]. Let us next compute the elasticity of the value-added ratio with respect to the retention rate.

$$\frac{\partial \ln \Delta_\gamma}{\partial \ln(1-\tau)} = \frac{\rho(\alpha_2 - \alpha_1)}{1-\gamma\rho} \tag{13}$$

Proof 2. *see Appendix A*

The equation (13) shows that increasing the corporate tax retention rate by one percent reduces the services to goods value-added ratio by $abs\left(\frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}\right)$ percent. In light of

[3]Herrendorf et al. (2021) find that the sectors are complement. They calculate the elasticity of substitution and discover that it is equal to zero. Using 35-sector KLEM data base, Alvarez-Cuadrado et al. (2018) compute the labor income share. They find that between 1960 and 2005, the labor income share was higher in the goods sector than in the services sector. They also find that the difference in labor income share fell during this time period. The data from Herrendorf et al. (2021) show that between 1947 and 2000, the labor income share was higher in the goods sector than in the services sector, and that the labor share was increasing in the services sector while decreasing in the goods sector in this time frame.

[4]The reversed mechanism exposed in Scenario 2 is the mechanism by which increased corporate taxes affect negatively structural change in this Scenario.

equation (13), the third assumption implies that the negative effect of corporate tax on structural change weakens over time. The corporate tax's effect is weakened because the capital intensity gap between goods and services is closing. Indeed, the smaller the disparity in capital intensities, the smaller the relative change in marginal cost across sectors as a result of corporate tax cuts.

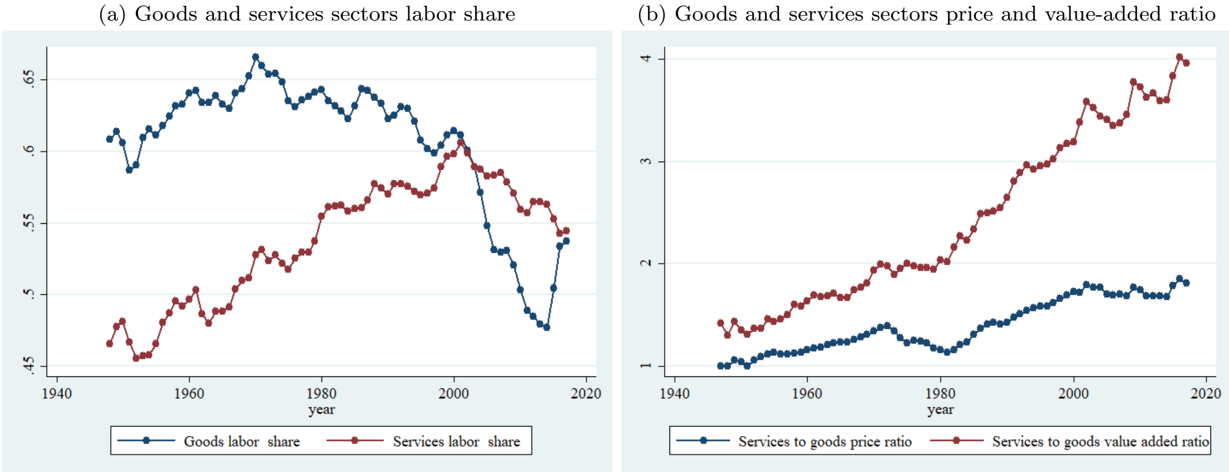
It is more plausible to assume that goods and services are complement. Indeed, the price ratio to the power ρ is collinear to the value-added ratio to the power $\rho-1$ according to the CES aggregate production function as stated in equation (14).

$$\left(\frac{P_1}{P_2}\right)^{\rho} = \frac{\psi}{1-\psi}\left(\frac{P_1 Q_1}{P_2 Q_2}\right)^{\rho-1} \tag{14}$$

Figure 2b depicts the price ratio (in blue line) and the value-added ratio (in red line). Both series progress in the same direction. It implies that the signs of ρ and $\rho - 1$ must be the same. As a result, ρ is negative (i.e. the sectors are complement) because $\rho < 1$.

(a) Goods and services sectors labor share

(b) Goods and services sectors price and value-added ratio



Note: The data source is Herrendorf et al. (2021)).

The labor share in the goods and services sectors is depicted in Figure 2a (the blue line represents the goods sector and the red line represents the services sector). It shows that the labor share in the goods sector was higher and more stable from 1947 to 2000. During the same time period, the labor share in the services sector increased. Labor share fell dramatically in both sectors beginning in 2001, but faster in the goods sector. Since 2003, the labor share was lower in the goods sector.

The above-mentioned theoretical results are consistent with constant return-to-scale production functions within the sectors. The corresponding results are obtained by changing γ to one[5]. Corollary 1 shows the marginal effect of corporate tax on sectoral value-added shares, when the production function within the sectors has a constant return to scale.

Corollary 1. *Let us assume that the sectoral production functions have a constant return to scale ($\gamma = 1$). The marginal effect of corporate tax on the value-added shares is the following*

$$\frac{\partial S_1}{\partial \tau} = -\frac{\partial S_2}{\partial \tau} = \frac{\rho(\alpha_2 - \alpha_1)}{1-\rho} \frac{\Delta_1}{1-\tau} S_1^2$$

Proof 3. *See Appendix A*

The effect of the corporate tax on structural change is qualitatively identical in decreasing return to scale and constant return to scale cases.

3. Empirical Study

In this section, I evaluate the quantitative impact of corporate taxes on structural change. First, I present the model to estimate, which is derived from the framework developed in sections 1 and 2. Second, I go over the data sources and variables used for the identification. Third, I describe the identification strategy and present the findings for the US economy. Finally, I demonstrate the robustness of the results by extending the estimation to the OECD countries, using different data sources.

[5] Sandwidi (2023) shows the relationship between economies with decreasing and constant return to scale production functions respectively. He demonstrates that a linear economy characterized by a production function with constant return to scale is the limit of an economy with decreasing return to scale production function when the return to scale parameter tends to one .

3.1. *Model Specification*

The goal is to define a linear relationship between structural change and corporate tax that is consistent to the framework described in sections 1 and 2. To that end, I apply the log sign to both sides of equation (10). It provides the following relationship.

$$\ln \Delta_\gamma = \frac{\ln\left(\frac{1-\psi}{\psi}\theta^{-\rho}\right)}{1-\gamma\rho} + \frac{\rho}{1-\gamma\rho}\ln\left(\frac{A_2}{A_1}\right) + \frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}\ln\left(\frac{w}{r}\right) + \frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}\ln(1-\tau) \quad (15)$$

The linear relationship between the log ratio of value-added and the log of corporate tax retention rate is given by equation (15). The equation is the same as in the case of constant return to scale. Indeed, replacing γ by one yield the corresponding results with a constant return to scale (see footnote 5). Therefore, for simplicity, I drop the subscript γ hereafter. The following describes the empirical model used for estimation.

$$\ln \Delta = \delta_0 + \delta_1 \ln(1-\tau) + \delta_2 X + \epsilon \quad (16)$$

where $1-\tau$ is the corporate tax retention rate and X is the set of control variables that includes the TFP ratio and the cost of factors ratio.

3.2. *Data Sources and Variable Constructions*

To run the regressions, I use a variety of data sets. The first source is Federal Reserve Economic Data (FRED). It provides the profit before tax (Π_b), and the profit after tax (Π_a) between 1947 and 2022[6]. The average corporate tax rate is given by $\frac{\Pi_b-\Pi_a}{\Pi_b}$.

The second source is Herrendorf et al. (2021). It gives the value-added of goods and services sectors, the sectoral TFPs, the labor income at current prices (wL), the efficiency hours worked (L), and the final good price index (P) between 1947 and 2017. The following is how the real wage is calculated: $\frac{wL}{PL}$.

[6] The data of the profit after tax is available on https://fred.stlouisfed.org/series/CP and the data of the profit before tax is taken from https://fred.stlouisfed.org/series/A053RC1Q027SBEA

The third source is the World Development Indicators. It shows the real interest rates for each country from 1961 to 2021. The real interest rate is the lending rate adjusted for inflation using the GDP deflator. The data also includes the total tax and contribution rate paid by corporations as a percentage of profit per country between 2005 and 2019. The total tax rate is the amount of taxes and mandatory contributions paid by businesses after accounting for allowable deductions and exemptions as a percentage of commercial profits.

The fourth source is the United Nations Statistics Division. It provides sectoral value-added data for seven industries: (i) Agriculture, hunting, forestry, and fishing (ISIC A-B); (ii) Mining, Manufacturing, Utilities (ISIC C-E); (iii) Manufacturing (ISIC D); (iv) Construction (ISIC F); (v) Wholesale, retail trade, restaurants and hotels (ISIC G-H); (vi) Transport, storage, and communication (ISIC I); (vii) Other Activities (ISIC J-P)[7]. I divide the seven industries into two categories. The first four industries are classified as goods, while the last three are classified as services. The time span is from 1970 to 2021.

The final source is the OECD. It provides data on OECD countries corporate income tax rates (statutory) from 1981 to 2023[8].

3.3. Identification Strategy and Estimation Results

I begin with OLS estimation by combining the different control variables to estimate the parameters of equation (16). The OLS estimation results are stored in table 1. Column (1) contains the OLS estimates with the log of the retention rate as a covariate. The log of the TFP ratio is added as a control variable in column (2). As a control, column (3) adds the log of the factor cost ratio. Finally, column (4) includes both the log of the TFP ratio and the log of the cost of factors as control variables.

[7]ISIC is an abbreviation for International Standard Industrial Classifications. The data is available on http://data.un.org/Data.aspx?d=SNAAMA&f=grID%3A201%3BcurrID%3AUSD%3BpcFlag%3A0%3BitID%3A12

[8]The OECD data on corporate tax rates prior to 2000 was collected from Table II.1 at https://www.oecd.org/tax/tax-policy/tax-database/#C_CorporateCapital. The post-2000 data was obtained from Table II.1 at https://stats.oecd.org/index.aspx?DataSetCode=Table_II1%20.

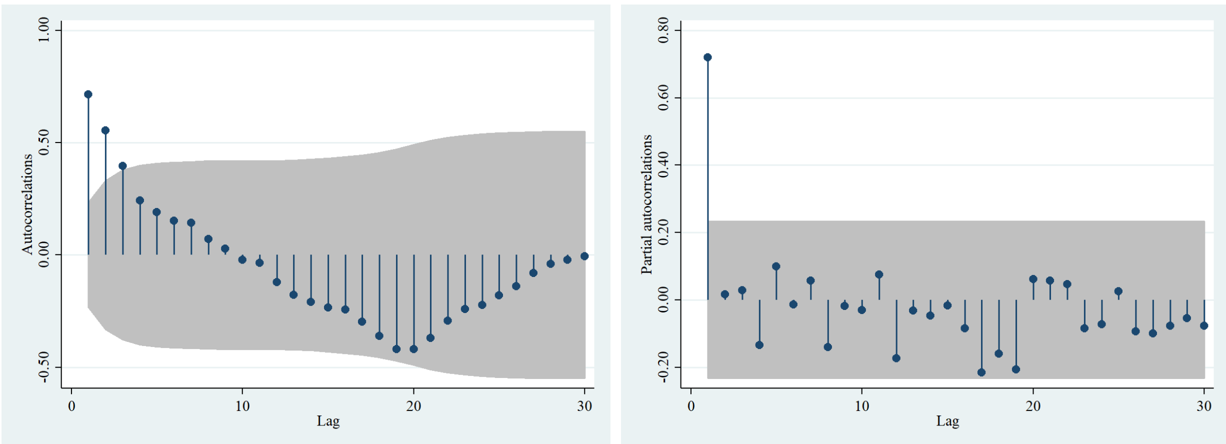
The OLS estimation, however, reveals that the error terms are autocorrelated. Thus, I use the Box-Jenkins method to identify the parameters of equation (16). To get stationary series, I first fit the series of interest with linear trends and subtract the fitted values from the original data.

$$\widehat{\ln \Delta_t} = \zeta_{\Delta 0} + \zeta_{\Delta 1} t; \qquad \widehat{\ln(1-\tau_t)} = \zeta_{\tau 0} + \zeta_{\tau 1} t \tag{17}$$

$$\widetilde{\ln \Delta_t} = \ln \Delta_t - \widehat{\ln \Delta_t}; \qquad \widetilde{\ln(1-\tau_t)} = \ln(1-\tau_t) - \widehat{\ln(1-\tau_t)} \tag{18}$$

t is the time variable. Equation (17) consists in fitting the series of log of the value-added ratio and log of the retention rate by linear trends. Equation (18) consists in subtracting from the series of log of value-added ratio and the log of the retention rate their respective fitted trends. The series with the *tilde* sign are stationary.

Figure 3: Autocorrelation and Partial Autocorrelation of $\widetilde{\ln \Delta}$



Note: Bartlett's formula for MA(q) 95% confidence bands.

Note: 95% confidence bands (se=$\frac{1}{\sqrt{n}}$).

Next, I determine the order of the autoregressive and moving average terms. The autocorrelation plot and partial autocorrelation plot of the stationary series of the log value-added ratio show that the best specification is AR(1). Indeed, the autocorrelation coefficients alternate between positive and negative values before decaying to zero. Furthermore, only the first order partial autocorrelation differs significantly from zero. Thus, the best model to estimate is as follows:

$$\widetilde{\ln \Delta_t} = \delta_0 + \delta_1 \widetilde{\ln \Delta_{t-1}} + \delta_2 \widetilde{\ln(1-\tau_t)} + \epsilon_t \tag{19}$$

To identify the parameters of the model (19), I use likelihood maximization with the Berndt-Hall-Hall-Hausman and Broyden-Fletcher-Goldfarb-Shanno algorithms[9]. The estimation results are in column (5) of Table 1.

Table 1: Corporate taxation and structural change

	(1)	(2)	(3)	(4)	(5)
Corporate retention rate	2.28^{***}	1.48^{***}	2.12^{***}	1.48^{***}	0.27^{***}
	(0.14)	(0.09)	(0.27)	(0.16)	(0.1)
TFP ratio		-1.6^{***}		-1.89^{***}	
		(0.12)		(0.14)	
Factors cost ratio			0.06	-0.1^{***}	
			(0.05)	(0.02)	
AR(1)					0.83^{***}
					(0.07)
R^2	0.69	0.89	0.58	0.88	

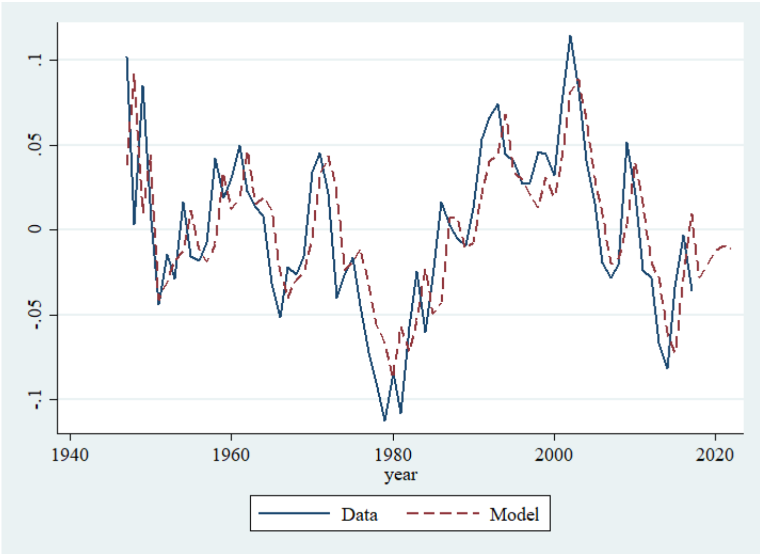
Note: The time period has 71 years.
$^{*}\, p < 10\%$, $^{**}\, p < 5\%$, $^{***}\, p < 1\%$

The data considered in this section for the estimation results in table 1 are data from the Federal Reserve Economic Data on Corporate Taxes; data from Herrendorf et al. (2021) of the sectoral value-added, sectoral TFPs, and cost of labor; and data from the World Development Indicator for the cost of capital. The coefficient of the log of the retention rate is significant and positive in all five models, ranging from 0.27 to 2.28. It implies that a 1% increase in the retention rate leads to an increase in the services value-added relative to the goods value-added of 0.27 to 2.28 percentage points. Specifically, according to Box-Jenkins method, 1% increase in the retention rate increases the services value-added relative to the goods value-added by 0.27%.

In addition to the relative TFP (Herrendorf et al. (2021), Ngai and Pissarides (2007)),

[9]These two algorithms are Stata's default algorithms for ARMA class model estimation.

Figure 4: Model v.s. Data



and the relative cost of factors (Alvarez-Cuadrado et al. (2018), Acemoglu and Guerrieri (2008), Sandwidi (2023)), institutional factors also contribute to structural change in the US economy, which is characterized by a decline in the goods value-added share relative to the services value-added share. Specifically, the ongoing reduction in corporate tax to stimulate production. Since 1980, the effective tax on labor has remained relatively constant and around 25.5% (Acemoglu et al. (2020)), while the corporate tax has experienced a steady decline. Between 1947 and 2022, the retention rate increased by approximately 28.4% as a result of lower corporate taxes. This change resulted in a 7.1% increase in the value-added of the services sector relative to the goods sector during this time period.

The TFP ratio measures the TFP of the services sector relative to the goods sector. The TFP ratio coefficient is significantly negative. That means that a 1% decrease in services sector TFP relative to goods sector TFP contributes to a 1.6% increase in services value-added relative to goods sector TFP. Between 1947 and 2017, changes in the relative TFP contributed to a 65.6% increase in the value-added of the services sector relative to the goods sector TFP.

Figure 4 compares the model with the data. The data is the series of the log of the value-added ratio of services and goods, with the trend removed. The model is simulated using equation (19) with the parameters listed in column (5) of table 1. The blue line represents the data, and the red line represents the model. The model is a good predictor of the data as it replicates the fluctuations observed in the data. Thus, model (19) is appropriate for investigating the relationship between corporate taxation and structural change. Furthermore, the Portmanteau test reveals that the residual is white noise.

3.4. Robustness Check

In this section, I examine the robustness of the relationship between corporate tax and structural change, using additional data sources. I make use of the fact that the decline in corporate taxation is not unique to the United States. The corporate tax rate has been reduced in the majority of OECD countries. The OECD countries' corporate statutory tax is depicted in Figure B.5. Apart from Chile, where the corporate tax has steadily increased, and Colombia and Costa Rica, where it has remained relatively constant, the other OECD members have reduced the corporate tax rate between 1981 to 2021.

I consider panel data on OECD countries of corporate tax rate and the sectoral value-added. The model under consideration is as follows:

$$\ln \Delta_{it} = \delta_0 + \delta_1 \ln(1 - \tau_{it}) + \gamma_i + \epsilon_{it} \tag{20}$$

where t is the time variable, i represents the country, and γ_i is the country fixed effect. The error terms are autocorrelated

$$\epsilon_{it} = \delta_\epsilon \epsilon_{it-1} + \nu_{it}$$

where ν_{it} are i.i.d.

Δ_{it} is the value-added ratio of services to goods calculated using United Nations Statistics Division data. The retention rate is calculated using data on corporate statutory tax rates provided by OECD countries. It is an unballanced panel covering 30 of OECD countries from 1981 to 2021. I identify the parameters by using generalized least squares with autocorrelation structure within panels. The results are listed in Table 2.

Column (1) corresponds to the estimates of the model (20) with OLS and clustered standard errors, ignoring the error terms autocorrelation structure. Columns (2) and (3) look at the autocorrelation structure without taking into account the country fixed effect. Column (3) controls for heteroskedasticity across countries in addition to autocorrelation. Column (4) takes into account the autocorrelation structure as well as the country fixed effect.

Table 2: Corporate taxation and structural change

	(1)	(2)	(3)	(4)
Corporate retention rate	1.04***	0.19***	0.15***	0.13***
	(0.19)	(0.05)	(0.03)	(0.05)
country FE	Yes			Yes

Note: $^{*}p < 10\%$, $^{**}p < 5\%$, $^{***}p < 1\%$
The number of observations is 1010

According to the estimation, the increased corporate tax retention rate has also contributed to structural change in OECD countries. Indeed, a 1% increase in retention rates contributes to an increase in services value-added relative to goods value-added of at least 0.13% on average across the OECD countries. The average marginal effect of the OECD countries' corporate tax is less than that of the United States alone. However, the effect is statistically and economically significant.

The estimation results of the model (20) using world indicator data on corporate statutory taxes are shown in table 3. It also covers 30 OECD countries between 2005 and 2019. The identification strategy is identical to Table 2, for each column, respectively. This data represents a shorter time horizon, but it also demonstrates that the relationship between retention rate and structural change is positive. The coefficient is statistically significant for columns (1) and (3) but not for columns (2) and (4). The relationship between corporate tax retention rates and structural change is, thus robust.

Table 3: Corporate taxation and structural change

	(1)	(2)	(3)	(4)
Corporate retention rate	0.39^{***}	0.08	0.08^{***}	0.06
	(0.08)	(0.05)	(0.04)	(0.06)
country FE	Yes			Yes

Note: $^{*}p < 10\%$, $^{**}p < 5\%$, $^{***}p < 1\%$
The number of observation= is 433.

Concluding remarks

In addition to the various sources listed in the literature, the institutional factor has also contributed to structural change. Particularly, the US corporate tax cut, which aims to boost domestic production and competitiveness, has reduced the marginal cost of the capital-intensive sector relative to the labor-intensive sector. As a result of the reduction in corporate tax cuts, the relative value-added across sectors has changed. Three scenarios are proposed to explain how corporate tax cuts contribute to a relative increase in the services value-added share relative to the goods value-added share.

The first scenario assumes that the goods sector is capital-intensive, while the services sector is labor-intensive, and that the two sectors complement each other. In this case, lowering the corporate tax rate reduces the goods sector marginal cost relative to the services sector. As a result, the optimal output of services relative to goods is reduced. However, because goods and services are gross complements, the price of services skyrockets in comparison to the price of goods, causing service value-added to rise compared to goods value-added.

The second scenario assumes that the sectors are gross substitutes, with the services sector more capital-intensive than the goods sector. The lower corporate tax raises the marginal cost of the goods sector relative to the services sector in this case. As a result, the optimal output in terms of services versus goods rises. Because the sectors are gross substitutes, increased supply has little effect on service prices. As a result, the value-added share of the goods sector falls.

The third scenario is based on three assumptions consistent with Herrendorf et al. (2021) and Alvarez-Cuadrado et al. (2018)' estimates. First, the services sector is capital-intensive, whereas the goods sector is labor-intensive. Second, goods and services are complement. Third, the difference in factor intensities is narrowing over time. In this case, decreasing corporate taxes reduces the value-added disparity between goods and services. However, the contribution of corporate taxes to reducing the value-added divergence between goods and services diminishes over time.

I conduct an empirical analysis, in order to quantify the contribution of corporate tax cuts to structural change. Increasing the tax retention rate by 1% results in a 0.27% increase in the value of services relative to the value of goods. The corporate tax increased the value-added of services by 7% relative to the goods sector between 1947 and 2021.

Tax changes have an impact on structural change because the sectors have different factor intensities. I use Herrendorf et al. (2021) data to document changes in factor intensities in the United States from 1947 to 2017. Prior to 2002, the labor share in the goods sector was higher than in the services sector. However, since 2003, the labor share in the services sector has increased. Thus, factor intensities are structurally different across sectors.

The positive effect of corporate taxation on structural change is not limited to the United States, but applies to all OECD countries. However, there is no empirical evidence of this relationship when developing countries are considered.

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Appendices

Appendix A.

Proof of Proposition 1

$$\frac{\partial S_1}{\partial \tau} = \frac{\partial (1-S_2)}{\partial \tau} = -\frac{\partial S_2}{\partial \tau}$$

$$\frac{\partial \Delta}{\partial \tau} = -\frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}\frac{\Delta_\gamma}{1-\tau}; \qquad \frac{\partial S_1}{\Delta_\gamma} = -S_1^2$$

$$\frac{\partial S_1}{\partial \tau} = \frac{\partial S_1}{\partial \Delta_\gamma}\frac{\partial \Delta_\gamma}{\partial \tau} = \frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}\frac{\Delta_\gamma}{1-\tau}S_1^2$$

Proof of equation (13)

$$\Delta_t = \left(\frac{1-\psi}{\psi}\right)^{\frac{1}{1-\gamma\rho}}\left(\frac{1}{\theta}\frac{A_{2t}}{A_{1t}}\left(\frac{w_t}{r_{\tau t}}\right)^{\alpha_{2t}-\alpha_{1t}}\right)^{\frac{\rho}{1-\gamma\rho}}$$

$$\ln\Delta = \frac{\rho}{1-\gamma\rho}\left(\ln\frac{A_2}{A_1} + (\alpha_2-\alpha_1)\ln\frac{w}{r} + (\alpha_2-\alpha_1)\ln(1-\tau)\right)$$

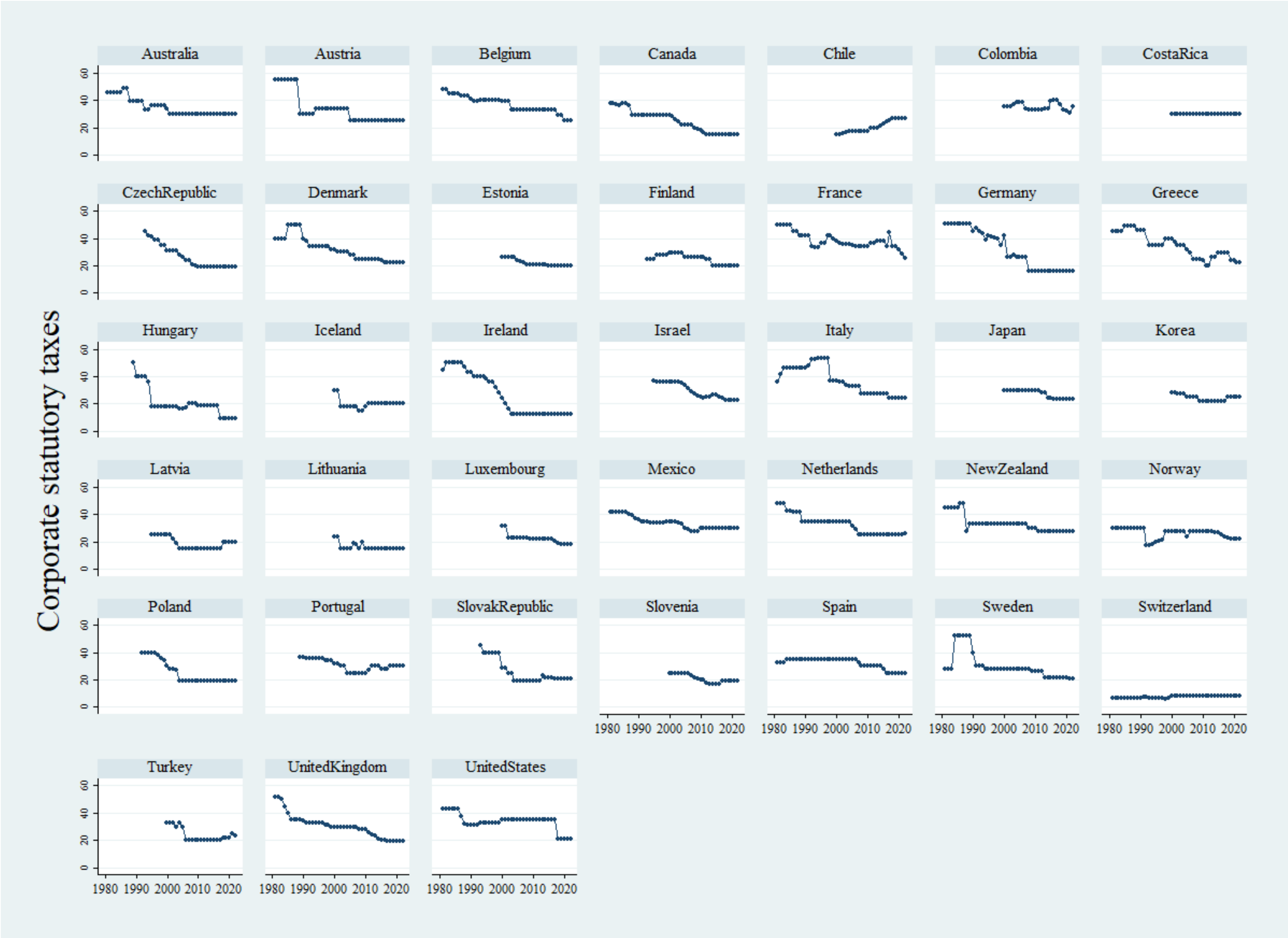
$$\frac{\partial \ln\Delta}{\partial \ln(1-\tau)} = \frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}$$

Proof of Corollary 1

Let us consider the decreasing return to scale case. Let us denote by $\Phi_\gamma = \frac{\rho(\alpha_2-\alpha_1)}{1-\gamma\rho}\frac{\Delta_\gamma}{1-\tau}S_1^2$. The limit of Φ_γ when γ tends to one exists and equals $\Phi_1 = \frac{\rho(\alpha_2-\alpha_1)}{1-\rho}\frac{\Delta_1}{1-\tau}S_1^2$; where $S_1 = \frac{1}{1+\Delta_1}$. According to Sandwidi (2023), $\frac{\partial S_1}{\partial\tau}$ in the constant return to scale model is the limit of Φ_γ when γ tends to one, which is equal to Φ_1.

Appendix B.

Figure B.5: Corporate statutory taxes across OECD countries



Note: The data source is OECD.