ESSAYS ON GROWTH, STRUCTURAL CHANGE AND TAXATION

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ABSTRACT

Essays on Growth, Structural Change and Taxation

This thesis examines economies' long-run dynamics with theoretical and empirical tools. It is composed of three chapters. In Chapter 1, we provide evidence for the labor share, structural change, fixed costs, and productivity divergence for the US economy that we observe in the data. The theoretical model with increasing fixed cost and dispersion in TFP growth across firms explains the most significant part of the decrease in aggregate labor share. The differentiation in labor shares of the two sectors can also stem from the difference in the standard deviation of TFP growth. In Chapter 2, we estimate a panel Structural VAR model for eleven OECD countries using yearly data between 1973 and 2015. We identify a permanent shock to the corporate income tax rate, which is exogenous to economic activity. Our results show that a cut in corporate income taxation positively influences hours worked and aggregate output for the whole sample. While corporate taxation has been almost halved in OECD countries over the last four decades, the effects of its decline are quite distinct between the two groups of countries. In Chapter 3, we investigate the effect of tax amnesty on the firm dynamics. We use the Difference in Differences (DiD) model to investigate the impact of the tax amnesty in 2011 in Turkey on firms' employment and net sales. The results show that tax amnesty significantly and negatively impacts the employment and net sales of firms that have tax debt before the amnesty.

ÖZET

Büyüme, Yapısal Değişim ve Vergilendirme Üzerine Yazılar

Bu tez, ekonomilerin uzun vadeli dinamiklerini teorik ve ampirik araçlarla incelemektedir. Üç bölümden oluşmaktadır. Bölüm 1'de, 1980'lerden bu yana verilerde gözlemlediğimiz ABD ekonomisi için emek payının, yapısal değişimin, sabit maliyetlerin ve üretkenlik farklılığının evrimine dair kanıtlar sunuyoruz. Toplam işgücü payındaki düşüşün en önemli kısmını, artan sabit maliyet ve Total-Faktör-Verimlilik (TFV) büyümesinde firmalar arası dağılımlı model açıklamaktadır. Modelin karşı olgusal simülasyonları, emek yoğun ve sermaye yoğun sektörlerin emek paylarındaki farklılaşmanın, iki sektörün TFV büyümesinin standart sapması arasındaki farktan kaynaklanabileceğini göstermektedir. Bölüm 2, 1973 ve 2015 yılları arasındaki yıllık verileri kullanarak on bir OECD ülkesi için bir Panel Yapısal VAR modeli tahmin etmektedir. İlk olarak ekonomik faaliyete dışsal olan kurumlar vergisi oranına kalıcı bir şok tespit ediyoruz. Sonuçlarımız, kurumsal gelir vergisindeki bir kesintinin, tüm örnek için çalışma saati ve toplam çıktıyı olumlu etkilediğini göstermektedir. OECD ülkelerinde kurumlar vergisi son kırk yılda neredeyse yarı yarıya azaltılmış olsa da, düşüşün etkileri iki ülke grubu arasında oldukça farklıdır. Bölüm 3'te, Türkiye'de 2011 yılında uygulanan vergi affının firmaların istihdamı ve net satışları üzerindeki etkisini araştırmak için Farklardaki Fark metodolojisini kullanıyoruz. Sonuçlar, vergi affının af öncesi vergi borcu olan firmaların istihdamını ve net satışlarını önemli ölçüde ve olumsuz etkilediğini göstermektedir.

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CHAPTER 1

EVOLUTION OF LABOR SHARE AND STRUCTURAL CHANGE

1.1 Introduction

After the 1980s, the United States economy has been experiencing crucial changes in labor share and sectoral allocation of labor and value-added. The decrease in the U.S. labor share is well documented in the literature (Piketty and Zucman (2014), Karabarbounis and Neiman (2014), Autor, Dorn, Katz, Patterson, and Van Reenen (2020)). Structural change is deeply analyzed because of its inevitable relationship with countries' economic growth and development (Herrendorf, Rogerson, & Valentinyi (2014)). The link between these two phenomena is not examined in the literature with considering the productivity divergence between firms and the increase in fixed operating costs. The first chapter of this thesis provides empirical evidence for the evolution of labor share, structural change, productivity dispersion, and fixed costs. We then construct a theoretical model to present how productivity divergence between firms and fixed cost growth lead to a decline in labor share and structural transformation.

Our first observation is regarding the evolution of labor share at the sectoral level [1]. Labor share is almost constant for labor-intensive sectors, whereas it is 12 percent decreasing for the capital-intensive sector from 1987 to 2015[2]. Second fact is that the US economy has been experiencing a structural change, that is the reallocation of employment and value-added between capital-intensive and labor-intensive sectors in the same period. Thirdly, we state that the fixed cost share in total cost or value-added

[1] We separate sectors in terms of labor share as labor and capital-intensive sectors, similarly to Acemoglu and Guerrieri (2008).

[2] Alvarez-Cuadrado, Long, & Poschke (2018) also imply that the decline in labor share is more in manufacturing than service sectors.

has been increasing since the 1980s. The increase from 1987 to 2015 is almost 11 percentage points, and this observation is compatible with the related literature (e.g., De Loecker, Eeckhout, & Unger (2020), De Ridder, M. (2019)). As a final observation, within sector TFP differentiation is explored. The standard deviation of log TFP is increasing in both sectors. Literature examines the productivity divergence both within and between sectors (e.g., Decker, Haltiwanger, Jarmin, & Miranda (2020) and Chiavari,& Goraya (2020)). Also, we show that the results are robust to classifying sectors as manufacturing and non-manufacturing, instead of labor intensive and capital intensive.

The importance of our study is to propose a model for the investigation of these four observations. We present a model to illustrate how capital deepening combined with productivity divergence and fixed cost growth affects factor shares and the sectoral composition of the value added. Our model benefits from Acemoglu and Guerrieri (2008) to link capital deepening and reallocation of labor between two sectors. As in Atkeson and Burstein (2008), we use variable markups by assuming that firms operate in a Cournot competition setting. We calibrate the described model to examine whether the evolution of labor share in the model is consistent with the evolution of labor share in US data. The simulations enable us to make a counterfactual analysis of the following mechanisms: the impact of capital deepening, fixed costs, and the productivity dispersion of firms overtime on labor share and structural change.

The model can explain almost all of the long-run decrease in aggregate labor share and more than half of labor share in the capital intensive sector. It can fit the flow of labor from the capital to the labor-intensive sector but overstates the long-run decline in the labor share of the labor-intensive sector. We check for robustness by

taking fixed costs as intellectual property products and changing fixed costs for each sector and sector classification. The results are very similar in robustness experiments to the baseline experiment. With the help of counterfactual experiments, we can argue that the decline in aggregate labor shares is primarily because of fixed costs and the TFP dispersion of sectors. Also, the difference in the evolution of labor shares between two sectors stems from the rise in the standard deviation of productivity in sectors rather than a fixed cost increase. The flow of employment to the labor-intensive sector can be explained by productivity dispersion. Additionally, we extend the model by adding capital-labor substitutability to simulate the structural change and the evolution of labor income shares via the -impact of capital labor substitution. The simulation of the extended model indicates that the model can match the US data well.

The contribution of this study to the literature is to construct a theoretical model to simulate the mechanisms that emerge in empirical analysis. As far as we know, no study presents a model to investigate the structural change and differentiation in labor shares of capital and labor-intensive sectors via the joint impacts of productivity divergence and fixed cost. Our model provides a novel simulation setting to analyze each mechanism separately by counterfactual analysis.

1.2 Literature review

There is an ongoing debate in the literature about the reasons for the secular decline of labor share in value-added for most developed countries. A potential explanation focuses on decreased labor share because of falling investment, capital prices, and capital accumulation. Karabarbounis and Neiman (2014) present evidence for the fall in labor share in the U.S. They argue that the lower price of investment goods is the main reason behind this trend. Koh, Santaeulalia-Llopis, and Zheng (2020) argue that

the decrease in U.S. labor share is due to the transition towards a more intellectual property products capital-intensive economy.

Barkai (2020) documents that while the labor and capital shares decline, there has been an increase in the profit share in the US non-financial corporate sector since the 1980s. He shows that the decline in capital share is not a result of unobserved capital, and the increase in pure profit offsets this. Salas, Juan, and Valles (2018) analyze the evolution of labor, capital, and profit in the gross value added for five developed countries. Their results support the argument that the rise in market power leads to changes in the composition of gross value added between labor, capital, and profit over time for the US. Gutierrez (2017) examines labor and profit share evolution in twelve developed countries. They show that the real estate sector is the primary driver of declining labor shares except in the US, where a decrease in competition can explain it. De Loecker et al. (2020) investigate the evolution of markups by using firm-level US data since 1950. They show that markups have been increasing since the 1980s, which is not explained by the rise in overhead costs. They argue that the rise in markup leads to a decrease in labor and capital share.

On the other hand, market concentration is also analyzed as a part of this literature. Autor et al. (2020) document that market concentration increases when industries become increasingly dominated by superstar firms which occurs due to globalization and technological improvement. Between firms reallocation leads to a decrease in labor share. Grullon, Larkin, and Michaely (2019) provide evidence for the US for the higher profit because of increased concentration.

The evolution of these factor shares has been investigated in the growth literature via theoretical models. Aghion, Bergeaud, Boppart, Klenow, and Li (2019) set up

an endogenous growth model with heterogeneous firms to show that a falling labor share can be explained by the rising market share of low labor share firms. Grossman, Helpman, Oberfield, and Sampson (2017) show that productivity slowdown is the main reason behind the decline in the US labor share by using a neoclassical growth model. Ray and Mookherjee (2022) argue that the decline in labor share is a primary result of a growth model that includes the fundamental asymmetry between the accumulation of physical and human capital. Glover and Short (2019) construct a neoclassical growth model to show that capital deepening cannot yield a decrease in labor share by estimating the elasticity of substitution between capital and labor less than one.

Structural transformation is studied through several channels in the literature because of its inevitable impacts on growth and development[3]. The thesis chapter will investigate the relationship between the evolution of factor shares and development via the structural change channel. In doing so, this study mainly benefits from Acemoglu and Guerrieri (2008). They construct a two-sector general equilibrium model in which differences in factor proportions and capital deepening lead to non-balanced growth. The more capital-intensive sector grows faster because of capital deepening but labor and capital move to the other sector. Thus, the more capital-intensive sector has higher output growth but lesser employment growth. Some papers analyze the link between labor share and structural transformation across sectors. Alvarez-Cuadrado et al. (2018) imply that the decline in labor share is more in manufacturing than service sectors. They show with a theoretical model that the productivity and the capital-labor substitutability differences across sectors are vital determinants of observed trends. Suzuki, Oishi, and Paul (2019) document the impact of trade openness and structural

[3]See Echevarria (1997), Laitner (2000) and Kongsamut, Rebelo and Xie (2001), Baumol (1967), Ngai and Pissarides (2007), and Acemoglu and Guerrieri (2008).

transformation on the labor income share empirically for 54 countries across five regions.

Our study is also related to De Loecker, Eeckhout, & Mongey (2021). They propose a general equilibrium model with oligopolistic output markets. They explain the rise in market power with technology, via productivity shocks and the cost of entry, and market structure, via changes to the number of potential competitors. However, they do not examine market power and reallocation of resources at the sector level. The most related study to our research is Catalán (2018). He sets up a two-sector model to present the aggregate decrease in labor share and the differentiation between service and non-service sectors. In his setting, the divergence stems from the differences in capital-labor substitutability and technical change between sectors. Nonetheless, our model is differentiated from his model by including firm heterogeneity, and we can model fixed cost-share and productivity divergence. Also, our simulations can mimic the reallocation of labor across sectors that we observe in the data.

1.3 Data and empirical facts

In this section, we present the empirical evidence for the evolutions of labor share, structural change, productivity dispersion, and fixed cost.

1.3.1 Data

As a first step we calculate the factor income shares. Labor, capital and profit shares are calculated by using the 2017 EU KLEMS database. It includes the data based on NACE 2 industry classification, which is compatible with ISIC Revision 4 industry classification but not entirely incompatible with the North American Industry Classification System (NAICS). It includes the data on output, value-added, employment, gross

fixed capital formation, prices, and capital stocks for 34 industries plus eight aggregates. The study captures the market economy, which covers all industries minus L, O, P, Q, T, and U for all output and capital files variables.

We calculate capital compensation using the cost of capital inputs used in the production as in Barkai (2020). Capital input data includes ten asset types as in Table B1 in Appendix B. After calculation of capital compensation, we drop negative capital compensation values. This leads to non-negligible gaps in the sectors; Mining and quarrying and Real estate activities. Thus, we drop these sectors. Agriculture and Postal and courier activities are dropped because there is missing data on the IT investment of these industries. As a result the market economy in United States have 23 sectors[4].

For nominal cost of borrowing in financial markets Ameco central government benchmark bonds are used. GDP per-capita is taken from World Bank data-set.

The evolution of labor share is investigated at the sector level. Categorization in Acemoğlu & Guerrieri (2008) is used while grouping industries; they divide sectors into two groups with approximately 50% of employment. However, in EU KLEMS, employment data starts from 2000, so labor compensation is used in this analysis. We compute the average labor share over the whole period (1987-2015). Industries are classified as above and below median labor share, which creates two groups of

[4]These sectors are: Food products, beverages and tobacco, Textiles, wearing apparel, leather and related products, Wood and paper products; printing and reproduction of recorded media, Coke and refined petroleum products, Chemicals and chemical products, Rubber and plastics products, and other non-metallic mineral products, Basic metals and fabricated metal products, except machinery and equipment, Electrical and optical equipment, Machinery and equipment n.e.c., Transport equipment, Other manufacturing; repair and installation of machinery and equipment, Wholesale trade, except of motor vehicles and motorcycles, Retail trade, except of motor vehicles and motorcycles, Transport and storage, Postal and courier activities, Publishing, audiovisual and broadcasting activities, IT and other information services , forestry and fishing, Electricity, gas and water supply, Construction, Accommodation and food service activities, Financial and insurance activities, Professional, scientific, technical, administrative and support service activities, Arts, entertainment and recreation, Other service activities.

industries, each with approximately 50% of labor compensation. Another way of grouping is manufacturing and non-manufacturing, which we use for robustness analysis. The median labor share is 0.65, and the sectors below and above the median labor share are listed in Table 1. The sector descriptions with capital letters are for the aggregate sectors and the descriptions with small letters indicates the industries.

Table 1. The List of Labor Income Share for Industries

Description	Average Labor Share
Coke and refined petroleum products	0.19
ELECTRICITY, GAS AND WATER SUPPLY	0.30
Chemicals and chemical products	0.355
Publishing, audiovisual and broadcasting activities	0.39
Food products, beverages and tobacco	0.44
Wholesale trade, except of motor vehicles and motorcycles	0.53
FINANCIAL AND INSURANCE ACTIVITIES	0.59
Electrical and optical equipment	0.61
Retail trade, except of motor vehicles and motorcycles	0.62
Transport equipment	0.624
Rubber and plastics products, and other non-metallic mineral products	0.625
ACCOMMODATION AND FOOD SERVICE ACTIVITIES	0.65
Basic metals and fabricated metal products, except machinery and equipment	0.67
Machinery and equipment n.e.c.	0.68
Wood and paper products; printing, and reproduction of recorded media	0.68
Transport and storage	0.69
Other manufacturing; repair and installation of machinery and equipment	0.69
Arts, entertainment and recreation	0.76
Other service activities	0.77
Textiles, wearing apparel, leather and related products	0.80
PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	0.82
CONSTRUCTION	0.83
IT and other information services	0.85

The first group contains the industries with a labor share above the median, called the labor-intensive sector. The other group is the capital-intensive sector. It is clear from the table that the above and below median sectors are not split into manufacturing and services. Six manufacturing industries are in the capital-intensive sector, whereas five are in the labor-intensive sector. This categorization is essential to investigate the structural change in the real economy and the reallocation within the individual sectors. All analyses are also done for manufacturing[5] and non-manufacturing industries [6].

We investigate the productivity dispersion estimating TFP using the Compustat North America data-set. The data range is 1950 – 2020. We are only interested in firms incorporated in the United States, so we drop firms with FIC not equal to the USA. Also, we drop firms with a currency that is not equal to USD. The measure of capital is Property, Plant, and Equipment – Total (Gross). Outliers in 5% are dropped for net investment and total sales. Also, observations with negative employment or sales values are dropped. Compustat and EU KLEMS are merged by using 12 NAICS 2 industries. The list of merged industry codes for EU KLEMS and Compustat is in the Table B2 in Appendix B.

[5]Manufacturing sectors are the sectors with code between 10-33 in EU KLEMS classification: Food products, beverages and tobacco, Textiles, wearing apparel, leather and related products, Wood and paper products; printing and reproduction of recorded media Coke and refined petroleum products, Chemicals and chemical products, Rubber and plastics products, and other non-metallic mineral products, Basic metals and fabricated metal products, except machinery and equipment, Electrical and optical equipment, Machinery and equipment n.e.c., Transport equipment and Other manufacturing; repair and installation of machinery and equipment.

[6]Non-manufacturing sectors are Construction, Electricity, gas and water supply, Financial and insurance activities, Wholesale and retail trade, except of motor vehicles and motorcycles, Transport and storage, Postal and courier activities, Accommodation and food service activities, Publishing, audiovisual and broadcasting activities, IT and other information services, Administrative and support activities, Public administration and defence; compulsory social security, Education, Health and social work, Arts, entertainment and recreation and Other service activities.

1.3.2 Factor share calculations

Labor compensation is available in EU KLEMS, but capital compensation is simply calculated as value-added minus labor compensation. Therefore, we need to calculate capital compensation ourselves using the cost of capital inputs used in the production as in Barkai (2020). He calculates capital compensation as a multiplication of the required rate of return on capital and the value of the capital stock. The model of accounting for an economy is

$$P_t^Y Y_t = w_t L_t + R_t P_{t-1}^K K_t + \Pi_t$$

where P_t^Y is the price of output and $P_t^Y Y_t$ is gross value-added. $w_t L_t$ is labor compensation. R_t required rate of return on capital, P_{t-1}^K is price of capital and K_t is capital stock. Π_t is profit value.

Required rate of return on capital input k:

$$R_k = i\text{–}E(\pi_k) + \delta_k$$

where i is nominal cost of borrowing in financial markets that is taken from Ameco central government benchmark bonds and π_k is the inflation rate of capital which is calculated by using gross fixed capital formation price index for the capital input k. δ_k is depreciation rate. $E(\pi_k)$ is three year moving average of inflation.

Nominal payments to capital of type k is

$$E_{k,t} = R_{k,t} P_{k,t-1}^K K_{k,t}$$

where $P^K_{k,t-1}K_{k,t}$ is nominal capital stock. Summing across the different types of capital input, total capital payment for each sector j is

$$E_{j,t} = \sum_k R_{k,t} P^K_{k,t-1} K_{k,t}$$

Aggregate required rate of return is

$$R_{j,t} = \frac{E_{j,t}}{\sum_k P^K_{k,t-1} K_{k,t}}$$

Capital share in sector j is

$$S_{kj} = \frac{E_j}{P^Y_j Y_j}$$

$P^Y_j Y_j$ is current national currency value of gross value added of sector j. Aggregate capital share in market economy at time t is calculated as

$$S_{k,t} = \frac{\sum_j E_{j,t}}{P^Y_t Y_t}$$

Labor share is defined as labor compensation over total gross value-added.

$$S_{l,t} = \frac{w_t L_t}{P^Y_t Y_t}$$

The gross value-added minus capital compensation and labor compensation reveals a residual. It is called as ”factorless income” in Karabarbounis and Neiman (2019). They argue that it stems from the difference between rental rate of capital and the bond returns. On the other hand, Barkai (2020) shows that the decline in capital share is not a result of unobserved capital and argue that increase in pure profit offsets this

residual. Also, De Loecker et al. (2020), demonstrates that the increase in markups is higher than the rise in overhead costs, so this creates profitability. Therefore, we call residual share as profit share throughout the paper.

$$S_{p,t} = 1 - S_{k,t} - S_{l,t}$$

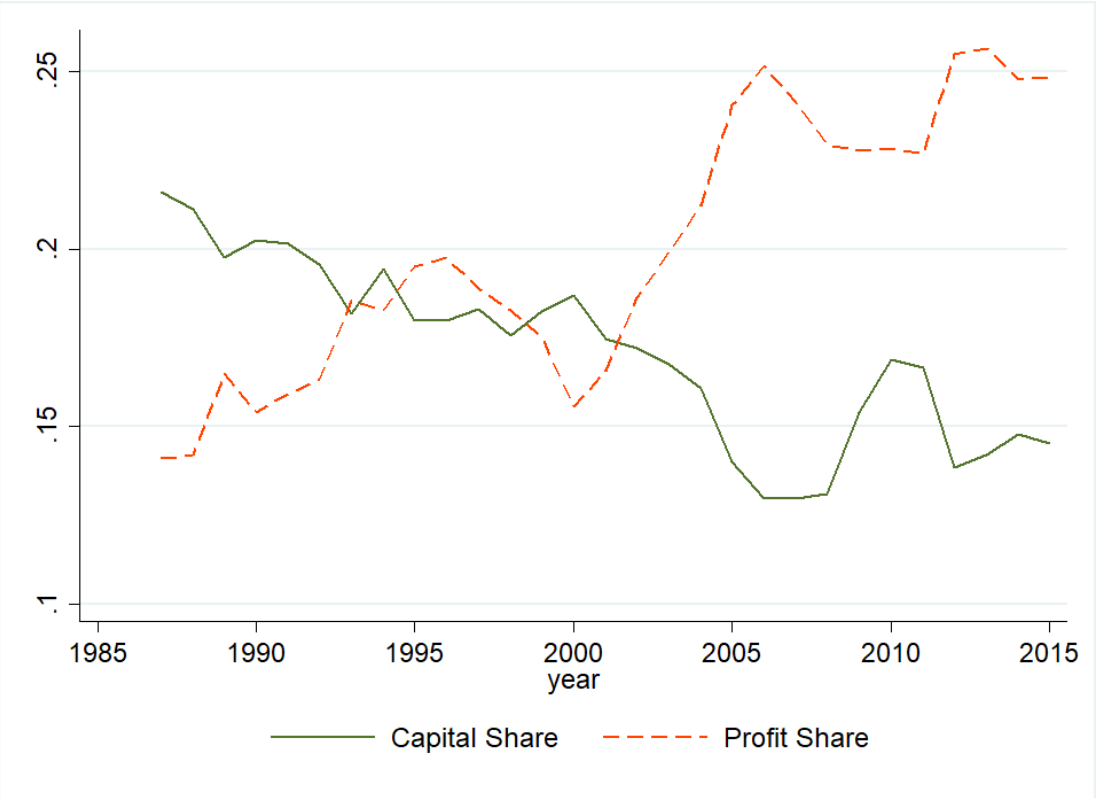


Figure 1. Calculated capital and profit shares of the US

Using the method stated above, evolution of labor, capital and profit shares for United States are plotted in the Figure 1. Capital share declines from 0.22 to 0.15 and profit share increases from 0.14 to 0.25. Evolution of factor shares is compatible with the related literature. Barkai (2020) shows that the capital share falls 7 percentage point and the profit share increases 13.5 percentage point from 1987 to 2014 in the US.

1.3.3 Empirical observations

In this section, four empirical observations are documented. Firstly, the evolution of labor share is shown for both the aggregate US economy and labor intensive and capital intensive sectors. Secondly, the structural transformation between capital-intensive and labor-intensive sectors is documented. Thirdly, we document the evolution of the standard deviation of log TFP for labor and capital intensive sectors. Finally, the change in fixed cost share is given for the aggregate US economy.

1.3.3.1 Fact 1: evolution of labor share

The decrease in the U.S. labor share is well documented in the literature. Karabarbounis and Neiman (2014) present evidence for the decline in labor share since the 1980s. They argue that the lower price of investment goods is the main reason behind this trend. Koh, et al. (2020) argue that the decrease in U.S. labor share is due to the transition towards a more intellectual property products capital-intensive economy. Barkai (2020) documents the decline in labor and capital share, increasing profit share in the U.S. non-financial corporate sector. He argues that the decline in capital share is not a result of unobserved capital and that an increase in pure profit offsets this.

Labor compensation is available in EU KLEMS, and it is derived from employee compensation plus an imputed self-employed compensation, as the National Accounts reported. Labor compensation for the self-employed is imputed, assuming the same hourly wages as employees. Data is available for 1987-2015, and it includes labor allocation of proprietors from BLS (Bureau of Labor Statistics). Figure 2 shows the evolution of aggregate labor share in United States.

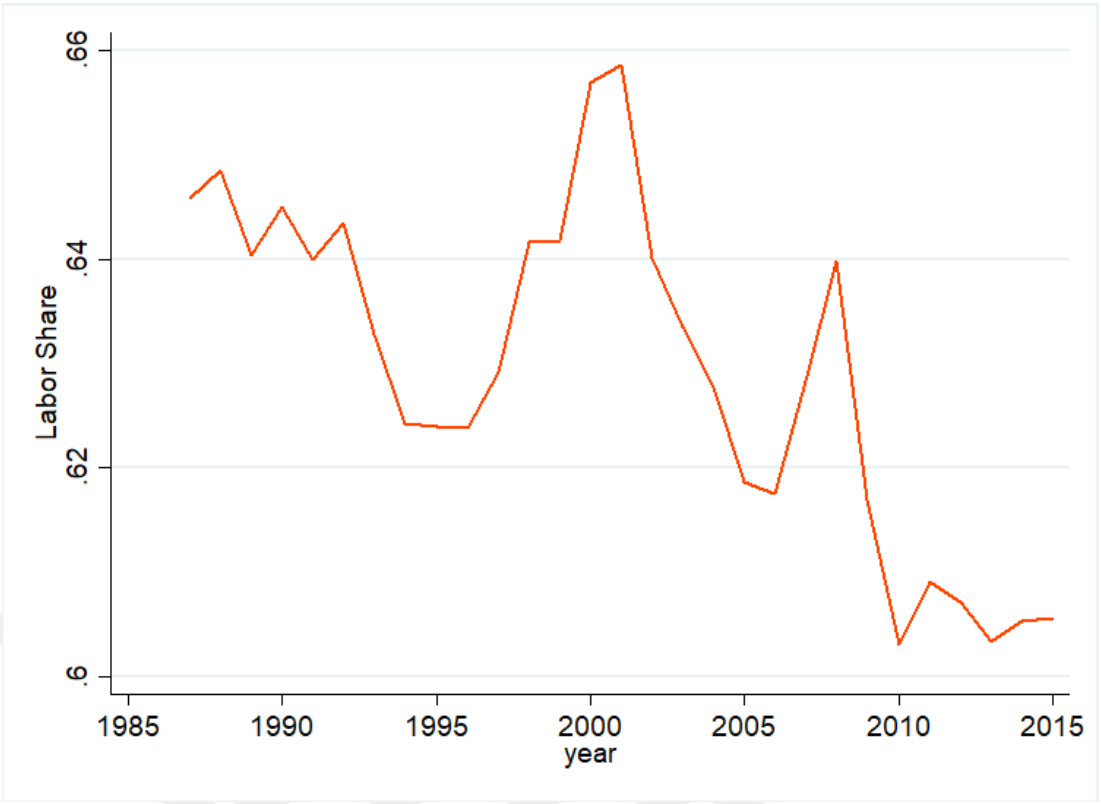


Figure 2. Evolution of aggregate labor share

Labor share decreases from 0.64 to 0.60 between 1987 and 2015 which corresponds to a six percent decline. Figure 3 shows the evolution of labor share for two groups of sectors.

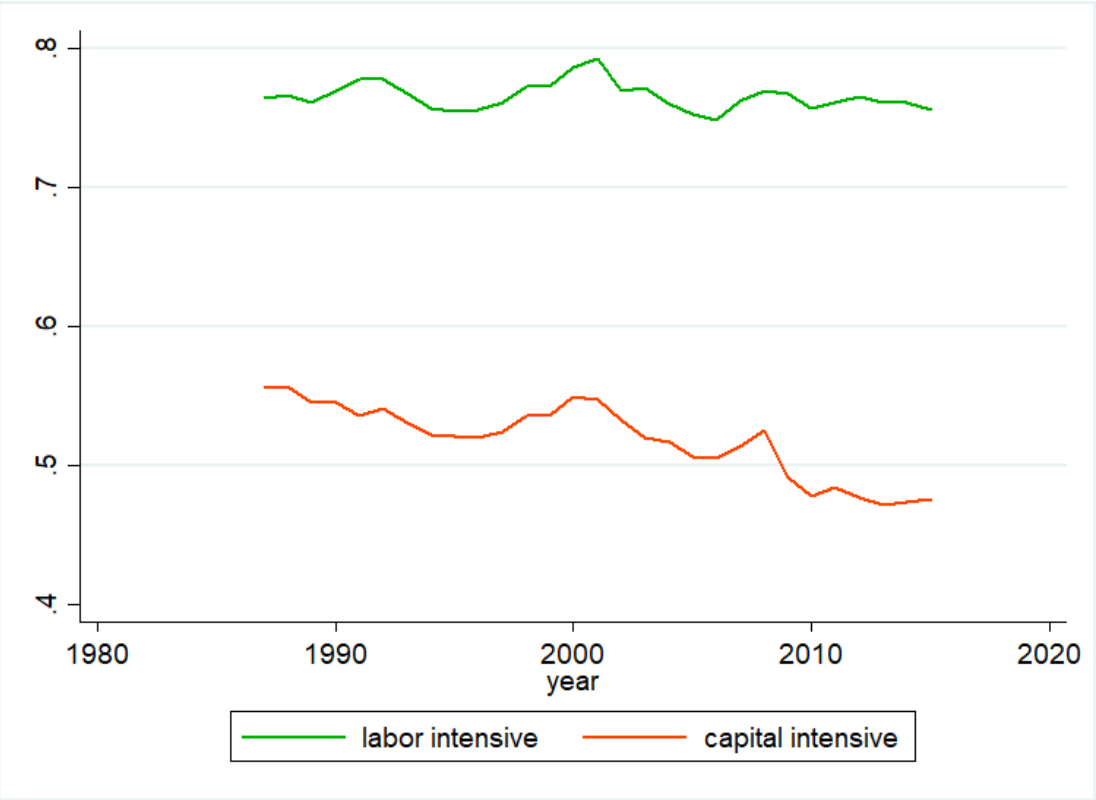


Figure 3. Evolution of labor shares for labor and capital intensive sectors

Besides the heterogeneity in the decline of labor share between the two groups, the initial levels are also different. In particular, the fall in the capital-intensive sector is much flatter than in the labor-intensive sector. The labor share in the labor-intensive sector is 0.76 in 1987 and 0.75 in 2015, and the change is 1 percentage point. In the capital-intensive sector, the labor share decreased from 0.55 to 0.48 between 1987 and 2015, and the decline is 12 percent. It is clear that there is a decline in aggregate labor share, and labor and capital intensive sectors display different labor share evolutions.

The evolution of labor share for manufacturing and non-manufacturing sectors is different from the previous segregation at the initial points which are close to each other. The decline in non-manufacturing sector is much steeper than manufacturing sector. Labor share in non-manufacturing sector is 0.645 in 1987 and 0.64 in 2015

and it is almost constant except short run fluctuations, whereas in manufacturing sector the labor share falls from 0.65 to 0.47 between 1987 and 2015 and the decline is 27%. This result is consistent with Alvarez-Cuadrado, Long and Poschke (2018) who imply that the decline in labor share is more in manufacturing than service sectors.

1.3.3.2 Fact 2: structural change

Since the 1980s US economy has experienced an outstanding decrease in labor share with a transformation in the sectoral composition of employment and value-added. Structural change is deeply analyzed because of its inevitable relationship with countries' economic growth and development. Figure 4 shows the evolution of labor and value-added for the ratio of low relative to high labor intensive sector.

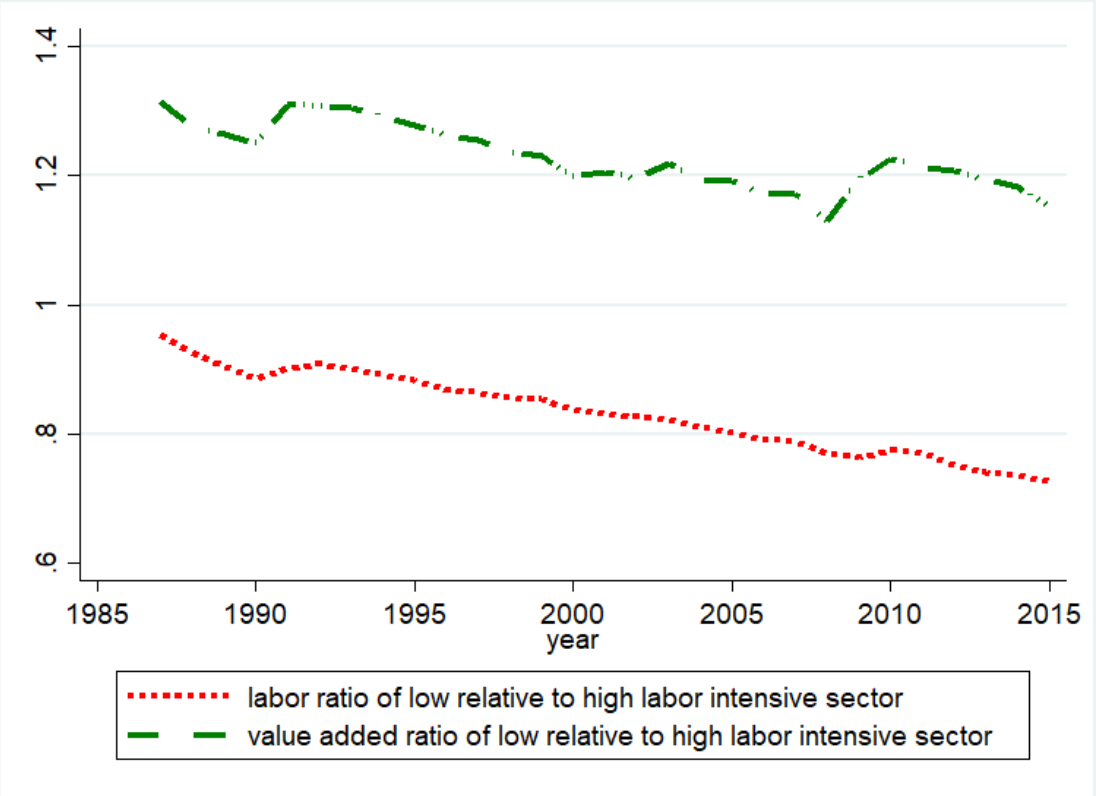


Figure 4. Structural change measured in terms of sectoral employment ratio (dotted line) and value added ratio (dashed line)

There is more rapid growth of labor compensation in less capital-intensive sectors, and the growth rate of gross value added is faster in more labor-intensive sectors. This means a reallocation of resources from the capital-intensive to the labor-intensive sector. The dashed green line shows the value-added ratio in the low, relatively high labor-intensive sector. The decreasing trend implies a sharp fall in the contribution of capital-intensive sectors to gross value added relative to labor-intensive sectors.

1.3.3.3 Fact 3: productivity divergence

There are different methods to estimate productivity at the firm level. We use Olley and Pakes (1996) approach to evaluate TFP. Olley and Pakes (1996) assume that if a firm stays in the market, it chooses variable input (e.g., labor) and investment level. The firm's profit is realized based on state variables (e.g., capital stock and age of the firm). Conditional on the exit and investment decision, Olley and Pakes (1996) specify a production function to estimate the parameters. Thus, it is a novel approach to eliminating the simultaneity problem by using investment as a proxy for productivity and selection problems by using exit probabilities.

Firm-level TFP is estimated by using a Stata code (opreg) implemented by Yasar, Raciborski, and Poi, (2008) with the following equation

$$log(y_{i,t}) = \alpha_0 + \alpha_k log(k_{i,t-1}) + \alpha_n log(n_{i,t}) + \alpha_a log(a_{i,t}) + \varepsilon_{i,t},$$

where $y_{i,t}$ is real sales, $k_{i,t-1}$ is capital stock, $n_{i,t}$ is employment, $a_{i,t}$ is the age of the firm.

Firm-Level TFP has been computed with Compustat North America dataset. We merged Compustat North America dataset with EU KLEMS dataset so that the

time coverage is 1987-2015. There are 14 Naics 2 industries in the EU KLEMS dataset. Mining, real estate, and some four-digit industries such as Wholesale and retail trade and repair of motor vehicles and motorcycles are dropped because of non-negligible gaps in US data. Compustat and EU Klems are merged by using 12 NAICS 2 industries. The list of merged industry codes for EU KLEMS and Compustat is in the Appendix B.

TFP dispersion is evaluated as the standard deviation of TFP in six-digit NAICS industries. First, the standard deviation of TFP for each NACE industry is calculated. Then standard deviations of labor-intensive and capital-intensive sectors are computed by weighted and unweighted averages of standard deviations of NACE industries. Figure 5 shows the evolution of the weighted average of standard deviation for labor and capital intensive sectors.

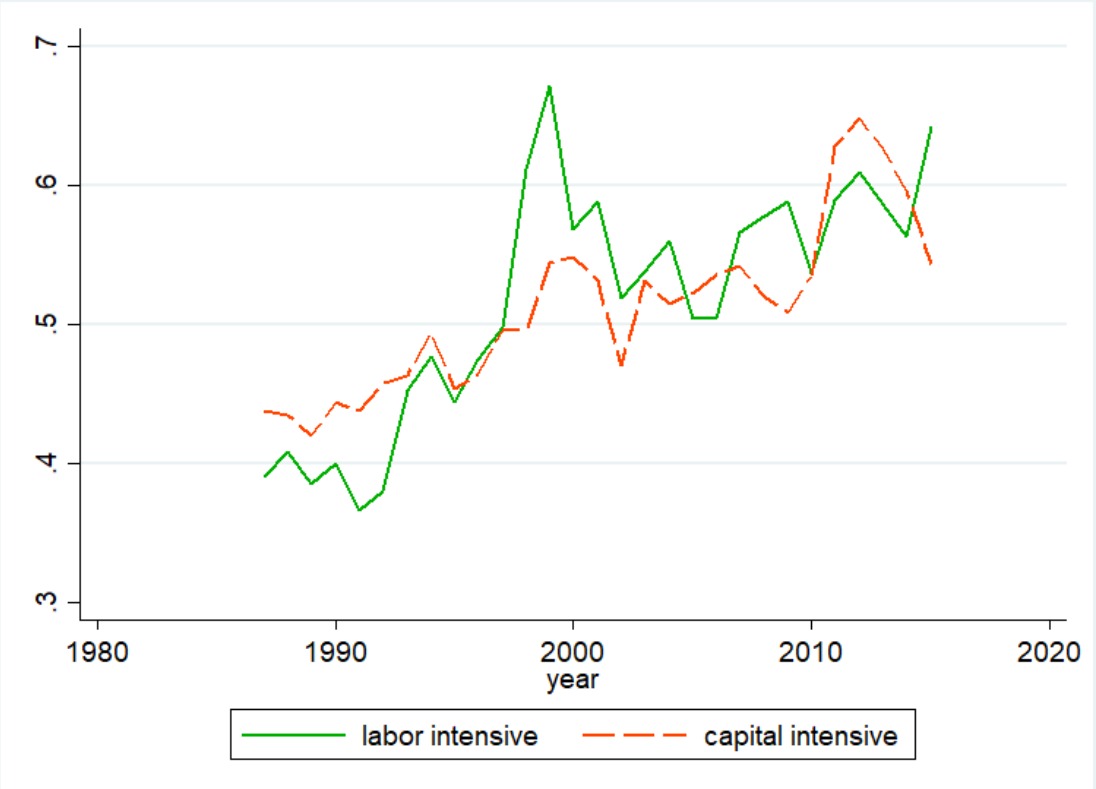


Figure 5. Weighted averages of standard deviation of logarithm of TFP

It rises from 0.4 to 0.6, and the increase is almost 50%. This observation is compatible with the recent literature. Decker et al. (2020) show that within-industry TFP dispersion increases for manufacturing. Their estimation indicates that dispersion of TFP-Shares rises from about 0.46 to 0.51 between the 1980s and 2000s. Chiavari and Goraya(2021) present that the rise in TFPR is almost 50%. Figure 6 demonstrates the evolution of un-weighted average of TFP for labor and capital intensive sectors.

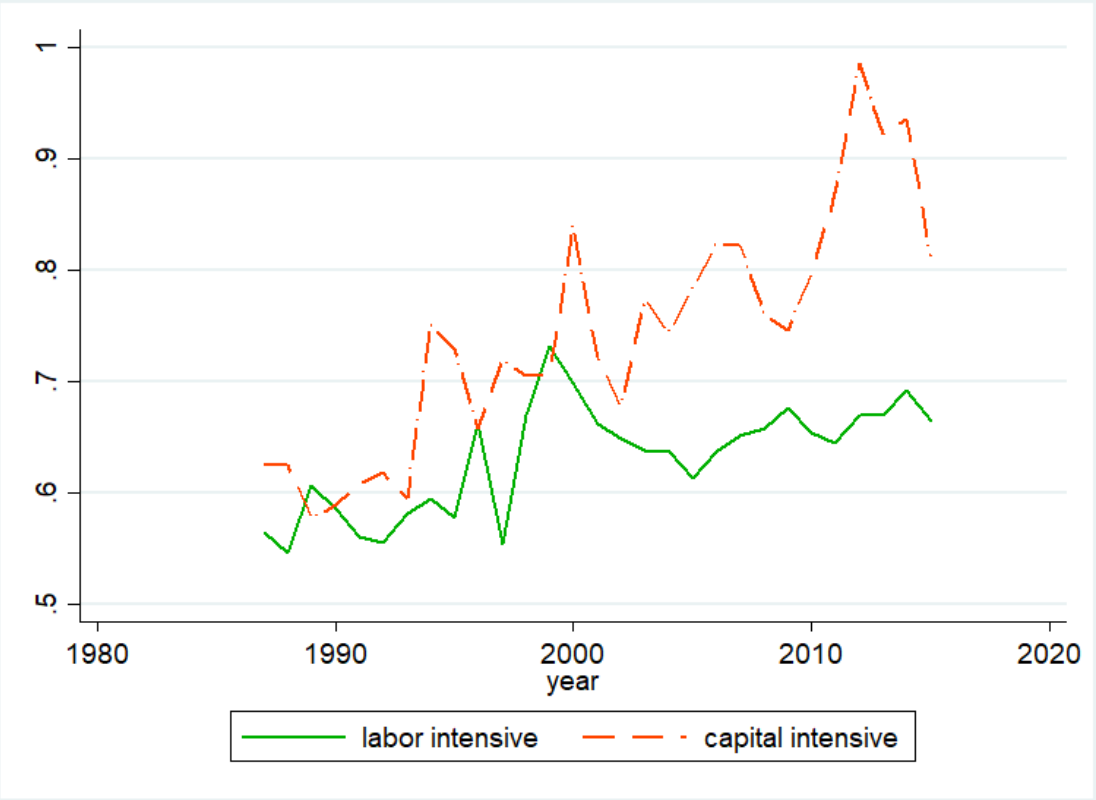


Figure 6. Un-weighted average of standard deviation of logarithm of TFP

In this case, the evolution of the two groups is different from each other. Productivity dispersion in labor-intensive sectors is smaller than in capital-intensive sectors. The increase in the capital-intensive sector is almost 50% while it is only 15% in the labor-intensive sector.

1.3.3.4 Fact 4: rise in fixed costs

Fixed costs are usually defined as non-financial assets used regularly or constantly during production for more than one year. However, it is not easy to measure fixed costs because firms do not record their expenses as fixed and variable costs. In the previous works, fixed costs are measured as firms' profits. In this study, we calculate fixed costs as the difference between the marginal cost markup and profit rate following De Ridder (2021). Thus, fixed cost is

$$\frac{F}{PY} = \frac{(P - MC)Y}{PY} - \frac{\pi}{PY}$$

where F is fixed cost, P is price of output, Y is output so PY is value added. MC is for marginal cost and π is profit.

$$S_f = \left(1 - \frac{1}{\mu}\right) - S_p$$

where μ is markup. De Ridder (2021) calculates the fixed cost at the firm level, but we do not have firm or industry level markup data. Therefore, fixed cost is calculated at the country level for the United States by using markup data from De Loecker et al. (2020). They use the production approach to measure markup, estimated from the individual firm output and input data, using firms' minimization decisions. Profit is defined as the gross value added minus labor and capital compensations. Figure 7 shows the evolution of fixed cost in the total cost since 1987 for the US.

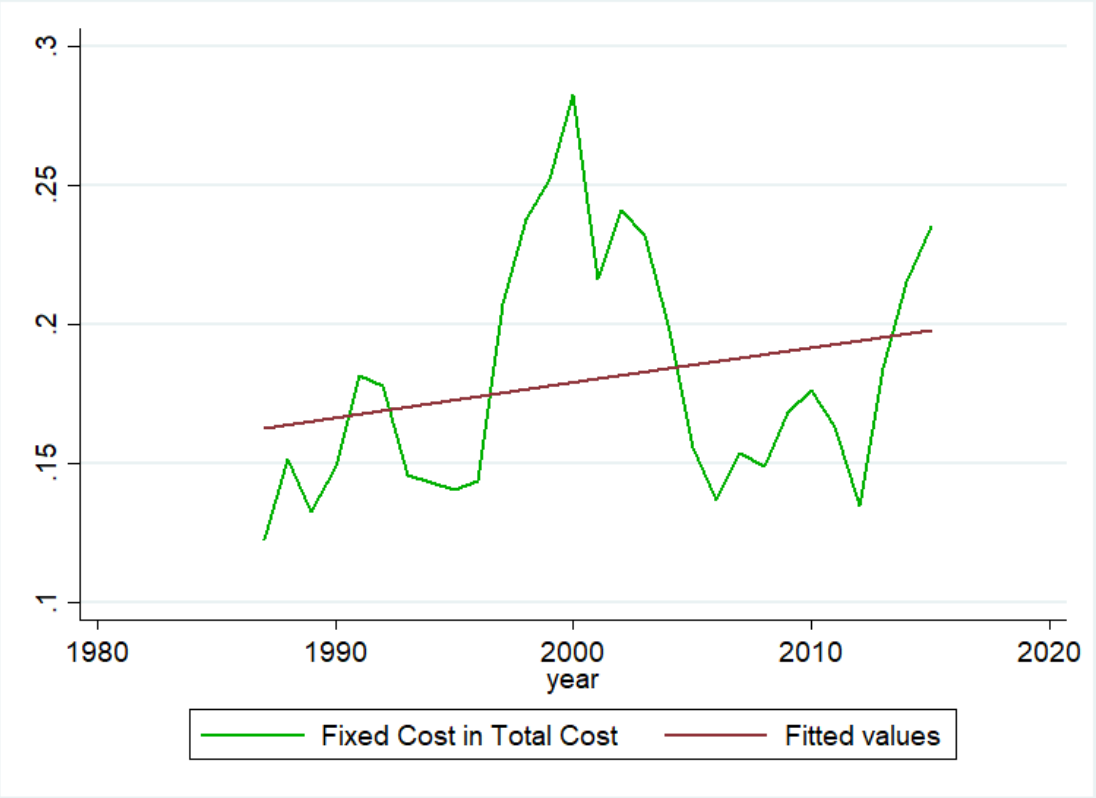


Figure 7. Aggregate fixed cost in total cost

There is an increasing trend in the fixed cost as it was 0.12 in 1987 and 0.23 in 2015. Although our calculation is not at the firm level, the results are compatible with the recent literature. De Ridder (2021) shows that fixed costs were 13.9% of costs for American firms in 1980 and close to 24.5% in 2016. De Loecker et al. (2020) shows that overhead costs (fixed costs) increased almost four times between 1980 and 2016. They use selling, general and administrative expenses (SG&A) in calculating fixed costs. In Figure 8, blue line shows overhead costs measured by them in the graph below. Even though their fixed cost estimations are higher than ours, the trend is very similar.

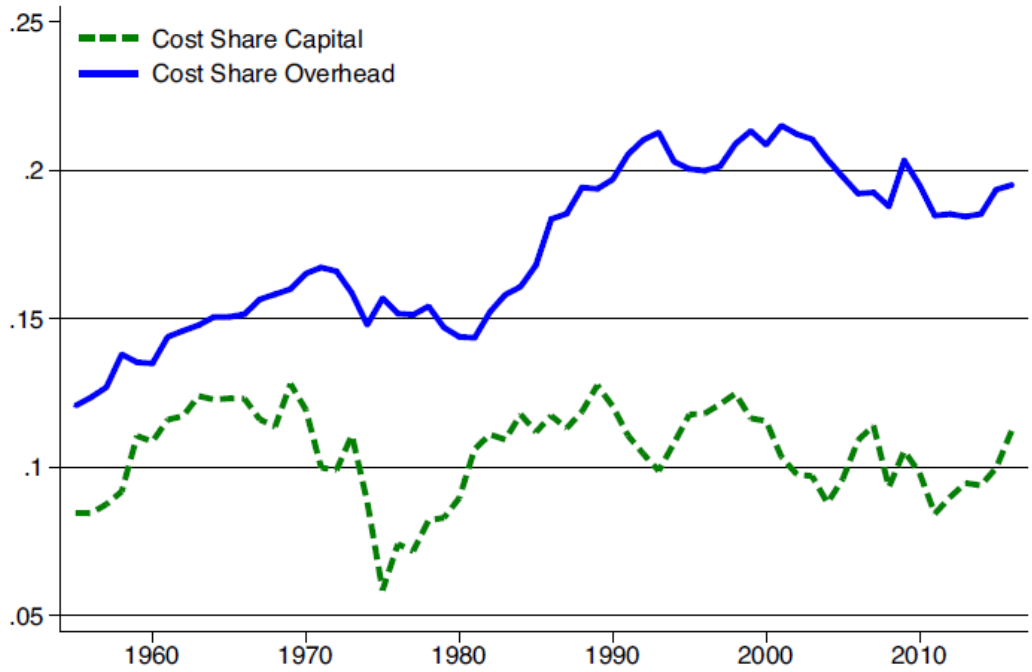


Figure 8. Aggregate overhead and capital cost shares of total cost

Source: De Loecker, J., Eeckhout, J., and Unger, G. (2020). The rise of market power and the macroeconomic implications. The Quarterly Journal of Economics, 135(2), 561-644, Figure VII.

Based on our calculation and evidence in the recent literature, we can argue for an increasing trend in the aggregate fixed cost share in total cost. Fixed cost is calculated for the aggregate economy because we only have markup for the aggregate economy. Thus, we could not calculate the fixed cost for labor or capital-intensive sectors.

1.4 Model

The previous section provided evidence about the changes in labor share, structural change, increase in productivity dispersion and fixed cost share. This section presents a model to illustrate how capital deepening combined with concentration and markup increase leads to change in factor shares. Our model combines the models in Acemoglu and Guerrieri (2008) and Atkeson and Burstein (2008).

1.4.1 Model environment

The unique final good is produced by output from two sectors with the elasticity of substitution ε. Sectors are assumed to be at the bottom of segregation used in economic censuses and price index construction, which means there are no sub-sectors or industries.

$$Y = \left[Y_1^{\frac{\varepsilon-1}{\varepsilon}} + Y_2^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

where Y_1 and Y_2 are the aggregation of goods produced in sector 1 and 2, respectively. Resource constraint:

$$Y = rK + wL + \pi + F$$

where F is the total of fixed operational costs and entry costs which are assumed to be in terms of final output.

In each sector, firms produce output which are aggregated with the elasticity of substitution σ

$$Y_1 = \left(\int_0^{N_1} y_1(i)^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

$$Y_2 = \left(\int_0^{N_2} y_2(i)^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where $y_1(i)$ and $y_2(i)$ are the goods produced by firms in each sector. There are N_j number of domestic firms in each sector. To summarize, goods are aggregated into sectors and two sectors are aggregated into the final good. To simplify the notation, we drop time subscript t. The individual goods producing firms are engaged in imperfect competition based on the following assumptions.

Assumption 1: Goods are imperfect substitutes: $\sigma < \infty$.

Assumption 2: Goods within a sector are more substitutable than goods across sectors: $\varepsilon < \sigma$. Also, it is assumed that $\varepsilon < 1$ as in Acemoğlu and Guerrieri (2008).

Assumption 3: Sector one is less capital intensive than sector 2: $\alpha_1 > \alpha_2$.

Assumption 4: Firms take place in a Cournot competition in which they choose the quantity they produce, the output chosen by other firms, equilibrium wage rate, price of the final good, and final good quantity are taken as given. When σ goes to infinity, goods in a sector become perfect substitutes, and the price discrimination in that sector disappears.

Firms produce goods with the following Cobb-Douglas technologies

$$y_1(i) = A_1(i) l_1(i)^{\alpha_1} k_1(i)^{1-\alpha_1} \tag{3}$$

$$y_2(i) = A_2(i) l_2(i)^{\alpha_2} k_2(i)^{1-\alpha_2} \tag{4}$$

Each firm i based in sector j draws its idiosyncratic productivity $A_j(i)$ from a log-normal distribution. l_j and k_j are the firms' labor and capital.

Market clearing:

$$\int_0^{N_1} l_1(i) + \int_0^{N_2} l_1(i) = L_1 + L_2 = L$$
$$\int_0^{N_1} k_1(i) + \int_0^{N_2} k_1(i) = K_1 + K_2 = K$$

1.4.2 Equilibrium

Prices for Y_1 and Y_2 are denoted as P_1 and P_2 and the final good price is normalized to one. $[p_1(i)]_{i=1}^{N_1}$ and $[p_2(i)]_{i=1}^{N_2}$ are the prices for firms in sector 1 and sector 2.

Definition: An equilibrium is given by prices r, w, P_j, and $[p_j(i)]_{i=1}^{N_1}$, employment and capital allocation $[l_j(i)]_{i=1}^{N_2}$, and $[k_j(i)]_{i=1}^{N_2}$ for $j \in \{1,2\}$ such that firms maximize profits and markets clear, and consumption and savings decisions, C and K, maximize consumer utility.

Final good producer maximizes

$$PY - \sum_{j=1}^{2} P_j Y_j$$

Price of final good is taken as numeriare.

$$1 = [P_1^{1-\varepsilon} + P_2^{1-\varepsilon}]^{1/1-\varepsilon}$$

Demand for output in each sector is determined by following equations.:

$$P_1 = \left(\frac{Y_1}{Y}\right)^{-1/\varepsilon} \tag{5}$$

$$P_2 = \left(\frac{Y_2}{Y}\right)^{-1/\varepsilon} \tag{6}$$

the demands for firms' output are given by similar isoelastic demand curves:

$$y_1(i) = \left(\frac{p_1(i)}{P_1}\right)^{-\sigma} Y_1 \tag{7}$$

$$y_2(i) = \left(\frac{p_2(i)}{P_2}\right)^{-\sigma} Y_2 \tag{8}$$

the price of each sector, P_j for $j \in \{1,2\}$, satisfies:

$$P_1 = \Big(\int_0^{N_1} p_1(i)^{1-\sigma} di \Big)^{\frac{1}{1-\sigma}}$$

$$P_2 = \Big(\int_0^{N_2} p_2(i)^{1-\sigma} di \Big)^{\frac{1}{1-\sigma}}$$

As explained in Assumption 4, there is quantity competition among firms in the same sector. Equilibrium prices of a sector can be found by solving the maximization problem of firms given the marginal cost of production and productivity distribution.

$$\pi_j(i) = p_j(i) y_j(i) - c_j(i) y_j(i) - f$$

where $c_j(i)$ marginal cost and f is the fixed cost of production.This profit maximization combined with the demand functions in (7) and (8) gives the prices as in Atkeson and Burstein (2008)

$$p_j(i) = \left(\frac{\sigma - 1}{\sigma} + \Big(\frac{1}{\sigma} - \frac{1}{\varepsilon} \Big) s_j(i) \right)^{-1} c_j(i) = \frac{\varepsilon(s)}{\varepsilon(s) - 1} c_j(i) \tag{9}$$

where $s_j(i)$ is the market share of firm i in sector j.

$$s_j(i) = \frac{p_j(i)^{1-\sigma}}{P_j^{1-\sigma}} \tag{10}$$

markup is defined as

$$m_j(i) = \frac{\varepsilon(s)}{\varepsilon(s) - 1}$$

Price of sector j is

$$P_j = \left(\int_0^{N_j} (m_j(i)c_j(i))^{1-\sigma} di \right)^{1/1-\sigma} \tag{11}$$

By plugging (10) and (11) into (9), markup can be found in terms of productivity distributions and elasticity of substitution between firms and sectors.

$$m_j(i) = \left(\frac{\sigma - 1}{\sigma} + \left(\frac{1}{\sigma} - \frac{1}{\varepsilon} \right) \frac{(m_j(i)A_j(i)^{-1})^{1-\sigma}}{\int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di} \right)^{-1} \tag{12}$$

Given productivity distributions, we can find markup distributions numerically from the equation (12).

Capital and labor demand of a firm i in a sector j are independent of time because choices of different periods are not linked. The productivity distribution does not change over time, so firms exit the market only if the expected profit is negative. If the firm remains in the market, it chooses labor and capital to maximize current period profit.

$$\pi_j(i) = c_j(i)y_j(i) - wl_j(i) - rk_j(i) - f$$

$$\frac{d\pi_j(i)}{dl_j(i)} : l_j(i) = \frac{c_j(i)\alpha_j y_j(i)}{w} = \frac{c_j(i)^{1-\sigma} m_j(i)^{-\sigma} \alpha_j P_j^{\sigma} Y_j}{w}$$
$$\frac{d\pi_j(i)}{dk_j(i)} : k_j(i) = \frac{c_j(i)(1-\alpha_j) y_j(i)}{r} = \frac{c_j(i)^{1-\sigma} m_j(i)^{-\sigma} (1-\alpha_j) P_j^{\sigma} Y_j}{r}$$

combining above equations gives the marginal cost of production for firm i in sector j

$$c_j(i) = A_j(i)^{-1} \left(\frac{w}{\alpha_j} \right)^{\alpha_j} \left(\frac{r}{1-\alpha_j} \right)^{1-\alpha_j} \tag{13}$$

Let

$$\bar{c}_j = \left(\frac{w}{\alpha_j}\right)^{\alpha_j} \left(\frac{r}{1-\alpha_j}\right)^{1-\alpha_j} \tag{14}$$

(11), (13) and (14) imply

$$\frac{P_j}{\bar{c}_j} = \left(\int_0^{N_j} (m_j(i)(A_j(i))^{-1})^{1-\sigma} di \right)^{1/1-\sigma} \tag{15}$$

Aggregating $l_j(i)$ and $k_j(i)$ gives the aggregate labor and capital for sector j:

$$\int_0^{N_j} l_j(i) = L_j = \frac{\alpha_1}{w} P_j^{\sigma} Y_j \int_0^{N_j} c_j(i)^{1-\sigma} m_j(i)^{-\sigma} di \tag{16}$$

$$\int_0^{N_j} k_j(i) = K_j = \frac{1-\alpha_1}{r} P_j^{\sigma} Y_j \int_0^{N_j} c_j(i)^{1-\sigma} m_j(i)^{-\sigma} di \tag{17}$$

by using equations (15), (16) and (17)[7], we get

$$Y_j = \left(\int_0^{N_j} A_j(i)^{\sigma-1} m_j(i)^{-\sigma} di \right)^{-1} \left(\int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di \right)^{-\sigma/1-\sigma} L_j^{\alpha_j} K_j^{1-\alpha_j} \tag{18}$$

By using (5), (6), (16) and (17), the factor prices are found as:

$$w = \alpha_j \left(\frac{Y}{Y_j}\right)^{1/\varepsilon} \frac{Y_j}{L_j} \left(\int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di \right)^{-1} \int_0^{N_j} A_j(i)^{\sigma-1} m_j(i)^{-\sigma} di$$

$$r = (1-\alpha_j) \left(\frac{Y}{Y_j}\right)^{1/\varepsilon} \frac{Y_j}{K_j} \left(\int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di \right)^{-1} \int_0^{N_j} A_j(i)^{\sigma-1} m_j(i)^{-\sigma} di$$

Given productivity distributions, wage rate and capital rental rates can be found numerically.

[7] First write $L_j^{\alpha_j} K_j^{1-\alpha_j}$ by using (16) and (17), then plug (15) into it. Y_j can be derived from it.

1.4.3 Entry decision

In the model, firms are heterogeneous in terms of productivity and there is Cournot competition in each sector. Within sector profit distribution of firms depends on initial productivity distribution. Thus, firms with higher productivity have higher profit.

After finding r, w, P_j, and $[p_j(i)]_{i=1}^{N_1}$, employment and capital allocation $[l_j(i)]_{i=1}^{N_2}$, and $[k_j(i)]_{i=1}^{N_2}$ for $j \in \{1,2\}$ each firm calculates its profit. There is a fixed cost of production, f, and potential firms will choose to enter a sector if their expected profits are equal or higher than zero. So the number of firms will be lower in the equilibrium.

$$\pi_j(i) = p_j(i)y_j(i) - l_j(i)w - k_j(i)r \geq f$$

Corollary: We can find a threshold level of productivity A_j^* such that if the productivity draw is below this level, the firm will exit the market as in Autor et al. (2017). Since the firms which exit the market are the ones with lower productivity and market share, concentration will increase.

1.4.4 Factor allocations and shares

Allocation of capital and labor can be found from above equations. The fraction of capital and labor in the labor intensive sector is $\kappa = K_1/K$ and $\lambda = L_1/L$. By combining (16) and (17)

$$\kappa = \left[1 + \left(\frac{1-\alpha_2}{1-\alpha_1}\right)\left(\frac{Y_1}{Y_2}\right)^{\frac{1-\varepsilon}{\varepsilon}} \frac{\eta_1}{\eta_2}\frac{\phi_2}{\phi_1}\right]^{-1} \tag{19}$$

$$\lambda = \left[\left(\frac{1-\alpha_1}{1-\alpha_2}\right)\frac{\alpha_2}{\alpha_1}\left(\frac{1-\kappa}{\kappa}\right) + 1\right]^{-1} \tag{20}$$

where

$$\eta_j = \int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di$$

$$\phi_j = \int_0^{N_j} A_j(i)^{\sigma-1} m_j(i)^{-\sigma} di$$

After finding $m_j(i)$s from (12), η_j and ϕ_j can be calculated easily. Solving system of equations (18), (19) and (20) gives us Y_1, Y_2, κ and λ and therefore wage rate, rental rate, L_j and K_j for $j \in \{1,2\}$.

Factor shares:

$$s_k = (1-\alpha_j)\left(\frac{Y_j}{Y}\right)^{\frac{\varepsilon-1}{\varepsilon}} \frac{\eta_j^{-1}\phi_j}{\kappa}$$

$$s_l = \alpha_j\left(\frac{Y_j}{Y}\right)^{\frac{\varepsilon-1}{\varepsilon}} \frac{\eta_j^{-1}\phi_j}{\lambda}$$

$$s_p = 1 - s_k - s_l$$

Finally, factor shares are calculated.

1.5 Numerical analysis

1.5.1 Calibration of the baseline model

We set up the calibration of the described model to examine whether the evolution of factor shares in the model is consistent with the evolution in the US data. As in the previous sections, we use the 2017 EU KLEMS industry database to calculate the average labor share of sectors over the whole period. Then we classify sectors as above and below median labor share as in Acemoğlu and Guerrieri (2008). We calculate the labor share in the production function as $s_l/(s_l+s_k)$, which does not

include profit share because the profit is not a part of our Cobb-Douglas production function. We take the labor share in production as the value in 1987 for α_1 and α_2. Table 2 shows the parameters used in the calibration.

Table 2. Parameters in Simulations

Parameter	Value	Description
α_1	0.83	Sector 1 Labor Income Share
α_2	0.76	Sector 2 Labor Income Share
ε	0.5	Elasticity of substitution between sectors
σ	7	Elasticity of substitution between firms
N_1	1500	Number of potential firms in sector 1
N_2	2400	Number of potential firms in sector 2
L_0	7655915	Labor Force in 1987
K_0	29631074	Capital Stock in 1987

Capital stock at constant national prices for the United States in 1987 is taken from Federal Reserve Economic Data. The labor force is calculated as the multiplication of Labor Force Participation Rate and Active Population: Aged 15-64: All Persons for the United States from Federal Reserve Economic Data. The average growth rate of per capita capital is calculated as 0.014. The elasticity of substitution between sectors is taken at 0.5, as in Acemoğlu and Guerrieri (2008). The elasticity of substitution between firms within each sector is σ chosen as 7 for targeting the initial factor shares in 1987. The number of potential firms that decide whether to enter the sector is taken as 1500 and 2400 for sector one and sector two, respectively, as close to the number of firms in Compustat database.

Table 3 demonstrates the change in standard deviations of productivity distribution and fixed cost share for baseline simulation.

Table 3. Exogenous Variables in Simulation and Data

	Simulation			**US Data**		
	1987	2015	%Δ	1987	2015	%Δ
Standard deviation of productivity in sector 1	0.15	0.225	50	0.4	0.62	52
Standard deviation of productivity in sector 2	0.16	0.24	50	0.42	0.6	43
Share of fixed cost	0.04	0.05	20	0.04	0.05	20

Notes: Table shows the values for standard deviation of productivity in sector 1 and sector 2 and fixed cost share for both baseline simulation and US data.

The standard deviation of the firms is increased by 50%, similar to the data. As we stated in previous sections, fixed cost is calculated using markup and profit share. However, the shares of labor and capital compensation in the fixed cost cannot be observed. The literature emphasizes the link between fixed costs and intangible capital such as software, IT, and R&D investments. Thus, we investigate the relationship between fixed cost and intangible capitals both together and separately. The sum of IT, Software, and R&D investment have a significant positive relationship with the calculated fixed cost (the graphs that shows the link are in the Appendix A). Therefore, the sum of IT, Software, and R&D investment over value-added matches the simulations' fixed cost share (S_f). We will also use intellectual property products (sum of software and R&D) as a fixed cost in the robustness part. The average productivity in the labor-intensive sector grows from 0.6 to 0.75, whereas it grows from 0.85 to 1.48 in capital-intensive sectors to simulate the labor reallocation for all simulations.

Table 4 shows the results of baseline simulations and the actual data for labor allocations between capital and labor-intensive sectors (L_2/L_1), labor share in the aggregate economy, labor share in sector one, and labor share in sector two.

Table 4. Baseline Simulation Results and Data

	Baseline Simulation			US Data		
	1987	2015	%Δ	1987	2015	%Δ
S_L	0.65	0.6	-7.6	0.65	0.61	-6
S_{L1}	0.68	0.63	-7	0.76	0.75	-1
S_{L2}	0.62	0.55	-11	0.55	0.48	-13
L_2/L_1	0.77	0.57	-26	0.95	-73	-23

Notes: Table shows labor shares in sector 1 and sector 2 for simulation and US data. S_L, S_{L1} and S_{L2} is for labor share in the aggregate economy, Sector 1 and Sector 2, respectively.L_2/L_1 is the ratio of employment in capital-intensive sector to labor-intensive sector.

Labor allocation and factor shares are calculated by using the EU KLEMS database. In the baseline simulation, the growth rate of per capita capital is taken as 0.014, productivity dispersion is increasing by 50%, and fixed cost-share increases from 0.04 to 0.05. The decline is minimal in sector one and the large in sector two. Model fits the change in the long run for aggregate labor share and labor reallocation from capital-intensive to the labor-intensive sector. Also, it fits more than half of the change in labor share in sector two. However, the model overstates the change in the labor share of sector two. Although the model could not create the difference between the two sectors exactly, the decrease in labor share in sector one is seven percent, while it is 11 percent in sector two. Thus, the model can explain some differentiation between the two sectors. Table 5 shows the results of baseline simulations and the actual data for capital share (S_k), profit share (S_p), and capital-output ratio (K/Y).

Table 5. Baseline Simulation Results

	Baseline Simulation			**US Data**		
	1987	2015	%Δ	1987	2015	%Δ
S_K	0.205	0.20	-2.5	0.21	0.14	-33
S_P	0.14	0.20	42	0.14	0.25	78
K/Y	2.35	2.01	-14	3.48	3.13	-10

Notes: Table shows results of three simulations based on the change in production cost and the real data for capital share (S_k), profit share (S_p) and capital output ratio (K/Y).

The model matches the initial values of factor shares, but the labor ratio in sector two over sector one and capital-output ratio are below the data. The model explains more than half of the change in profit share, but the decrease in the capital is much smaller than the US data. The change in capital-output ratio in the model is -14%, and it is -10% in data. Thus, the model with increasing fixed cost and dispersion in TFP growth across firms explains the most significant part of the decrease in aggregate labor share. The differentiation in labor shares of the two sectors can also stem from the difference in the standard deviation of TFP growth. This model explains labor flow in the labor-intensive sector. However, the evolution of capital and profit share is understated in the simulation. It also overstates the decrease in the capital-output ratio. Table 6 represents the simulation results for holding productivity dispersion in sector one as constant and other parameters are same as in baseline simulation.

Table 6. Simulation 2 Results and US Data

	Simulation 2			US Data		
	1987	2015	%Δ	1987	2015	%Δ
S_L	0.65	0.63	-3	0.65	0.61	-6
S_{L1}	0.68	0.67	-1	0.76	0.75	-1
S_{L2}	0.62	0.57	-8	0.55	0.48	-13
L_2/L_1	0.77	0.54	-23	0.97	-74.69	-23
S_K	0.205	0.20	-2.5	0.21	0.14	-33
S_P	0.14	0.16	14	0.14	0.25	78
K/Y	2.35	2.2	-6	3.48	3.13	-10

Notes: Same as Table 5

The model can match labor share in sector 1 but in this case, the decrease in aggregate labor share and labor share in sector two becomes smaller than the decline in data.

This study aims to understand which factors are more crucial in the evolution of factor shares and structural change. For this purpose, we set up counterfactual simulations. We have three factors that can impact: productivity divergence, fixed cost, and capital deepening. The baseline simulation changes all of these factors based on the data. We eliminate one of these factors for each counterfactual simulation to see how the results differ from the baseline simulation. Table 7 presents the counterfactual simulations for aggregate labor share and structural change.

Table 7. Counterfactual Simulations

		Percentage Changes after 28 Periods				
	Period 1	Sim. 1	Sim. 2	Sim. 3	Sim. 4	Sim. 5
S_L	0.65	-8	-3	-0.8	-8	-6
S_{L1}	0.68	-7	-1	-1	-7	-6
S_{L2}	0.62	-11	-8	-3	-11	-10
L_2/L_1	0.77	-26	-23	-19	-25	-26
S_K	0.205	-2.5	-2.5	2	-2.5	-2.5
S_P	0.14	42	14	3	42	42
K/Y	2.35	-14	-6	-0.8	-36	-13

Notes: Sim. 1: baseline simulation. Sim 2: productivity distribution has a constant standard deviation in sector 1, per capita capital is growing, and fixed cost share in value-added is increasing. Sim. 3: the lack of productivity dispersion for both sectors, per capita capital is growing, and fixed cost share in value-added is increasing. Sim. 4: productivity dispersion within sectors is increasing, per capita capital is constant, and fixed cost share in value-added is increasing. Sim. 5 productivity dispersion within sectors is increasing, per capita capital is growing, and the fixed cost share is constant.

Table 7 shows the decomposition results for five simulations. The simulation 1 is for the baseline simulation in which there is productivity dispersion within two sectors, per capita capital is growing, and fixed cost share in value-added is increasing. The simulation 2 shows the results when productivity distribution has a constant standard deviation in sector 1, simulation 3 is for the lack of productivity dispersion for both sectors, and in simulation 4, per capita capital is constant. Finally, the simulation 5 indicates the case where the fixed cost share is constant.

The decrease in aggregate labor share is highest for simulation 1 and simulation 4, whereas it is smallest for the simulation 3 with no productivity dispersion. When productivity dispersion increases, firms with lower productivity cannot pay the fixed cost and exit the market. This will raise the profit share in value-added and decrease the labor share. The simulation 4 shows no capital deepening in the model, and the results are almost the same as the baseline simulation. The simulation 2 indicates

that the change in fixed cost-share also affects the decline in aggregate labor share. The intuition behind this is that firms with lower productivity exit the market because of the fixed operation cost and concentration increases. Thus, profit share rises, and labor share declines. The flow of labor from capital-intensive to the labor-intensive sector is highest when there is productivity dispersion, whereas it is smallest when there is no productivity dispersion in both sectors. This is because productivity dispersion is higher in sector two, prices are smaller relative to sector 1, and labor moves to sector 1. Thus, it can be argued that productivity dispersion has a role in the labor flow from capital intensive sector to the labor-intensive sector.

The diminish in labor share of sector one is most in baseline simulation and simulation 4 whereas it is smallest in the case of constant standard deviation of productivity (simulation 2 and 3). We can clearly argue that the most important determinant of the drop of labor share in sector level is the grow of standard deviation of productivity distribution in that sector and the increase in fixed cost share.

Based on these simulations, we can say that the main thing that change the labor share is the growth of productivity dispersion within sectors and fixed cost share in value added. When we combine fixed operation cost with exogenous shocks that will lead to increase concentration then labor shares decline and profit share increases. One of the phenomena that could increase the concentration is an increase in the variance of productivity distribution over time. By this way, the productivity segregation increases over time and firms with lower productivity , which can not pay the fixed cost, exit the market. Second one is the entry barrier which is a result of fixed cost. Productivity threshold should rise when the least productive firm exit the market, so that the number of firms will be lower in the new equilibrium. Since the

remaining firms have higher productivity and market share, concentration and profits increase. In both cases, because of fixed operation cost, firms with lower productivity exit the market and concentration increases. Thus, labor share declines. Also, the difference in the evolution of labor shares in two sectors stems from the difference in standard deviation of TFP growth in model. Labor flow towards the labor-intensive sector can be affected from the productivity dispersion in the model.

1.5.2 Robustness

1.5.2.1 Fixed cost differentiation across sectors

Fixed cost is calculated for the aggregate economy because we only have markup for aggregate economy. Thus, we could not calculate fixed cost for sector one and sector two. As it is explained above, the sum of IT, Software and R&D investments are used as a fixed cost. Thus, we calculate sum of these capital costs for sector one and sector two.

Fixed cost share increases from 0.03 to 0.04 in sector one and from 0.05 to 0.06 in sector two. Also, aggregate fixed cost share rises from 0.04 to 0.05. Therefore, we set up a simulation where sectors have different fixed cost shares. Other parameters are same as in baseline simulation. Also, capital deepening, productivity dispersion and increase in fixed costs are simulated. Table 8 displays the change of labor share and sectoral composition for this robustness analysis.

Table 8. Robustness 1 Results and US Data

	Percentage Changes from 1987 to 2015	
	Robustness 1	US Data
S_L	-7	-6
S_{L1}	-8	-1
S_{L2}	-11	-13
L_2/L_1	-25	-23

Notes: Table shows labor shares in sector one and sector two for simulation 2 and US data. S_L, S_{L1} and S_{L2} is for labor share in economy wide, sector one and sector two, respectively.L_2/L_1 is labor allocations between capital and labor-intensive sectors.

Results are very closed to baseline simulation. Model can explain the long run change in aggregate labor share. It over states the decline in share of labor intensive sector. Model can explain more than half of the long run decrease in labor share of sector two.

1.5.2.2 IPP as fixed cost

Because it could not be known that the distribution of fixed cost among capital and labor compensation, during the simulations we use the sum of IT , Software and R&D investment as a fixed cost. In this section, software plus R&D is used as a robustness test. In the literature, there are empirical evidence that shows intangible capital is significantly more sunk, meaning that it entails higher investment adjustment costs than traditional capital.(eg. Chiavari, & Goraya, S. (2020))

Therefore, in simulation, the fixed cost share is matched with IPP capital share which is 0.03 in 1987 whereas it is 0.044 in 2015. Other parameters are same as the baseline simulations. Also, there is capital deepening, productivity dispersion and increase in fixed costs in this simulation. Table 9 shows the change of labor shares and sectoral composition from 1987 for both model and data.

Table 9. Robustness 2 Results and US Data

	Percentage Changes from 1987 to 2015	
	Robustness 2	US Data
S_L	-6	-6
S_{L1}	-6	-1
S_{L2}	-8	-13
L_2/L_1	-25	-24

Notes: Table shows labor shares in sector 1 and sector 2 for simulation 2 and US data. S_L, S_{L1} and S_{L2} is for labor share in economy wide, Sector 1 and Sector 2, respectively.L_2/L_1 is labor allocations between capital and labor-intensive sectors.

Results are very similar to the baseline results. Model can match the long run change in aggregate labor share and more than half of the decline in labor share in sector 2. It over states the decline in share of labor intensive sector.

1.5.2.3 Manufacturing vs. non-manufacturing sectors

Structural change literature mostly analyzed the flow between manufacturing and service sectors. Thus, in this section, group of industries are separated as manufacturing and non-manufacturing industries. As it is stated in the empirical observations, manufacturing and non-manufacturing categorization has very similar features with the categorization that we used in the baseline simulation. Manufacturing sector resemble the capital intensive sector whereas non-manufacturing look like labor intensive sector in terms of evolution of labor share.

Therefore, in this simulation, the fixed cost share is matched with the sum of IT, Software and R&D capital compensation share as in baseline simulation. Other parameters are same as the baseline simulations. $\alpha_1 = 0.835$ for non-manufacturing and $\alpha_2 = 0.82$ for manufacturing. L_2/L_1 is much smaller than baseline and it is 0.39.

Also, there is capital deepening, productivity dispersion and increase in fixed costs in this simulation. In Table 10, results are very similar to the baseline simulation.

Table 10. Robustness 3 Results and US Data

	Percentage Changes from 1987 to 2015	
	Robustness 3	US Data
S_L	-8	-6
S_{Lman}	-8	-1
S_{Lnon}	-10	-28
L_2/L_1	-20	-54

Notes: Table shows labor shares in sector one and sector two for simulation 2 and US data. S_L, S_{L1} and S_{L2} is for labor share in economy wide, sector one and sector two, respectively.L_2/L_1 is labor allocations between capital and labor-intensive sectors.

Only difference is in the ratio of labor in sector two to labor in sector one. In the baseline simulation model overstates the evolution of this ratio whereas, model under states in this case. This is because of the initial values of model and data.

1.6 Model extension: capital-labor substitution

As an extension of the baseline model, we use CES (constant elasticity of substitution) production function with capital-labor substitutability instead of the Cobb Douglas production function. Thus, firms produce goods with the following CES technologies.

$$y_j(i) = A_j(i)\left[\alpha_j l_j(i)^{\frac{\gamma_j-1}{\gamma_j}} + (1-\alpha_j)k_j(i)^{\frac{\gamma_j-1}{\gamma_j}}\right]^{\frac{\gamma_j}{\gamma_j-1}} \tag{21}$$

elasticity of substitution between labor and capital is γ_j for $j = 1,2$. Every thing is same with the previous model so the factor prices are found as:

$$w = \alpha_j \left(\frac{Y}{Y_j}\right)^{1/\varepsilon} \left(\frac{Y_j}{L_j}\right)^{1/\gamma_j} \left(\int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di\right)^{\frac{\sigma-\gamma_j}{(1-\sigma)\gamma_j}} \left(\int_0^{N_j} A_j(i)^{\sigma-1} m_j(i)^{-\sigma} di\right)^{1/\gamma_j} \tag{22}$$

$$r = (1-\alpha_j) \left(\frac{Y}{Y_j}\right)^{1/\varepsilon} \left(\frac{Y_j}{L_j}\right)^{1/\gamma_j} \left(\int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di\right)^{\frac{\sigma-\gamma_j}{(1-\sigma)\gamma_j}} \left(\int_0^{N_j} A_j(i)^{\sigma-1} m_j(i)^{-\sigma} di\right)^{1/\gamma_j} \tag{23}$$

Given productivity distributions, wage rate and capital rental rates can be found numerically. Allocation of capital and labor can be found from above equations. Let the fraction of capital and labor in the labor intensive sector be $\kappa = K_1/K$ and $\lambda = L_1/L$. By combining (22) and (23)

$$\frac{\kappa^{1/\gamma_1}}{(1-\kappa)^{1-\gamma_2}} = \left(\frac{1-\alpha_2}{1-\alpha_1}\right)\left(\frac{Y_1}{Y_2}\right)^{-\frac{1}{\varepsilon}} \frac{Y_1^{1/\gamma_1}}{Y_2^{1/\gamma_2}} K^{1/\gamma_2 - 1/\gamma_1} \frac{\eta_1^{\frac{\sigma-\gamma_1}{(1-\sigma)\gamma_1}} \phi_1^{1/\gamma_1}}{\eta_2^{\frac{\sigma-\gamma_2}{(1-\sigma)\gamma_2}} \phi_1^{1/\gamma_2}} \tag{24}$$

$$\frac{\lambda^{1/\gamma_1}}{(1-\lambda)^{1/\gamma_2}} = \left(\frac{1-\alpha_2}{1-\alpha_2}\right)\frac{\alpha_1}{\alpha_2}\left(\frac{\kappa^{1/\gamma_1}}{(1-\kappa)^{1/\gamma_2}}\right) K^{1/\gamma_1 - 1/\gamma_2} L^{1/\gamma_2 - 1/\gamma_1} \tag{25}$$

where

$$\eta_j = \int_0^{N_j} (A_j(i)^{-1} m_j(i))^{1-\sigma} di$$

$$\phi_j = \int_0^{N_j} A_j(i)^{\sigma-1} m_j(i)^{-\sigma} di$$

After finding $m_j(i)$s from (12), η_j and ϕ_j can be calculated easily. Solving system of equations (18), (24) and (25) gives us Y_1, Y_2, κ and λ and therefore wage rate, rental rate, L_j and K_j for $j \in \{1,2\}$.

1.6.1 Numerical illustrations

In this section, there will be numerical examples which demonstrate how labor share and factor allocations change with capital-labor substitutability. We present the results for the following assumptions: goods are imperfect substitutes i.e. $\sigma = 7$, goods across sectors are complements i.e. $\varepsilon = 0.5$, and sector 1 is less capital intensive than sector 2 i.e. $\alpha_1 > \alpha_2$. Aggregate capital-labor ratio is defined as $k = K/L$ and it grows at a constant growth rate (g_k) as 0.4 and 0.2 to match the aggregate capital-labor ratio over time. Concentration[8] is taken as same for three cases. Table 11 shows the responses for the increase in aggregate capital-labor ratio.

Table 11. The Effect of the Aggregate Capital-Labor Substitutability

	$\gamma_1 = \gamma_2 = 1$, $g_k = 0.4$		$\gamma_1 = 0.7$, $\gamma_2 = 0.8$, $g_k = 0.4$		$\gamma_1 = 0.5$, $\gamma_2 = 1.5$, $g_k = 0.2$	
	Period 1	Period 10	Period 1	Period 10	Period 1	Period 10
S_L	0.66	0.66	0.72	0.79	0.64	0.62
S_{L1}	0.7	0.7	0.74	0.81	0.74	0.79
S_{L2}	0.64	0.64	0.69	0.77	0.52	0.34
κ	0.43	0.46	0.41	0.33	0.25	0.12
λ	0.54	0.56	0.54	0.56	0.62	0.79
P_1/P_2	1.17	1.51	1.18	1.54	1.3	2.5
w/r	15	564	23	2661	12	66
hf_1	0.012	0.012	0.012	0.012	0.012	0.012
hf_2	0.01	0.01	0.01	0.01	0.01	0.01

Notes: The effect of the aggregate capital-labor ratio on the factor income shares and κ, λ, Herfindahl index (hf_1 and hf_2) and P_1/P_2. S_L, S_{L1} and S_{L2} is for labor share in economy wide, Sector 1 and Sector 2, respectively. The variable κ (λ) stands for the fraction of capital (labor) allocated to Sector 1. Parameter values used are as follows. $\sigma = 7$, $\varepsilon = 0.5$, $\alpha_1 = 0.83$, $\alpha_2 = 0.76$

[8]Concentration is measured by the Herfindahl index which is calculated by summing the square of firms' market shares within a sector.

When $\gamma_1 = \gamma_2 = 1$, rise in aggregate capital-labor ratio increases the fractions of capital and labor allocated to Sector 1 (labor intensive sector). The intuition comes from the relative price effect. When capital-labor ratio increases, the capital intensive sector produce more output. Because two sectors are complements ($\varepsilon = 0.5$), relative price of Sector 2 decreases so that labor and capital flow to the labor intensive sector. However, it does not affect the labor share of the economy, because in Cobb-Douglas case, capital and labor income shares are not depend on the relative factor prices. When $\gamma_1 = 0.7$ and $\gamma_2 = 0.8$, capital and labor are complements for both sectors. If aggregate capital labor ratio increases, the ratio of wage to rental rate also increases. The more flexible sector is Sector 2 in which the demand for cheaper input rises more than Sector 1. Therefore, capital moves to Sector 2 whereas labor flows to Sector 1. This is called as "factor rebalancing effect" in Alvarez-Cuadrado et al. (2017). The demand for labor increases both sectors, because labor and capital are complements in both sectors. Hence, economy-wide and sector level labor shares rise.

When $\gamma_1 = 0.5$ and $\gamma_2 = 1.5$, capital and labor are complements in Sector 1 whereas they are substitute in Sector 2. As aggregate capital-labor ratio increases, the relative cost of labor to capital also rises. Sector 2 in which labor is substitutable with capital, uses capital more intensively. Sector 1 demands both capital and labor because it is not flexible to replace labor with capital. Therefore, capital moves to Sector 2 whereas labor flows to Sector 1. Thus, labor share in Sector 1 increases while it decreases in Sector 2. On the other hand, the increase in aggregate capital-ratio does not have an impact on the concentration levels of sectors.

1.6.2 Quantitative application

We set up a calibration of the described model to examine whether the evolution of factor shares in the model is consistent with the evolution in the US data. As in the previous sections, we use 2017 EU KLEMS industry database to calculate average labor share of sectors over the whole time period. Table 2 shows the parameters used in this calibration.

Table 3 demonstrates the change in standard deviations of productivity distribution and fixed cost share for baseline simulation. Standard deviation of the firms are increased 50% similar to the data. Also, the average productivity of labor intensive grows from 0.6 to 0.75 and from 0.85 to 1.48 for capital intensive sectors to simulate the labor reallocation for all simulations. Table 12 shows the results.

Table 12. Simulation and Data

	$\gamma_1 = 0.5, \gamma_2 = 1.5$			$\gamma_1 = 0.9, \gamma_2 = 1.1$			US Data		
	1987	2015	%Δ	1987	2015	%Δ	1987	2015	%Δ
S_L	0.65	0.62	-4.6	0.66	0.62	-6	0.65	0.61	-6
S_K	0.23	0.22	-4	0.22	0.21	-4.5	0.21	0.14	-33
S_P	0.12	0.15	25	0.12	0.167	39	0.14	0.25	78
S_{L1}	0.73	0.7	-4	0.71	0.66	-7	0.76	0.75	-1
S_{L2}	0.57	0.51	-10	0.615	0.57	-7	0.55	0.48	-13

Notes: Table shows the factor income shares in sector 1 and sector 2 for simulation and US data. Where capital share: S_K and profit share: S_P. S_L, S_{L1} and S_{L2} is for labor share in economy wide, Sector 1 and Sector 2, respectively.

Simulations are done for two different values of elasticity of substitution between capital and labor (γ_i). When $\gamma_1 = 0.5$, $\gamma_2 = 1.5$, the model can explain almost all of the long-run decrease in aggregate labor share and the differentiation between labor share between capital and labor intensive sectors.

Model can match with the initial values of factor shares but the increase in profit share and the decrease in capital share cannot matched in simulation with the data.

1.7 Conclusion

In the empirical part of this study, we provide evidence for the four facts for the US economy that we observe in the data. The first observation is the evolution of labor share at the sectoral level. Labor share is almost constant for labor-intensive sectors whereas it is decreasing for the capital-intensive sector from 1987 to 2015. The second fact is that the US economy has been experiencing a structural change which is the reallocation of employment and value-added between capital and labor-intensive sectors. Thirdly, we state that the fixed cost share in total cost or value-added has been increasing since the 1980s. The increase from 1987 to 2015 is almost 11 percentage points. As a final observation, within sector TFP differentiation is explored. The standard deviation of log TFP is increasing in both sectors.

We present a model to illustrate how capital deepening combined with productivity divergence and fixed cost growth lead to a change in factor shares and sectoral composition. We set up the calibration of the described model to examine whether the evolution of labor share in the model is consistent with the evolution of labor share in US data. The simulations aim to make a counterfactual analysis for the following mechanisms: the impact of capital deepening, fixed costs, and the productivity dispersion of firms overtime on labor share and structural change. The model with increasing fixed cost and dispersion in TFP growth across firms explains the biggest part of the decrease in aggregate labor share. The differentiation in labor shares of two sectors can also stem from the difference in the standard deviation of TFP growth. Labor flow towards the

labor-intensive sector is explained by this model. However, the evolution of capital and profit share is understated in the simulation. It also overstates the decrease in the capital-output ratio.

Also, the sectoral differences in capital-labor substitutability have a crucial role in structural change and factor income shares because of the relative price effect and factor rebalancing effects. In the final section, simulations of the described model indicate that the model can explain almost all of the long-run decrease in aggregate labor share and differentiation between capital and labor-intensive sectors.

CHAPTER 2

SECTORAL EFFECTS OF CORPORATE TAXATION IN OECD COUNTRIES

2.1 Introduction

Over the past 40 years, the world experienced great globalization with a decrease in corporate tax rates. Zucman (2014) indicates that the tax competition between countries with economic integration leads to the decline in statutory tax rates in developed countries. Devereux, Griffith, and Klemm (2002) argue that one of the most crucial reasons behind the corporate tax cuts is attracting multinational and more profitable firms. Almost all developed countries [9] have cut their corporate income taxes since the 1980s. For instance, the average corporate tax rate was 46% in the 1950s, and it was 16% in 2018 in the US. The average decline in the statutory corporate tax rate for OECD countries is around 22 percentage points between the 1980s and 2018. United States, United Kingdom, Germany, Finland, Austria, and Sweden have higher tax cuts than average, whereas Australia, Belgium, France, Japan, and Luxembourg have smaller decreases in their corporate tax rates. This secular trend has triggered a crucial debate among policymakers and academics about whether we are experiencing tax competition that could reduce countries' corporate income taxes.

Understanding the long-run consequences of the downward trend in corporate taxes is essential for macroeconomic and policy issues. Hence, this thesis chapter aims to test corporate income taxes' long-term macroeconomic and sectoral impacts on OECD countries. As far as we know, no study investigates the effect of corporate tax cuts on tradable and non-tradable sectors in the long run. The tax policies are

[9] Except for a few countries like Spain, Italy, and Norway.

applied mainly for long-run economic consequences, but most analyses in the literature are for short-run investigations. The first contribution of this study to the literature is that we identify a permanent exogenous shock to corporate income taxation to investigate the long-run consequences. We estimate a panel Structural VAR model with long-run restrictions for eleven OECD countries from 1973-to 2015.

The second contribution is our empirical results. Our results show that a cut in corporate income taxation positively influences labor and aggregate output for the whole sample. Although the output is positively affected in traded and non-traded sectors, exporting firms increase utilization-adjusted-total factor productivity, whereas non-exporting firms increase hours worked. While corporate taxes have almost halved in eleven OECD countries, the effects of the decline are quite distinct between the two groups of countries. The SVAR results reveal that following a decline in profits' taxation, firms in the traded sector significantly use more labor in continental European countries but do not increase innovation. The opposite is true in English-speaking and Scandinavian countries, where exporting firms increase TFP, as captured by the rise in utilization-adjusted-total factor productivity, while not significantly increasing labor. Our results are robust to different lag length selections and country-level analysis.

Thirdly, we provide some evidence that can explain the differences between sectors and country groups. We provide evidence on the differences in the R&D capital stock and investment, the wage flexibility differences, and the government spending levels among countries. These factors have a role in the responses of TFP and hours worked. Our suggested mechanism is as follows: A fall in the corporate income tax rate declines capital costs and increases corporate savings and capital investments. Higher capital accumulation increases the marginal product of labor.

If wages are rigid, the cost of labor relative to capital is small. Thus the demand increases for labor and employment rises. If wages are flexible, the firms' demand for intangible capital boosts because the user cost of intangible capital relative to labor is more minor. Hence the incentive for the investment in intangible capital (R&D) increase more. On the other hand, we can assume that the share of intangible capital is higher in the traded sector than non-traded sector. Thus, the cost of intangible capital relative to labor reduces more in the traded sector, and firms' demand for R&D investment in the traded sector increases more than in the non-traded sector. Thus, the traded sector is affected more than the non-traded sector in accumulating intangible capital, therefore TFP.

2.2 Literature review

There are various studies about the effect of corporate tax rates on the labor market, innovation, and welfare. Mertens and Ravn (2013) use narrative tax measures as an instrument in an SVAR analysis. They find that the federal corporate tax cuts increase investment, do not influence or even lower private consumption, and have no impact on employment. Chen, Karabarbounis, and Neiman (2017) argue that the decline in corporate income tax rate is one of the essential drivers of the recent rise in corporate savings. Their suggested mechanism is that decline in the corporate tax rate decreases cost of capital and raises the markups. Both of these increase the corporate profits and decrease labor share so that the corporate saving increases. Shuai and Chmura (2013) document for US states that the employment growth significantly increases with lower corporate tax rates. Karayalcin (1995) shows that the rise in capital tax instruments may increase welfare. Djankov, Ganser, McLiesh, Ramalho, and Shleifer

(2010) use a cross-country empirical analysis to show the negative impact of effective corporate tax on aggregate investment, FDI, and entrepreneurial activity. Also, their results indicate that corporate taxes are correlated with investment in the manufacturing sector, whereas they are not in the services sector. Arulampalam, Devereux and Maffini (2012) and Fuest, Peichl and Siegloch (2018) show that corporate tax leads to a decline in wages for European firms and German firms.

Backus, Henriksen, and Storesletten (2008) examine the sources of capital-output heterogeneity across countries, indicating that the corporate tax negatively affects it. Liu and Williams (2019) empirically demonstrate that corporate tax cuts affect less capital-intensive states more than the other states in the US. Their model indicates that the reallocation of resources between states and between sectors plays a vital role in explaining this result. Serrato and Zidar (2016) examine the welfare impacts of corporate tax on workers, landowners, and firms. Their mechanism is that a tax cut decreases the tax liability and raises the cost of capital for local firms. Lower tax rates attract firms, which boots the local labor demand and encourages migration to that state. Thus, the location decisions of both firms and workers determine the impact of tax cuts. Atanassov and Liu (2020) state that corporate innovation rises sharply with a corporate tax cut. Akcigit et al. (2022) empirically investigate the effect of corporate taxes on innovation at both firm and state levels. They show that corporate income taxes negatively affect the number of patents, whereas the number of citations of patents does not significantly change. Akcigit and Ates (2019) analyze the underlying factors behind the changes in US business dynamism. Their investigation implies that the corporate taxation does not have a powerful impact on the changes in business dynamism.

This study is closely related to the open economy structural change literature. There is well-established literature that explores the structural change in an open economy setting. Structural change is deeply analyzed individually and together with international trade because of its inevitable relationship with countries' economic growth and development (Herrendorf, Rogerson,& Valentinyi (2014)). Firstly, Matsuyama (2009) states that the closed economy models are not enough to test cross-country evidence for structural change. Uy, Yi, and Zhang. (2013) examine the importance of international trade in structural change in the case of South Korea. They show that non-homothetic preferences and the open economy explain trends in agriculture, services, and the rising part of manufacturing. Teignier (2018) reveals that the international trade of agricultural goods has an essential role in the structural transformation of Great Britain. In contrast, the role of trade in structural change is minor in South Korea. Swiecki (2017) indicates that the effect of international trade and changes in relative factor costs across sectors on labor reallocation is small. Cravino and Sotelo (2017) find that manufacturing employment is negatively affected by trade, whereas it positively affects skill premium. On the other hand, Lewis, Monarch, Sposi, and Zhang (2022) show that structural change in international trade is more than the impact of international trade on structural change. Some papers investigate the link between fiscal policy and structural change. Cardi, Romain, and Claeys (2020) show that government spending tends to benefit the non-traded sector, which experiences a labor inflow. Cruz and Raurich (2020) show that when labor income taxes are higher, the employment share of the service sector is more diminutive. Kaymak and Schott (2019) empirically document the positive relationship between corporate tax reduction and labor share in the manufacturing sector for US and OECD countries. Calibration

of their model indicates that almost half of the total decline in the labor share of manufacturing stems from the decrease in corporate tax rates. The mechanism behind their model is based on that a reduction in the corporate tax rate lowers the cost of capital relative to labor.

Our analysis is closest to Cloyne, Martinez, Mumtaz, and Surico (2022). They investigate the constant impact of changes in corporate income tax rates using a narrative identification approach for the U.S. Their result indicates that a corporate income tax cut causes a permanent rise in GDP and productivity, as in our results. Consistent with our results, they argue that hours worked and employment are much less affected. Our research is different from their analysis regarding the corporate tax shock identification and, therefore, the number of countries we investigate. Our study also documents differences in responses for traded and non-traded sectors.

2.3 Data and methodology

2.3.1 Data

We use the top statutory corporate income tax rates taken from Bachas, Fisher-Post, Jensen (2022) [10] for eleven OECD countries: Australia (AUS), Austria (AUT), Belgium (BEL), France (FRA), Germany (DEU), Finland (FIN), United Kingdom (GBR), Japan(JPN), Luxembourg (LUX), Sweden (SWE), and United States (USA)[11]

The primary sources for sectoral data are the OECD and EU KLEMS databases. Our dataset includes thirteen industries that are allocated as tradable or non-tradable as in Cardi and Restout (2022). Table 13 displays the classification of industries into tradable and non-tradable sectors. First, we set up the analysis for all economies at

[10] https://globaltaxation.world

[11] Spain, Norway, and Italy are dropped because they do not have a declining corporate income tax rate trend. We drop Canada, Netherlands, Greece, Ireland, Korea, Portugal, and Denmark because of the lack of data before 1980s.

the aggregate level. Second, we empirically explore the responses of broad sectors following a rise in corporate tax rate by 1 percentage point. Although the data for macroeconomic and sectoral data are available over the period 1970-2015, our preferred period is 1973-2015 since, for Australia and the United Kingdom, the corporate income tax rate data is unavailable before 1973.

Table 13. Summary of Sector Classification

Sector	ISIC-rev.4 Classification	
	Industry	Code
Tradable (T)	Agriculture, Forestry and Fishing	A
	Mining and Quarrying	B
	Total Manufacturing	C
	Transport and Storage	H
	Information and Communication	J
	Financial and Insurance Activities	K
Non Tradable (N)	Electricity, Gas and Water Supply	D-E
	Construction	F
	Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles	G
	Accomodation and Food Service Activities	I
	Real Estate Activities	L
	Professional, Scientific, Technical Administrative and Support Service Activities	M-N
	Community Social and Personal Services	O-U

Source: EU KLEMS (2017) and OECD (2017)

We used the following macroeconomic variables in the VAR estimations. All quantity variables are divided by the working-age population (15-64 years old) taken from OECD ALFS Database. All variables are from Cardi and Restout (2022). The definition of aggregate and sectoral variables are as follows (mnemonics are in parentheses):

- Aggregate variables: real GDP (Y) is the sum of traded and non-traded value added at constant prices. Total hours worked (L) is the sum of traded and non-traded hours worked.

- Sectoral quantities: traded value added at constant prices (Y_H), non-traded value added at constant prices (Y_N). Sectoral value added are constructed by adding value added for all sub-industries k in sector $j = T, N$

- Sectoral hours worked: traded hours worked (L_T), non-traded hours worked (L_N) which correspond to hours worked by persons engaged in sector j. Sectoral hours worked are constructed by adding hours worked for all sub-industries k in sector $j = T, N$

- Sectoral labor share (L_j/L), is the ratio of hours worked in sector j to total hours worked for $j = T, N$.

- Labor income share (LIS) is constructed as the ratio of labor compensation which is the total of compensation of employees and compensation of self-employed in sector $j = T, N$ to value added at current prices of that sector.

- Sectoral value added share is the ratio of value added at constant prices in sector j to GDP at constant prices, i.e., Y_j/Y for $j = T, N$

- Capital utilization adjusted total factor productivity, TFP, is constructed as the Solow residual from constant-price domestic currency series of GDP, labor income share and capital stock. The time-varying capital utilization series is constructed using the methodology in Imbs's (1999).

- R&D capital stock is the net capital stock in constant prices in Research and Development. R&D investment is gross fixed capital formation in constant prices in Research and Development.

- Sectoral nominal wage is calculated as the ratio of the labor compensation in sector $j = T,N$ to total hours worked by persons engaged in that sector. Nominal wages are divided to foreign price (W_j/P_j^* for $j = T,N$) which is exogenous geometric weighted sum of the traded value added deflator of the ten trade partners of the corresponding country i, the weight being equal to the share of imports from the trade partner k.

- Government spending is government final consumption expenditure.

2.3.2 Methodology

The novelty of our analysis is to identify a permanent shock to corporate income tax rate. The major problem in identifying shocks to corporate income taxation is to ensure that these shocks are exogenous to economic activity. Thus, it prevents us from using country-level corporate income tax rates as there is a clear endogeneity issue. The existing literature concentrated on the narrative measure of tax rates to identify the exogenous changes in tax rates (Romer and Romer(2010), Mertens and Ravn (2013) and Cloyne (2013)). However, the narrative measure of tax changes is not available most of the countries and in corporate tax rate level.

We construct an international corporate tax rates measure to identify an exogenous shock. Our identification of a permanent shock to the corporate tax rate lies in the worldwide convergence of corporate taxation caused by international competition across countries to attract multinational firms. To capture more accurately the degree

of international competition faced by each country i, we construct an international tax rate $k = 1...10$ of each country i by considering the trade intensity between the home country and its trade partner within eleven countries as a weight:

$$\tau_t^i = \sum_{k \neq i}^{10} \alpha_{IM}^{i,k} \tau_{kt} \tag{26}$$

where $\alpha_{IM}^{i,k}$ is the trade share of home countries i with the partner country k and τ_{kt} is the statutory corporate income tax rate of the partner country. The most important feature of this tax measure is that it does not contain the countries own corporate tax rate. This makes international tax rate exogenous to the country's economic conditions.

As an alternative measure for the international tax rate, we adopt the idea of Dupaigne and Fève (2009) for the Structural Vector Autoregression Model, which averages TFP across countries to extract pure technology effects which are not contaminated by persistent demand shocks. In the robustness part, we used the cross-country average corporate tax rate as a common component of the corporate tax rate. The analysis is done at the country level because the cross country average tax rate is not suitable for Panel SVAR as it is same for all countries.

As in Gali (1999), we base our identification method on the fact that the variable of interest, i.e. international corporate tax rate, has a unit root. Since the international tax rate variables are I(1), we can have permanent shock. Panel SVAR estimation is more suitable for our analysis than the other estimation methods such as VECM because there is no cointegration between international corporate tax rate and value-added and TFP. Westerlund (2007) test, which allows for dynamic heterogeneity, cannot

reject the null hypothesis of no cointegration (results are in the Appendix D). Additionally, no study in the literature theoretically shows cointegration between corporate tax shock and macroeconomic variables. Therefore, our long-run identification satisfies the panel SVAR analysis requirements, as Pedroni (2013) suggested. Although the SVAR estimations might be subject to small sample biases, a panel data with 11 countries can compensate the shortness of the time series. Also, the confidence bounds are tighter in the panel SVAR estimations than the country level estimations.

Our panel VAR estimation includes the international tax rate and the aggregate and sectoral level macroeconomic variables. Tax rates are in variation and macroeconomic variables enter the VAR model in growth rate and we impose long-run restrictions, i.e., we assume that the matrix of long-run effects is lower triangular.

To explore empirically the dynamic effects of a shock to the international corporate tax rate, we consider a vector of n observables

$$\hat{y}_{it} = [\Delta\tau_{it}, \hat{V}_{it}] \tag{27}$$

where $\Delta\tau_{it}$ consists of the first difference of the international tax rates in equations (26). $\hat{V}_{it}^{1}$ denote the growth rate of macroeconomic variables.

Let us consider the following reduced form of the VAR(p) model:

$$C(L)\hat{y}_{it} = u_{it} \tag{28}$$

where $C(L)$ is a p-order lag polynomial and u_{it} is a vector of reduced-form innovations with a variance-covariance matrix given by $E[u_{it}u_{it}'] = \sum_u$. The vector of orthogonal structural shocks $\varepsilon_{it} = [\varepsilon_{it}^{\tau}, \varepsilon_{it}^{V}]$ is related to the vector of reduced form residuals u_{it}

through: $u_{it} = A_0 \varepsilon_{it}$ which implies $\sum_A = A_0 A_0'$ with A_0 the matrix that describes the instantaneous effects of structural shocks on observable. The linear mapping between the reduced-form innovations and structural shocks leads to the structural moving average representation of the VAR model:

$$\hat{y}_{it} = B(L) A_0^{-1} A_0 u_{it} \tag{29}$$

where $B(L) = C(L)^{-1}$. To identify shocks to the productivity differential, ε_{it}^{Z}, we use the restriction that the unit root in the international tax rate originates exclusively from corporate tax shocks caused by cross country convergence. Long-run restrictions are implemented through restrictions on $A(L) = B(L)A_0^{-1}$ which implies that the upper triangular elements of the long-run cumulative matrix $A(1) = B(1)A_0^{-1}$ must be zero. When we estimate the reduced form VAR using OLS, structural shocks can be restored with $\varepsilon_{it} = A(1)B(1)u_{it}$ where the matrix $A(1)$ is computed as the Cholesky decomposition of $B(1)\sum B(1)'$.

We estimate the reduced form of the VAR model by panel OLS regression with country fixed effects. Our vector of endogenous variables are as follows:

- Aggreagate economy: $\hat{y}_{it} = [\Delta\tau_{it}, \hat{Y}_{it}, \hat{L}_{it}]$
- Sectoral level: $\hat{y}_{it} = [\Delta\tau_{it}, \hat{Y^s}_{it}, \hat{L^s}_{it}]$ for $s = T, N$
- Capital utilization adjusted TFP: $\hat{y}_{it} = [\Delta\tau_{it}, \hat{TFP^T}_{it}, \hat{TFP^N}_{it}]$
- Sectoral composition and labor allocation: $\hat{y}_{it} = [\Delta\tau_{it}, \widehat{Y_{it}^T/Y_{it}}, \widehat{L_{it}^T/L_{it}}]$
- Labor income share: $\hat{y}_{it} = [\Delta\tau_{it}, \hat{LIST}_{it}, \hat{LISN}_{it}]$

- R&D capital stock and investment: $\hat{y}_{it} = [\Delta\tau_{it}, \hat{K^s}_{it}, T\hat{F}P^s{}_{it}]$ for $s = T, N$ where K is for R&D capital stock. $[\Delta\tau_{it}, \hat{I^T}_{it}, \hat{I^N}_{it}]$ where I is for R&D investment.
- Wage rigidity: $\hat{y}_{it} = [\Delta\tau_{it}, \frac{\hat{W^H_{it}}}{P^{*H}_{it}}, \frac{\hat{W^N_{it}}}{P^{*H}_{it}}]$
- Government spending: $\hat{y}_{it} = [\Delta\tau_{it}, \hat{G}_{it}]$

All variables except international tax rate enter the VAR model in growth rate (denoted by a hat).

2.4 Results

Due to economic globalization and the international competition across countries to attract multinational firms, there is a worldwide convergence of corporate taxation. Figure 9 displays the country corporate tax rate, import share weighted tax rate and cross country average tax rate for eleven OECD countries.



Figure 9. The evolution of statutory country corporate income tax rates, cross country average tax rates and import share weighted corporate tax rates for 11 OECD Countries

It is apparent in the figure that there is a common stochastic trend for eleven countries but we check for the cross-sectional dependence to show that there is a standard shock that influences eleven countries. We test for weak cross-sectional dependence by applying the Pesaran (2015) test. It rejects the null hypothesis that errors are weakly cross-sectional dependent with CD = 40.823 and p-value = 0.000 for the country's corporate tax rate. Rejects the null hypothesis with CD = 48.157 and p-value = 0.000 for import share weighted corporate tax rate. This result implies that both series present cross-sectional dependence. Thus we have to apply unit root and cointegration tests that consider this dependence. Secondly, we test the unit root null hypothesis

in panel data [12]. The panel unit root hypothesis cannot be rejected for country-level corporate tax rates, and import share weighted corporate tax rates. We apply four additional panel unit root tests: Levin, Lin, and Chu (2002), Breitung (2001), Im, Pesaran, and Shin (2003), and Hadri (2000). For all tests, the null of a unit root is not rejected (Table D5 in Appendix D).Therefore there is a unit root and series are I(1).

As the last step, we estimate the cointegration relationship between the two series. We run three-panel cointegration tests to show the cointegration between a country's corporate tax rate and import share weighted corporate tax rate. They all reject the null hypothesis that there is no cointegration between two variables. Westerlund (2007) provides the most informative test. Among the four stats of Westerlund, two of them (Gt, Ga) reject the no cointegration null hypothesis (Table D6 in Appendix D). As Gt and Ga allow for some heterogeneity in the cointegration vector across individuals, we can conclude that there is a cointegration relationship between log country income corporate tax rate and log of import share weighted tax rate. We run two additional panel cointegration tests (Table D7 in Appendix D), which give us the same result that there is cointegration between two series. The unit root test cannot reject the null hypothesis that there is a unit root for the corporate tax rate for each country and cross-country average tax rate. The Johansen cointegration test implies cointegration between a country's corporate tax rate and the average tax rate for most countries (Table D8 and Table D9 in Appendix D). In light of these cointegration analyses, we can argue that a standard shock influences eleven countries for import share weighted average tax rate and cross-country average tax rate.

[12]Before the unit root test, we run a simple regression in panel (with country fixed effects) of log country corporate tax rate and log of import share weighted tax rate on a linear trend. The trend in both cases is statistically significant. However it is not relevant to add a trend to cointegration because the trend relationship between the variables in the cointegration is what we want to capture and explain, and adding an exogeneous trend makes the results less relevant.

We chose the lag length according to the five criteria LR, FPE, AIC, HQIC, and SBIC (the results are in Appendix D). Lag length criteria imply one lag for eight countries for import share weighted average corporate tax rate and two lags for ten countries for cross-country average corporate tax rate. In line with the current practice (e.g. Beetsma and Giuliodori (2011), Corsetti, Meier, Müller and Devereux (2012)), we use lag length 2 in baseline panel SVAR estimations. We also present results for lag length 1 in the robustness section. Our results remain unsensitive to the number of lag. We use lag length 2 in the country specific SVAR analysis because it is estimated by using average corporate tax rate.

We apply unit normalization for the impulse response results. Firstly, we run the estimation for international tax rate and country corporate tax rate. In the second step, we run the estimation for international tax rates and macroeconomic variables. We normalize the impulse response functions of the second step with the estimations in the first step. Thus, we have the impulse responses that demonstrate the response of variables of a shock to the international tax rate, which leads to a 1 percentage point (PPt) cut in the country's corporate tax rate. Additionally, we re scale the response of value added and hours worked in traded and non-traded sectors by the sample average of sectoral value added to GDP and sectoral labor compensation share. Thus, the interpretation of sectoral value added and hours worked is in percentage points of aggregate GDP and total hours worked, respectively.

2.4.1 Comparison with narrative measure

The literature accepts the narrative measure as exogenous identification for tax shocks because it is viewed as one-to-one mapping into the true structural shocks. However, it is only available in the United States for corporate tax rates. Hence, we compare

our corporate tax measure for the US with the narrative measure provided by Mertens and Ravn (2013) to provide evidence that our tax measures are also exogenous. Mertens and Ravn (2013) investigate the short-run impact of corporate tax rates by using narrative measure of corporate tax rate for the period between 1950 and 2006 with quarterly data. Their results indicate that a one percentage point cut in the average corporate tax rate increases real GDP per capita by 0.6 percent after one year, raises private sector investment, and has little effect on private consumption in the short run. We run a SVAR long run restrictions estimation for output consumption and investment by using narrative measure, cross country average tax rate and import share weighted average tax rate. Figure 10 presents the estimation results.

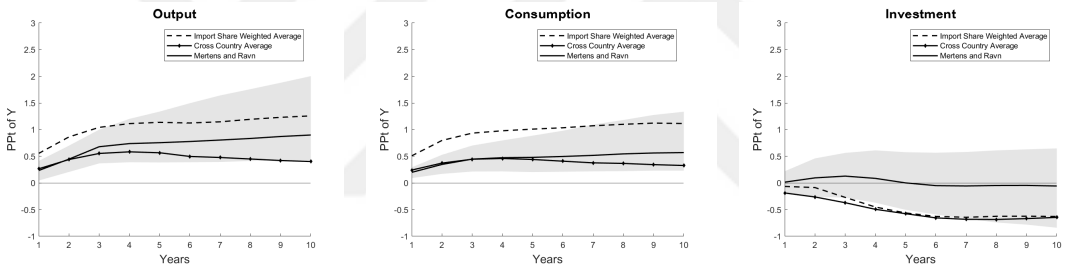


Figure 10. Comparison of international tax measures with narrative tax measure

Notes: A shock to exogenous tax measures leads to a 1 percentage point cut in the country's corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage point deviation from aggregate value-added trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: the US, 1973-2006, annual data.

Although we analyze the long-run responses, the impulse response functions for GDP per capita and consumption are close to the results of Mertens and Ravn (2013). GDP per capita increases by around 0.6 percent, and the rise in consumption is equivalent to a 0.5 percent point rise in GDP per capita.

The cross-country average corporate tax rate gives the same results for the first two years for output and five years for consumption with narrative measure. In the long-run average corporate tax rate underestimates the responses. On the other hand, the import share weighted corporate tax rate is very close to the narrative measure, but it little overestimates the responses for output and consumption. In the long-run, international tax measures stay within the 90% confidence bounds of narrative measure. The response for the investment is zero for the narrative measure but negative for international tax rates. The differences between international tax rates and narrative measures may stem from the fact that the narrative measures are computed by summarizing the significant events of a potentially very large information set into account.

2.4.2 Baseline results

In this section, we present the panel SVAR estimation results with lag length 2. The impulse response function (IRF) point estimates are centered 90% confidence interval with 10000 replications in Monte Carlo simulations. Figure 11 displays the impulse response results for value-added and hours worked to a corporate tax cut for eleven countries.

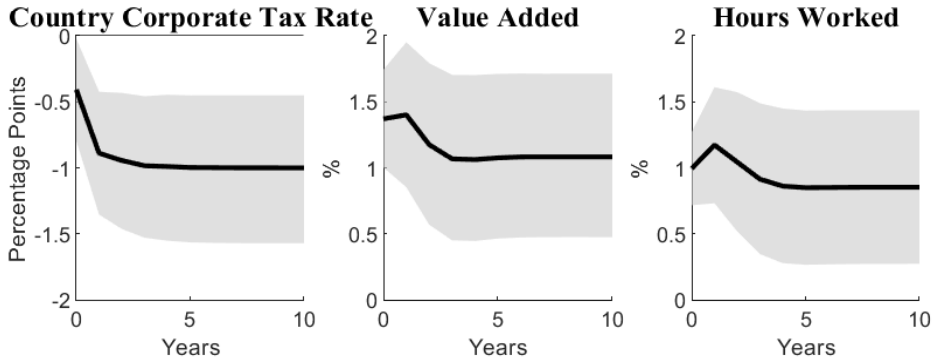
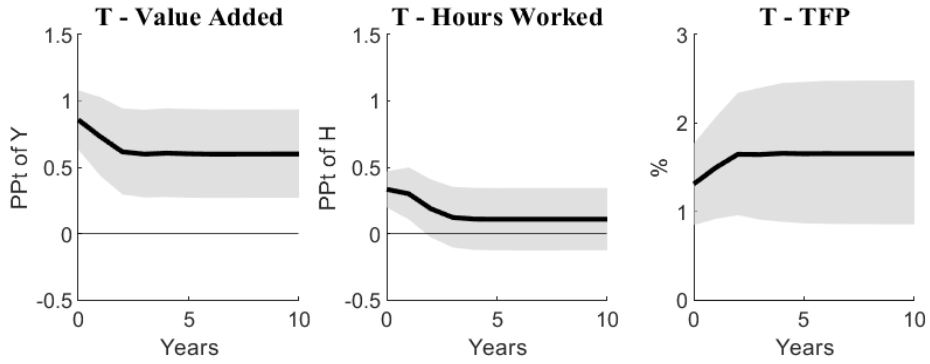


Figure 11. Effects of a permanent corporate tax shock on value added and hours worked

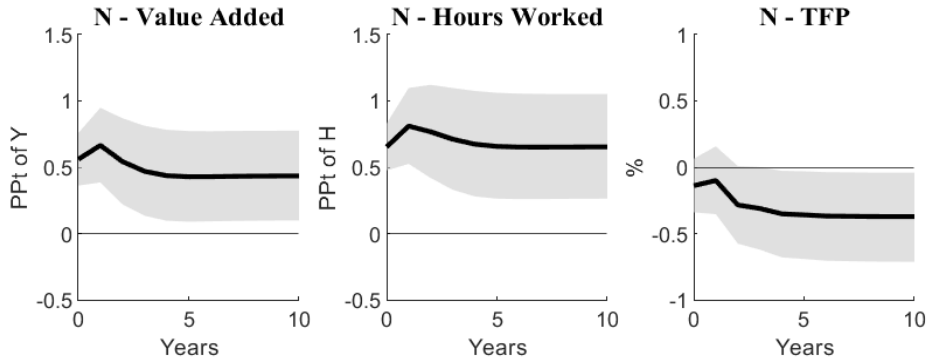
Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

The first graph shows the country's corporate tax rate response to the import share weighted corporate tax rate. The shock is normalized to a 1 percentage point decline. The second and third graphs demonstrate the responses of value-added and hours worked. The 1 percentage point cut in the corporate income tax rate generates a significant 1.08% rise in output per capita and 0.85% increase in hours worked in the long run for eleven countries. The results are compatible with Suarez, Serrato and Zidar (2016). They present that a 1 percentage point cut in business taxes leads to a rise between 3.35% and 4.07% in establishment growth and between 3.74% and 4.28% rise in population growth over ten years in the US.

We perform the previous exercise for the traded and non-traded sectors. The first row of Figure 12 shows the impulse responses for the traded sector, and the second row displays the IRFs for the non-traded sector.



(a) Traded Sector



(b) Non Traded Sector

Figure 12. Effects of a permanent cut in corporate tax rate on traded and non traded sectors

Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

For both sectors, the response of GDP per capita is positive and significant. Response of hours worked is 0.65% and significant in the non-traded sector. The impact of capital utilization adjusted TFP is significantly 1.65% in traded sector in ten years, whereas it is negative but not significant in the short-run in the non-traded sector. Thus, there is a differentiation between traded and non-traded sectors regarding the response of hours worked and utilization adjusted TFP. The impact to corporate tax shock may be different between sectors because corporate tax may influence sectors differently. Djankov et al. (2010) do a panel analysis for 85 countries and indicate

that corporate taxes are correlated with investment in the manufacturing sector, whereas they are not in the services sector. Thus, the response of sectors may be related to the labor or capital intensity of sectors.

Additionally, Figure 13 shows the response of labor income share to a 1 percentage point corporate tax shock in traded and non-traded sectors.

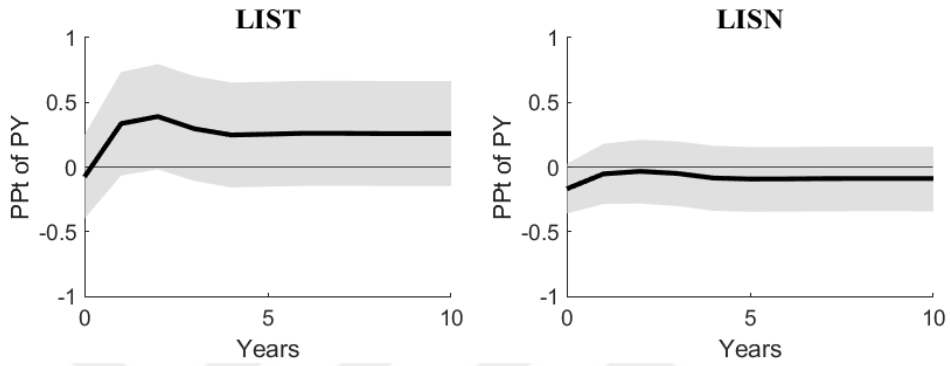


Figure 13. Effects of a permanent cut in corporate tax rate on labor income share

Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

One percentage corporate tax cut leads to an insignificant 0.26 percentage point increase in traded labor income share regarding value-added share. However, there is no significant variation in the labor income share in the non-traded sector following a permanent decrease in corporate taxation. Positive or unresponsive labor income shares contradict the findings by Kaymak and Schott (2020), who claim a positive relationship between corporate tax reduction and labor income share.

Starting from the differentiation between traded and non-traded sectors in the previous estimations, we analyze the effect on the output and labor allocations between traded and non-traded sectors to a permanent corporate tax shock. Figure 14 present the responses for output and labor allocations.

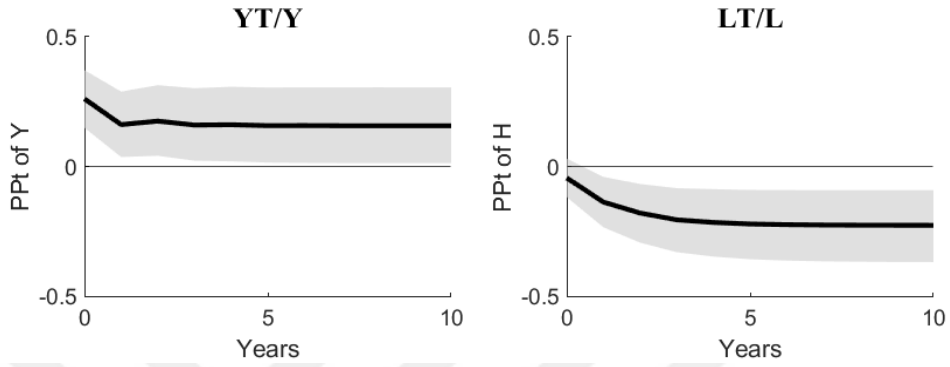


Figure 14. Effects of a permanent cut in corporate tax rate on output and labor allocations

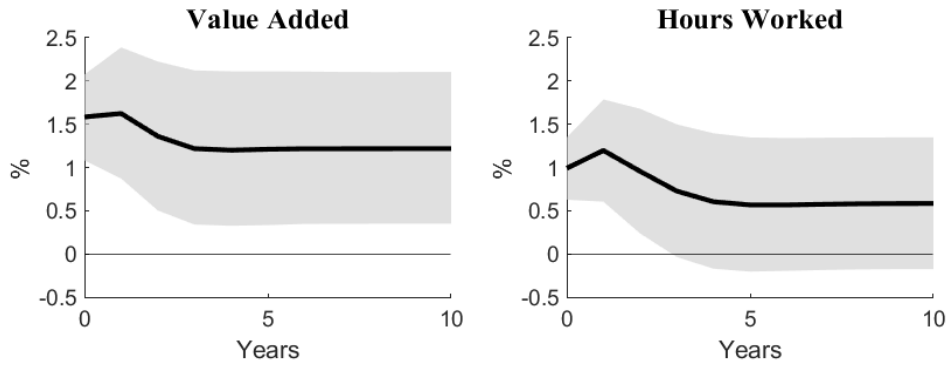
Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

The behaviours of value-added and hours worked allocations between traded, and non-traded sectors are opposite. A corporate tax cut has a positive but insignificant impact on the share of value-added of the traded sector in total value-added. However, the impact of the share of traded hours worked in total is -0.22 percentage point of hours worked, which is within the 90 percent confidence bounds. This result means that corporate tax cut contributes to allocating labor from traded to non-traded sectors. This result can be related to an increased utilization-adjusted TFP in the traded sector. It implies that the labor productivity in the traded sector increases more than it does in the non traded sector, which causes a rise in labor demand in the non-traded sector if traded and non-traded sectors are complements.

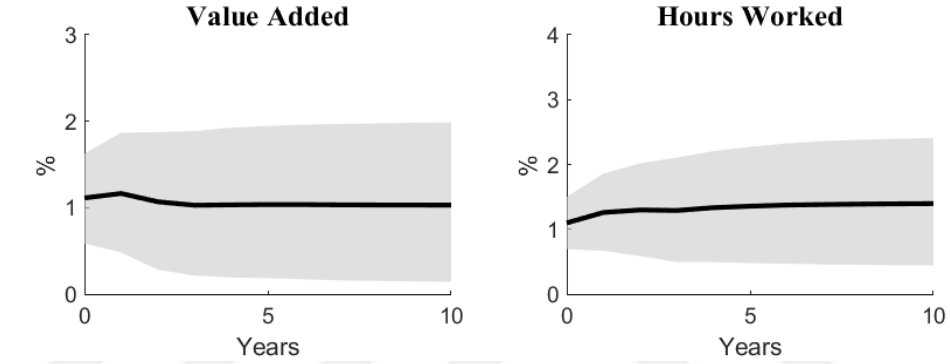
Our results show that a fall in corporate income taxation positively influences both labor and aggregate value added for the whole sample, but there are some differences between countries. The IRF graphs for individual countries are in the Appendix C. The impulse response functions for hours worked, and TFP adjusted with capital utilization show that a fall in corporate tax rate significantly increases hours worked for Austria, Belgium, Germany, France, Luxembourg, and Great Britain. The response is positive, statistically insignificant, and negligible for Australia, Japan, and the USA. On the other hand, the IRFs for TFP adjusted with capital utilization display a differentiation across countries, but it is positive and significant for most of them.

These differences reveal that continental European countries (including Austria, Belgium, France, Germany) experience a significant decline in total hours worked but slight variation in traded TFP, except Luxembourg. Conversely, English-speaking (Australia, United Kingdom, and United States), Scandinavian countries (Finland, Sweden), Japan, and Luxembourg experience a significant decline in traded TFP.

Because these two countries react differently to the shock of corporate tax, we also present the aggregate effects for each group of countries. Figure 15 displays the response of aggregate value-added and hours worked for two groups of countries to a permanent shock to the corporate tax rate.



(a) English Speaking and Scandinavian Countries



(b) Continental European Countries

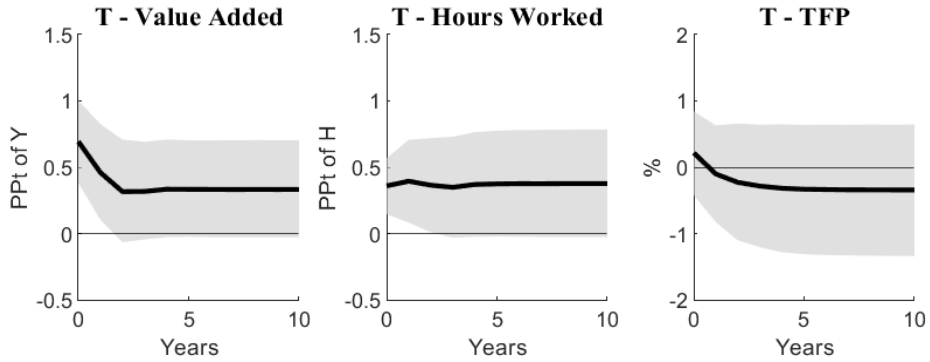
Figure 15. Effects of a permanent cut in corporate tax rate for two groups of countries

Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: Australia, United Kingdom, and United States, Finland, Sweden, Japan, and Luxembourg for first group and Austria, Belgium, France, Germany for second group, 1973-2015, annual data.

The permanent negative shock to corporate tax causes increased value-added and hours worked in both groups. The response of value-added is 1.22% in the first group and 1.03% in the second group in ten years. The increase in hours worked is 1.39% in continental European countries whereas it is 0.58% and insignificant in ten years in English Speaking and Scandinavian Countries. Figure 16 shows the IRFs for the traded sector for two groups of countries.



(a) English Speaking and Scandinavian Countries



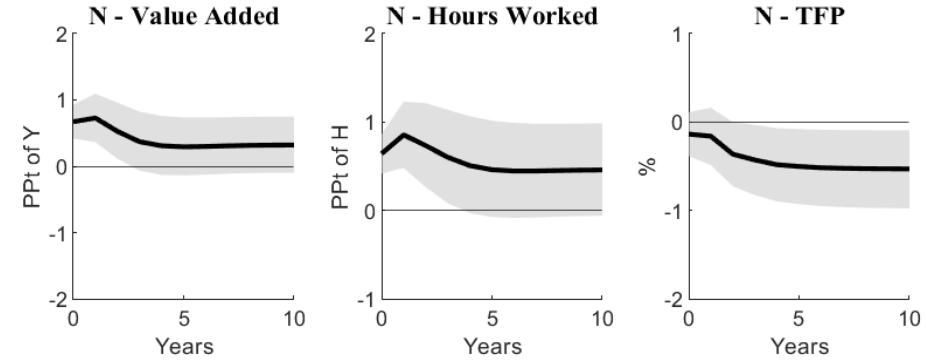
(b) Continental European Countries

Figure 16. Effects of a permanent cut in corporate tax rate in traded sector for two groups of countries

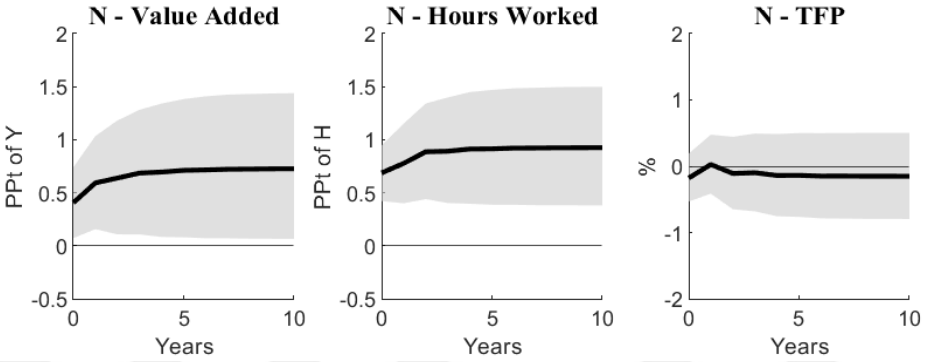
Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: Australia, United Kingdom, and United States, Finland, Sweden, Japan, and Luxembourg for first group and Austria, Belgium, France, Germany for second group, 1973-2015, annual data.

Traded sector's value added is positively influenced in both groups of countries. It is clear that the utilization adjusted TFP is positive and significantly affected by the corporate tax cut in English-speaking and Scandinavian countries, Japan and Luxembourg. The response is 2.72% in traded TFP to a 1 percentage point cut in corporate tax rate. However, the utilization adjusted TFP is not affected by the corporate tax shock in continental European countries. The decline is 0.34% but not significant. The result is vice versa for the hours worked. The response of hours worked is 0.38 percentage point of total hours worked in Continental European countries, but there is no impact

in English-speaking and Scandinavian countries, Japan and Luxembourg. Figure 17 shows the IRFs for the non-traded sector for two groups of countries.



(a) English Speaking and Scandinavian Countries



(b) Continental European Countries

Figure 17. Effects of a permanent cut in corporate tax rate in traded sector for two groups of countries

Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: Australia, United Kingdom, and United States, Finland, Sweden, Japan, and Luxembourg for first group and Austria, Belgium, France, Germany for second group, 1973-2015, annual data.

Non-traded sector's value added is positively influenced in both groups of countries but it is significant for continental European Countries but insignificant for the other group. The utilization adjusted TFP is negative and insignificantly affected by the corporate tax cut in the first group but it is not affected in the second group. The response of hours worked is positive in both groups but it is insignificant in the long-run for the first group of countries.The response of hours worked is 0.92 percentage point

of total hours worked in Continental European countries, but it is 0.46 percentage point of total hours worked in English-speaking and Scandinavian countries, Japan and Luxembourg.

Therefore we can conclude that there is a difference between Continental European countries and English-speaking and Scandinavian countries, Japan and Luxembourg. Continental European countries responded by increasing hours worked to a corporate tax cut. However, English-speaking and Scandinavian countries, Japan, and Luxembourg responded by raising utilization adjusted TFP to a permanent negative tax shock in the traded sector.

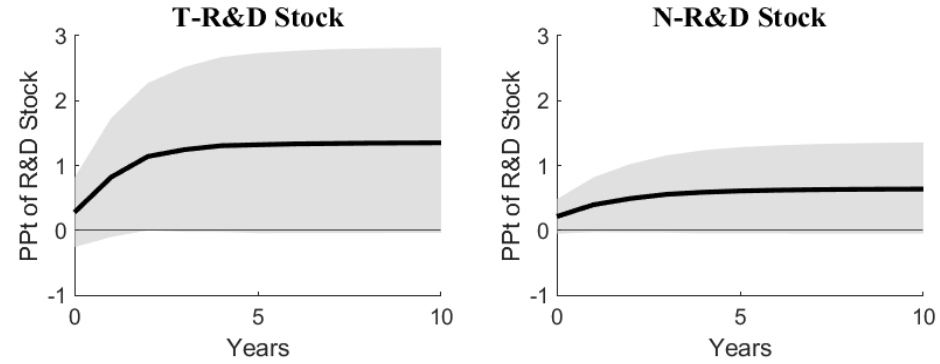
2.4 Mechanisms

It is clear from the results we present in the previous section that there is a difference in the responses of traded and non-traded sectors for all countries. A corporate income tax rate cut leads to increased traded TFP, whereas it increases non-traded hours worked. On the other hand, the impacts of fall in corporate tax rate are totally distinct between the two groups of countries. The SVAR results reveal that after a decline in profits' taxation, firms in the traded sector significantly use more labor in continental European countries but do not increase innovation defined as utilization-adjusted-total factor productivity. In English-speaking and Scandinavian countries, exporting firms increase innovation, which is captured by the rise in utilization-adjusted-total factor productivity, while not significantly increasing labor.

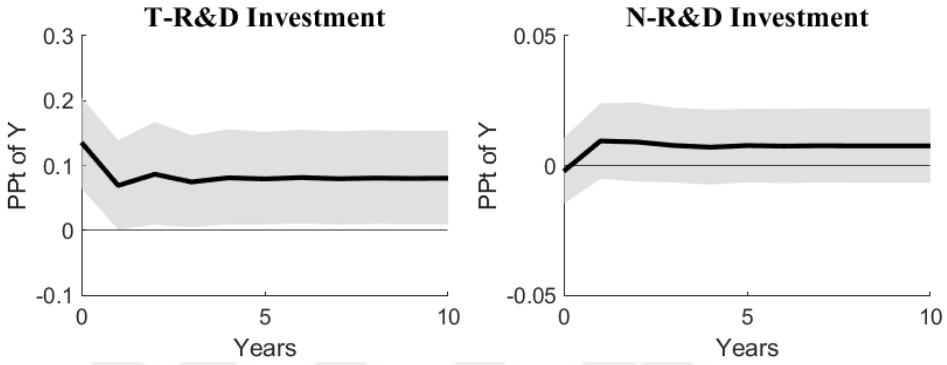
In this section, we provide some mechanisms that causes the differentiation between sectors and country groups. The first mechanism emerge via the R&D capital stock and investment. Second mechanism is the wage flexibility differences between countries. Our final suggested mechanism is based on response of the the government spending to corporate tax shock.

2.4.1 R&D capital stock and investment

Since the exporting firms are more productive than the non-exporting firms, it is natural that a shock to corporate tax affects two sectors asymmetrically. The mechanism behind this distinction stem from the differences in R&D intensity of these sector. Thus, we set up the panel SVAR to analyze for the impact of corporate tax shock on R&D stock and R&D investment. R&D capital stock and investment data are from the EU KLEM dataset, which is available between 1995 and 2017. The data is unavailable for Australia for both variables, and R&D investment data is not available for Belgium. Figure 18 displays the IRFs of the R&D stock and investment for traded and non-traded sectors for eleven countries.



(a) R&D capital stock



(b) R&D investment

Figure 18. Effects of a permanent cut in corporate tax rate on R&D capital stock and investment

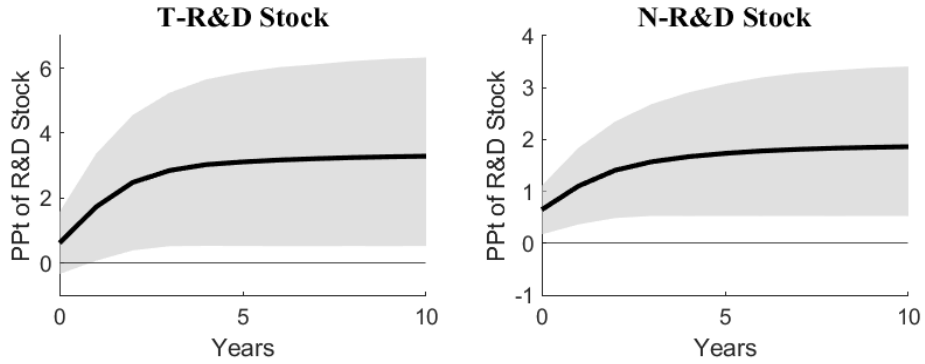
Notes: Exogenous 1 percentage point cut of import share weighted corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Samle: 1995-2017, annual data.

A permanent negative shock to the corporate income tax rate influences R&D stock positively for both sectors. The increase is 1.35 percentage points of total R&D capital stock in the traded sector, but it is 0.63 percentage points of total R&D capital stock in the non-traded sector. Similarly, a permanent shock to the corporate income tax rate has a significant positive impact on R&D investment in the traded sector. However, the impact is almost one-tenth of the traded sector and insignificant in the non-traded sector.

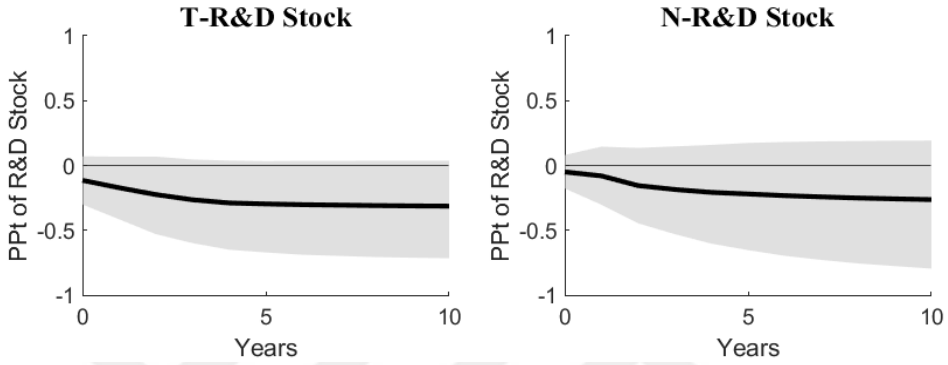
The decline in corporate tax rate decreases the cost of capital and increases capital investment. The share of intangible capital is higher in the traded sector than

in the non-traded sector. Hence, the cost of intangible capital relative to labor decreases more in the traded sector, and firms' demand for traded intangible capital increase more than non-traded intangible capital. Thus, the traded sector is affected more than the non-traded sector in accumulating intangible capital, therefore TFP rises more. This result is compatible with Akcigit et al. (2022), who empirically investigate the effect of corporate taxes on innovation at both firm and state levels in the US. They show a negative relationship between corporate income taxes and the number of patents. Therefore, a permanent tax cut increases R&D investment more in the traded sector than in the non-traded sector. It leads to a higher R&D capital accumulation in the traded sector, which is influenced by the TFP increase.

The results in the baseline estimations indicate a difference between English Speaking and Scandinavian Countries and Continental European countries. A corporate income tax rate cut leads to increased traded TFP in the first group, whereas it does not affect the TFP in the second group of countries. We estimate the panel SVAR analysis with R&D capital stock and investment for two groups to see the underlying mechanism behind this differentiation. Figure 19 shows the IRF results for R&D capital stock for two country groups.



(a) English Speaking and Scandinavian Countries

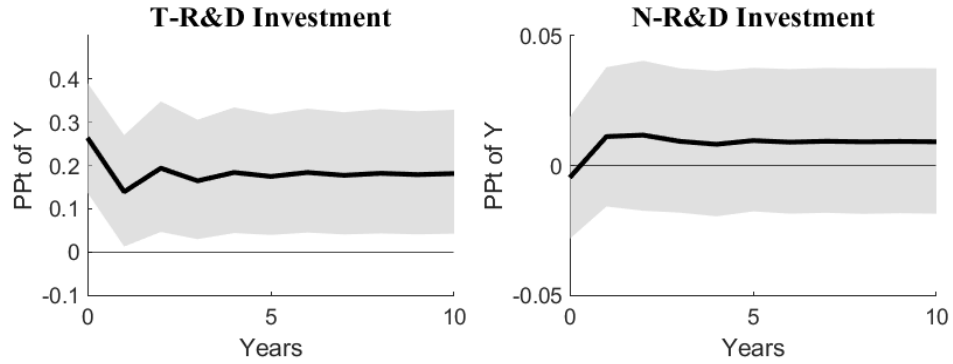


(b) Continental European Countries

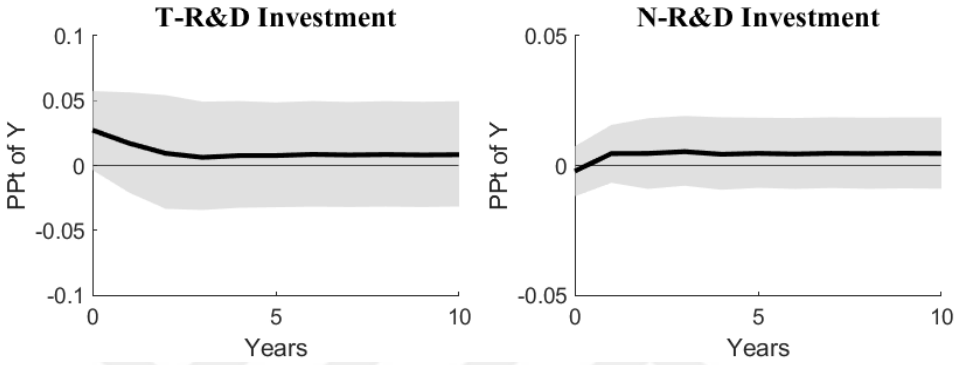
Figure 19. Effects of a permanent cut in corporate tax rate on R&D capital stock for two groups of countries

Notes: Exogenous 1 percentage point cut of import share weighted corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 1995-2017, annual data.

A permanent negative shock to the corporate income tax rate influences R&D stock significantly positively for both sectors in English Speaking and Scandinavian Countries. The increase is 3.28 percentage points in the traded sector and 1.86 percentage points of total R&D capital stock in the non-traded sector. The impact of corporate tax shock on R&D capital stock is negative and insignificant for both sectors in Continental European Countries. Figure 20 shows the IRF results for R&D investment for two country groups.



(a) English Speaking and Scandinavian Countries



(b) Continental European Countries

Figure 20. Effects of a permanent cut in corporate tax rate on R&D investment for two groups of countries

Notes: Exogenous 1 percentage point cut of import share weighted corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 1995-2017, annual data.

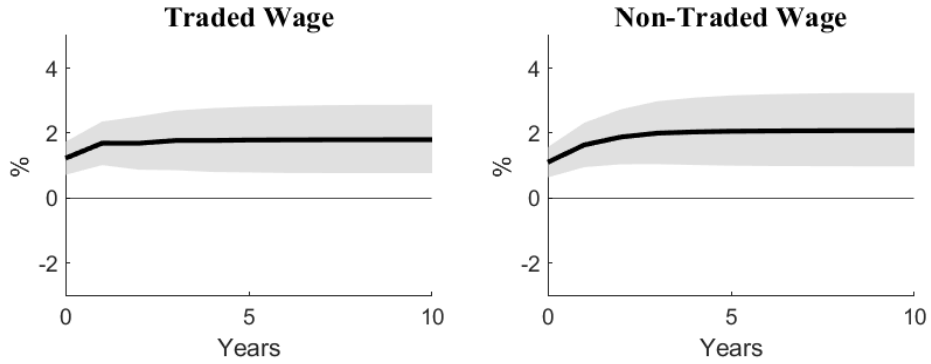
A permanent negative shock to the corporate income tax rate influences R&D investment significantly positively for traded sectors but insignificantly for non-traded sector in English Speaking and Scandinavian Countries. The increase is 0.18 percentage points in the traded sector of total value added. On the other hand, the effect of corporate tax shock on R&D investment is zero for both sectors in Continental European Countries.

The differences between the two groups of countries can be explained by the R&D capital stock and investment responses. The decline in corporate tax rate decreases the cost of capital and increases capital investment in English Speaking and Scandinavian Countries. The corporate tax rate cut does not affect R&D capital

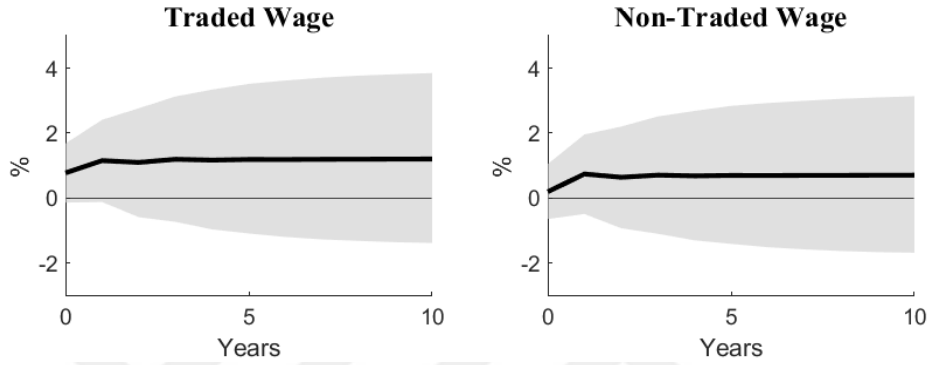
investment and accumulation in Continental European Countries. Therefore, the differentiation in TFP responses of two groups of countries stems from distinction in the R&D investment and stock.

2.4.2 Wage rigidity

The response of hours worked is positive in Continental Europe, but there is no impact in English Speaking and Scandinavian Countries, Luxembourg and Japan. Output is positively influenced in both groups of countries. More specifically, the second group of countries is known to have more flexible labor markets. In contrast, the reverse is valid for the first group of countries with more regulated labor markets. Hence, we set up a panel SVAR estimation to understand the mechanism behind the differences via wage rigidity between two groups in terms of hours worked. The IRF results for real wages in traded and non traded sector are in Figure 21.



(a) English Speaking and Scandinavian Countries



(b) Continental European Countries

Figure 21. Effects of a permanent cut in corporate tax rate on wages for two groups of countries

Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: Australia, United Kingdom, and United States, Finland, Sweden, Japan, and Luxembourg for first group and Austria, Belgium, France, Germany for second group, 1973-2015, annual data.

A permanent negative shock to the corporate income tax rate influences wage significantly positively for both sectors in English Speaking and Scandinavian Countries. On the other hand, the effect of corporate tax shock on R&D investment is zero for both sectors in Continental European Countries. Thus, the wages are rigid in both sectors in Continental European Countries, whereas they are flexible in English Speaking and Scandinavian Countries.

A cut in the corporate income tax rate decreases tangible and intangible capital costs so corporate savings and capital investment raises. Higher capital accumulation

increases the marginal product of labor. If wages are flexible, wages increases and demand for labor decreases. If wages are rigid, the cost of labor relative to capital is smaller. Thus, the demand increases for labor, and employment rises. We can argue that adjusting TFP is more costly than labor in Continental European Countries, so the response of these countries is to increase hours worked to a corporate tax shock. On the other hand, other countries have flexible and increasing wages, so the firms respond with R&D investment to a corporate tax shock.

2.4.3 Government spending

Even though government spending is not an explicit policy tool for TFP, it may indirectly influence innovation policy. Cozzi and Impullitti (2010) argue that government spending is crucial in innovation via the shift in the composition of public demand toward innovative goods and increasing the market size of high-tech firms, which works as an indirect innovation policy tool. Cardi and Restout (2022) show empirically and theoretically that government spending encourages firms in the traded sectors to improve their technology. Thus, we estimate the response of government spending to a permanent corporate tax cut shock. Figure 22 demonstrate the IRFs for government spending for two groups.

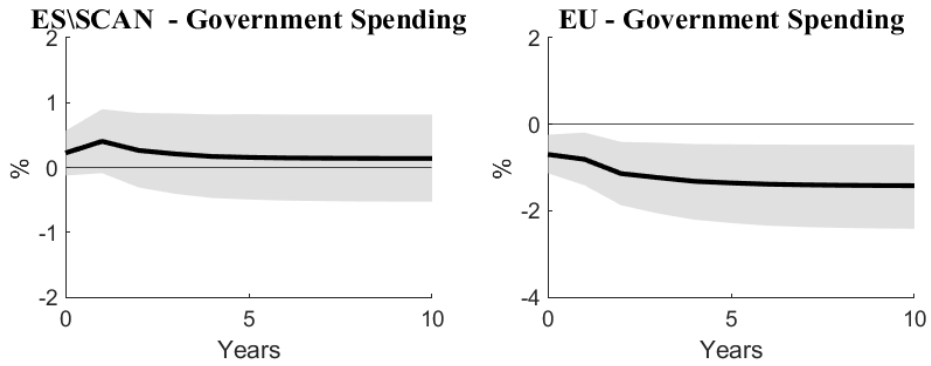


Figure 22. Effects of a permanent decrease in corporate tax rate on government spending

Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data. ES/SCAN: English Speaking and Scandinavian Countries, EU: Continental European Countries

It is apparent in the figure that a permanent tax cut leads to a significant 1.42% decline in government spending in Continental European Countries. However, there is no impact in English Speaking and Scandinavian Countries. A permanent corporate tax cut shock decreases government spending in Continental European Countries. It may decrease the government demand for high-tech goods, which mitigates the increase in TFP that stems from the tax cut shock. Also, because government spending is biased toward non-traded goods (Cardi and Restout (2022)), when it falls, it reallocates resources towards the traded sector which might explain a small part of the increase in hours worked in traded sector.

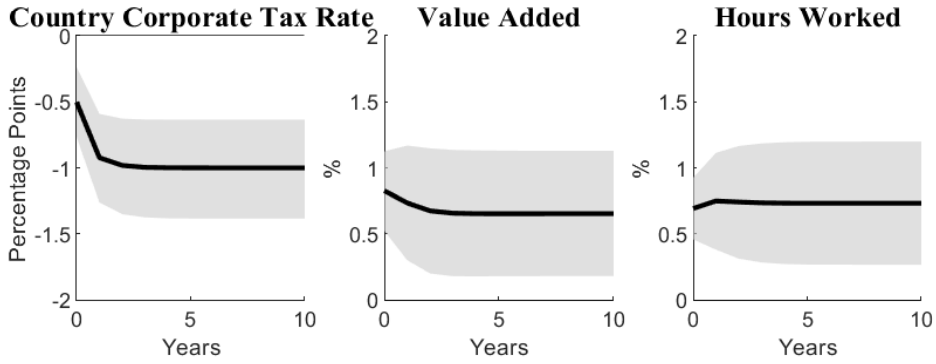
Another issue in explaining the difference between the two groups can be the government subsidies on R&D investment. Tax cuts may lead to a decrease in tax revenues and government spending. Thus, it may affect the subsidies to firms' R&D investment. The subsidy to R&D data is limited to after the 2000s, so we could not analyze the impact of corporate tax cuts on subsidies.

2.5 Robustness

For the sake of integrity, we check the robustness of our baseline results to the lag length selection and implement additional estimations at the country level.

2.5.1 Panel SVAR Estimations for Lag Length 1

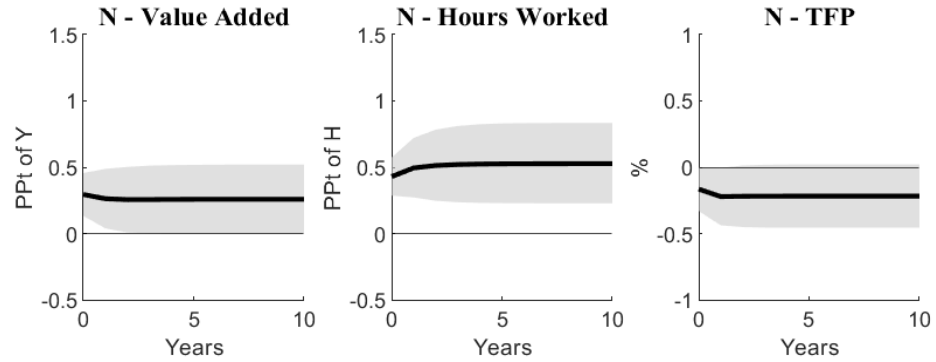
This section presents the panel SVAR estimation results for lag length 1.As in the baseline results, the IRF point estimates are centered 90% confidence interval with 10000 replications in Monte Carlo simulations. Figure 23 displays the impulse response results for value-added and hours worked to a corporate tax cut for eleven countries for aggregate and traded and non-traded sectors.



(a) Aggregate economy



(b) Traded sector



(c) Non-traded sector

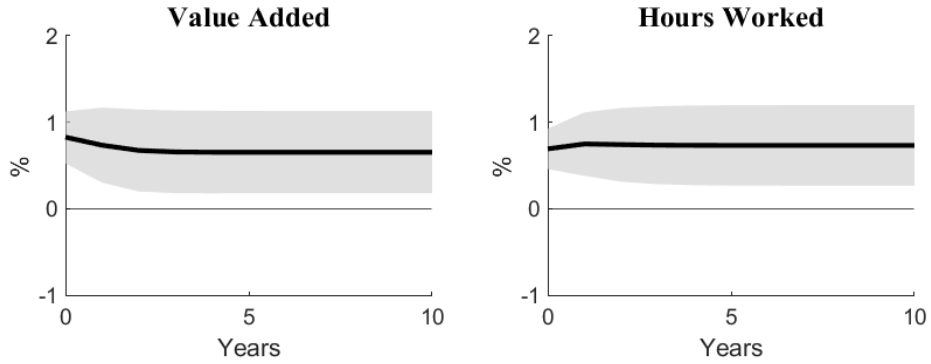
Figure 23. Effects of a permanent corporate tax rate shock

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

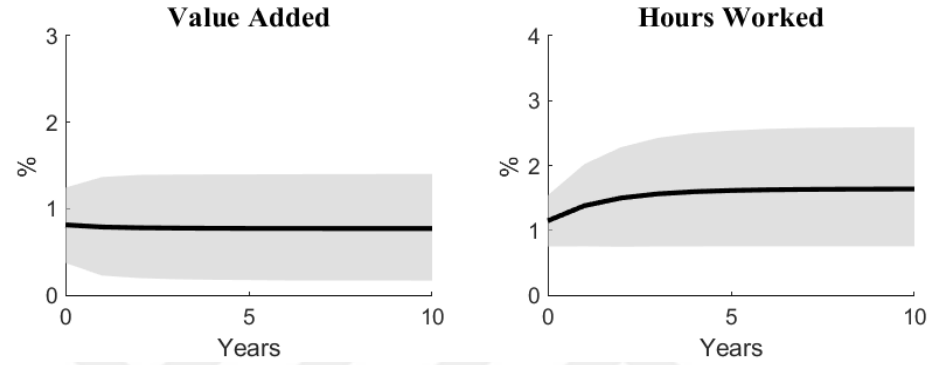
The first graph shows the country's corporate tax rate response to the import share weighted corporate tax rate. It is normalized to 1 percentage point decline. The second and third graphs demonstrate the responses of value-added and hours worked. The 1

percentage point cut in the corporate income tax rate generates a significant 0.65% rise in output per capita and 0.73% increase in hours worked in the long run for eleven countries. The IRFs exhibit smaller responses for lag length 1 but the confidence intervals are narrower than baseline estimations. The second row shows the impulse responses for the traded sector, and the third row displays the IRFs for the non-traded sector. For both sectors, the response of GDP per capita is positive and significant. Response of hours worked is 0.53% and significant in the non-traded sector but insignificant for the traded sector. The impact of capital utilization adjusted TFP is 0.88% in the traded sector in ten years, whereas it is negative but not significant in the non-traded sector. Thus, the differentiation between traded and non-traded sectors we present in baseline results holds for lag length 1.

Figure 24 displays the response of aggregate value-added and hours worked for two groups of countries to a permanent shock to the corporate tax rate.



(a) English Speaking and Scandinavian Countries



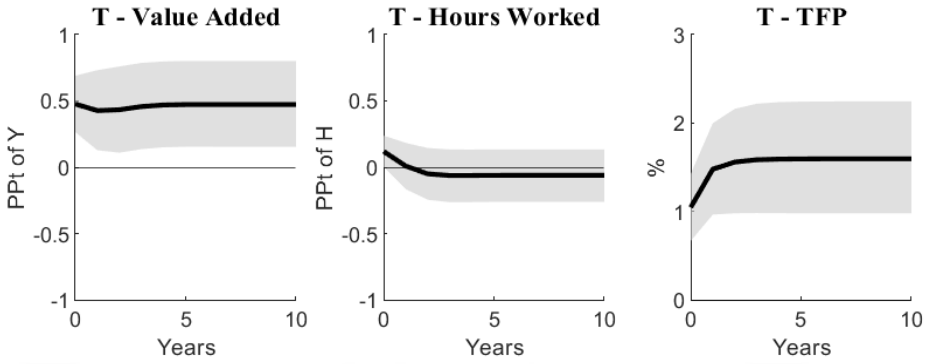
(b) Continental European Countries

Figure 24. Effects of a permanent cut in corporate tax rate for two groups of countries

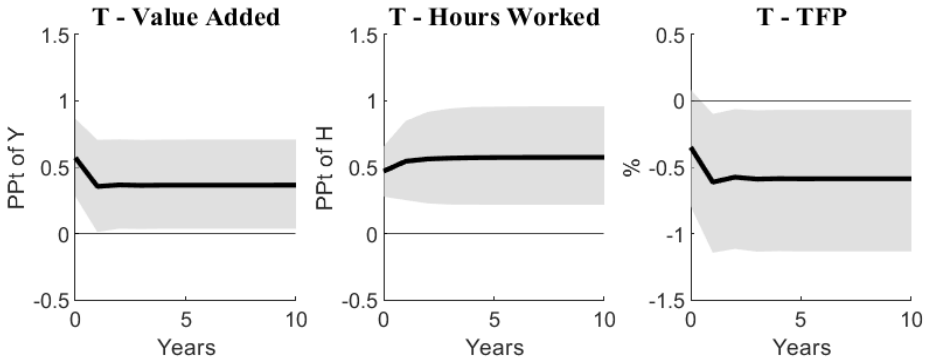
Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: Australia, United Kingdom, and United States, Finland, Sweden, Japan, and Luxembourg for first group and Austria, Belgium, France, Germany for second group, 1973-2015, annual data.

The permanent negative shock to corporate tax causes increased value-added and hours worked in both groups. The responses are significant at 90% level except for hours worked in English Speaking and Scandinavian Countries. Even if it is significant for the first three periods, it becomes insignificant in the long run. The response of value added is 0.55% in the first group and 0.77% in the second group in ten years. The increase in hours worked is 1.64% in continental European countries whereas it is 0.32% in English Speaking and Scandinavian Countries.

The results are consistent with the baseline results with larger responses and narrower confidence bounds. Figure 25 shows the IRFs for the traded sector for two groups of countries.



(a) English Speaking and Scandinavian Countries



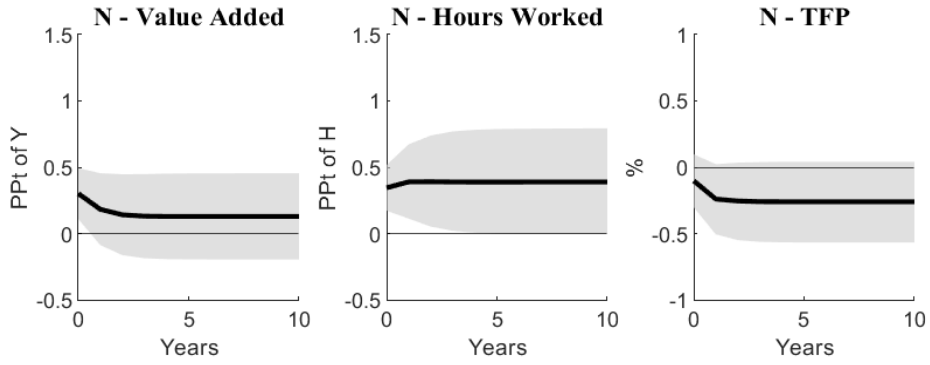
(b) Continental European Countries

Figure 25. Effects of a permanent cut in corporate tax rate in traded sector for two groups of countries

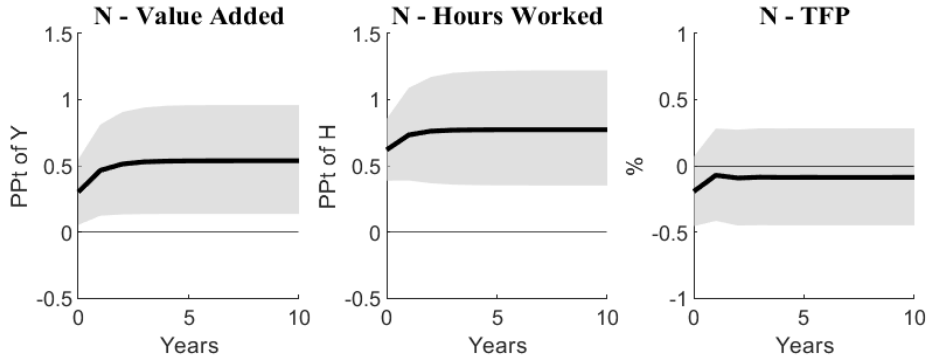
Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: Australia, United Kingdom, and United States, Finland, Sweden, Japan, and Luxembourg for first group and Austria, Belgium, France, Germany for second group, 1973-2015, annual data.

Traded value added is significantly positive influenced in the first group but insignificant in the second group in the long run. It is clear that the utilization adjusted TFP is positive and significantly affected by the corporate tax cut in English-speaking and Scandinavian countries, Japan and Luxembourg. The response is 1.6%, which is more than 1 percentage point less than the baseline estimations in traded TFP. On

the other hand, the utilization adjusted TFP is negatively affected by the corporate tax shock in continental European countries, but different from the baseline estimation, it is significant. The result is vice versa for the hours worked. The response of hours worked is 0.57 percentage point of total hours worked in Continental European countries, but there is no impact in English-speaking and Scandinavian countries, Japan and Luxembourg. Hence, the differentiation between the two groups of countries holds regarding the adjusted TFP and hours worked in the estimations with lag length 1. Figure 26 shows the IRFs for the non-traded sector for two groups of countries.



(a) English Speaking and Scandinavian Countries



(b) Continental European Countries

Figure 26. Effects of a permanent cut in corporate tax rate in non-traded sector for two groups of countries

Notes: Exogenous cut of import share weighted corporate tax rate that leads to an 1 percentage point cut in corporate tax rate. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: Australia, United Kingdom, and United States, Finland, Sweden, Japan, and Luxembourg for first group and Austria, Belgium, France, Germany for second group, 1973-2015, annual data.

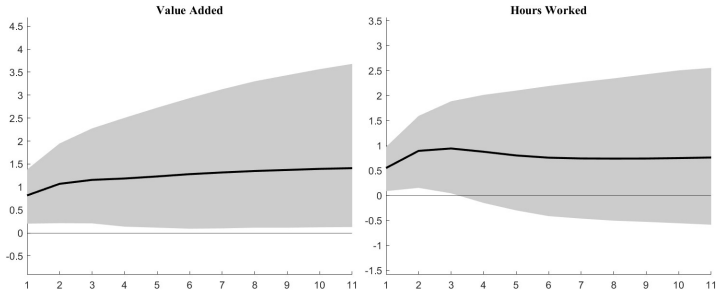
Non-traded value added is positively influenced in both countries, but it is significant for continental European Countries but insignificant for the other group. The utilization adjusted TFP response differs from the baseline estimation as it is insignificantly affected in English-speaking and Scandinavian countries, Japan, and Luxembourg. The response of hours worked is significantly positive in both groups. The response of hours worked is 0.77 percentage points of total hours worked in Continental European countries, which is 0.15 percentage points less than the baseline estimation result.

2.4.2 Country level analysis

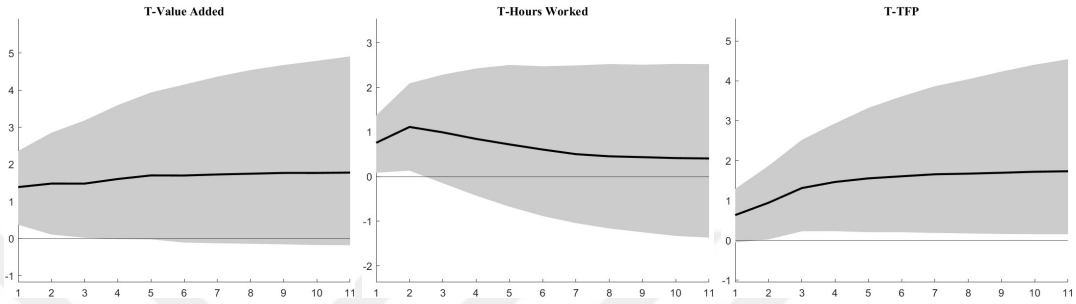
We estimate the VAR model for one country at a time and denote the identified structural shocks by each country with cross country average corporate tax rate. The cross-country average corporate income tax captures the common component of corporate taxation across eleven OECD countries which is by construction not correlated with the country-level economic activity. The assumption of international tax competition paves the way for the identification of permanent shocks as this hypothesis ensures that the tax rates display a clear downward trend which is common across countries. The measure is the average of country-level statutory corporate tax rates:

$$\tau_t^{avt} = \frac{1}{11}\sum_{i}^{11}\tau_{it} \tag{30}$$

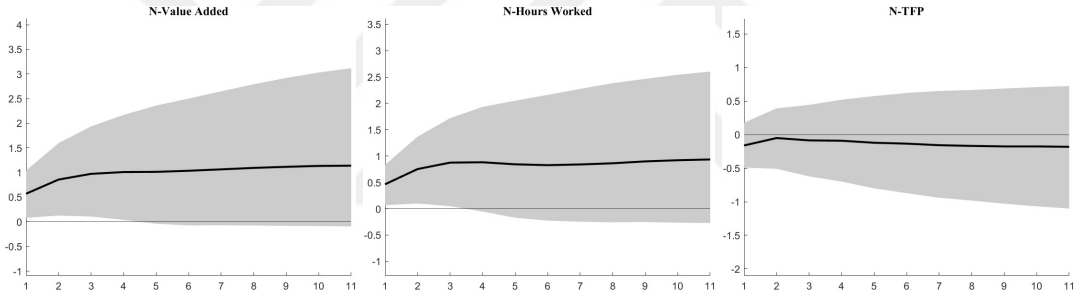
Lag length is 2 for all countries. To display the response of the whole sample, we take the mean IRF of eleven countries (median IRFs are very similar). The impulse response function (IRF) is centered at the 90 percent confidence interval obtained by standard bootstrap techniques, using 1000 draws from the sample residuals. In Figure 27, there are impulse response graphs aggregated for aggregate economy, traded and non-traded sectors aggregated across all countries.



(a) Aggreagate economy



(b) Traded sector



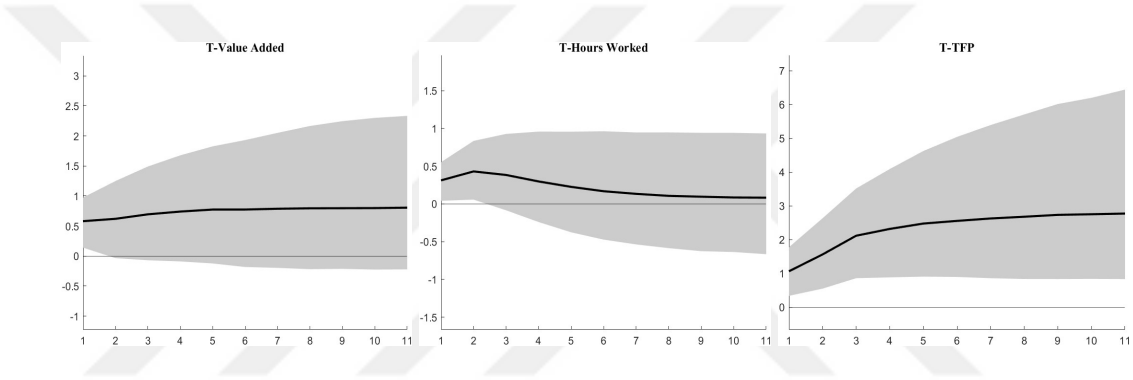
(c) Non-traded sector

Figure 27. Mean of effects of a permanent corporate tax rate shock

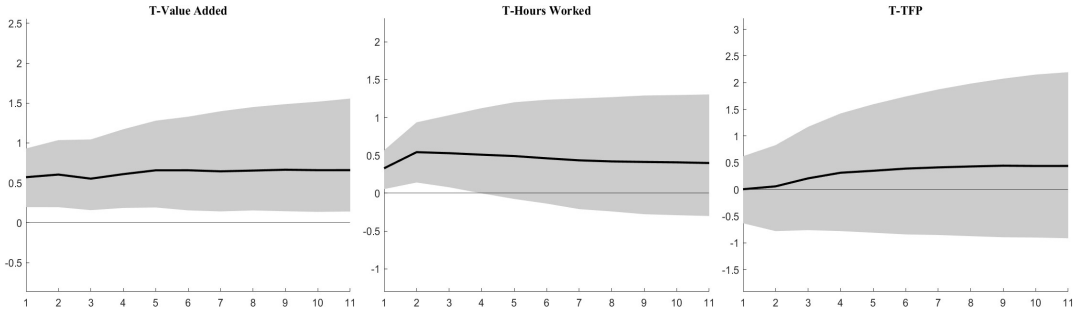
Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

The first graph shows the country's corporate tax rate response to the import share weighted corporate tax rate. It is normalized to 1 percentage point decline. The second and third graphs demonstrate the responses of value-added and hours worked. The 1 percentage point cut in the corporate income tax rate generates a significant increase in value-added. The confidence intervals are broader for the country-level analysis

because of the smaller number of observations. The second row shows the impulse responses for the traded sector, and the third row displays the IRFs for the non-traded sector. For both sectors, the response of GDP per capita is positive but not significant. The impact of capital utilization adjusted TFP is significantly positive in the traded sector in ten years, whereas it is negative but not significant in the non-traded sector. Thus, the differentiation between traded and non-traded sectors regarding TFP holds for country-level analysis.Figure 28 presents the estimation results in traded sector for two group of countries.



(a) English Speaking and Scandinavian Countries

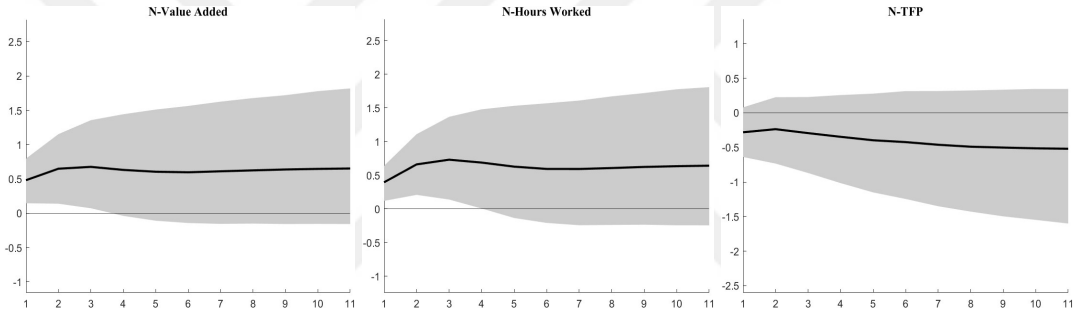


(b) Continental European Countries

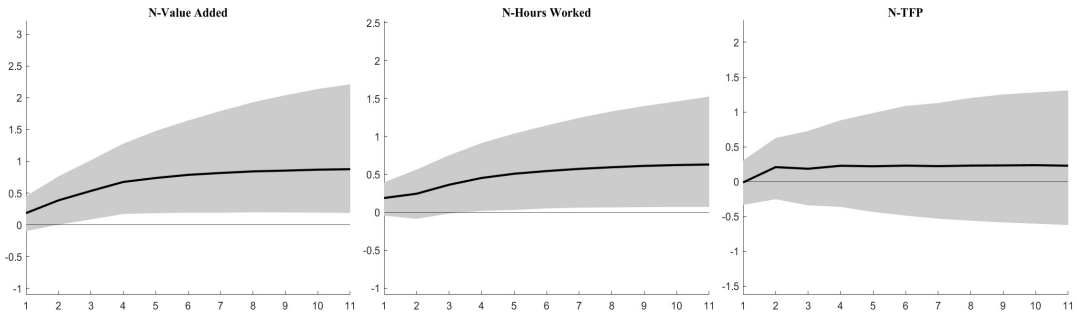
Figure 28. Effects of a permanent decrease in corporate tax rate on traded sector for two group of countries

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data

The permanent negative shock to corporate tax causes increased value-added in both groups. The responses are significant in 90 % except for value-added in Continental European Countries. Even if the response of hours worked is significant for the first three periods, it becomes insignificant in the long run in Continental European Countries. The response in hours worked is zero in English Speaking and Scandinavian Countries. Utilization-adjusted TFP significantly increases in the first group but is insignificant in the second group. The results are consistent with the baseline results with wider confidence bounds. Figure 29 demonstrates that the responses to a permanent corporate tax shock in non-traded sector for two groups.



(a) English Speaking and Scandinavian Countries



(b) Continental European Countries

Figure 29. Effects of a permanent decrease in corporate tax rate on non-traded sector for two group of countries

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data

The response of utilization adjusted TFP is zero in the non-traded sector for two groups of countries. Response of hours worked, and output is positive and significant in continental European countries.

The country-level analysis gives similar results for all the estimations. It is very similar to the results in the baseline estimation in terms of the point estimation of IRFs, but the confidence intervals are larger than the baseline estimation. The main results hold for country-level estimations. The traded sector is affected by the TFP, whereas the non-traded sector is affected by hours worked. English Speaking and Scandinavian countries respond by utilization adjusted TFP, whereas countries in continental Europe respond by hours worked.

2.6 Conclusion

We estimate a panel Structural VAR model for eleven OECD countries by using yearly data for the period between 1973 and 2015. We identify a permanent shock to corporate income tax rate which is exogenous to economic activity. Our results show that a cut in corporate income taxation positively influences labor and aggregate output for the whole sample.

While corporate taxation has been almost halved in OECD countries over the last four decades, the effects of its decline are quite distinct between the two groups of countries. The SVAR results reveal that following a decline in profits' taxation, firms in the traded sector significantly use more labor in continental European countries but do not increase innovation. The other way around is true in English-speaking and Scandinavian countries where exporting firms increase innovation, as captured by the rise in utilization-adjusted-total factor productivity, while they do not significantly increase labor.

Thirdly, we provide some mechanisms that causes the differentiation between sectors and country groups. We provide evidence on distinction in the R&D capital stock and investment, the wage flexibility differences and the government spending between countries. These factors have role on the responses of TFP and hours worked.

The empirical results of this study open new doors for future studies. The information produced in this thesis can be effectively combined with dynamic macroeconomic models, which investigate the impacts of corporate tax shock. It would be a crucial contribution to the literature.

CHAPTER 3

THE EFFECT OF TAX AMNESTY ON GROWTH AND EMPLOYMENT: EVIDENCE FROM TURKEY

3.1 Introduction

Tax amnesty allows individuals and firms to partially or fully pay their unpaid taxes without being subject to financial and penal sanctions (Alm, Martinez-Vazquez, Wallace (2009)). On the other hand, Luitel and Sobel (2007) define tax amnesty as a grant for evaders by governments for a short period. Governments apply the tax amnesties mostly in economic crises to increase the government revenue, raise the tax compliance of taxpayers, and repatriate flight capital (Borgne and Baer (2008)). Because of the widespread effects of tax amnesty, it is a commonly used fiscal policy tool in developed and developing countries. The frequency of amnesty sometimes is at an interval as short as every two years in Argentina, France, India, Ireland, and Italy (Luitel (2014)). Tax amnesty has been a tool to increase revenue in the USA since the 1980s. For instance, the fifty states of the US offered a total of sixty-five amnesties between 2001 and 2012[13].

The literature on tax amnesties mainly focuses on the impact of tax amnesty on tax revenues and tax compliance[14]. Alm et al. (2009) argue that the usefulness of tax amnesties is questionable because they demonstrate that the tax amnesties in Russian Federation have little impact on revenues. Mujahid and Siddiqui (2019) indicate with a panel study for 24 countries that the tax amnesty impacts GDP per capita and FDI not directly but via unemployment and tax compliance. On the other

[13] According to the Federation of Tax Administrators (Luitel (2014))

[14] Mikesell (1986), Lopez-Laborda and Rodrigo (2003), Borgne (2006), Fox and Murray (2011), Kilonzo (2012), Luitel and Mahar (2013), Bayer et al. (2014) and Luitel and Tosun (2014)

hand, empirical studies reveal that as the frequency of amnesties increases, the benefits to be obtained from the amnesty decrease. Studies in this group primarily focus on the possible effects of tax amnesties on taxpayer behavior and constitute the majority of empirical studies on tax amnesties.[15] Luitel and Sobel (2007) argue that the frequency of tax amnesty can affect the short-run impact of tax amnesty negatively and can generate a disincentive for future tax compliance. Ibrahim, Myrna, Irawati, and Kristiadi (2017) show by using data on nine Asian countries that an effective tax amnesty program can be achieved if amnesty's frequency and duration are low.

Theoretical literature on tax amnesties is very scarce. Alm and Beck (1990) show with a model that the total effect of tax amnesties on tax collection is uncertain. Bayer and Winner (2015) set up a game theoretical model to show that the occurrence of amnesties is determined by the government's fiscal requirements and agents' expectations for future amnesties.

Empirical studies on tax amnesties are minimal and primarily descriptive for Turkey [16]. Şanver (2017) shows that tax amnesties did not cause a significant income increase in tax revenues in Turkey and did not increase tax revenues permanently. Kaya (2013) shows empirically that tax amnesties explain only 8.5% of the change in tax revenues in Turkey, and the increasing effect of tax amnesties on tax revenues gradually weakens over time. Güler (2020) shows that when the six and twelve-month effects of tax amnesties issued after 2010 in Turkey are taken into account, it is seen that they do not have a statistically significant effect on tax revenues. In other studies, mostly not the effect of tax amnesties on macroeconomic variables, but the effects

[15] Fisher et al. (1989), Malik and Schwab (1991), Marchese and Privileggi (1997), Christian et al. (2002), Torgler and Schaltegger (2005), Rechberger et al. (2010), Ross and Buckwalter (2012), Bose and Jetter (2012)

[16] Öz and Buyrukoğlu (2011), Yaraşır (2013), Edizdoğan and Gümüş (2013), Şenyüz (2014), Yalman (2017) and Keskin and Özcan (2021).

of tax amnesties on taxpayer behavior are discussed. According to İpek, Öksüz, and Özkaya (2012), which is conducted in the Thrace Region, tax amnesty encourages tax evasion, hurts confidence in government, and decreases tax compliance.

In this study, we analyze the effect of tax amnesty on the firm dynamics. As far as we know, there is no such paper in the literature investigating this topic. We use the Difference in Differences (DiD) methodology to analyze the impact of the 2011 tax amnesty on firms' employment and net sales in Turkey. The results show that tax amnesty has a significant and negative impact on the employment and net sales of firms that have tax debt before the amnesty. We offer a potential mechanism that would lead to this result. Firms should pay the first installment of their unpaid tax within three months after the amnesty is announced to benefit from tax amnesty. Therefore, the tax amnesty will be an extra cost shock for firms with unpaid taxes and apply to benefit from the tax amnesty. We set up DiD estimations by differentiating firms regarding financial liability, capital intensity, and sectors to support this potential explanation.

3.2 The case of Turkey

Since the establishment of the Republic of Turkey, many tax amnesties have been applied. The main reasons for the amnesties are closing budget deficits, increasing public revenues, resolving country-specific economic problems, and informality. On the other hand, Bülbül and Karadeniz (2004) suggest that during the election periods in Turkey, political parties used tax amnesty to please their voters and collect votes. Table 14 shows the tax amnesties offered in Turkey for the last 20 years.

Table 14. Tax Amnesties offered in Turkey since 2001

Date	Law
06.02.2001	Law No. 414 General Communiqué on Collections
03.04.2002	Law No. 4751 Amending the Tax Procedure Law, Real Estate Tax Law and the Law on Fees
25.02.2003	Law No. 4811 Tax Peace
13.11.2008	Law No. 5811 on Bringing Some Assets to the National Economy
13.02.2011	Law No. 6111 on Restructuring of Certain Claims and Amending the Social Insurance and General Health Insurance Law and Some Other Laws and Decrees
21.05.2013	Law No. 6486 Amending Social Insurance and General Health Insurance Law and Some Laws
10.09.2014	Law No. 6552 Amending the Labor Law and Some Laws and Decrees with the Force of Law and Restructuring of Some Receivables
03.08.2016	Law No. 6736 on Restructuring of Certain Receivables
18.05.2017	Law No. 7020 on Restructuring Some Claims and Amending Some Laws and a Decree-Law
11.05.2018	Law No. 7143 on Restructuring of Taxes and Some Other Receivables and Amending Certain Laws
17.07.2019	Law No. 7186 Amending Income Tax Law and Some Laws

Source: Keskin, E. & Mastar Özcan, P. (2021). "Vergi Affı Uygulamaları: Türkiye ve Seçilmiş Ülkeler Açısından Bir Değerlendirme", International Journal of Public Finance, 6(1), 137-158.

The tax amnesty in 2001 was extensive and was issued for all taxpayers to pay their unpaid taxes. The 2001 amnesty was followed by some tax amnesty changes in 2002. The tax peace process, which started in 2003, continued in 2008 with some changes and enlargements. The New Wealth Peace, adopted in 2013, aims to bring the assets included in the article owned by actual and legal persons, to the national economy, by registering them with a very low tax rate without any examination and investigation. (Şeren and Dedebek, 2013). The other amnesties are amendments to various tax

laws, including the restructuring of some public claims. This study focuses on the tax amnesty in 2011, unlike the 2002 amnesty, as it is inclusive, and the 2003, 2008 and 2013 welfare peace, as it is the target audience of all taxpayers in Turkey. In addition, the 3-year period until the next comprehensive tax amnesty, 2014, provides an opportunity to examine the effects of the 2011 tax amnesty.

Law No. 6111 on restructuring certain receivables was published in the Official Gazette on 13.02.2011. This tax amnesty covers all taxes based on the declaration, such as annual income, corporations, value-added, special consumption, income (withholding tax), corporations (withholding tax), and stamp tax that must be declared until 31.12.2010, and annual fees accrued before 31.12.2010. Tax penalties, delayed interest, and delay hikes related to these debts of taxpayers who pay their debts calculated based on the update rate (WPI/PPI) will be forgiven. Income, corporate and value-added tax, income, and corporate tax withholding amount calculated in the tax base and tax increase can be paid in cash or 6, 9, 12, and 18 equal installments. In case of an increase in the tax base and tax, tax examination and assessment will not be made in terms of income, corporate, and value-added tax for the years in which the tax base and tax increases are made[17]. The corporate tax return is submitted to the tax office of the taxpayer from the first day of the fourth month to the evening of the twenty-fifth day of the following the month in which the accounting period is closed. Corporate tax is paid until the end of the month in which the return is filed [18].

With Law No. 6111, which entered into force in 2011 and is accepted as one of the most comprehensive amnesty laws. The reconstructed tax debt was 3 % of GDP and 15 % of total tax revenues in 2011[19]. Approximately 39.4 billion TL worth

[17]Source: https://www.gib.gov.tr/fileadmin/beyannamerehberi/6111rehber.pdf
[18]Source: https://www.mevzuat.gov.tr/MevzuatMetin/1.5.5520.pdf
[19]Source: TUIK and https://sbb.gov.tr/

of tax debt was restructured, and a record 81% collection level was achieved in the first installment payments (Yaraşır, 2013).

In Turkey, most of the tax amnesties are primarily independent of the economic situation. After 1980, before and after the elections, permanent tax amnesties came to the agenda and were enacted in Turkey. For example, a tax amnesty law was enacted again in 2001; this was followed by a new tax amnesty law and elections in 2002. The elections held in 2007 were followed by the tax amnesty law of 2008, and the referendum in 2010 were followed by a tax amnesty law that took place at the beginning of 2011 (Kaya (2013)). The reform was later published in the Official Gazette on 13.02.2011 which is four months before 2011 General Election of Turkey. Figure 30 demonstrates the percent change in real GDP and government debt to GDP ratio between 2006 and 2013.

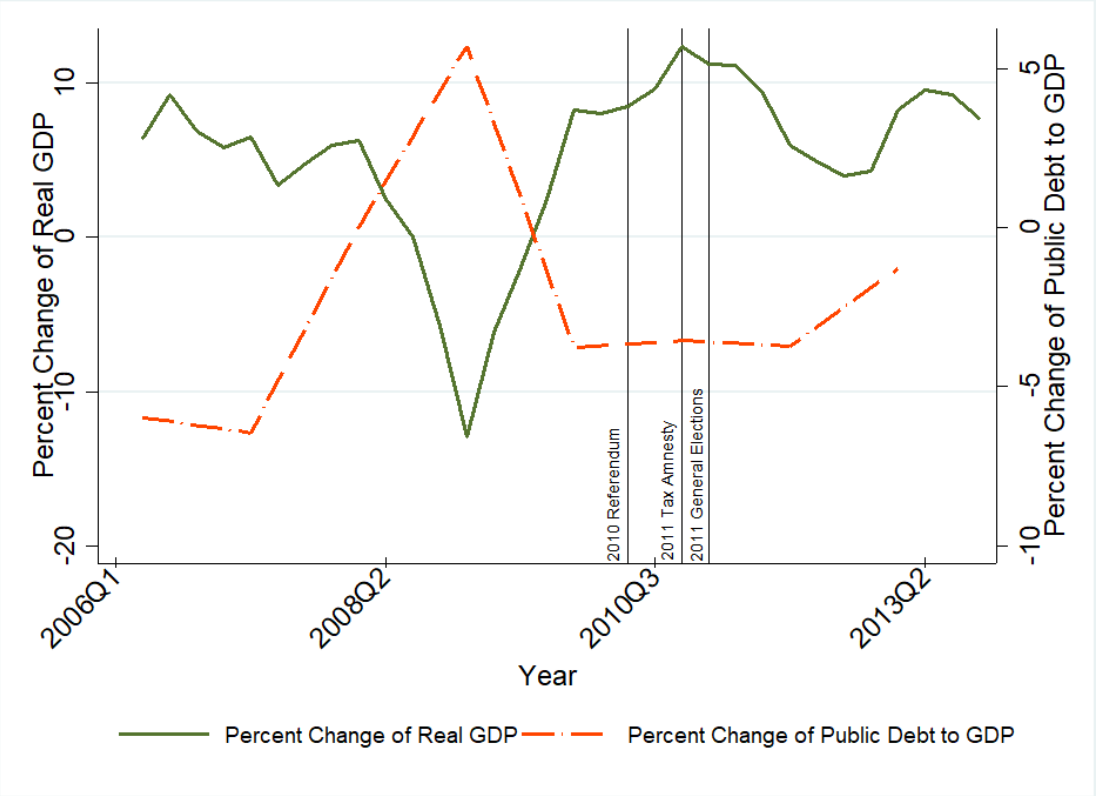


Figure 30. Percent change of real GDP and public debt to GDP

Note: General government gross debt for Turkey is the change from year ago and percent of GDP. Annual, Not Seasonally Adjusted. Real Gross Domestic Product for Turkey is percent change from year ago of (domestic currency). Quarterly, Seasonally Adjusted. Source: Federal Reserve Bank of St. Louis

It is apparent in Figure 30 that the percent change of real GDP is positive and the percent change in public debt to GDP ratio is negative during 2010 and 2011. Thus, the tax amnesty in 2011 had primarily political causes rather than economic reasons.

3.3 Empirical strategy

3.3.1 Data

We used the Entrepreneurship Information System (EIS) as the primary data source. It includes the data on the economic activities of businesses in the administrative records of different public institutions and organizations but does not include the

finance and public sectors. Data includes the NACE Rev. 2 Classification on firms' sector and covers the employees who have a contract in the private sector. We construct employment series using the average of records for March, June, September, and December. It does not include the public sector and self-employed employees. Almost 80 percent of the sample are firms with less than ten employees (Akcigit et al. (2020)). We categorize firms in terms of size: 1 for firms with 1-9 employees, 2 for firms with 10-49 employees, and 3 for firms with more than 50 employees. The data set includes the data from 2006 to 2019, but we constrained our analysis between 2006 and 2014 because of another tax amnesty in 2014. Capital intensity is calculated as capital stock over net sales. Investment rate is calculated as

$$I_t = \frac{\Delta K_t}{1/2(K_t + K_{t-1})} \tag{31}$$

where K_t is the fixed capital stock in time t. Table 15 and Table 16 show the summary statistics for the whole sample and the 10th, 50th, and 90th percentiles of the main sample.

Table 15. Summary Statistics for The Main Analysis Sample, 2010

	Obs.	Mean	Std. Dev.
Net Sales (Million TL)	572,304	43.1	1230
Fixed Assets (Million TL)	572,304	16.5	573
Financial Liability	572,304	3371641	82.8
Employment	572,304	13	10
Size	572,304	1.3	.55

Table 16. Summary Statistics for The Percentiles, 2010

	Percentiles		
	10th	50th	90th
Net Sales	353122	4536465	4.20e+07
Fixed Assets	84.5	469688	7039666
Financial Liability	0	0	1971506
Employment	1	3.5	20.75
Size	1	1	2

Net sales are the firm's sales net of discounts. Fixed assets are all fixed capital assets, and financial liability is the total financial debt of firms. Employment is the number of employees in the firm. Trade is a variable for the total import and export values. Size is variable to indicate the number of employees in a firm: 1 is for 1-9, 2 is for 10-49, and 3 is for the number of employees higher than 49.

3.3.2 Methodology

Our empirical methodology relies on the difference in differences approach around the initiation of tax amnesty to understand better the causal effect of tax amnesty on firms' employment and sales. In the DiD estimation, there are observations for two groups and two periods. The first group is exposed to treatment in the second period but not in the first period. The second group is the control group and is not exposed to the treatment in both periods. The DiD is applied by taking the double differences in two stages. The first stage is the difference of the mean of the outcome variable between the two periods for each group. In the second stage, it takes the differences between the first stage differences. The differences in outcome variable changes between the two groups give the policy variable's causal impact. [20]

[20]Guido Schwerdt, Ludger Woessmann, in The Economics of Education (Second Edition), 2020

Analyses are done for two groups of control and treatment firms. The treatment firms are the firms with overdue tax liability, and the control group is the firms with no overdue tax liability. We have 3536587 observations for 572,304 firms, and firms with unpaid tax make up almost ten percent of this group. The DiD specification is as follows:

$$Y_{i,t} = \alpha_{i,t} + \gamma_{j,t} + \gamma * treated_i + \delta * post_t + \beta * treated_i * post_t + \varepsilon_{i,t}$$

$Y_{i,t}$ is the output variable, either employment or net sales of firm i in year t. $\alpha_{i,t}$ and $\gamma_{j,t}$ are industry-year and size-year fixed effects, respectively. $treated_i$ is a dummy equal to one for firms in treatment group and 0 for control group. $post_t$ is a dummy equal to one in and after the 2010. $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the firm-level.

We set the treatment year as 2010 because it is known by the public that there will be a tax amnesty in 2011. On January 27, 2010, the Chairman of the Confederation of Turkish Tradesmen and Craftsmen (TESK) stated that the tax and social insurance premium debts of tradesmen, craftsmen, and SMEs should be restructured [21]. On the September of the same year, right before the 2010 Turkish constitutional referendum, prime minister of Turkey state that "I gave instructions to our Minister of Labor and Social Security on this matter. Our colleagues will work on this." [22]. Thus, it is reasonable to set the treatment year as 2010 because the public knows there will be a tax amnesty in 2011.

[21] Source: https://www.dunya.com/gundem/tesk-esnaf-sanatkar-ve-kobi039lerin-sorunlarina-cozum-istedi-haberi-103837

[22] Source: https://www.ntv.com.tr/turkiye/erdogan-hayir-diyen-darbecidir,3Mps0zpovU6e7teAiunsIw

3.3.3 Results

Before analyzing the impact of tax amnesty on firms' employment and net sales, we document the evolution of employment for treatment and control groups in Figure 31. The treatment and control groups exhibit a declining parallel trend for employment and net sales before the tax amnesty introduction. Figure 31 demonstrates the evolution of average employment for treatment and control groups.



Figure 31. Number of workers employed

Notes:Treatment firms (doted red line) are the firms with unpaid taxes and control group (solid green line) is the firms with zero unpaid taxes.

We can deduce that the average employment of firms with unpaid tax is less than those with zero unpaid tax. The trend for the two groups is downward and almost parallel until 2010. However, after 2010, the gap between groups widens. Thus, we deduce that the parallel trends assumption is not violated for both groups. Tables 17,

18 and 19 show the impact of the tax amnesty on the log of employment, net sales, and investment.

Table 17. Difference in Differences Regression Results for Employment

	log_emp	*log_emp*	*log_emp*
DID	-0.202***	-0.200***	-0.128***
	(-67.91)	(-66.79)	(-44.42)
Observations	3536587	3536587	3536587
Time FE	Yes	Yes	Yes
Size*Time FE	No	Yes	Yes
Sector*Time FE	No	No	Yes

Standard errors are clustered at the firm level. t statistics are in parentheses and $*p < 0.05, **p < 0.01, ***p < 0.001$.

Table 18. Difference in Differences Regression Results for Net Sales

	log_sale	*log_sale*	*log_sale*
DID	-0.250***	-0.262***	-0.212***
	(-46.69)	(-48.58)	(-40.09)
Observations	3407974	3407974	3407974
Time FE	Yes	Yes	Yes
Size*Time FE	No	Yes	Yes
Sector*Time FE	No	No	Yes

Standard errors are clustered at the firm level. t statistics are in parentheses and $*p < 0.05, **p < 0.01, ***p < 0.001$.

We add size-time fixed effects in column (2) and sector-time fixed effects in column (3) so the size and sector effects are removed from the regression. The standard errors are clustered at the firm level in all regressions. DiD results indicate that the tax amnesty in 2011 led to a 13% percent decline in employment and a 21% decline in net sales for the firms with unpaid taxes before the amnesty.

Table 19. Difference in differences regression results for investment rate

	invest_rate	*invest_rate*	*invest_rate*
DID	-0.0410***	-0.0368***	-0.0345***
	(-15.20)	(-13.54)	(-12.66)
Obs.	1922746	1922746	1922746
Time FE	Yes	Yes	Yes
Size*Time FE	No	Yes	Yes
Sector*Time FE	No	No	Yes

Standard errors are clustered at the firm level. t statistics are in parentheses and $*p < 0.05, **p < 0.01, ***p < 0.001$.

On the other hand, the tax amnesty leads to a 3% percent decline in the investment rate. Firms should pay the first installment of their unpaid tax within three months after the amnesty is announced to benefit from tax amnesty. Thus, the tax amnesty works as a positive corporate tax shock for the firms with unpaid tax before the tax amnesty. There is a negative relationship between corporate tax and corporate savings; therefore, between corporate tax and corporate investment as well (Chen et al. (2017), Djankov et al. (2010)). Thus, the decline in the investment is expected because of the extra cost that comes with the tax amnesty.

3.4 Mechanisms

In the previous section, our findings indicate that the tax amnesty in 2011 has negatively affected the employment, sales, and investment rate of firms. One potential mechanism that would lead to this result is that the benefiting from the tax amnesty bear extra cost for the firms. Firms should pay the first installment of their unpaid tax within three months after the amnesty is announced to benefit from tax amnesty. Therefore, the tax amnesty will be an extra cost shock for the liquidity flows of the firms with

unpaid taxes. In this part, we present some pieces of evidence to support this potential explanation.

3.4.1 Financial liabilities

Firms' ability to access the financial sector and their financial liabilities are essential factors for the impact of tax amnesty because the tax amnesty will bring an extra cost to the firms with unpaid taxes. We set up a regression for the firms with financial liability by adding the log of financial liabilities as a control variable to the baseline regression. It includes only the firms with positive financial liabilities. Table 20 and Table 21 show the results for the log of employment and net sales. We add size-time fixed effects in column (2) and sector-time fixed effects in column (3); standard errors are clustered at the firm level in all regressions.

Table 20. Difference in Differences Regression Results for Employment Controlling the Effect of Financial Liability

	log_emp	*log_emp*	*log_emp*
DID	-0.219***	-0.219***	-0.133***
	(-38.57)	(-38.52)	(-24.28)
log_debt	0.0463***	0.0466***	0.0383***
	(78.11)	(78.52)	(70.78)
Obs.	1288660	1288660	1288660
Time FE	Yes	Yes	Yes
Size*Time FE	No	Yes	Yes
Sector*Time FE	No	No	Yes

Standard errors are clustered at the firm level. t statistics are in parentheses and $*p < 0.05, **p < 0.01, ***p < 0.001$.

Table 21. Difference in differences regression results for net sales controlling the effect of financial liability

	log_sale	*log_sale*	*log_sale*
DID	-0.230***	-0.238***	-0.181***
	(-26.32)	(-27.04)	(-20.92)
log_debt	0.138***	0.138***	0.132***
	(52.87)	(52.88)	(50.44)
Obs.	1271373	1271373	1271373
Time FE	Yes	Yes	Yes
Size*Time FE	No	Yes	Yes
Sector*Time FE	No	No	Yes

Standard errors are clustered at the firm level. t statistics are in parentheses and $*p < 0.05, **p < 0.01, ***p < 0.001$.

There is a positive correlation between employment and financial liabilities, which is consistent with the argument that accessing financial services is more difficult for small firms because of the higher information and transaction costs (Beck, Demirguc-Kunt, Laeven, & Levine (2008)). The coefficients of the DiD estimator are almost the same for employment but are smaller than the baseline regressions for net sales. Thus, the tax amnesty has a smaller impact on the net sales for firms with positive financial liability.

There can be two reasons behind the smaller impact. The first reason is that these firms have access to financial services more efficiently to use bank credit to avoid the extra cost of tax amnesty. Thus, the negative impact of tax amnesty for the firms with financial liability is smaller than the baseline group. Secondly, Fernández-Rodríguez, García-Fernández, and Martínez-Arias, A. (2021) shows that firms with more debt pay less tax. Firms should pay the first instalment of their unpaid tax within three months to benefit from tax amnesty. Therefore firms with higher financial liability

may not benefit from the tax amnesty to avoid the extra cost that the amnesty will bring to them.

3.4.2 Capital intensity

Corporate taxes mostly work as capital costs because the labor cost is deduced from corporate taxation. Hence, we want to examine the effect of tax amnesty on firms that have different capital intensity levels. We divide the firms into four categories in terms of their capital intensity: [0,0.1], (0.1,0.45], (0.45,0.9] and (0.9,-]. We run the baseline regressions for these four groups. Size-time fixed effects and sector-time fixed effects are added, and standard errors are clustered at the firm level in all regressions. Table 22 shows the Difference in differences regression results for different capital intensity levels.

Table 22. Difference in Differences Regression Results for Capital Intensity

Capital Intensity	[0,0.1]	(0.1,0.45]	(0.45,0.9]	(0.9,-]
	log_emp	*log_emp*	*log_emp*	*log_emp*
DID	-0.0633***	-0.0788***	-0.0865***	-0.0342***
	(-13.77)	(-15.19)	(-7.63)	(-3.88)
Obs.	1501490	1060176	307594	458460
	log_sale	*log_sale*	*log_sale*	*log_sale*
DID	-0.0945***	-0.112***	-0.123***	-0.309***
	(-16.19)	(-18.98)	(-10.70)	(-13.96)
Obs.	1501490	1060173	307594	330279
Time FE	Yes	Yes	Yes	Yes
Size*Time FE	Yes	Yes	Yes	Yes
Sector*Time FE	Yes	Yes	Yes	Yes

Standard errors are clustered at the firm level. t statistics are in parentheses and $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

The regression results in Table 22 indicate that the negative impact of tax amnesty on employment increases with the capital intensity levels of firms except for the last category. This is because capital-intensive firms can replace labor with capital easier than labor-intensive firms. Thus, the firms with unpaid tax in the capital intensive sector can bear the cost of tax amnesty by changing their production input from labor to capital. On the other hand, the effect of tax amnesty on net sales increases with capital intensity. According to the tax avoidance literature, firms with higher fixed assets have less tax burden because the depreciation costs are deducted from the income while calculating the corporate tax (Rodriguez and Arias (2012), Ardyansah and Zulaikha (2014), Fernández-Rodríguez et al. (2021)). Although the firms with higher fixed assets have less tax burden, the cost that the amnesty brings to the firms is higher for capital intensive firms relative to the capital intensive firms that do not have unpaid taxes. The extra cost to these firms prevent them to invest on the capital which is the main element of their production.

3.4.3 Sectoral differences

The impact of tax amnesty may differentiate between sectors because corporate tax may influence sectors differently. For example, Djankov et al. (2010) do a panel analysis for 85 countries and indicate that corporate taxes are correlated with investment in the manufacturing sector, whereas they are not in the services sector. We analyze the impact of the tax amnesty in terms of the different sectors to understand the underlying mechanism of the effect of tax amnesty. Figure 32 shows the distribution of firms with unpaid tax in ten main sectors.

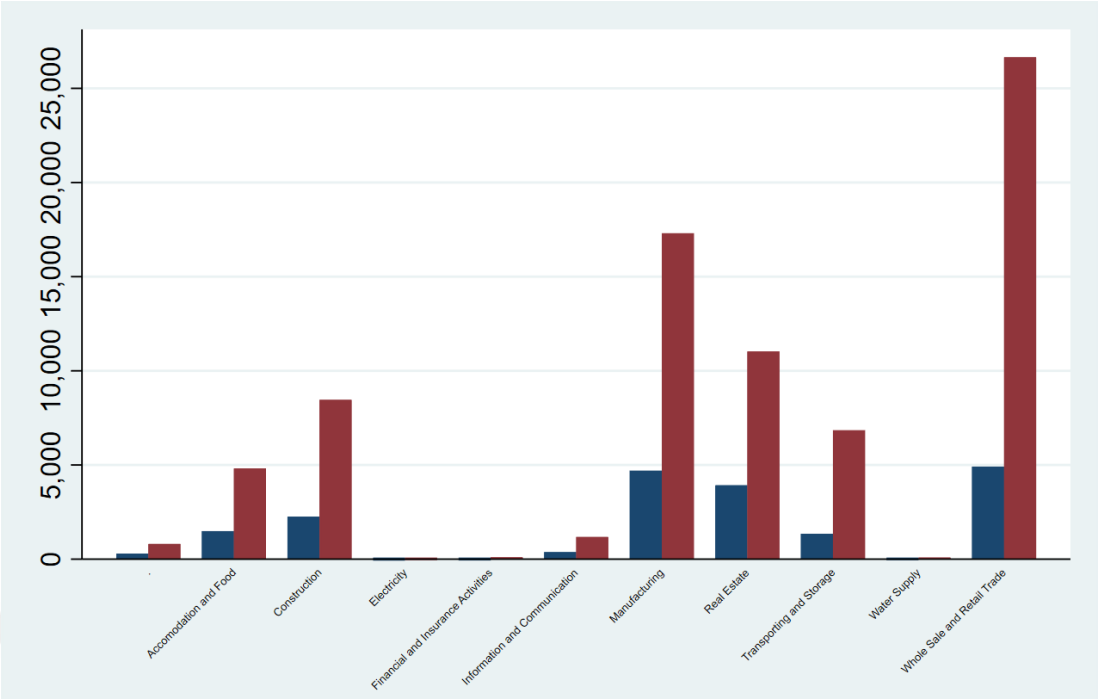


Figure 32. Number of firms with unpaid tax in sectors

Notes:Red bars show the number of firms with debt and blue bars show the number of firms in top 25 percentile of the firms with unpaid tax

The whole sale and retail trade sector have the highest number of firms with unpaid tax. Manufacturing, real estate, transporting and storage, construction and accomodation, and food sectors have significant number of firms with tax debt. Thus, we set up a regression analysis for the six sectors that have highest number of firms. Before moving to the impact of tax amnesty on employment and sales for different sectors, we need to understand the dynamics of the distribution of sectors in Turkey. Figure 33 shows the share of sectors in GDP between 1998 and 2014.

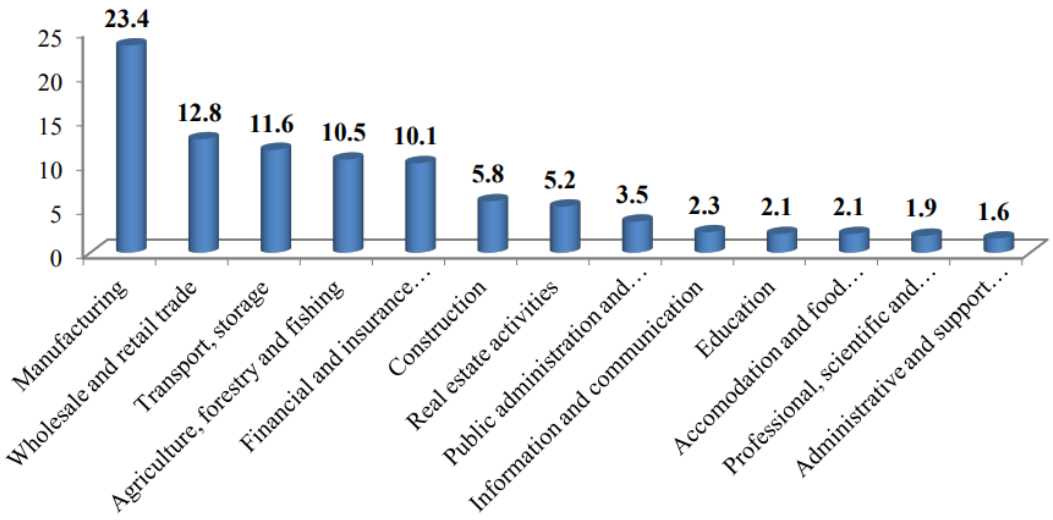


Figure 33. Sector shares in GDP (%) 1998-2014

Source: Erol, I., and Unal, U. (2015). Role of construction sector in economic growth: New evidence from Turkey.

Manufacturing has the highest share and accomodation, and the food sector has the lowest share within the six analyzed sectors. Erol and Unal (2015) show that between 2002 and 2014, the construction sector has a growth rate of 6.5 percent, transport and storage had 6.2, and manufacturing and wholesale and retail trade have 5.5 percent and 5.6 percent growth rates, respectively. The GDP growth rate is 4.9 percent for the same period, and the accomodation and food sector has a slower growth rate than the GDP. Table 23 shows the regression results for six sectors.

Table 23. Difference in Differences Regression Results for Sectors

Sector	**Manufacturing**	**Accommodation and Food**	**Construction**	**Whole Sale and Retail Trade**	**Real Estate**	**Transporting and Storage**
	log_emp	*log_emp*	*log_emp*	*log_emp*	*log_emp*	*log_emp*
DID	-0.143***	-0.0848***	-0.0605***	-0.159***	-0.102***	-0.150***
	(-21.99)	(-7.00)	(-6.78)	(-35.46)	(-12.59)	(-15.38)
Obs.	683125	158628	375401	1495173	434879	274808
	log_sale	*log_sale*	*log_sale*	*log_sale*	*log_sale*	*log_sale*
DID	-0.191***	-0.106***	-0.214***	-0.252***	-0.196***	-0.197***
	(-17.75)	(-5.80)	(-10.97)	(-28.19)	(-14.17)	(-11.78)
Obs.	666078	154637	331974	1462013	418111	268771
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Size*Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector*Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors are clustered at the firm level. t statistics are in parentheses and $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

Firms in accomodation and food sectors are affected least by the tax amnesty, which has a smaller share of GDP than the other sectors that we analyzed. The impact of tax amnesty is similar for all of these sectors except accomodation and food. Also, all of these sectors except accomodation and food have a higher growth rate than GDP. Although employment in construction is affected least, sales are influenced more than the other sectors. Construction is a labor-intensive sector in Turkey, so it is challenging to replace labor with capital. On the other hand, the growth rate for the construction sector was 18.3 percent and 11.5 percent in 2010 and 2011, respectively (Erol and Unal 2015). The extra cost of tax amnesty negatively affects the firms with unpaid tax relative to those without unpaid tax in the construction sector more than it does in the other sectors. The wholesales and retail trade sector is affected most by tax amnesty.

3.5 Robustness

As a robustness test, we categorized firms in terms of Overdue tax liability/net sales in 2010 and separated firms into 25 percentile groups. Treatment firms are in the top 25 percentile of the overdue tax liability, and control firms are in the bottom 75 percentile. We have 331858 observations for 53717 firms. Figure 34 demonstrates the evolution of average employment for treatment and control groups.

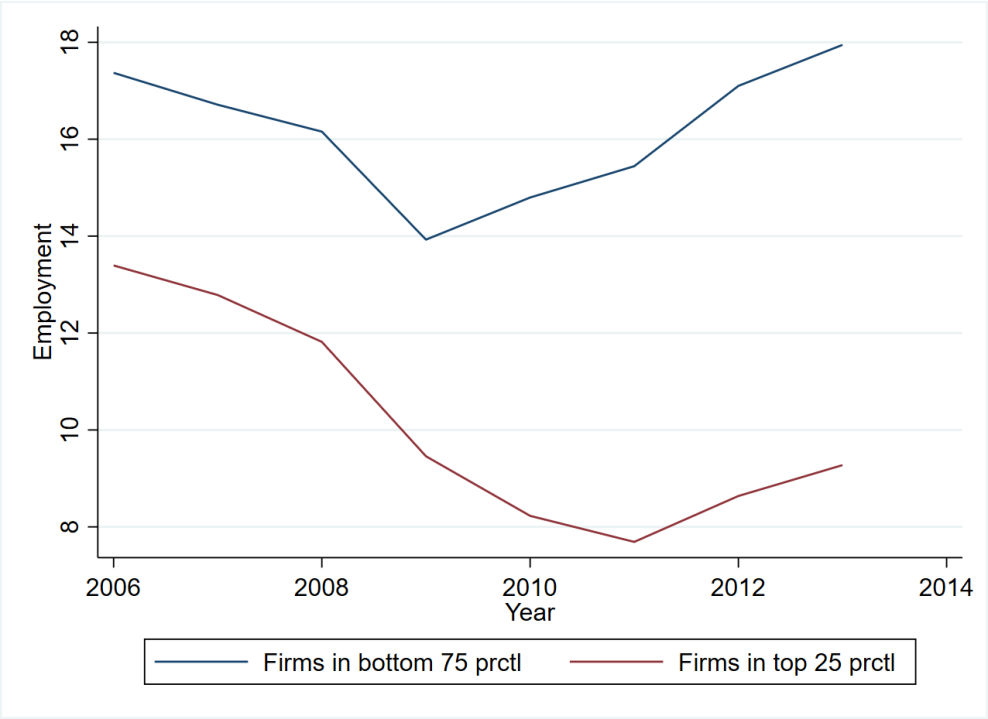


Figure 34. Number of workers employed in top 25 and bottom 75 percentiles

Notes:Treatment firms are the firms in the top 25 percentile (red line). Control firms are the firms at the bottom 75 percentile (blue line)

We can deduce that the average employment of firms in the top 25 percentile is less than those in the bottom 75 percentile. The trend for the two groups is downward and almost parallel until 2010. However, after 2010, the gap between groups widens. Thus, the parallel trends assumption holds Table 24 and Table 25 show the results for the log of employment and net sales, respectively.

Table 24. Difference in Differences Regression Results for Employment

	log_emp	*log_emp*	*log_emp*
DID	-0.282***	-0.299***	-0.204***
	(-37.09)	(-38.90)	(-26.71)
Obs.	331858	331858	331858
Time FE	Yes	Yes	Yes
Size FE	No	Yes	Yes
Sector FE	No	No	Yes

t statistics in parentheses $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

Table 25. Difference in Differences Regression Results for Net Sales

	log_sale	*log_sale*	*log_sale*
DID	-0.614***	-0.650***	-0.564***
	(-46.73)	(-48.56)	(-42.44)
Obs.	331858	331858	331858
Year FE	Yes	Yes	Yes
Size FE	No	Yes	Yes
Sector FE	No	No	Yes

t statistics in parentheses $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

Tax amnesty leads to a 20% decline in employment and a 56% decline in net sales when the treatment group is composed of firms in the top 25 percentile of the overdue tax liability. The effect of tax amnesty is higher than the baseline estimation when the treatment group firms in the top 25 percentile of the overdue tax liability. 3.6

Conclusion

In this study, we analyze the effect of tax amnesty on the firm dynamics. As far as we know, this is the first study to do so. We use the Difference in Differences model to investigate the impact of the tax amnesty in 2011 in Turkey on firms' employment and net sales. The results show that tax amnesty has a significant and negative impact on

the employment and net sales of firms that have tax debt before the amnesty. One possible mechanism behind this result is that the tax amnesty bears the extra cost for the firms because firms should pay the first installment of their unpaid tax within three months after the amnesty is announced to benefit from tax amnesty. Therefore, the tax amnesty can act as an extra cost for firms who did not pay these taxes in previous years. The differentiated results from the DiD analysis for financial liability, capital intensity, and sector level differences support this potential explanation.

APPENDIX A

FIGURES IN CHAPTER 1

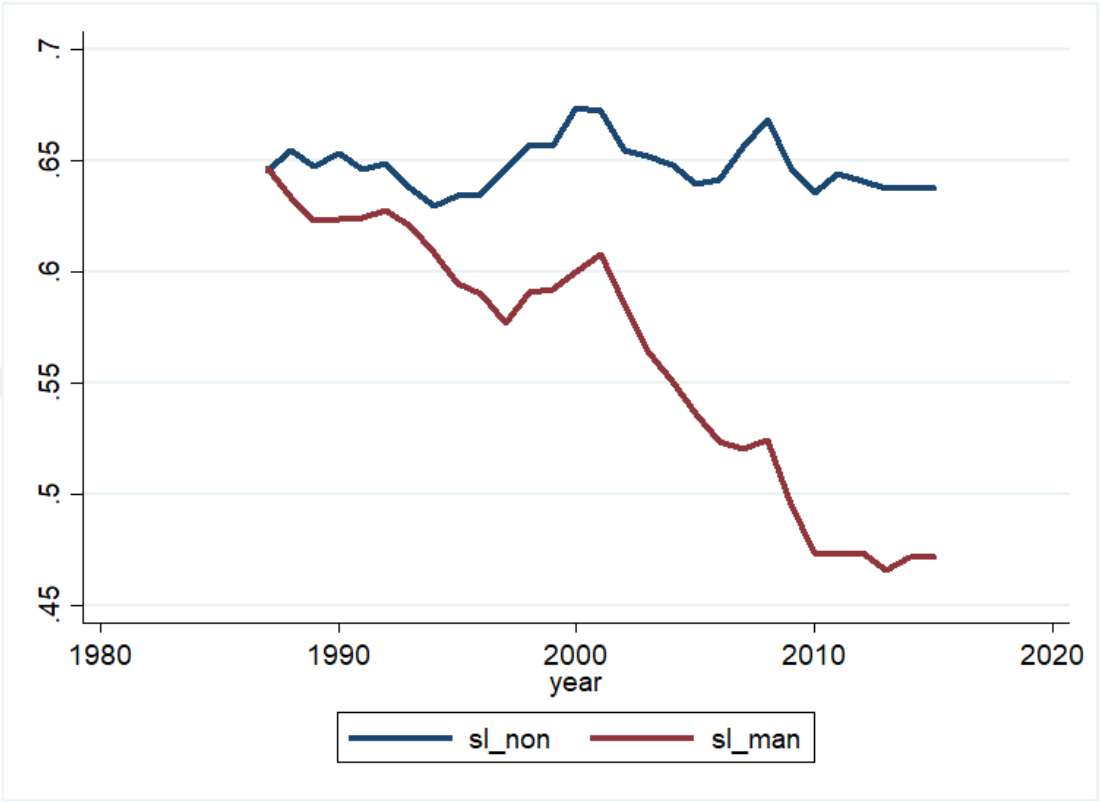


Figure A1. Evolution of labor share for manufacturing and non-manufacturing sectors

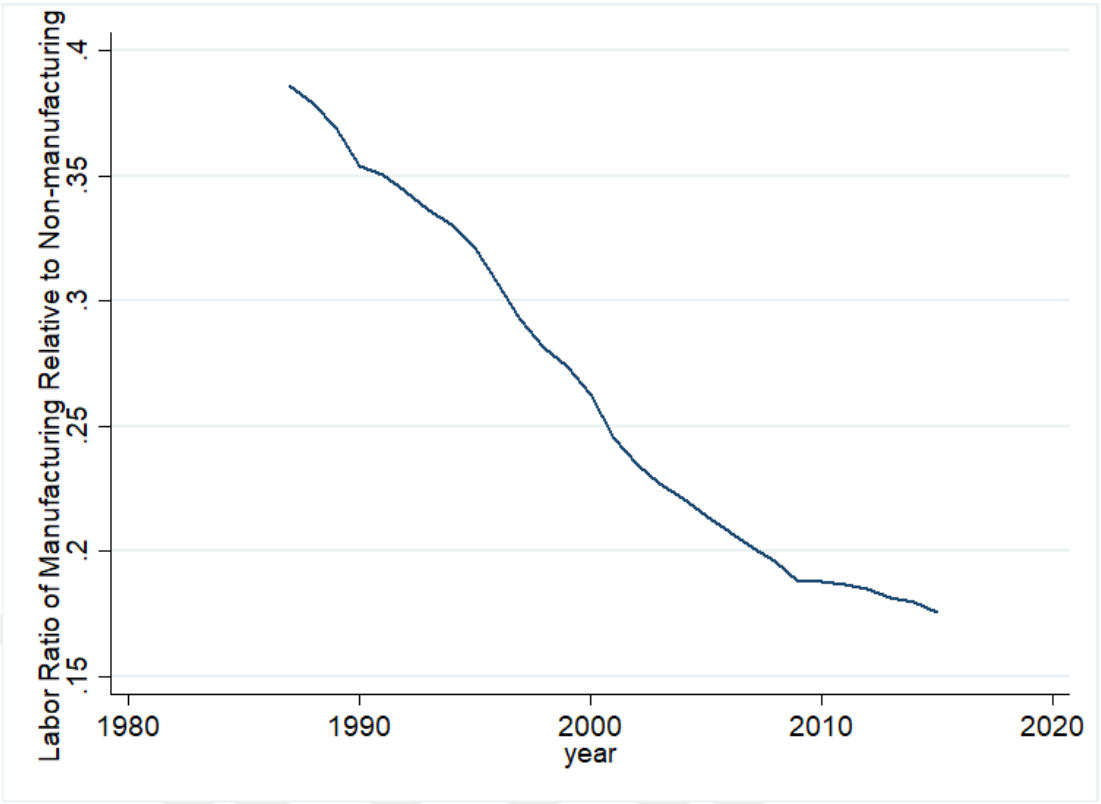


Figure A2. The ratio of labor manufacturing relative to non-manufacturing

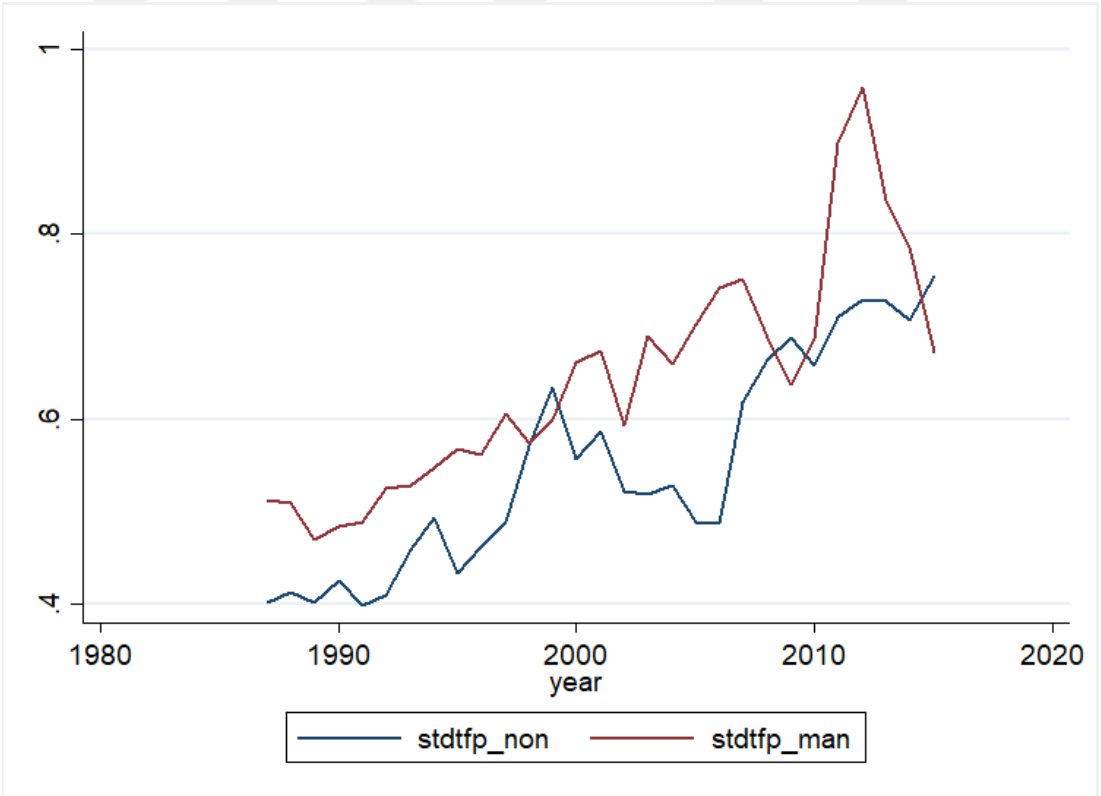


Figure A3. Standard deviation of Log TFP

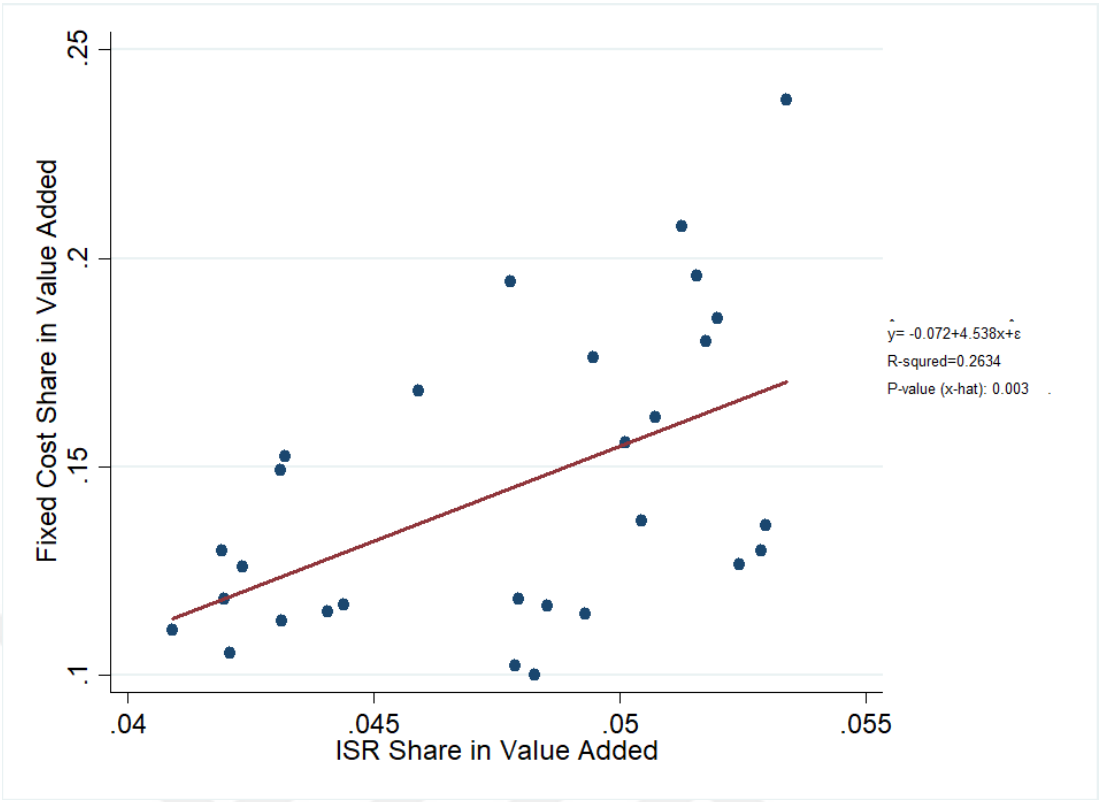


Figure A4. Fitted values for fixed cost and IPP-Software-R&D

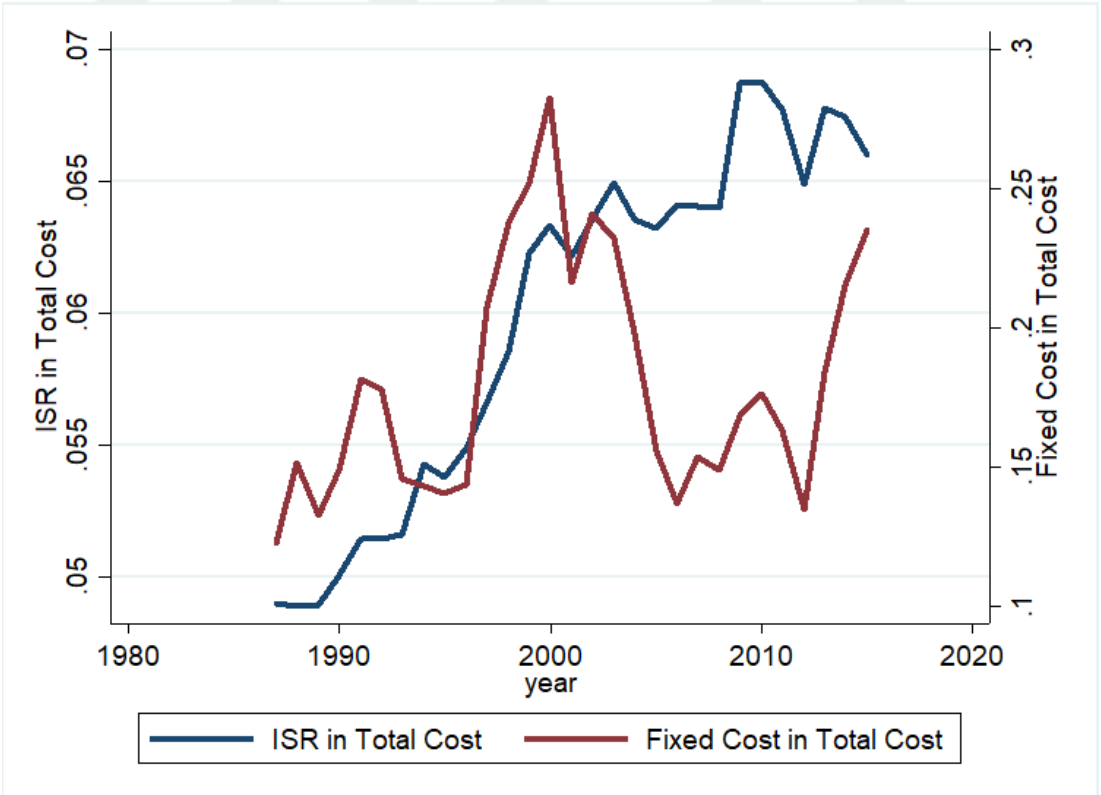


Figure A5. Evolution of fixed cost and IPP-Software-R&D

APPENDIX B

TABLES IN CHAPTER 1

Table B1. EU KLEMS Asset Types, Based on ESA 2010

Code	EU KLEMS Asset Name	Short
N111G	Residential structures	RStruc
N112G	Total non-residential investment	OCon
N1131G	Transport equipment	TraEq
N11321G	Computing equipment	IT
N11322G	Communications equipment	CT
N11OG	Other machinery and equipment and weapon systems	OMach
N115G	Cultivated assets	Cult
N117G - N1173G-N1171G	Other Intellectual Property Products	OIPP
N1171G	Research and development	RD
N1173G	Computer software and databases	Soft_DB

Source: EU KLEMS (2017)

Table B2. US NAICS-NACE Rev.2 Industry Concordance

ISIC Rev. 4 code	NAICS code	ISIC Rev. 4 code	NAICS code
A	111CA, 113FF	47	441, 445, 452, 4A0
B	211, 212, 213	H	481, 482, 483, 484, 485, 486, 4870S, 493, GFE
C	311FT, 313TT, 315AL, 321, 322, 323, 324, 325, 326, 327, 331, 332, 334, 335, 333, 3361MV, 3364OT, 337, 339	49-52	481, 482, 483, 484, 485, 486, 4870S, 493
10-12	311FT	53	GFE
13-15 (15 n.a.)	313TT, 315AL	I	721, 722
16-18	321, 322, 323	J	511, 512, 513, 514, 5415
19	324	58-60	511, 512, 513
20-21 (21 n.a.)	325	61 (n.a.)	-
22-23	326, 327	62-63	514, 5415
24-25	331, 332	K	521CI, 523, 524, 525
26-27	334, 335	L	531
28	333	M-N	532RL, 54(5411+5412OP, excl. 5415), 55,561
29-30	3361MV, 3364OT	0	GFGD, GFGN, GSLG, GSLE
31-33 (33 n.a.)	337, 339	P	61
D-E	22, 562	Q	621, 622, 623, 624
F	23	R	711AS, 713
G	42, 441, 445, 452, 4A0	S (S-T)	81
45 (n.a.)	-	T	integrated in S
46	42	U (n.a.)	-

Source: EU KLEMS (2017)

APPENDIX C

FIGURES IN CHAPTER 2

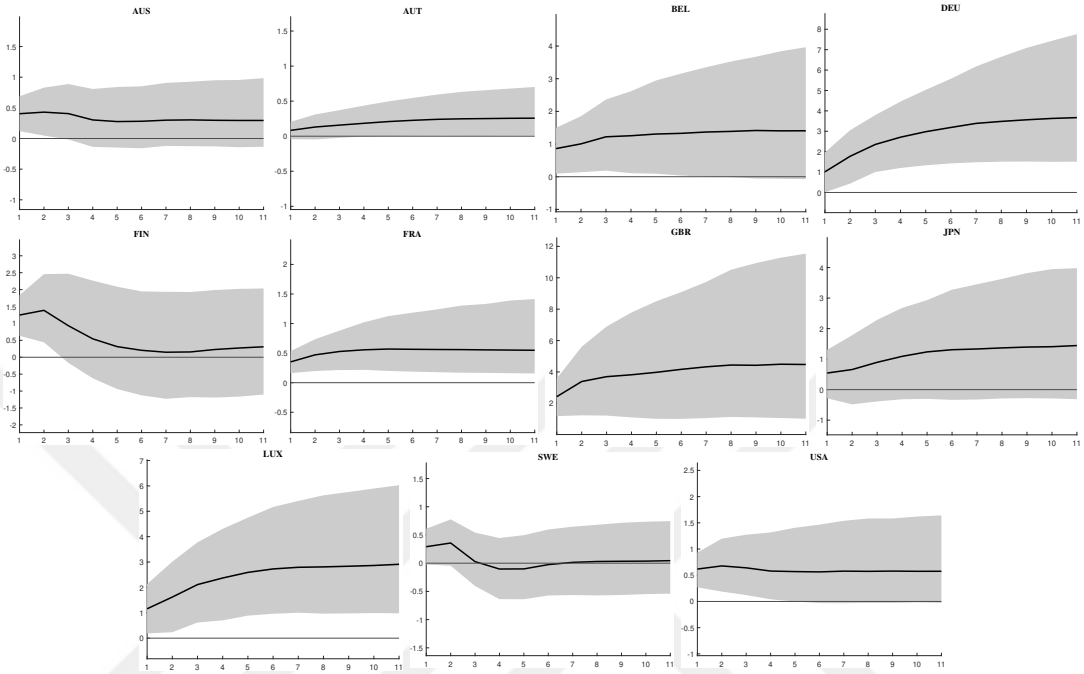


Figure C1. Effects of a cut in corporate tax rate on aggregate GDP per capita

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

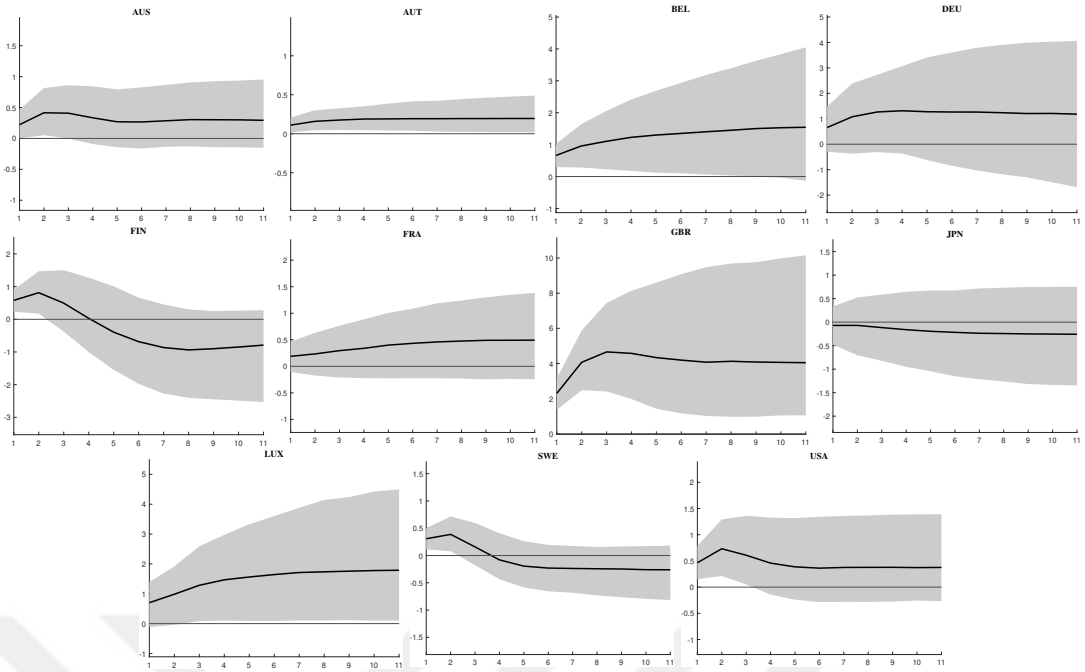


Figure C2. Effects of a cut in corporate tax rate on aggregate hours worked

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

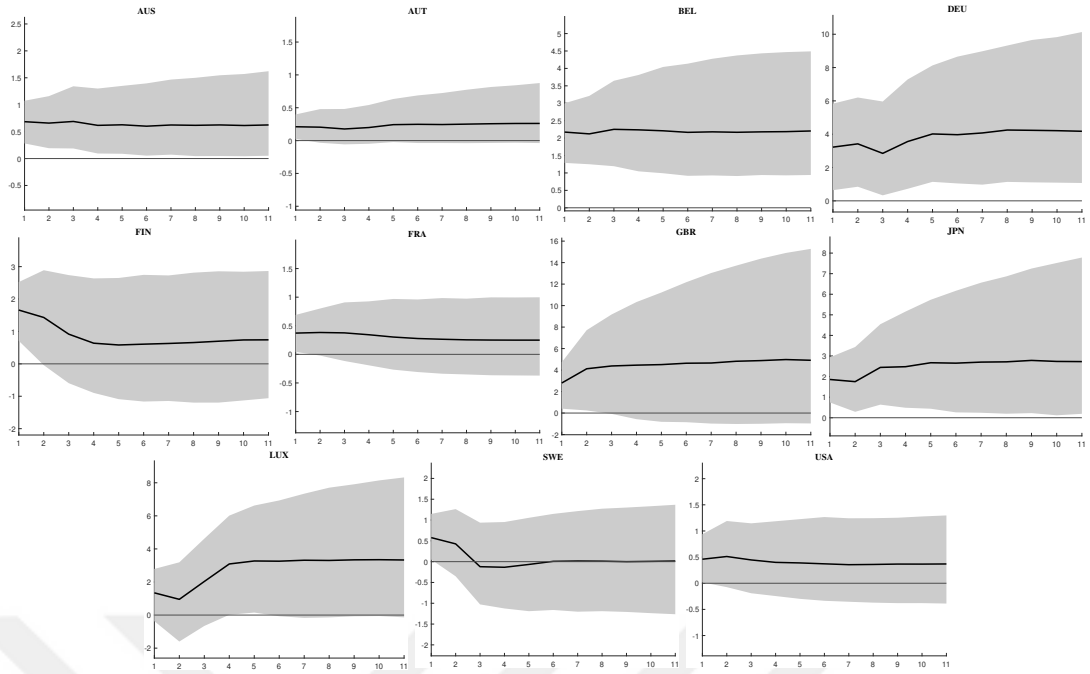


Figure C3. Effects of a cut in corporate tax rate on traded value added

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

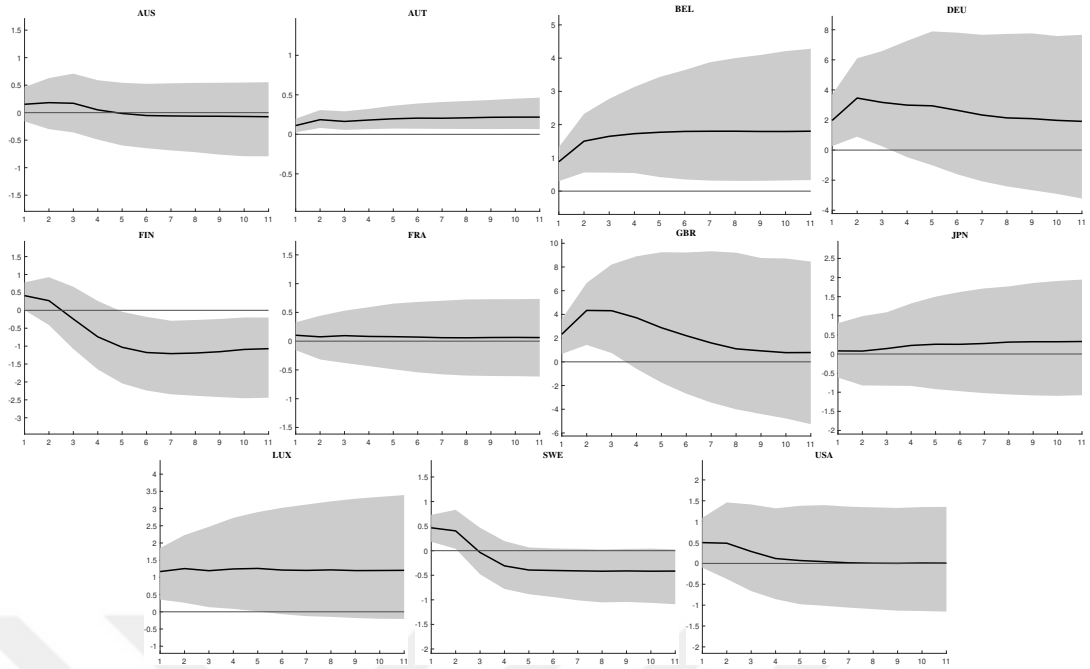


Figure C4. Effects of a cut in corporate tax rate on traded hours worked

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

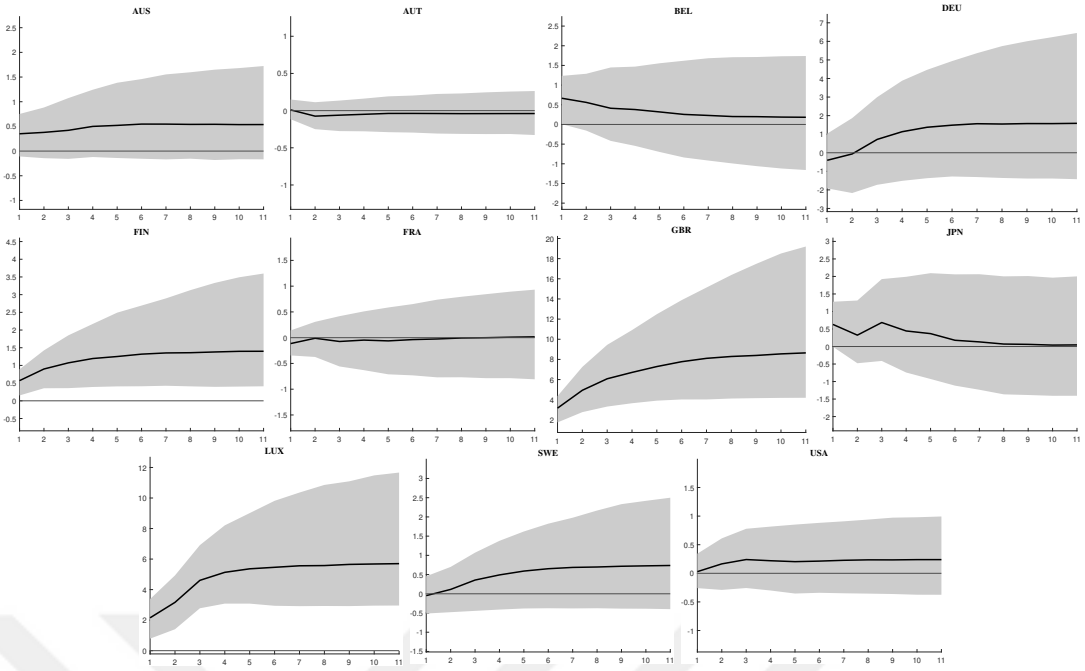


Figure C5. Effects of a cut in corporate tax rate on traded TFP

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

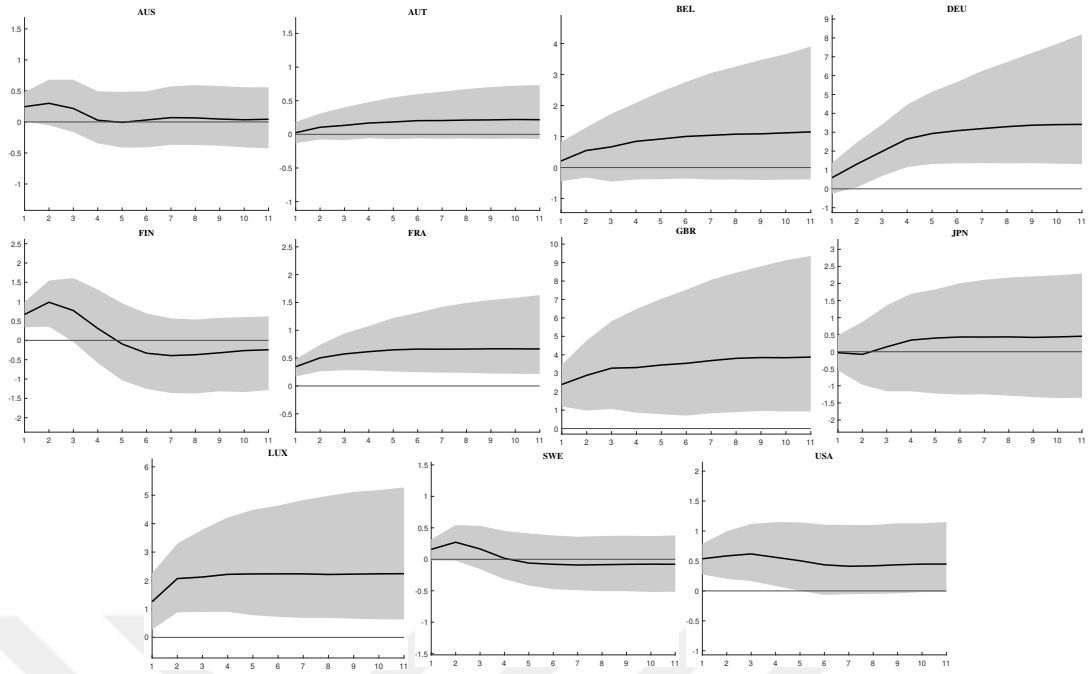


Figure C6. Effects of a cut in corporate tax rate on non-traded value added

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

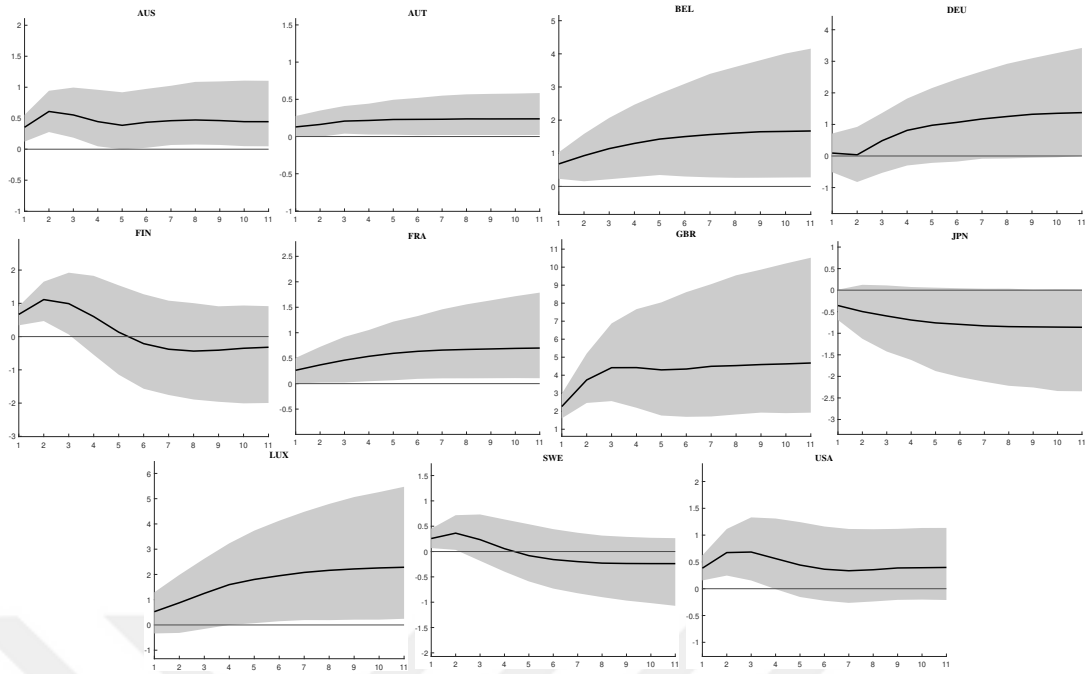


Figure C7. Effects of a cut in corporate tax rate on non-traded hours worked

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

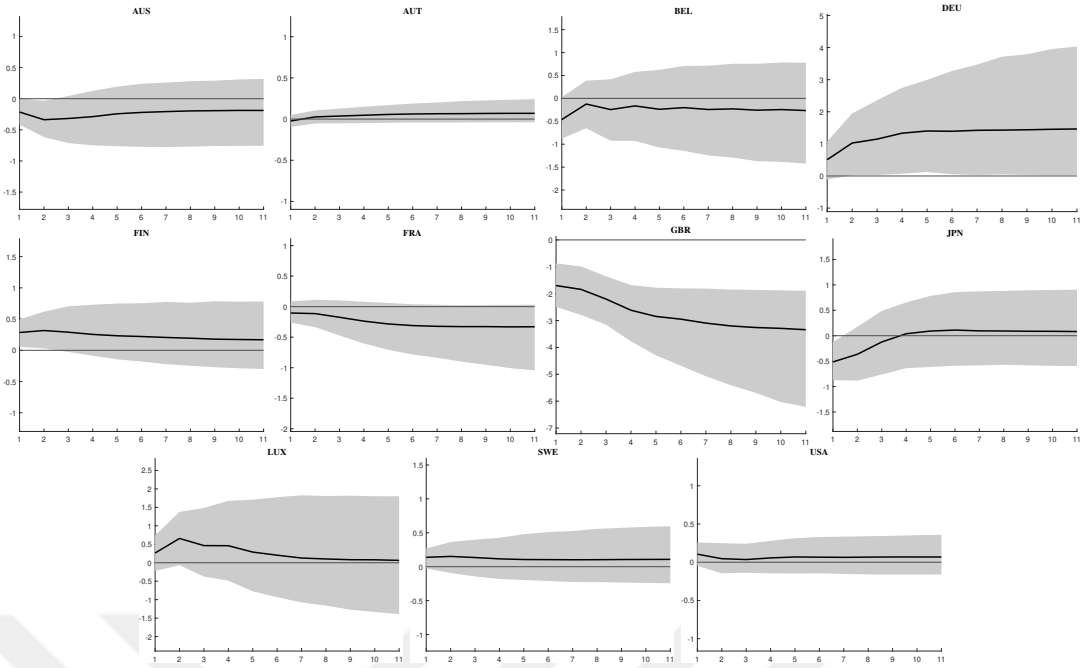


Figure C8. Effects of a cut in corporate tax rate on non-traded TFP

Notes: Exogenous cut of statutory corporate tax rate in by 1 percentage point. Horizontal axes indicate years. Vertical axes measure percentage deviation from trend in GDP units. Shaded areas indicate the 90 percent confidence bounds obtained by bootstrap sampling. Sample: 11 OECD countries, 1973-2015, annual data.

APPENDIX D

TABLES IN CHAPTER 2

Table D1. Westerlund ECM panel cointegration tests for aggregate value added and import share weighted corporate tax rate

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-1.069	2.616	0.996	0.940
Ga	-4.989	1.312	0.905	0.660
Pt	-2.813	2.000	0.977	0.900
Pa	-3.563	0.499	0.691	0.660

Note: The null hypothesis of no cointegration is rejected if the p-value is below 0.05 (0.1) at 5% (10%) significance level 1 lag, 1 lead and a constant.

Table D2. Westerlund ECM panel cointegration tests for aggregate TFP and import share weighted corporate tax rate

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-1.126	2.407	0.992	0.860
Ga	-4.690	1.494	0.932	0.630
Pt	-2.994	1.817	0.965	0.750
Pa	-3.263	0.723	0.765	0.570

Note: The null hypothesis of no cointegration is rejected if the p-value is below 0.05 (0.1) at 5% (10%) significance level 1 lag, 1 lead and a constant.

Table D3. Lag Length Criteria for Import Share Weighted Average Corporate Tax Rate

Country	lag	LR	FPE	AIC	HQIC	SBIC
AUS	1	204.33*	1.6e-08*	-12.2e-03*	-12.1e-03*	-11.9e-03*
AUT	1	185.5*	7.8e-07*	-8.4e-04*	-8.4e-04*	-8.1e-04*
BEL	1	196.31	1.4e-08*	-12.4e-03*	-12.3e-03*	-12.1e-03*
DEU	2	22.157*	3.5e-08*	-11.5e-03*	-11.3e-03*	-11.1e-03*
FIN	1	214.2*	9.6e-08*	-10.5e-03*	-10.4e-03*	-10.2e-03*
FRA	1	272.42	1.8e-08	-12.1e-03	-12.0e-03*	-11.881*
GBR	2	20.294*	1.3e-08*	-12.5e-03*	-12.3e-03*	-12.1e-03*
JPN	1	231.93*	1.7e-08*	-12.2e-03*	-12.1e-03*	-11.1e-03*
LUX	2	19.404*	2.9e-08*	-11.7e-03*	-11.5e-03*	-11.3e-03*
SWE	1	228.47*	1.2e-07*	-10.3e-03*	-10.2e-03*	-10.0314*
USA	1	254.62*	1.8e-08	-12.2e-03	-12.1e-03*	-11.9e-03*

Note: Endogenous variables are country corporate tax rate and import share weighted average corporate tax rate. Test results are significant at 0.01.

Table D4. Lag Length Criteria for Cross Country Average Corporate Tax Rate

Country	lag	LR	FPE	AIC	HQIC	SBIC
AUS	2	31.895*	1.3e-08*	-12.4864*	-12.3342*	-12.0685*
AUT	2	21.783*	5.9e-08*	-10.9768*	-10.8247*	-10.5589*
BEL	2	25.579	5.6e-09*	-13.3284*	-13.1762*	-12.9104*
DEU	2	25.688*	3.2e-08*	-11.5723*	-11.4201*	-11.1544*
FIN	2	24.302*	2.2e-08*	-11.9491*	-11.7969*	-11.5312*
FRA	2	24.321*	3.2e-09*	-13.8774*	-13.7252*	-13.4594*
GBR	2	33.954*	4.8e-09*	-13.4879*	-13.3357*	-13.07*
JPN	2	17.697*	7.3e-09*	-13.0566*	-12.9044*	-12.6387*
LUX	2	18.693*	1.8e-08*	-12.1488*	-11.9966*	-11.7309*
SWE	1	269.68*	2.3e-08*	-11.9099*	-11.8185*	-11.6591*
USA	2	18.657	6.8e-09	-13.1319	-12.9797	-12.714*

Note: Endogenous variables are country corporate tax rate and cross country average corporate tax rate. Test results are significant at 0.01.

Table D5. Panel Unit Root Tests (p-values) for Country Corporate Tax Rate and Import Share Weighted Average Tax Rate

		Variables	
Test	Stat	CIT	INT
Pesaran (2007)	Z[t-bar]	0.477	0.427
Levin et al. (2002)	t-stat	0.213	0.589
Breitung (2000)	t-stat	0.71	0.99
Im et al. (2003)	W-stat	0.99	1.000
Hadri (2000)	Z_{mu}-stat	0.000	0.000

Note: For all tests, except for Hadri (2000), the null of a unit root is not rejected if $p-value \geq 0.05$ at a 5% significance level. For Hadri (2000), the null of stationarity is rejected if $p-value \leq 0.05$ at a 5% significance level.

Table D6. Westerlund ECM panel cointegration tests for country corporate tax rate and import share weighted corporate tax rate

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-2.265	-1.800	0.036	0.030
Ga	-8.678	-0.936	0.175	0.060
Pt	-6.096	-1.302	0.097	0.170
Pa	-6.040	-1.352	0.088	0.110

Note: The null hypothesis of no cointegration is rejected if the p-value is below 0.05 (0.1) at 5% (10%) significance level 1 lag, 1 lead and a constant.

Table D7. Panel Cointegration Test Results (p-values)

	Equations	
Test	CIT&AVT	CIT&INT
Johansen Fisher Panel Cointegration Test	0.000	0.000
Kao Residual Cointegration Test	0.003	0.017

Note: The null hypothesis of no cointegration is rejected if the p-value is below 0.01 (0.05) at 1 percentage point (5%) significance level.CIT: Country income tax rate, AVT: Cross country average tax rate, INT:Import share weighted tax rate.

Table D8. Unit Root Test for Country Corporate Tax Rate and Cross Country Average Tax Rate

Country	Test Statistic	p-value
AUS	-0.794	0.8208
AUT	-1.207	0.6705
BEL	-0.987	0.7580
DEU	-0.077	0.9517
FIN	-1.167	0.6875
FRA	-1.682	0.4406
GBR	-0.948	0.9500
JPN	-0.094	0.9500
LUX	-1.271	0.6425
SWE	-1.119	0.7075
USA	-1.750	0.4055
AVT	-1.018	0.7468

Note: Interpolated Dickey-Fuller Test 1 percentage point Critical Value is -3.634, 5% Critical Value is -2.952 and 10% Critical Value -2.610

Table D9. Johansen Fisher Cointegration Test for Country Corporate Tax Rate and Cross Country Average Tax Rate

Country	Trace Test Statistics	Prob.**	Max-Eign Test Statistics	Prob.**
AUS	28.3258	0.0031	18.4512	0.0194
AUT	25.9170	0.0074	17.2600	0.0303
BEL	25.3491	0.0091	15.1619	0.0648
DEU	17.1201	0.1281	14.4593	0.0828
FIN	21.7036	0.0315	17.2736	0.0302
FRA	21.1962	0.0371	16.0061	0.0480
GBR	48.7964	0.0000	45.1041	0.0000
JPN	21.8905	0.0296	15.9295	0.0493
LUX	18.0143	0.0990	11.9657	0.1880
SWE	55.3195	0.0000	52.3734	0.0000
USA	38.7189	0.0001	34.0392	0.0000

Note: Null Hypothesis is no cointegration. ** p-values. Trend assumption: No deterministic trend (restricted constant).

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