Online Appendix for: Automation, Power, and Profit

Juan Jacobo
Universidad Externado de Colombia
juan.jacobo@uexternado.edu.co

Abstract This document present the code solving the steady-state equilibrium in Section 4 of Automation, Power, and Profit.

Table of contents

1 Introduction

This document presents all the computational steps required to replicate the results in Section 4 of Automation, Power, and Profit. Here, I also present additional data and robustness results, showing that the key conclusions of the paper do not vary with variations on the measures of automation, normal rate of unemployment, or welfare policy.

2 Code Related to Section 4

Download the required packages. Use import Pkg; Pkg.add([“Distributions”,"XLSX", “CairoMakie”, “LaTeXStrings”, “Makie”, “CSV”,"FileIO"]). To download HPFilter, use Pkg.add(url = “https://github.com/sdBrinkmann/HPFilter.jl”).

```
using CairoMakie,LaTeXStrings,NLboxsolve,Distributions,HPFilter,XLSX,ReadStat,DataFrames,CSV
```

The following code presents the definition of the parameters as in Table 1 of the main text.

2.1 Calibrated Parameters

```
## Calibrated (static) parameters
α = 1.64 # labor augmenting parameter
σ=0.6    # elasticity of substitution
Ak=0.02  # capital auugmenting parameter
A= 1     # Hicks neutral parameters
ρm=(1+0.26)^(1/12)-1   # this is obtained from Andreoni and Sprenger (2012)
gm = (1+0.02)^(1/12)-1   # this is the average of labor productivity growth
δm = (1+0.068)^(1/12)-1  # this is the average of the depreciation rate
# Beveridge curve
λ0 = 0.025  # Separation rate
ṁ = 0.0000  # Equilibrium value
Ṁ = gm/α  # derived from the steady-state growth equation.
ι = 1.25      #  Same as Petrosky-Nadeu (2018)
ρ = ρm    # subjective discount rate
γf = 0.45   #  Response time of capitalists
ξ = 8.2    # calibrated to be about 2 times the average productivity of labor
δ = δm      # Standard
φ = 0.3     # Relative price of capital
```

```
0.3
```

The following code maps the equations in Definition 1 in the main text, with T^w as an endogenous variable. This is the first step to deduce the OLS estimators of

$$\ln T_t^w = \beta_0^w + \beta_1^w \ln \mathcal{W}_t + \beta_2^w \ln(Y_t/L_t) + \nu_t.$$

Keep in mind that, as noted in the Table 1 in the main text, $q(\theta) = (1+\theta^{\iota})^{-\iota}$. Each line of the code is accompanied with a brief description.

2.2 Nonlinear Solver of Steady-State

```
# Code for solving the steady-state (with Tw as an endogenous variable)
function sys2!(FF,x,m,α,σ,λ0,ι,ρ,ṁ,Ṁ,γf,b_y,ξ,δ,L,Pr,A,Ak,φ)
    w=x[1]; wu=x[2]; wn=x[3];  k=x[4]; ku=x[5]; kn=x[6];
    μ=x[7]; θ = x[8]; θu = x[9]; θn = x[10]; fθ = x[11]; qθ = x[12];
    fθu = x[13]; qθu = x[14]; fθn= x[15]; qθn = x[16]; Tw = x[17];
    Lu=x[18]; Ln=x[19]; Γna = x[20]; Γnb = x[21]; Ψna = x[22];
    Ψnb=x[23] ; Ψn = x[24]; y = x[25]; ∂yL = x[26]; ∂yk = x[27];
    yu = x[28]; ∂yLu=x[29]; yn =x[30]; ∂yLn=x[31]; ∂ykn=x[32];∂yku=x[33];
     μu = x[34]; μn = x[35]; Ψu = x[36]; UAL = x[37]; g = x[38]; λ = x[39];
b=x[40]
    FF[1] = qθ - (1+θ^(ι))^(-1/ι)        #  probability of filling a vacancy
    FF[2] = fθ - qθ*θ                    # job finding probability
    FF[3] = L - fθ/(λ+fθ)                # steady-state employment
```

```
    FF[4] = qθu - (1+θu^(ι))^(-1/ι)      # probability of filling a vacancy in collective bargaining
    FF[5] = fθu - qθu*θu                 # job finding probability in collective bargaining
    FF[6] = Lu - fθu/(λ+fθu)             # steady-state employment in collective bargaining
    FF[7] = qθn - (1+θn^(ι))^(-1/ι)      # probability of filling a vacancy in individual bargaining
    FF[8] = fθn - qθn*θn                 # job finding probability in individual bargaining
    FF[9] = UAL - (1-exp(α*(σ-1)*(Ṁ-ṁ))*(exp(α*(σ-1)*(m+ṁ))-1)/(exp(α*(σ-1)*m)-1)) # marginal technological unemployment
    FF[10] = λ - λ0 - UAL                # separation rate
    FF[11] = g - α*Ṁ                     # growth rate
    FF[12] = Ln- fθn/(λ+fθn)             # steady-state employment in individual bargaining
    FF[13] = Γna - γf/(1+γf)             # Intrinsic bargaining power (case a)
    FF[14] = Γnb-γf*(1-qθn)/(1+γf+qθn*(1-γf)) # Intrinsic bargaining power (case b)
    FF[15] = Ψna - Γna*(ρ-g+λ+fθn)/(ρ-g+λ+  Γna*fθn)  # Actual bargaining power (case a)
    FF[16] = Ψnb - Γnb*(ρ-g+λ+fθn)/(ρ-g+λ+  Γnb*fθn)  # Actual bargaining power (case b)
    FF[17] = Ψn - ((Tw*Γnb +θn*Γna)/(θn+Tw))*(ρ-g+λ+fθn)/(ρ-g+λ+((Tw*Γnb +θn*Γna)/(θn+Tw))*fθn) # Actual bargaining power (individual protocol)
    FF[18] = Ψu - Γna*(ρ-g+λ+fθu)/(ρ-g+λ+  Γna*fθu)  # Actual bargaining power (collective protocol)
    FF[19] = y -A*((1-m)^(1/σ) *(Ak*k)^((σ-1)/σ) + ((exp(α*(σ-1)*m)-1)/(α*(σ-1)))^(1/σ))^(σ/(σ-1)) # production function
    FF[20] = ∂yk - (Ak*A)^((σ-1)/σ)*(y/k)^(1/σ) * (1-m)^(1/σ)       # Marginal prod. capital
    FF[21] = ∂yL - (y - k*∂yk)                                     # Marginal prod. labor
    FF[22] = yu - A*((1-m)^(1/σ) *(Ak*ku)^((σ-1)/σ) + ((exp(α*(σ-1)*m)-1)/(α*(σ-1)))^(1/σ))^(σ/(σ-1))  # production function collective bargaining
    FF[23] = ∂yku - (A*Ak)^((σ-1)/σ)*(yu/ku)^(1/σ) * (1-m)^(1/σ)       # Marginal prod. capital with collective bargaining
    FF[24] = ∂yLu - (yu - ku*∂yku)                                     # Marginal prod. labor with collective bargaining
    FF[25] = yn - A*((1-m)^(1/σ) *(Ak*kn)^((σ-1)/σ) + ((exp(α*(σ-1)*m)-1)/(α*(σ-1)))^(1/σ))^(σ/(σ-1)) # production function individual bargaining
    FF[26] = ∂ykn - (A*Ak)^((σ-1)/σ)*(yn/kn)^(1/σ) * (1-m)^(1/σ)       # Marginal prod. capital (equation (A1)) with individual bargaining
    FF[27] = ∂yLn -(yn - kn*∂ykn)                                      # Marginal prod. labor (equation (A1)) with individual bargaining
    FF[28] = wn -( b + Ψn*(∂yLn-b))                                    # Hypothetical wage individual bargaining
    FF[29] = wn -( ∂yLn- ξ*(ρ-g+λ)/qθn)                                #
```

```
Hypothetical labor demand with individual bargaining  (these equations solve
θn,wn)
     FF[30] = wu -( b + Ψu*(∂yLu-b + (ρ-g+λ)/(ρ-g) *(yu-∂yLu)))           #
Hypothetical wage collective bargaining
     FF[31] = wu -( ∂yLu- ξ*(ρ-g+λ)/qθu )                                  #
Hypothetical labor demand with collective bargaining  (these equations solve
θu,wu)
     FF[32] = w -(Pr*wu + (1-Pr)*wn)                                       #
Aggregate wage
    FF[33] = w -(∂yL- ξ*(ρ-g+λ)/qθ)                                  # Labor
demand equation
    FF[34] = μ -((∂yL/w)-1)                                         # markup
     FF[35] = ∂yk - δ*(1+μ)/φ                                              #
Capital market equilibrium
    FF[36] = μn -((∂yLn/wn)-1)                                      # markup
(individual bargaining)
    FF[37] = μu - ((∂yLu/wu)-1)                                     # markup
(collective bargaining)
     FF[38] = ∂yku - δ*(1+μu)/φ                                            #
Capital market equilibrium (collective bargaining)
     FF[39] = ∂ykn - δ*(1+μn)/φ                                            #
Capital market equilibrium (individual bargaining)
     FF[40] = b - b_y*y                                                    #
Steady-state unemployment benefits
end
```

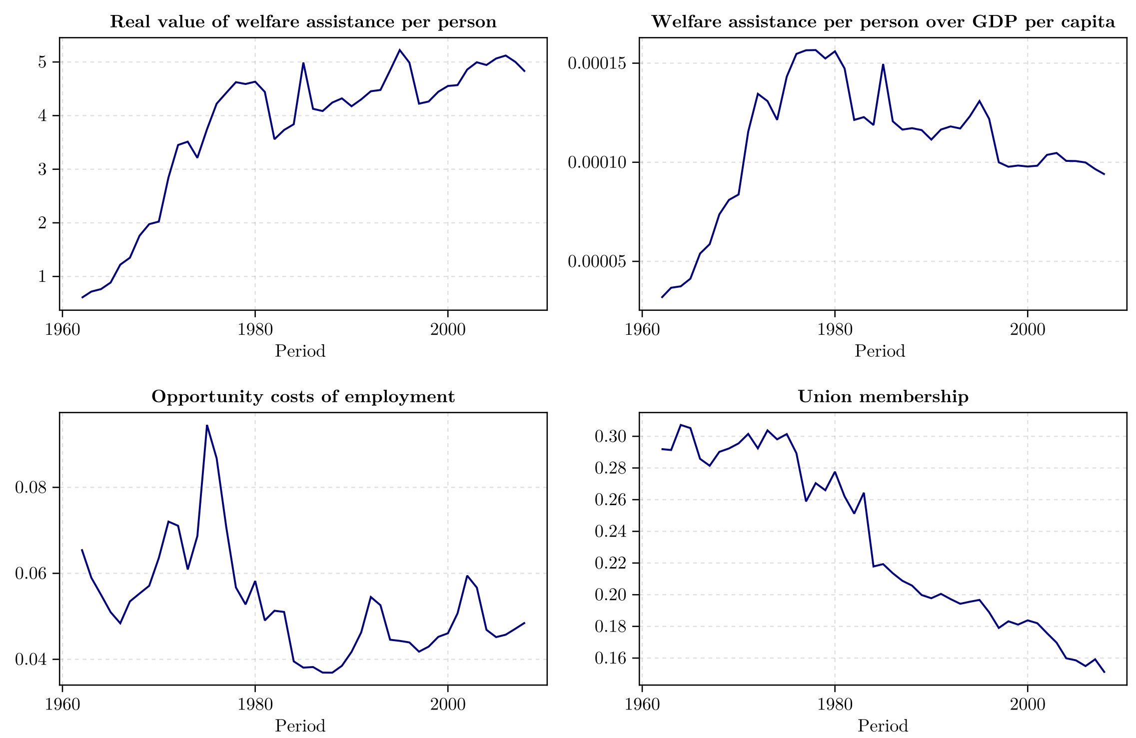
```
sys2! (generic function with 1 method)
```

2.3 Data

```

## Time-Varying Parameters
# Download the necessary data
data_calibration    =    XLSX.readxlsx("/Users/juanjacobo/Documents/Documents/
JSCED_submission_2024/Data/data_in_calibrations.xlsx");
data_annual=data_calibration["annual!A1:AW83"];
data_quarterly=data_calibration["quarterly!A1:N290"]
data_monthly=data_calibration["monthly!A1:G962"]
## the data is annual from 1948 to 2008
time_annual = convert(Array{Float64,1},data_annual[12:end-11,1])
g_penn = convert(Array{Float64,1},data_annual[12:end-11,5])  # growth rate penn
world data
unions = convert(Array{Float64,1},data_annual[12:end-11,2])  # union data
poor_welfare = convert(Array{Float64,1},data_annual[26:end-11,45])  # 1962-2010
poor_welfare_PTANF  =  convert(Array{Float64,1},data_annual[26:end-11,46])    #
1962-2010
poor_welfare_PTANFMEDICAID                                                     =
```

```
convert(Array{Float64,1},data_annual[26:end-11,47])  # 1962-2010
poor_welfare_ALL_LTAXCREDITS                                                   =
convert(Array{Float64,1},data_annual[26:end-11,48])  # 1962-2010
automation_mann = convert(Array{Float64,1},data_annual[38:72,49])   # 1974-2008

## the data is quarterly from 1948 to 2008
time_quarterly = collect(range(1948,length= 245, stop=2009))
b_chodorow_q     =     convert(Array{Float64,1},data_quarterly[6:end-40,4])     #
Opportunity costs from Chodorow-Reich, & Karabarbounis
NRU_q= convert(Array{Float64,1},data_quarterly[10:end-40,5])      # Noncyclical
rate of unemployment
YL=convert(Array{Float64,1},data_quarterly[6:end-40,2])                # GDP per
capita
# Compute moving averages
b_chodorow =zeros(61)
NRU = [5.25;zeros(60)]
yl = zeros(61)
for i=1:61
    b_chodorow[i]=mean(b_chodorow_q[1+(i-1)*4:i*4])
    yl[i]=mean(YL[1+(i-1)*4:i*4])
end
for i=1:60
    NRU[i+1]=mean(NRU_q[1+(i-1)*4:i*4]) # Natural rate of unemployment
end
## the data is monthly from 1948 to 2009
time_monthly = collect(range(1948,length= 733, stop=2009))
un_civil_m    =    convert(Array{Float64,1},data_monthly[110:842,5])    #    civil
unemployment
vacancies_m   =   convert(Array{Float64,1},data_monthly[110:842,7])   #   monthly
vacancies
un_c,vac=zeros(61),zeros(61),zeros(61),zeros(61)
for i=1:61
    un_c[i]=mean(un_civil_m[1+(i-1)*12:i*12])
    vac[i]=mean(vacancies_m[1+(i-1)*12:i*12])
end
θs = vac./un_c   # Labor market tightness
bcho_HP = HP(b_chodorow,6)  # unemployment benefts (b)
unions_HP = HP(unions,6)  # Union data
G_hp = HP(g_penn,6)  # Penn world Table growth data
g_ms = (G_hp.+1).^(1/12).-1 # monthly
Ṁs = 1.0*g_ms./α;  # Growth in the creation of new tasks



with_theme(theme_latexfonts()) do
    f = Figure(size = (900, 600))
    ax = Axis(f[1, 1],
        xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
```

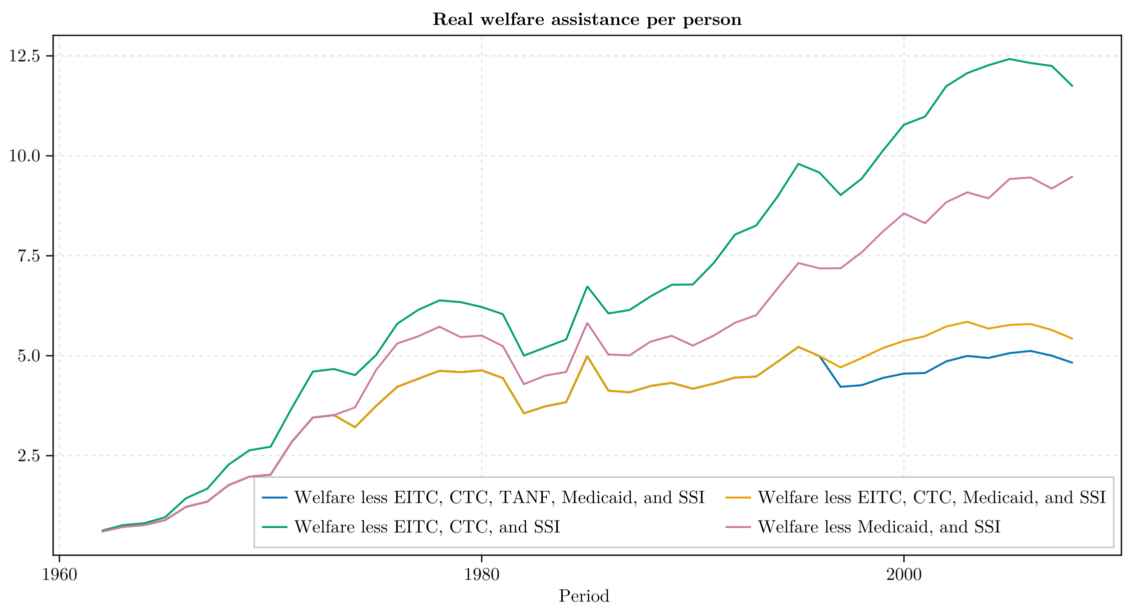
```
        title = "Real value of welfare assistance per person",
    )
    lines!(ax, time_annual[15:end], poor_welfare, color = :navy)
    ax = Axis(f[1, 2],
    xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
    title = "Welfare assistance per person over GDP per capita",
)
  lines!(ax, time_annual[15:end], poor_welfare./yl[15:end], color = :navy)
  ax = Axis(f[2, 1],
  xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
  title = "Opportunity costs of employment",
)
lines!(ax, time_annual[15:end], b_chodorow[15:end], color = :navy)
ax = Axis(f[2, 2],
xlabel = "Period",xgridstyle = :dash, ygridstyle = :dash,
title = "Union membership",
)
lines!(ax, time_annual[15:end], unions[15:end], color = :navy)
    f
    end
```



The real value of welfare assistance per person is retrived from https://federalsafetynet.com/poverty-and-spending-over-the-years-2/. In particular, I compute Total welfare spending-Refundable tax credits (EITC and CTC) - SSI - Medicaid -TANF.

The differences generated by omitting refundable tax credits and Medicaid is presented in the following graph. This illustrates the transition of the welfare state in the United States from a need-based to a work-based system (Moffitt (2015); Parolin et al. (2023); Noble (1997)).

```
poor_measures=[poor_welfare    poor_welfare_PTANF    poor_welfare_PTANFMEDICAID
poor_welfare_ALL_LTAXCREDITS]
with_theme(theme_latexfonts()) do
    f = Figure(size = (900, 500))
    ax = Axis(f[1, 1],
        xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
        title = "Real welfare assistance per person",
    )
     lines!(ax, time_annual[15:end],poor_measures[:,1], label = "Welfare less
EITC, CTC, TANF, Medicaid, and SSI")
     lines!(ax, time_annual[15:end],poor_measures[:,2], label = "Welfare less
EITC, CTC, Medicaid, and SSI")
     lines!(ax, time_annual[15:end],poor_measures[:,3], label = "Welfare less
EITC, CTC, and SSI")
     lines!(ax, time_annual[15:end],poor_measures[:,4], label = "Welfare less
Medicaid, and SSI")
    axislegend(; position = :rb, nbanks = 2, framecolor = (:grey, 0.5))
    f
    end
```



2.3.a Data on Productive Sectors

Following Basu & Foley (2013), I create a database of the labor share, markup, and capital-output ratio for sectors without questionable imputations of value-added. These sectors—which exclude agriculture and mining—are summarized in the following table.

BEA Industry Category	BLS Industry Category
Utilities	Utilities
Construction	Construction
Manufacturing	
	Wood products
	Nonmetallic mineral products
	Primary metals
	Fabricated metal products
	Machinery
	Computer and electronic products
	Electrical equipment, appliances, and components
	Motor vehicles, bodies and trailers, and parts
	Other transportation equipment
	Furniture and related products
	Miscellaneous manufacturing
	Food and beverage and tobacco products
	Textile mills and textile product mills
	Apparel and leather and allied products
	Paper products
	Printing and related support activities
	Petroleum and coal products
	Chemical products
	Plastics and rubber products
Wholesale trade	Wholesale trade
Retail trade	Retail trade
Transporting and warehousing	
	Air transportation
	Rail transportation

BEA Industry Category	BLS Industry Category
	Water transportation
	Truck transportation
	Transit and ground passenger transportation
	Pipeline transportation
	Other transportation and support activities
	Warehousing and storage
Information	
	Publishing industries, except internet
	Motion picture and sound recording industries
	Broadcasting and telecommunications
	Data processing and

The following code uses data from Eldridge et al. (2020) and BEA Fixed Assets Accounts Tables to construct the relevant variables in the paper.

```
#bea_bls_data is the data from Eldridge et al. (2020)
data          =          XLSX.readxlsx("/Users/juanjacobo/Documents/Documents/
JSCED_submission_2024/Data/bea_bls_data.xlsx")
data_depre       =       XLSX.readxlsx("/Users/juanjacobo/Documents/Documents/
JSCED_submission_2024/Data/current_dep_assets.xlsx")
curr_c_cap       =       XLSX.readxlsx("/Users/juanjacobo/Documents/Documents/
JSCED_submission_2024/Data/cost_assets.xlsx")
data_1947_1963=data["1947-1963!A2:W750"]
data_1963_2016=data["1963-2016!A2:W3404"]
full_sample=[data_1947_1963;data_1963_2016] # merges the time periods
data_D=data_depre["Sheet2!A1:U72"] # depreciation data
cost_assets=curr_c_cap["Sheet2!A1:U72"] # value of assets
#  The  following  computes  the  empirical  variables  in  the  text  using  the
experimental BEA-BLS data
function economy_lab_shares(full_sample,data_D,cost_assets)
    VA_t=zeros(17);         VA_t2=zeros(54);        VA_t3=zeros(71);
    la_c_t=zeros(17);       la_c_t2=zeros(54);         la_c_t3=zeros(71);
    la_nc_t=zeros(17);  la_nc_t2=zeros(54);         la_nc_t3=zeros(71);
    MA_t=zeros(17);         MA_t2=zeros(54);     MA_t3=zeros(71)
    KA_t=zeros(17);         KA_t2=zeros(54);     KA_t3=zeros(71)
    rVA_t=zeros(17);        rVA_t2=zeros(54);       rVA_t3=zeros(71);
    L_t = zeros(17);        L_t2=zeros(54);         L_t3=zeros(71);
    h_t=zeros(17);          h_t2=zeros(54);         h_t3=zeros(71);
   depret=sum(data_D[2:end-1,i]./1 for i ∈ [5,6,7,8,9,10,11,16,19,20,21]).*1000
                    Kts=sum(cost_assets[2:end-1,i]./1      for      i      ∈
```

```
[5,6,7,8,9,10,11,16,19,20,21]).*1000
                                                  for                 i
=[6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,59,60,61]
        agr_VA=findall(x -> x ==i, full_sample[:,2])
        VA=full_sample[agr_VA,4].-full_sample[agr_VA,5]
        rVA=full_sample[agr_VA,13].-full_sample[agr_VA,14]
                                  LL      =     (full_sample[agr_VA,20].
+full_sample[agr_VA,21]).*full_sample[agr_VA,22]
        VA_t3=VA_t3.+VA
        rVA_t3=rVA_t3.+rVA
        MA_t3=MA_t3.+full_sample[agr_VA,5]
        la_c=full_sample[agr_VA,11]
        la_c_t3=la_c_t3+la_c
        la_nc=full_sample[agr_VA,12]
        h_nc=full_sample[agr_VA,22]
        la_nc_t3=la_nc_t3+la_nc
        h_t3=h_nc+h_t3
        L_t3 = L_t3 + LL
    end
    for i=[2936,3740,5152,5758]
        agr_VA=findall(x -> x ==i, full_sample[:,2])
        VA=full_sample[agr_VA,4].-full_sample[agr_VA,5]
        rVA=full_sample[agr_VA,13].-full_sample[agr_VA,14]
        VA_t=VA_t.+VA
        rVA_t=rVA_t.+rVA
                                  LL      =     (full_sample[agr_VA,20].
+full_sample[agr_VA,21]).*full_sample[agr_VA,22]
        MA_t=MA_t.+full_sample[agr_VA,5]
        la_c=full_sample[agr_VA,11]
        la_c_t=la_c_t+la_c
        la_nc=full_sample[agr_VA,12]
        la_nc_t=la_nc_t+la_nc
        h_nc=full_sample[agr_VA,22]
        h_t=h_nc+h_t
        L_t = L_t + LL
    end
    for i=[29,30,31,32,33,34,35,36,37,38,39,40,51,52,57,58]
        agr_VA=findall(x -> x ==i, full_sample[:,2])
        VA=full_sample[agr_VA,4].-full_sample[agr_VA,5]
        rVA=full_sample[agr_VA,13].-full_sample[agr_VA,14]
                                  LL      =     (full_sample[agr_VA,20].
+full_sample[agr_VA,21]).*full_sample[agr_VA,22]
        VA_t2=VA_t2.+VA
        rVA_t2=rVA_t2.+rVA
        MA_t2=MA_t2.+full_sample[agr_VA,5]
        la_c=full_sample[agr_VA,11]
        la_c_t2=la_c_t2+la_c
        la_nc=full_sample[agr_VA,12]
```

```
        la_nc_t2=la_nc_t2+la_nc
        h_nc=full_sample[agr_VA,22]
        h_t2=h_nc+h_t2
        L_t2 = L_t2 + LL
    end
    la_c=[la_c_t;la_c_t2].+la_c_t3;
    la_nc=[la_nc_t;la_nc_t2].+la_nc_t3;
    L_total =[L_t;L_t2].+L_t3
    h = [h_t;h_t2].+h_t3;
    VA=[VA_t;VA_t2].+VA_t3
    rVA= [rVA_t;rVA_t2].+rVA_t3
    YL = VA./L_total
    PL = rVA./(h.*(la_c.+la_nc))
    MA=[MA_t;MA_t2].+MA_t3
    KA= [KA_t;KA_t2].+KA_t3
    Cap=la_nc[2:end].+la_c[2:end].+depret.+MA[2:end]
    Cap2 = la_nc[2:end].+la_c[2:end].+depret
    Prof=(VA[2:end].-depret.-la_nc[2:end].-la_c[2:end])
    VA_N=VA[2:end].-depret
return   [(la_nc)./VA   (la_nc.+la_c)./VA   [0;Prof./Cap2]   [0;(la_nc[2:end].
+la_c[2:end])./VA_N]    [0;Prof./(Kts.+depret)]    [0;(Kts.+depret)./VA[2:end]]
[0;(Prof.+depret.+la_nc[2:end].+la_c[2:end])./(VA[2:end])]     [0;depret./(Kts.
+depret)]]
end
economy_LS=economy_lab_shares(full_sample,data_D,cost_assets)
LS_NCP =economy_LS[:,1]         # labor share (unskilled labor)
LS_C = economy_LS[:,2].-LS_NCP  # labor share (skilled labor)
w_share =  economy_LS[1:end,2]  # labor share
μ_data =  economy_LS[2:end,3]   # rate of return
r_data =  economy_LS[2:end,5]    # rate of profit
KY = economy_LS[2:end,6] ;        # capital-output ratio
dep_cap=economy_LS[2:end,end]; # depreciation  of capital
```

2.4 Construction of Automation measure

Now, I use

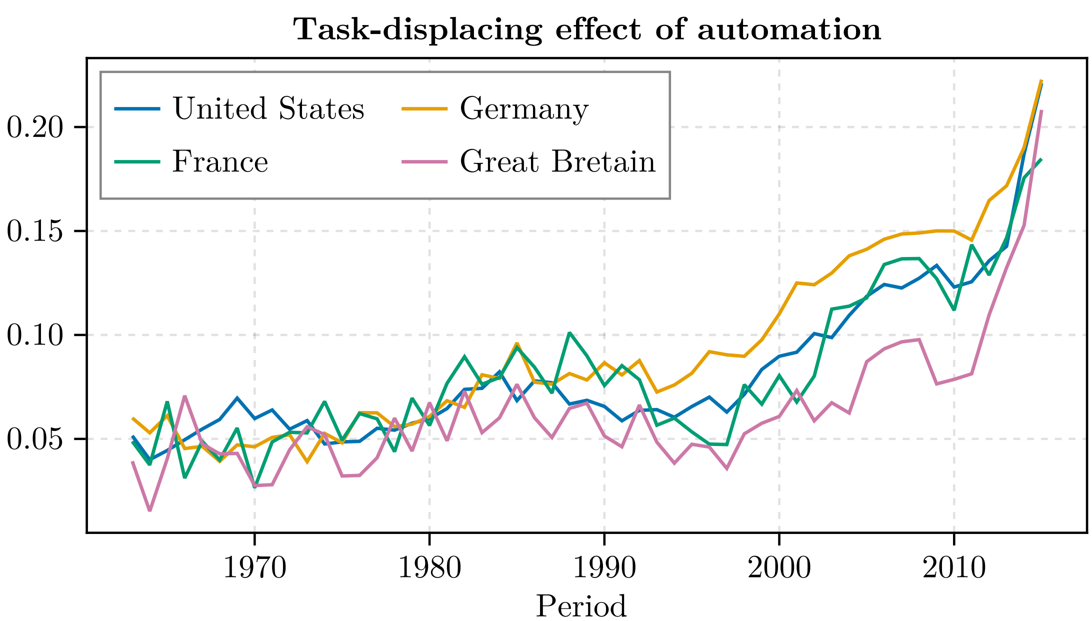
$$1 - m_t^* = \Big(\frac{K_t}{\varphi Y_t}\Big)^{\text{BEA}} A^k \varphi^{1-\sigma} \left(\delta\big(1+\mu_t^{\text{BEA-BLS}}\big)\right)^{\sigma},$$

to obtain the theoretical measure of automation.

```
KYm=KY.*12  # remember that the calibration is based on monthly data
dep_capm = (dep_cap.+1).^(1/12).-1
m_star =-((mean(dep_capm).*(μ_data.+1)).^(σ)* (Ak*φ)^(1-σ).*(KYm)).+1
mm=-m_star.+1;
```

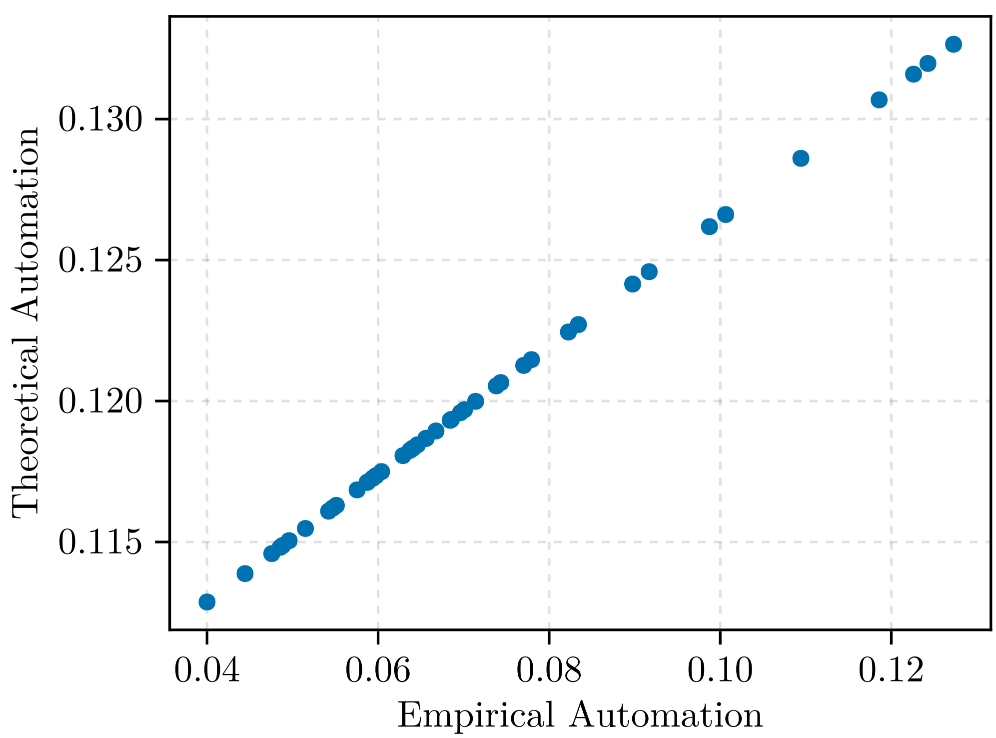
Next, I construct the time series data in Hémous, Olsen, Zanella, & Dechezleprêtre (2025). Note that this is the same as Figure 2 in their paper. Here it is interesting to note that all countries have similar trajectories on the behavior of automation, yet only the Anglo-Saxon contries experienced rapid income inequality following the 1980s.

```
#automation_hemous.csv is obtained from hemous_2025.jl
merged_ctry=CSV.read("/Users/juanjacobo/Documents/Documents/
JSCED_submission_2024/Code/automation_hemous.csv", DataFrame)

with_theme(theme_latexfonts()) do
    f = Figure(size = (500, 300))
    ax = Axis(f[1, 1],
        xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
        title = "Task-displacing effect of automation",
    )
   lines!(ax, merged_ctry.Year,merged_ctry.Auto95_USA, label = "United States")
    lines!(ax, merged_ctry.Year,merged_ctry.Auto_95_Germany, label = "Germany")
    lines!(ax, merged_ctry.Year,merged_ctry.Auto_95_France, label = "France")
   lines!(ax, merged_ctry.Year,merged_ctry.Auto_95_GB, label = "Great Bretain")
    axislegend(; position = :lt, nbanks = 2, framecolor = (:grey, 0.95))
    f
    end
```



With this result, I now make the theoretical and empirical measures of automation comparable.

```
## Automation from Hemous 2025. Auto95 US
Mech=merged_ctry.Auto95_USA # data  1963:2015
Xmech=[ones(46) Mech[1:end-7]]
M̂1 = Xmech*(inv(Xmech'Xmech)*(Xmech'mm[16:end-9]))
mM̂2=-M̂1.+1;
f = with_theme(theme_latexfonts()) do
    fig = Figure(size = (400, 300))
    ax = Axis(fig[1, 1],
        xlabel = "Empirical Automation",
        xgridstyle = :dash,
        ygridstyle = :dash,
        ylabel = "Theoretical Automation"
    )
    scatter!(ax, Mech[1:end-7], M̂1)
    fig  # <-- return the figure explicitly!
end
display(f)
```




```
CairoMakie.Screen{IMAGE}
```

2.5 Model Calibration

Now that we have all the data we need. We proceed to solve the OLS estimators in equation (25) in the main text. For this purpose, I first solve the steady-state assuming that T^w perfectly tracks the noncyclical rate of unemployment. This is presented in the following code.

```
# Set the initial values using

### This code sets the initial values.
function init_v(m,α,σ,λ0,ι,ρ,ṁ,Ṁ,γf,b_y,ξ,δ,Tw,Pr,A,Ak)
     k0=10.95; ku0=11.3; kn0=10.65; θ0=0.7; θu0=0.016; θn0=0.72; g=α*Ṁ ;   UAL
=(1-exp(α*(σ-1)*(Ṁ-ṁ))*(exp(α*(σ-1)*(m+ṁ))-1)/(exp(α*(σ-1)*m)-1));   λ = λ0 +
UAL;
      qθ0=(1+θ0^(ι))^(-1/ι);  fθ0=qθ0*θ0  ;    qθu0=  (1+θu0^(ι))^(-1/ι);  fθu0  =
qθu0*θu0;  qθn0=(1+θn0^(ι))^(-1/ι);   fθn0=qθn0*θn0;   L0=fθ0/(fθ0+λ);  Lu0=fθu0/
(fθu0+λ);
    Ln0=fθn0/(fθn0+λ); Γna0 = γf/(1+γf);  Γnb0 = γf*(1-qθn0)/(1+γf+qθn0*(1-γf));
     Ψna0=Γna0*(ρ-g+λ+fθn0)/(ρ-g+λ+  Γna0*fθn0);
     Ψnb0=Γnb0*(ρ-g+λ+fθn0)/(ρ-g+λ+  Γnb0*fθn0);
     Ψ0 = ((Γna0*θ0+Γnb0*Tw)/(Tw+θ0))*(ρ-g+λ+fθn0)/(ρ-g+λ+   ((Γna0*θ0+Γnb0*Tw)/
(Tw+θ0))*fθn0);
     Ψu0=Γna0*(ρ-g+λ+fθu0)/(ρ-g+λ+   Γna0*fθu0);
     y0 = A*((1-m)^(1/σ) *(Ak*k0)^((σ-1)/σ) + ((exp(α*(σ-1)*m)-1)/(α*(σ-1)))^(1/
σ))^(σ/(σ-1))
     b = b_y*y0
     ∂yk0= (Ak*A)^((σ-1)/σ)*(y0/k0)^(1/σ) * (1-m)^(1/σ)
     ∂yL0 = y0 - k0*∂yk0
     yu0=A*((1-m)^(1/σ) *(Ak*ku0)^((σ-1)/σ) + ((exp(α*(σ-1)*m)-1)/(α*(σ-1)))^(1/
σ))^(σ/(σ-1))
     yn0=A*((1-m)^(1/σ) *(Ak*kn0)^((σ-1)/σ) + ((exp(α*(σ-1)*m)-1)/(α*(σ-1)))^(1/
σ))^(σ/(σ-1))
     ∂yku0 = (Ak*A)^((σ-1)/σ)*(yu0/ku0)^(1/σ) * (1-m)^(1/σ)
     ∂ykn0 = (Ak*A)^((σ-1)/σ)*(yn0/kn0)^(1/σ) * (1-m)^(1/σ)
     ∂yLu0 = yu0 - ku0*∂yku0
     ∂yLn0 = yn0 - kn0*∂ykn0
     wu0=∂yLu0- ξ*(ρ-g+λ)/qθu0
     wn0=∂yLn0- ξ*(ρ-g+λ)/qθn0
     w0=∂yL0- ξ*(ρ-g+λ)/qθ0
     μu0=(∂yLu0/wu0)-1
     μn0=(∂yLn0/wn0)-1
     μ0=(∂yL0/w0)-1
     return [w0,wu0,wn0,k0,ku0,kn0,μ0,θ0,θu0,θn0,fθ0,qθ0,fθu0,
     qθu0,fθn0,qθn0,L0,Lu0,Ln0,Γna0,Γnb0,Ψna0,Ψnb0,Ψ0,y0,∂yL0,
     ∂yk0,yu0,∂yLu0,yn0,∂yLn0,∂ykn0,∂yku0,μu0,μn0, Ψu0,UAL,g,λ,b]
     end

     lbt=[0.15,0.26,0.05,0.0,0.0,0.0,0,0,0.0005,0,0,0,0,0,0,0,0,0.35,
     0.0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0.0,0,-1,-0.2,0,0] # lower bounds
     # upper bounds
```

```
    ubt=[50,50,50,50,50,50,50,50,50,50,
    1,1,1,1.0001,1,1,6.5,1,1,1,1,1,1,1,
    10,10,10,10,10,10,10,10,10,10,10.0,1,0.1,0.1,0.1,1]

## Calibrate steady-state values assuming you know the NRU
function inverse_calibration(Pr,m,b_y,L,Ṁ,γf,λ0)
    x0=init_v(m,α,σ,λ0,ι,ρ,ṁ,Ṁ,γf,b_y,ξ,δ,1.5,Pr,A,Ak)
    x0[17]=1.75  # this is just an initial guess
                             rlb       =       nlboxsolve((FF,x)       ->sys2!
(FF,x,m,α,σ,λ0,ι,ρ,ṁ,Ṁ,γf,b_y,ξ,δ,L,Pr,A,Ak,φ),
  x0,lbt,ubt,xtol=1e-4,ftol=1e-4)
  sol =rlb.zero
 # aggregate wage; capital; rate of exploitation; labor-market tightness;
 # rel. mobility of labor; output; worker power
   w=sol[1];   k=sol[4];μ   =   sol[7];θ=   sol[8];Tw   =sol[17];y   =sol[25];Ψn
=sol[24];b=sol[40]
    return [w;k;μ;θ;Tw;y;Ψn;b]
end
L_NRU=0.01*(-NRU.+100) # natural rate of unemployment
results_5H=zeros(8,46)
## Hypothesis: Changes in labor institutions  and technical change with NRU given
for i=1:46
 results_5H[:,i]=inverse_calibration(unions_HP[i+15],mM̂2[i],bcho_HP[i+15],
 L_NRU[i+15],Ṁs[i+15],γf,λ0)
end
# Results
Ωs5H=results_5H[1,:]./results_5H[6,:] # Labor share
kys5H= results_5H[2,:]./results_5H[6,:] * (1/φ) # capital-output
Vs5H = results_5H[4,:].*NRU[16:end]./100 # vacancy rate
tsw5H = results_5H[5,:]                 # Threat of competition
μs5H = results_5H[3,:]                  # markup
r5H = (μs5H./(μs5H.+1))./kys5H          # rate of profit
Ψn5H = results_5H[7,:]                  # Worker power
θ5sH = results_5H[4,:];                 # labor market tightness
```

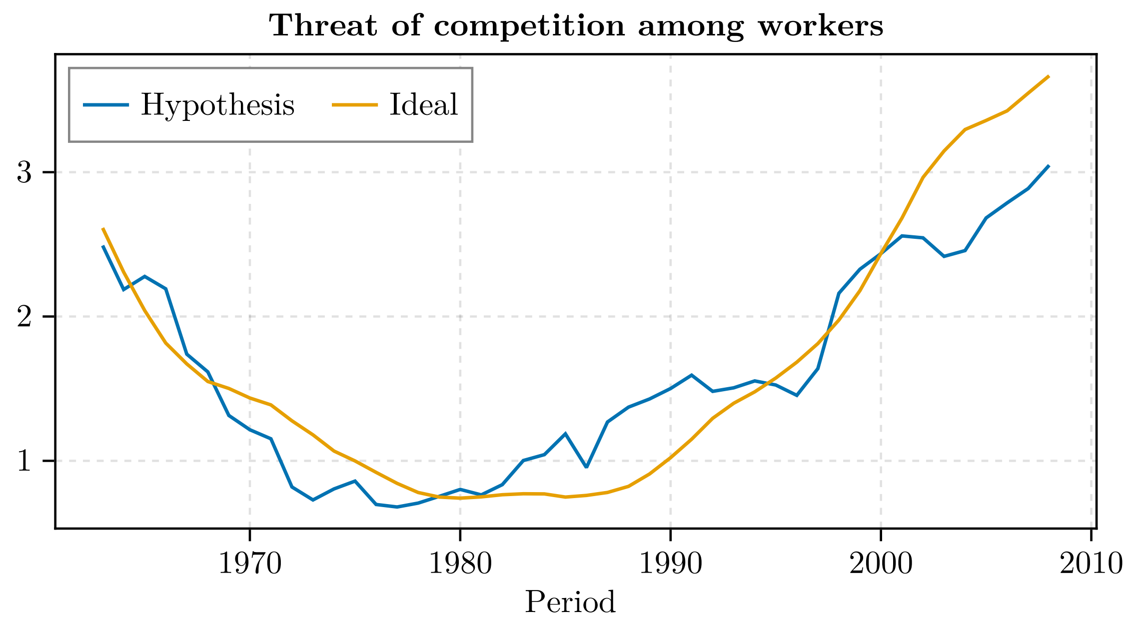
2.5.a Threat of Competition Among Workers

Given the ``ideal'' value of the threat of competition among workers obtained above, I now check the hypothesis that the threat of competition is largely determined by what I referred to as the allowed for by civil society.

```
# Unlike the previous hypotheses, the rate of unemployment is determined by the
model and Tw is an exogenous parameter
function sys2d!(FF,x,m,α,σ,λ0,ι,ρ,ṁ,Ṁ,γf,b_y,ξ,δ,Tw,Pr,A,Ak,φ)
    w=x[1]; wu=x[2]; wn=x[3];  k=x[4]; ku=x[5]; kn=x[6];
    μ=x[7]; θ = x[8]; θu = x[9]; θn = x[10]; fθ = x[11]; qθ = x[12];
    fθu = x[13]; qθu = x[14]; fθn= x[15]; qθn = x[16]; L = x[17];
    Lu=x[18]; Ln=x[19]; Γna = x[20]; Γnb = x[21]; Ψna = x[22];
```

```
    Ψnb=x[23] ; Ψn = x[24]; y = x[25]; ∂yL = x[26]; ∂yk = x[27];
    yu = x[28]; ∂yLu=x[29]; yn =x[30]; ∂yLn=x[31]; ∂ykn=x[32];∂yku=x[33];
     μu = x[34]; μn = x[35]; Ψu = x[36]; UAL = x[37]; g = x[38]; λ = x[39];
b=x[40]
    FF[1] = qθ - (1+θ^(ι))^(-1/ι)
    FF[2] = fθ - qθ*θ
    FF[3] = L - fθ/(λ+fθ)
    FF[4] = qθu - (1+θu^(ι))^(-1/ι)
    FF[5] = fθu - qθu*θu
    FF[6] = Lu - fθu/(λ+fθu)
    FF[7] = qθn - (1+θn^(ι))^(-1/ι)
    FF[8] = fθn - qθn*θn
   FF[9] = UAL-(1-exp(α*(σ-1)*(Ṁ-ṁ))*(exp(α*(σ-1)*(m+ṁ))-1)/(exp(α*(σ-1)*m)-1))
    FF[10] = λ - λ0 - UAL
    FF[11] = g - α*Ṁ
    FF[12] = Ln- fθn/(λ+fθn)
    FF[13] = Γna - γf/(1+γf)
    FF[14] = Γnb-γf*(1-qθn)/(1+γf+qθn*(1-γf))
    FF[15] = Ψna - Γna*(ρ-g+λ+fθn)/(ρ-g+λ+  Γna*fθn)
    FF[16] = Ψnb - Γnb*(ρ-g+λ+fθn)/(ρ-g+λ+  Γnb*fθn)
       FF[17]  =  Ψn  -  ((Tw*Γnb  +θn*Γna)/(θn+Tw))*(ρ-g+λ+fθn)/(ρ-g+λ+((Tw*Γnb
+θn*Γna)/(θn+Tw))*fθn)
    FF[18] = Ψu - Γna*(ρ-g+λ+fθu)/(ρ-g+λ+   Γna*fθu)
       FF[19]  =  y  -A*((1-m)^(1/σ)  *(Ak*k)^((σ-1)/σ)  +  ((exp(α*(σ-1)*m)-1)/
(α*(σ-1)))^(1/σ))^(σ/(σ-1))
    FF[20] = ∂yk - (Ak*A)^((σ-1)/σ)*(y/k)^(1/σ) * (1-m)^(1/σ)
    FF[21] = ∂yL - (y - k*∂yk)
      FF[22]  =  yu  -  A*((1-m)^(1/σ)  *(Ak*ku)^((σ-1)/σ)  +  ((exp(α*(σ-1)*m)-1)/
(α*(σ-1)))^(1/σ))^(σ/(σ-1))
    FF[23] = ∂yku - (A*Ak)^((σ-1)/σ)*(yu/ku)^(1/σ) * (1-m)^(1/σ)
    FF[24] = ∂yLu - (yu - ku*∂yku)
      FF[25]  =  yn  -  A*((1-m)^(1/σ)  *(Ak*kn)^((σ-1)/σ)  +  ((exp(α*(σ-1)*m)-1)/
(α*(σ-1)))^(1/σ))^(σ/(σ-1))
    FF[26] = ∂ykn - (A*Ak)^((σ-1)/σ)*(yn/kn)^(1/σ) * (1-m)^(1/σ)
    FF[27] = ∂yLn -(yn - kn*∂ykn)
    FF[28] = wn -( b + Ψn*(∂yLn-b))
    FF[29] = wn -( ∂yLn- ξ*(ρ-g+λ)/qθn)
    FF[30] = wu -( b + Ψu*(∂yLu-b + (ρ-g+λ)/(ρ-g) *(yu-∂yLu)))
    FF[31] = wu -( ∂yLu- ξ*(ρ-g+λ)/qθu )
    FF[32] = w -(Pr*wu + (1-Pr)*wn)
    FF[33] = w -(∂yL- ξ*(ρ-g+λ)/qθ)
    FF[34] = μ -((∂yL/w)-1)
    FF[35] = ∂yk - δ*(1+μ)/φ
    FF[36] = μn -((∂yLn/wn)-1)
    FF[37] = μu - ((∂yLu/wu)-1)
    FF[38] = ∂yku - δ*(1+μu)/φ
    FF[39] = ∂ykn - δ*(1+μn)/φ
    FF[40] = b - b_y*y
```

```
end
# lower bounds
lbd=[0.15,0.26,0.05,0.0,0.0,0.0,0,0,0.005,0,0,0,0,0,0,0,0,0.0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0.0,0,-λ0,-0.2,0,0]
# upper bounds
ubd=[50,50,50,50,50,50,50,50,50,50,
1,1,1,1.0001,1,1,1,1,1,1,1,1,1,1,
10,10,10,10,10,10,10,10,10,10,10.0,1,0.1,0.1,0.1,1]

function inverse_calibrationd(Pr,m,b_y,Tw,Ṁ,γf,λ0,φ)
x0d=init_v(m,α,σ,λ0,ι,ρ,ṁ,Ṁ,γf,b_y,ξ,δ,Tw,Pr,A,Ak)
rlb                =                nlboxsolve((FF,x)                ->sys2d!
(FF,x,m,α,σ,λ0,ι,ρ,ṁ,Ṁ,γf,b_y,ξ,δ,Tw,Pr,A,Ak,φ),
x0d,lbd,ubd,xtol=1e-4,ftol=1e-4)
sol =rlb.zero
w=sol[1]; k=sol[4];μ = sol[7]; θ= sol[8]; L = sol[17]; y = sol[25]; Ψn = sol[24];
b=sol[40]
return [w;k;μ;θ;L;y;Ψn;b]
end
# Estimate equation (25)
X_tw=[ones(46) log.(((poor_welfare[1:end-1]))) log.(yl[15:end-1])]
β_tw=inv(X_tw'X_tw)*(X_tw'log.(tsw5H))
tsw_indiriect=X_tw*β_tw# sol[1].*cdf(Normal(0,1), X_tw*β̂_b)

with_theme(theme_latexfonts()) do
    f = Figure(size = (500, 300))
    ax = Axis(f[1, 1],
        xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
        title = "Threat of competition among workers",
    )
    lines!(ax,time_annual[16:end],exp.(tsw_indiriect), label = "Hypothesis")
    lines!(ax, time_annual[16:end],tsw5H, label = "Ideal")
    axislegend(; position = :lt, nbanks = 2, framecolor = (:grey, 0.95))
    f
    end
```

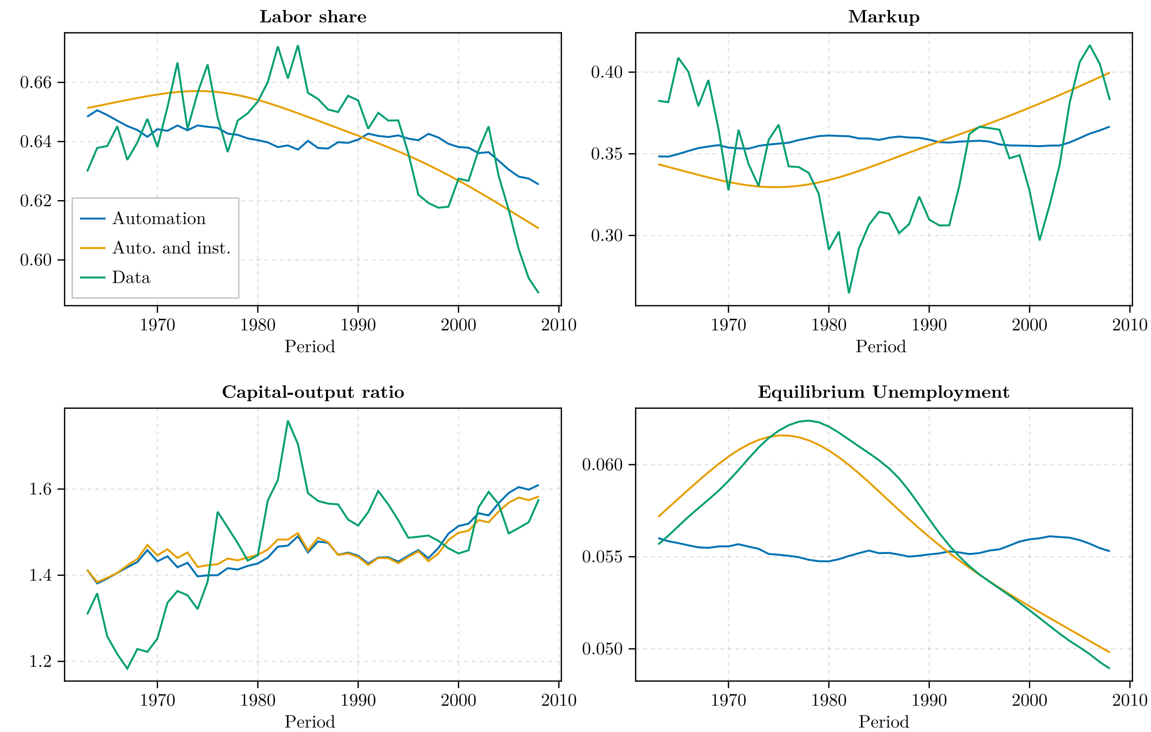


2.5.b Calibration Details and Results

With this result, I now present the code generating the results of the automation and institutions and automation hypotheses in the main text.

```
# Automation alone: Task-displacing and labor-augmenting technical change
results_1dH=zeros(8,46)
for i=1:46
    results_1dH[:,i]=inverse_calibrationd(mean(unions_HP[16:end]),mM̂2[i],
    mean(bcho_HP[16:end]),mean(tsw5H),Ṁs[i+15],γf,λ0,φ)
end
# Automation and labor augmneting technical change
ΩsdH=results_1dH[1,:]./results_1dH[6,:]
kysdH= results_1dH[2,:]./results_1dH[6,:] * (1/φ)
VsdH = results_1dH[4,:].*(-results_1dH[5,:].+1)
UsdH = -results_1dH[5,:].+1
μsdH = results_1dH[3,:]
θsdH= results_1dH[4,:]
rsdH = (12*μsdH./(μsdH.+1))./kysdH
ΨndH= results_1dH[7,:];

results_2dH=zeros(8,46)
# Institutions and automation
for i=1:46
   results_2dH[:,i]=inverse_calibrationd(unions[i+15],mM̂2[i],b_chodorow[i+15],
    exp.(tsw_indiriect)[i],Ṁs[i+15],γf,λ0,φ)
end
```

```
Ωsd2H=results_2dH[1,:]./results_2dH[6,:]
kysd2H= results_2dH[2,:]./results_2dH[6,:] * (1/φ)
Vsd2H = results_2dH[4,:].*(-results_2dH[5,:].+1)
Usd2H = -results_2dH[5,:].+1
μsd2H = results_2dH[3,:]
θsd2H= results_2dH[4,:]
rsd2H = (12*μsd2H./(μsd2H.+1))./kysd2H
Ψnd2H= results_2dH[7,:];

# Graphs

with_theme(theme_latexfonts()) do
    f = Figure(size = (900, 600))
    ax = Axis(f[1, 1],
        xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
        title = "Labor share",
    )
    lines!(ax, time_annual[16:end], ΩsdH, label="Automation")
       lines!(ax, time_annual[16:end], HP(Ωsd2H,1000), label="Auto. and inst.")
          lines!(ax, time_annual[16:end], w_share[16:end-10], label="Data")
           axislegend(; position = :lb, nbanks = 1, framecolor = (:gray, 0.5))
    ax = Axis(f[1, 2],
    xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
    title = "Markup",
)
 lines!(ax, time_annual[16:end], μsdH)
       lines!(ax, time_annual[16:end], HP(μsd2H,1000))
          lines!(ax, time_annual[16:end], μ_data[17:end-8])
  ax = Axis(f[2, 1],
  xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
  title = "Capital-output ratio",
)
lines!(ax, time_annual[16:end], kysdH./12)
       lines!(ax, time_annual[16:end], kysd2H./12)
          lines!(ax, time_annual[16:end],KY[16:end-9])
ax = Axis(f[2, 2],
xlabel = "Period",xgridstyle = :dash, ygridstyle = :dash,
title = "Equilibrium Unemployment",
)
 lines!(ax, time_annual[16:end], UsdH)
       lines!(ax, time_annual[16:end], HP(Usd2H,1000))
          lines!(ax, time_annual[16:end], NRU[16:end]./100)
    f
    end
```



3 Robustness Results

In this section, I use the 90th percentile data in Hémous, Olsen, Zanella, & Dechezleprêtre (2025), the automation measure in Mann & Püttmann (2023), and different measures of welfare policy as alternatives to the automation and institutions hypothesis in the main text. Here, I only contrast the baseline results with the alternatives explored below.

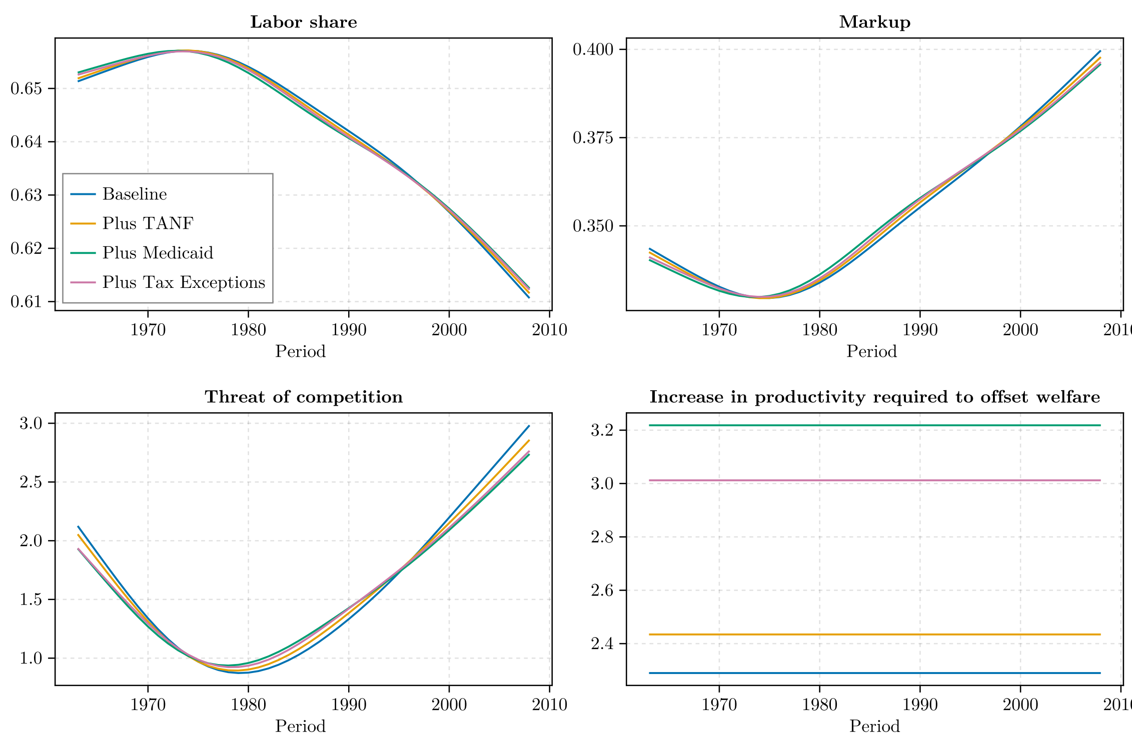
3.1 Alternative Measures of Welfare

The following graph compares the baseline results of the main paper with the different alternatives of welfare. The key results of the paper remain unchanged. The only critical variation is that —as expected—the increase in productivity required to offset the effect of welfare on labor supply is lower in the baseline measure. This result is reasonable because the baseline measure only computes welfare assistance that primarily targets the poor, making it easier to induce people to work when there is less help available to lift them out of poverty.

```
# Instead of using
poor_measures
function
alternative_measures(unions,mM̂2,b_chodorow,poor_measure,yl,Ṁs,γf,λ0,φ,tsw)
X_tw=[ones(46) log.(((poor_measure[1:end-1]))) log.(yl[15:end-1])]
β_tw=inv(X_tw'X_tw)*(X_tw'log.(tsw))
tsw_indiriect=X_tw*β_tw
results_alt=zeros(8,46)
```

```
# Institutions and automation
for i=1:46
   results_alt[:,i]=inverse_calibrationd(unions[i+15],mM̂2[i],b_chodorow[i+15],
    exp.(tsw_indiriect)[i],Ṁs[i+15],γf,λ0,φ)
end
Ω=results_alt[1,:]./results_alt[6,:]
ky= (results_alt[2,:]./results_alt[6,:] * (1/φ))./12
V = results_alt[4,:].*(-results_alt[5,:].+1)
U = -results_alt[5,:].+1
μ = results_alt[3,:]
θ= results_alt[4,:]

return Ω,μ,ky,U,exp.(tsw_indiriect),β_tw[3]/β_tw[2]
end



sol_plus_TANF=alternative_measures(unions,mM̂2,b_chodorow,poor_measures[:,2],
yl,Ṁs,γf,λ0,φ,tsw5H)
sol_plus_Medicaid=alternative_measures(unions,mM̂2,b_chodorow,poor_measures[:,3],
yl,Ṁs,γf,λ0,φ,tsw5H)
sol_plus_tax=alternative_measures(unions,mM̂2,b_chodorow,poor_measures[:,4],
yl,Ṁs,γf,λ0,φ,tsw5H);

with_theme(theme_latexfonts()) do
    f = Figure(size = (900, 600))
    ax = Axis(f[1, 1],
        xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
        title = "Labor share",
    )
       lines!(ax, time_annual[16:end], HP(Ωsd2H,1000), label="Baseline")
         lines!(ax, time_annual[16:end], HP(sol_plus_TANF[1],1000), label="Plus
TANF")
                lines!(ax,  time_annual[16:end],  HP(sol_plus_Medicaid[1],1000),
label="Plus Medicaid")
          lines!(ax, time_annual[16:end], HP(sol_plus_tax[1],1000), label="Plus
Tax Exceptions")
           axislegend(; position = :lb, nbanks = 1, framecolor = (:grey, 0.95))
    ax = Axis(f[1, 2],
    xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
    title = "Markup",
)
       lines!(ax, time_annual[16:end], HP(μsd2H,1000))
         lines!(ax, time_annual[16:end], HP(sol_plus_TANF[2],1000), label="Plus
TANF")
                lines!(ax,  time_annual[16:end],  HP(sol_plus_Medicaid[2],1000),
label="Plus Medicaid")
          lines!(ax, time_annual[16:end], HP(sol_plus_tax[2],1000), label="Plus
Tax Exceptions")
```

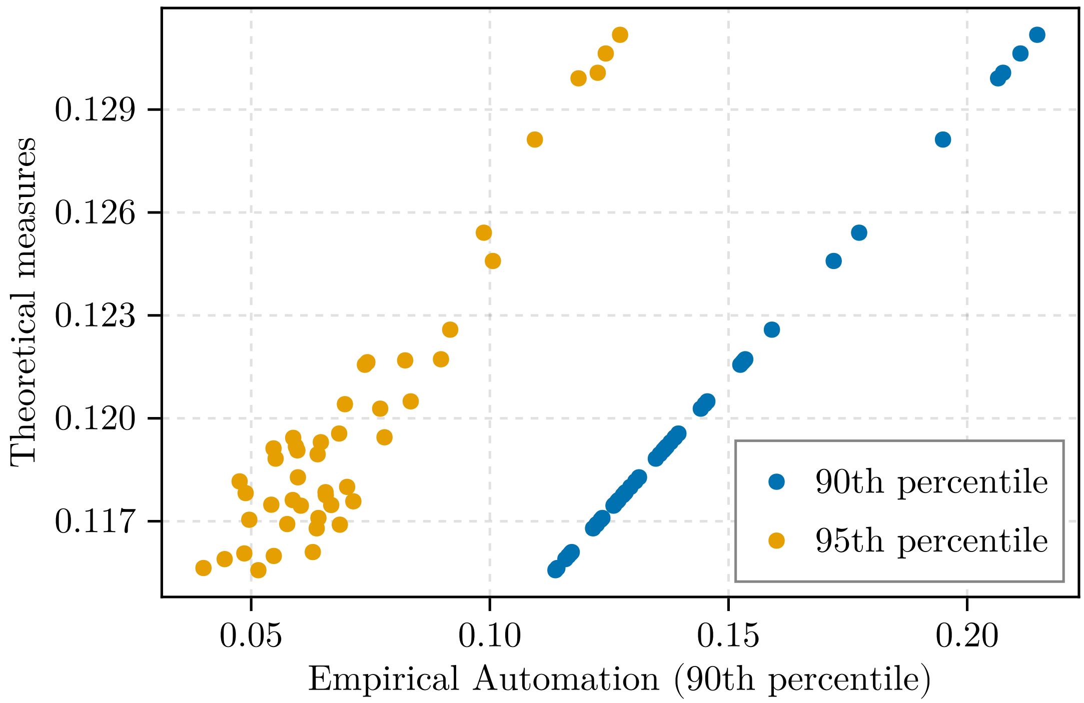
```
  ax = Axis(f[2, 1],
  xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
  title = "Threat of competition",
)
       lines!(ax, time_annual[16:end], HP(exp.(tsw_indiriect),1000))
         lines!(ax, time_annual[16:end], HP(sol_plus_TANF[5],1000), label="Plus
TANF")
                lines!(ax,  time_annual[16:end],  HP(sol_plus_Medicaid[5],1000),
label="Plus Medicaid")
          lines!(ax, time_annual[16:end], HP(sol_plus_tax[5],1000), label="Plus
Tax Exceptions")
ax = Axis(f[2, 2],
xlabel = "Period",xgridstyle = :dash, ygridstyle = :dash,
title = "Increase in productivity required to offset welfare",
)
       lines!(ax, time_annual[16:end], -ones(46).*(β_tw[3]/β_tw[2]))
                  lines!(ax,  time_annual[16:end],  -ones(46).*sol_plus_TANF[6],
label="Plus TANF")
             lines!(ax,  time_annual[16:end],   -ones(46).*sol_plus_Medicaid[6],
label="Plus Medicaid")
         lines!(ax, time_annual[16:end], -ones(46).*sol_plus_tax[6],label="Plus
Tax Exceptions")
    f
    end
```



3.2 90th percentile automation data in Hémous, Olsen, Zanella, & Dechezleprêtre (2025)

The following plot repeats the same code of the main text, replacing the automation measure using the 95th percentile for the 90th percentile measure in Hémous, Olsen, Zanella, & Dechezleprêtre (2025). The code and results are depicted in the following graph.

```
merged_ctry=CSV.read("/Users/juanjacobo/Documents/Documents/
JSCED_submission_2024/Code/automation_hemous90.csv", DataFrame)
## Automation from Hemous 2025. Auto95 US
Mech90=merged_ctry.Auto95_USA # data  1963:2015
Xmech=[ones(46) Mech90[1:end-7]]
M̂90 = Xmech*(inv(Xmech'Xmech)*(Xmech'mm[16:end-9]))
mM̂90=-M̂90.+1;
f = with_theme(theme_latexfonts()) do
    fig = Figure(size = (450, 300))
    ax = Axis(fig[1, 1],
        xlabel = "Empirical Automation (90th percentile)",
        xgridstyle = :dash,
        ygridstyle = :dash,
        ylabel = "Theoretical measures"
    )
    scatter!(ax, Mech90[1:end-7], M̂90, label="90th percentile")
    scatter!(ax, Mech[1:end-7], M̂90, label="95th percentile")
    axislegend(; position = :rb, nbanks = 1, framecolor = (:grey, 0.95))
    fig  # <-- return the figure explicitly!
end
display(f)
```

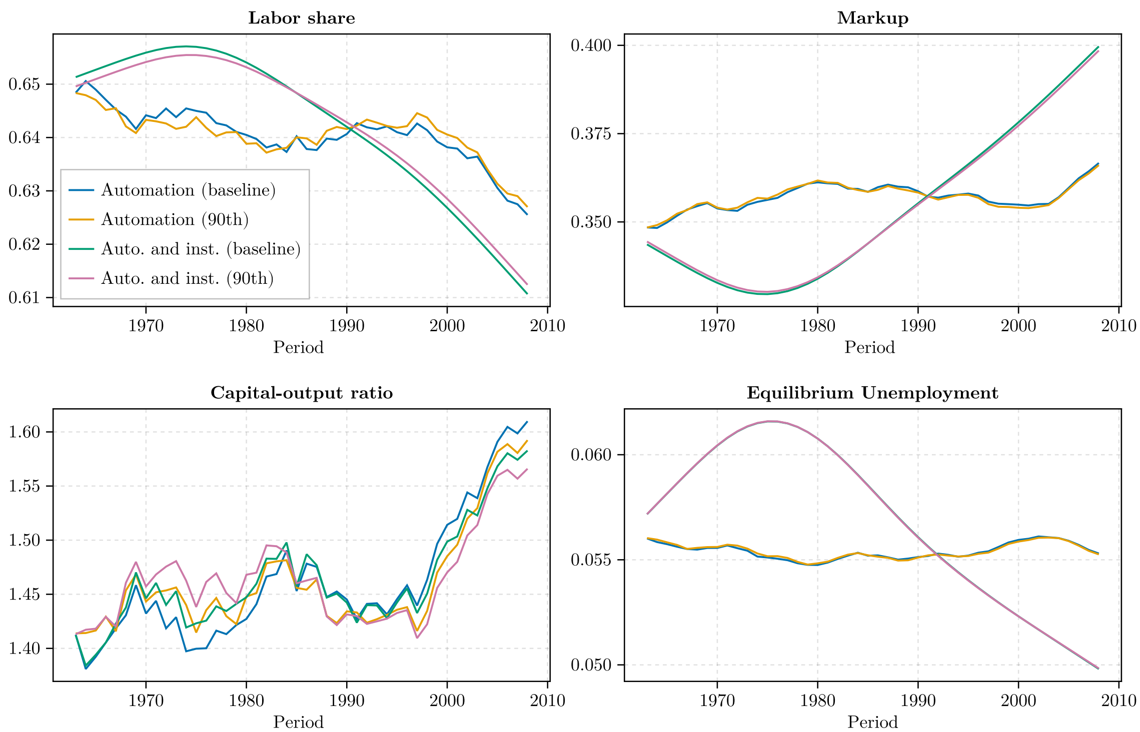



```
CairoMakie.Screen{IMAGE}
```

```
# Step 1: Estimate ideal Tw with new measure of automation
results_H90=zeros(8,46)
## Hypothesis: Changes in labor institutions  and technical change with NRU given
for i=1:46
 results_H90[:,i]=inverse_calibration(unions_HP[i+15],mM̂90[i],bcho_HP[i+15],
 L_NRU[i+15],Ṁs[i+15],γf,λ0)
end
# Results
ΩsH90=results_H90[1,:]./results_H90[6,:] # Labor share
kysH90= results_H90[2,:]./results_H90[6,:] * (1/φ) # capital-output
tswH90 = results_H90[5,:]                # Threat of competition
μsH90 = results_H90[3,:]                 # markup

# Steap 2: Use OLS estimators of welfare policy
# Estimate equation (25)
X_tw90=[ones(46) log.(((poor_welfare[1:end-1]))) log.(yl[15:end-1])]
β_tw90=inv(X_tw'X_tw)*(X_tw'log.(tswH90))
tsw_indiriect90=X_tw90*β_tw90


# Automation alone: Task-displacing and labor-augmenting technical change
```

```
results_1dH90=zeros(8,46)
for i=1:46
    results_1dH90[:,i]=inverse_calibrationd(mean(unions_HP[16:end]),mM̂90[i],
    mean(bcho_HP[16:end]),mean(tswH90),Ṁs[i+15],γf,λ0,φ)
end
# Automation and labor augmneting technical change
ΩsdH90=results_1dH90[1,:]./results_1dH90[6,:]
kysdH90= results_1dH90[2,:]./results_1dH90[6,:] * (1/φ)
UsdH90 = -results_1dH90[5,:].+1
μsdH90 = results_1dH90[3,:]

results_2dH90=zeros(8,46)
# Institutions and automation
for i=1:46

results_2dH90[:,i]=inverse_calibrationd(unions[i+15],mM̂90[i],b_chodorow[i+15],
    exp.(tsw_indiriect90)[i],Ṁs[i+15],γf,λ0,φ)
end
Ωsd2H90=results_2dH90[1,:]./results_2dH90[6,:]
kysd2H90= results_2dH90[2,:]./results_2dH90[6,:] * (1/φ)
Usd2H90 = -results_2dH90[5,:].+1
μsd2H90 = results_2dH90[3,:]

# Graphs

with_theme(theme_latexfonts()) do
    f = Figure(size = (900, 600))
    ax = Axis(f[1, 1],
        xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
        title = "Labor share",
    )
    lines!(ax, time_annual[16:end], ΩsdH, label="Automation (baseline)")
          lines!(ax, time_annual[16:end], ΩsdH90, label="Automation (90th)")
        lines!(ax, time_annual[16:end], HP(Ωsd2H,1000), label="Auto. and inst.
(baseline)")
       lines!(ax, time_annual[16:end], HP(Ωsd2H90,1000), label="Auto. and inst.
(90th)")
           axislegend(; position = :lb, nbanks = 1, framecolor = (:gray, 0.5))
    ax = Axis(f[1, 2],
    xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
    title = "Markup",
)
 lines!(ax, time_annual[16:end], μsdH, label="Automation (baseline)")
          lines!(ax, time_annual[16:end], μsdH90, label="Automation (90th)")
        lines!(ax, time_annual[16:end], HP(μsd2H,1000), label="Auto. and inst.
(90th)")
       lines!(ax, time_annual[16:end], HP(μsd2H90,1000), label="Auto. and inst.
(90th)")
```

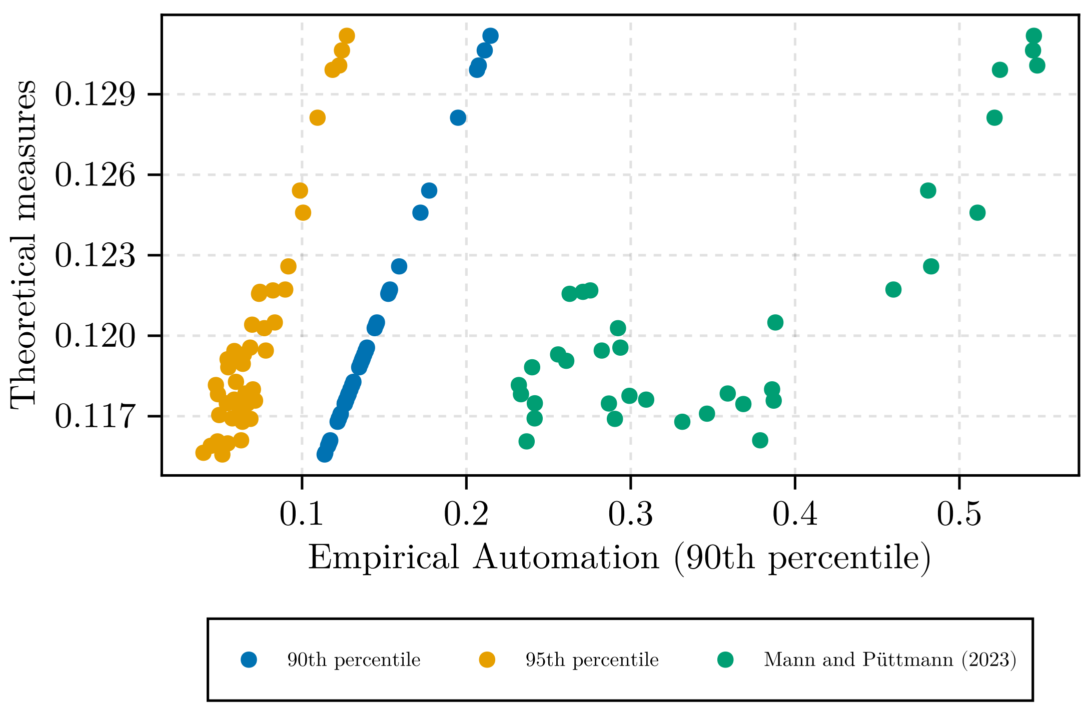
```
  ax = Axis(f[2, 1],
  xlabel = "Period ",xgridstyle = :dash, ygridstyle = :dash,
  title = "Capital-output ratio",
)
lines!(ax, time_annual[16:end], kysdH./12)
lines!(ax, time_annual[16:end], kysdH90./12)
       lines!(ax, time_annual[16:end], kysd2H./12)
           lines!(ax, time_annual[16:end], kysd2H90./12)
ax = Axis(f[2, 2],
xlabel = "Period",xgridstyle = :dash, ygridstyle = :dash,
title = "Equilibrium Unemployment",
)
 lines!(ax, time_annual[16:end], UsdH)
  lines!(ax, time_annual[16:end], UsdH90)
       lines!(ax, time_annual[16:end], HP(Usd2H,1000))
         lines!(ax, time_annual[16:end], HP(Usd2H90,1000))
    f
    end
```



3.3 Automation data in Mann & Püttmann (2023)

I complete the Online Appendix with the data of the automation measure in Mann & Püttmann (2023). The results in the figure below show that all automation variables are strongly correlated, though the measure in Mann & Püttmann (2023) has a smaller slope, meaning that automation in this case will be less significant than before.

```
MechMann=automation_mann # data  1974-2008
Xmech=[ones(35) MechMann]
M̂Mann = Xmech*(inv(Xmech'Xmech)*(Xmech'mm[27:end-9]))
mM̂Mann=-M̂Mann.+1;
M̂90[11:end]
f = with_theme(theme_latexfonts()) do
    fig = Figure(size = (450, 300))
    ax = Axis(fig[1, 1],
        xlabel = "Empirical Automation (90th percentile)",
        xgridstyle = :dash,
        ygridstyle = :dash,
        ylabel = "Theoretical measures"
    )
    scatter!(ax, Mech90[1:end-7], M̂90, label="90th percentile")
    scatter!(ax, Mech[1:end-7], M̂90, label="95th percentile")
        scatter!(ax, MechMann, M̂90[12:end], label="Mann and Püttmann (2023)")
        Legend(fig[2, 1], ax; orientation = :horizontal,labelsize = 8)
    fig  # <-- return the figure explicitly!
end
display(f)
```



```
CairoMakie.Screen{IMAGE}
```

Bibliography

Basu, D., & Foley, D. K. (2013). Dynamics of output and employment in the US economy. *Cambridge Journal of Economics*, *37*(5), 1077–1106. https://doi.org/https://doi.org/10.1093/cje/bes088

Eldridge, L. P., Garner, C., Howells, T. F., Moyer, B. C., Russell, M., Samuels, J. D., Strassner, E. H., & Wasshausen, D. B. (2020). Toward a bea-bls integrated industry-level production account for 1947–2016. In *Measuring Economic Growth and Productivity* (pp. 221–249). Elsevier. https://doi.org/10.1016/B978-0-12-817596-5.00011-1

Hémous, D., Olsen, M., Zanella, C., & Dechezleprêtre, A. (2025). Induced Automation Innovation: Evidence from Firm-level Patent Data. *Journal of Political Economy*, *113*(6), 1975–2028. https://doi.org/https://doi.org/10.1086/734778

Mann, K., & Püttmann, L. (2023). Benign effects of automation: New evidence from patent texts. *Review of Economics and Statistics*, *105*(3), 562–579. https://doi.org/https://doi.org/0.1162/rest_a_01083

Moffitt, R. A. (2015). The deserving poor, the family, and the US welfare system. *Demography*, *52*(3), 729–749.

Noble, C. (1997). *Welfare as we knew it: A political history of the American welfare state*. Oxford University Press.

Parolin, Z., Desmond, M., & Wimer, C. (2023). Inequality below the poverty line since 1967: The role of the US welfare state. *American Sociological Review*, *88*(5), 782–809.