Distributional aspects of rent seeking activities in a DSGE setup

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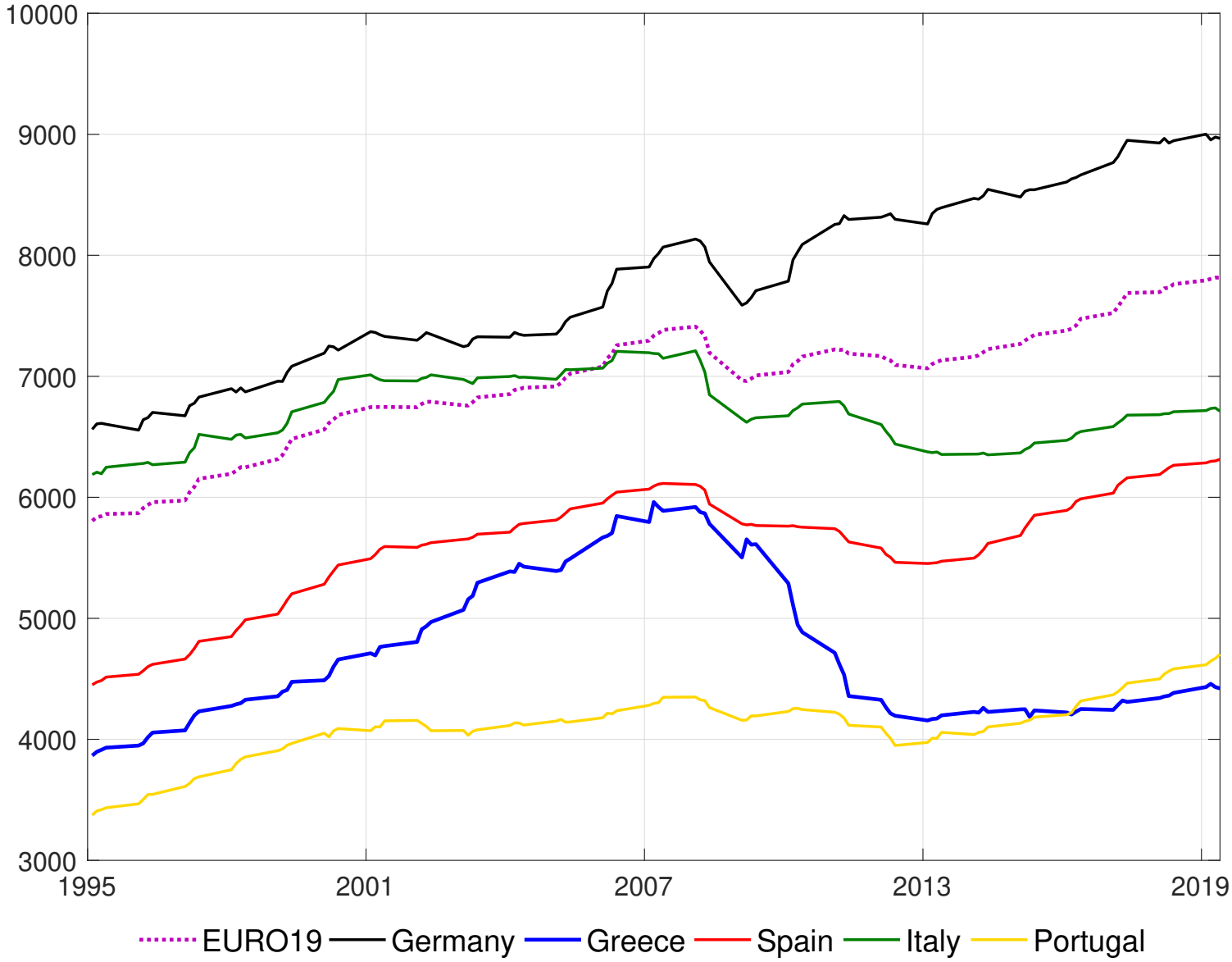
Outline

1. Data and motivation
2. Literature and research questions
3. Modeling rent seeking behavior in a simple RBC model with heterogeneous agents
   - Wedges
   - Parameterization and long-run solution
   - Second moment properties and impulse response functions
   - Conclusion

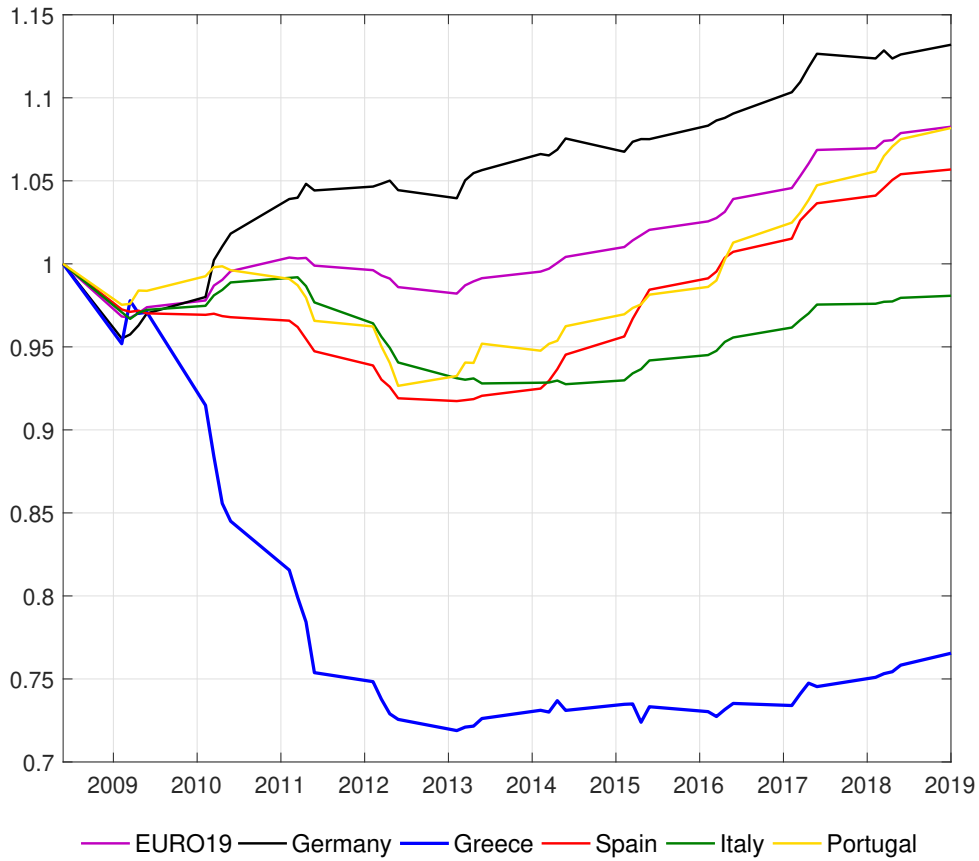
Data: Real per capita GDP (quarterly), Eurostat



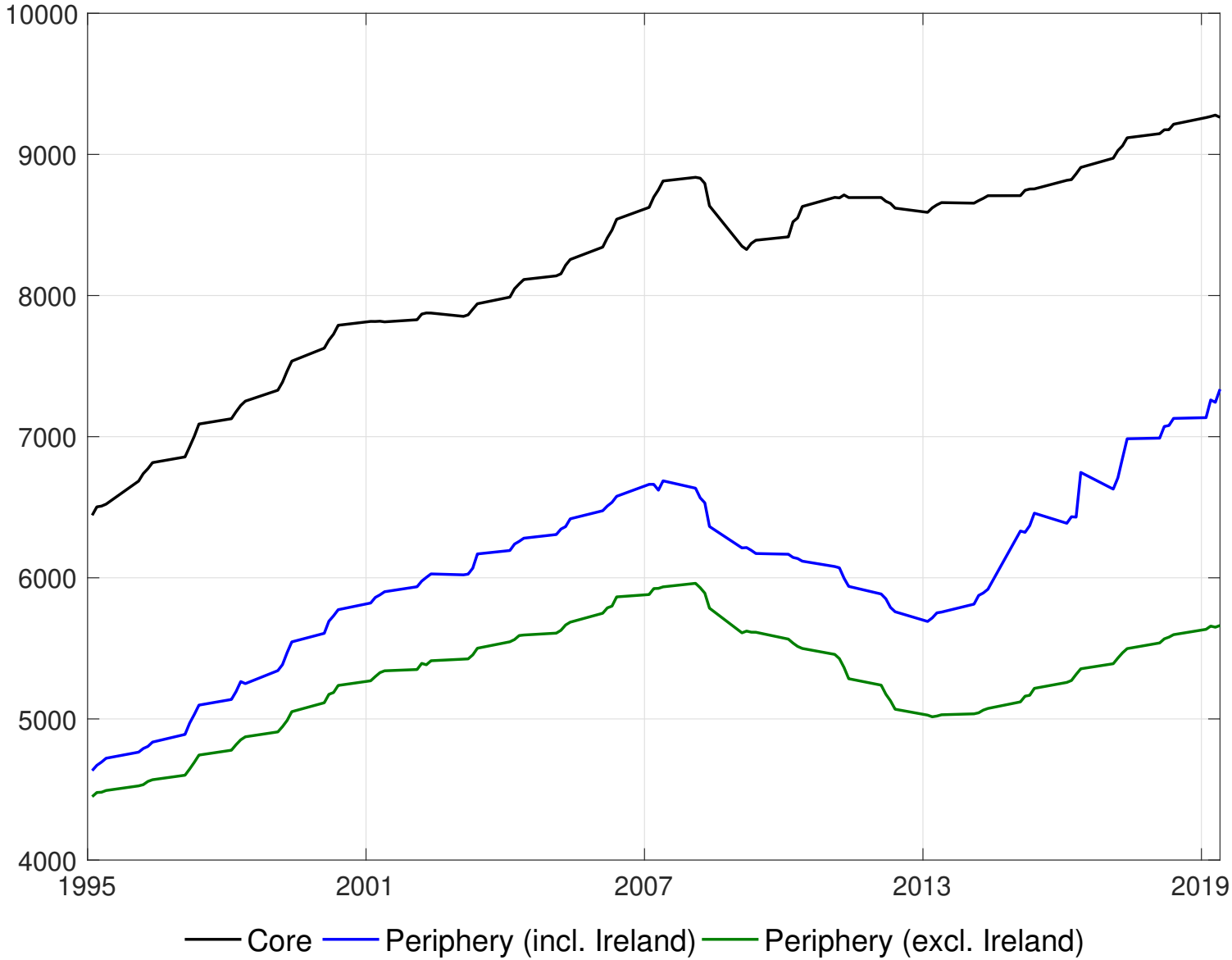
Data: Post-crisis to pre-crisis GDP ratio, $y \equiv \frac{GDP_{2008+i}}{GDP_{2008}}$

All countries apart from Germany are characterized by slow recovery with Greece experiencing the most persistent and sustained effects of the crisis.

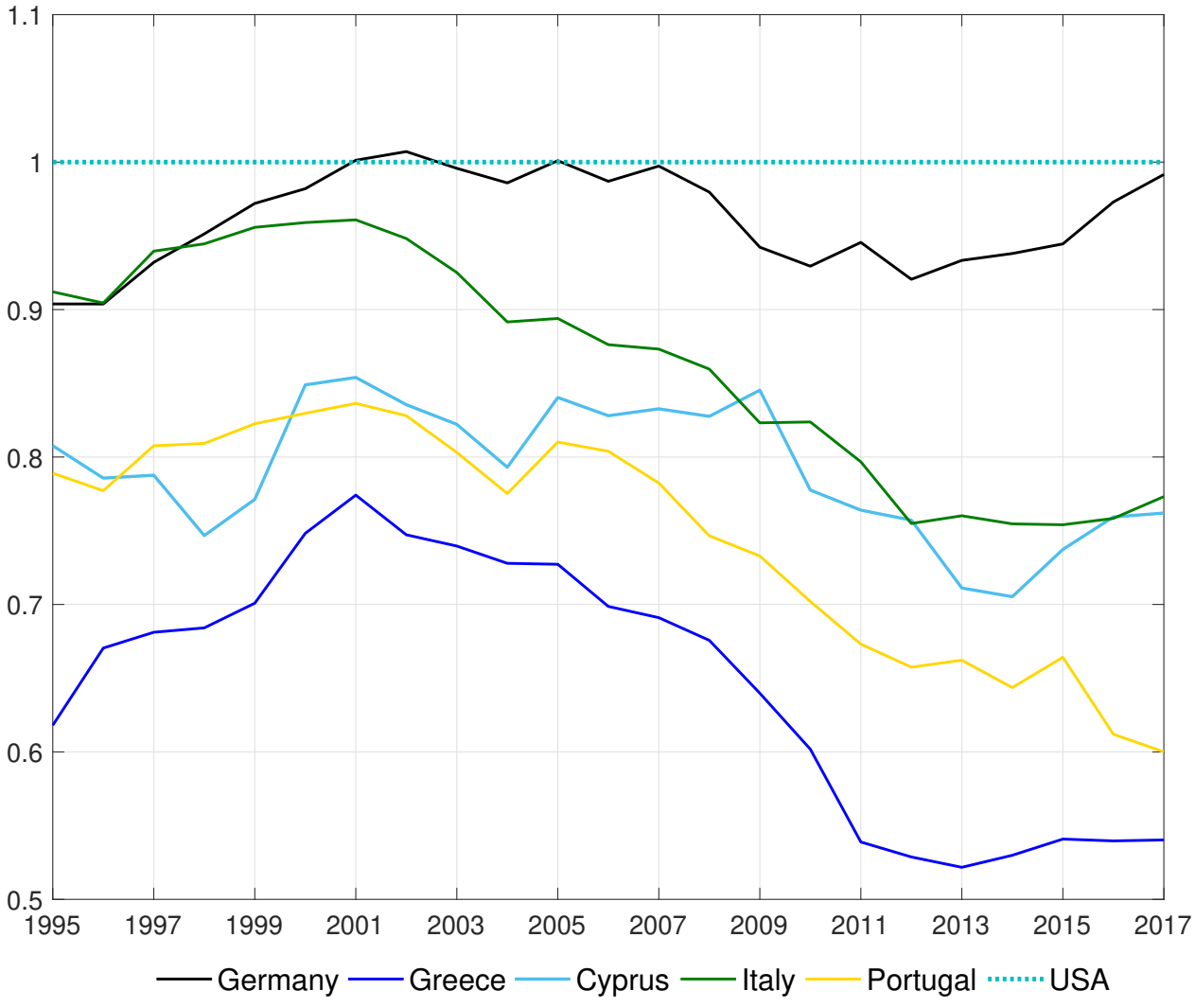
Depth of the crisis index: the minimum point of this ratio for each country. This provides an indication on how deep was the effect of the crisis on real per capita GDP.



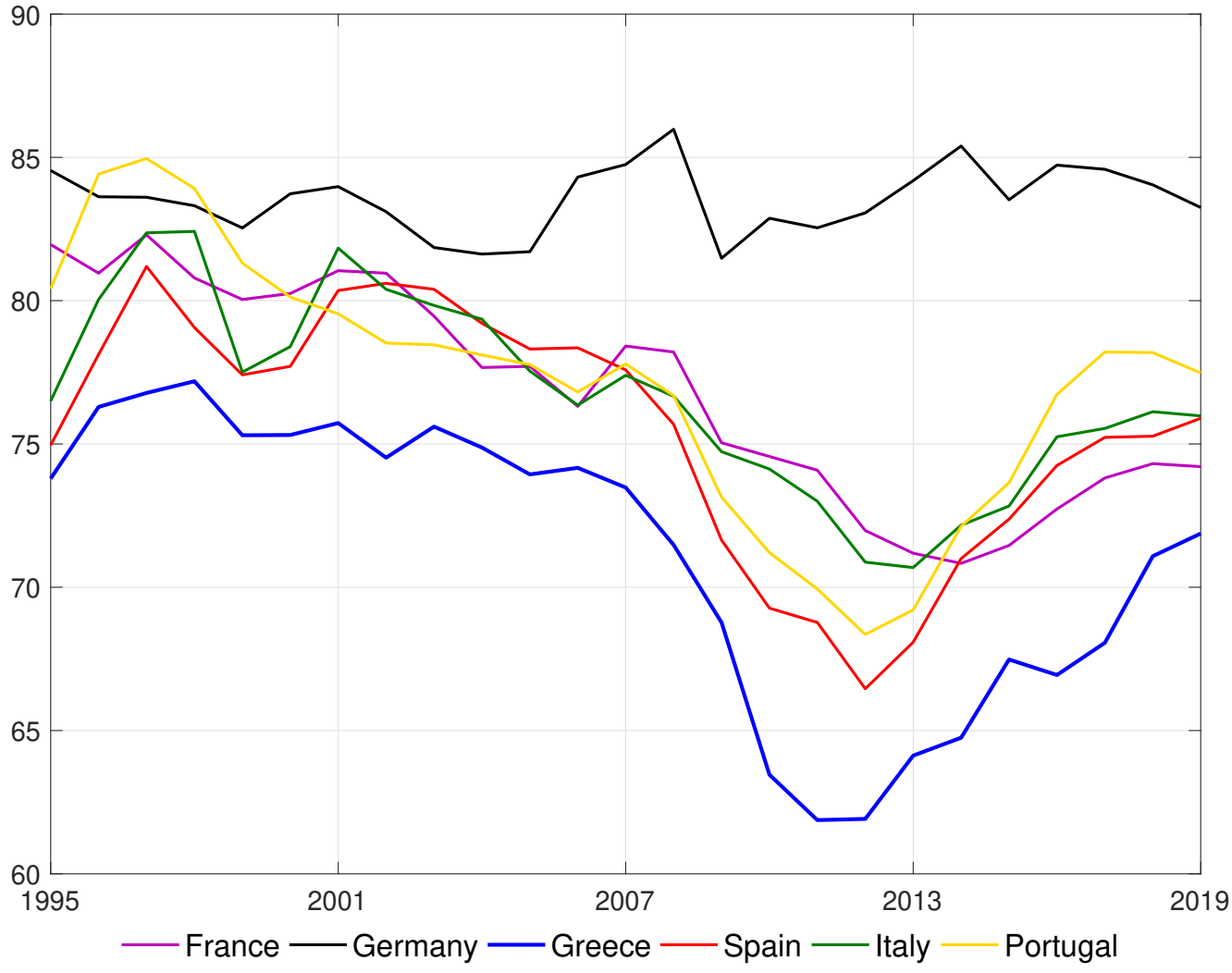
Real per capita GDP (quarterly), Eurostat



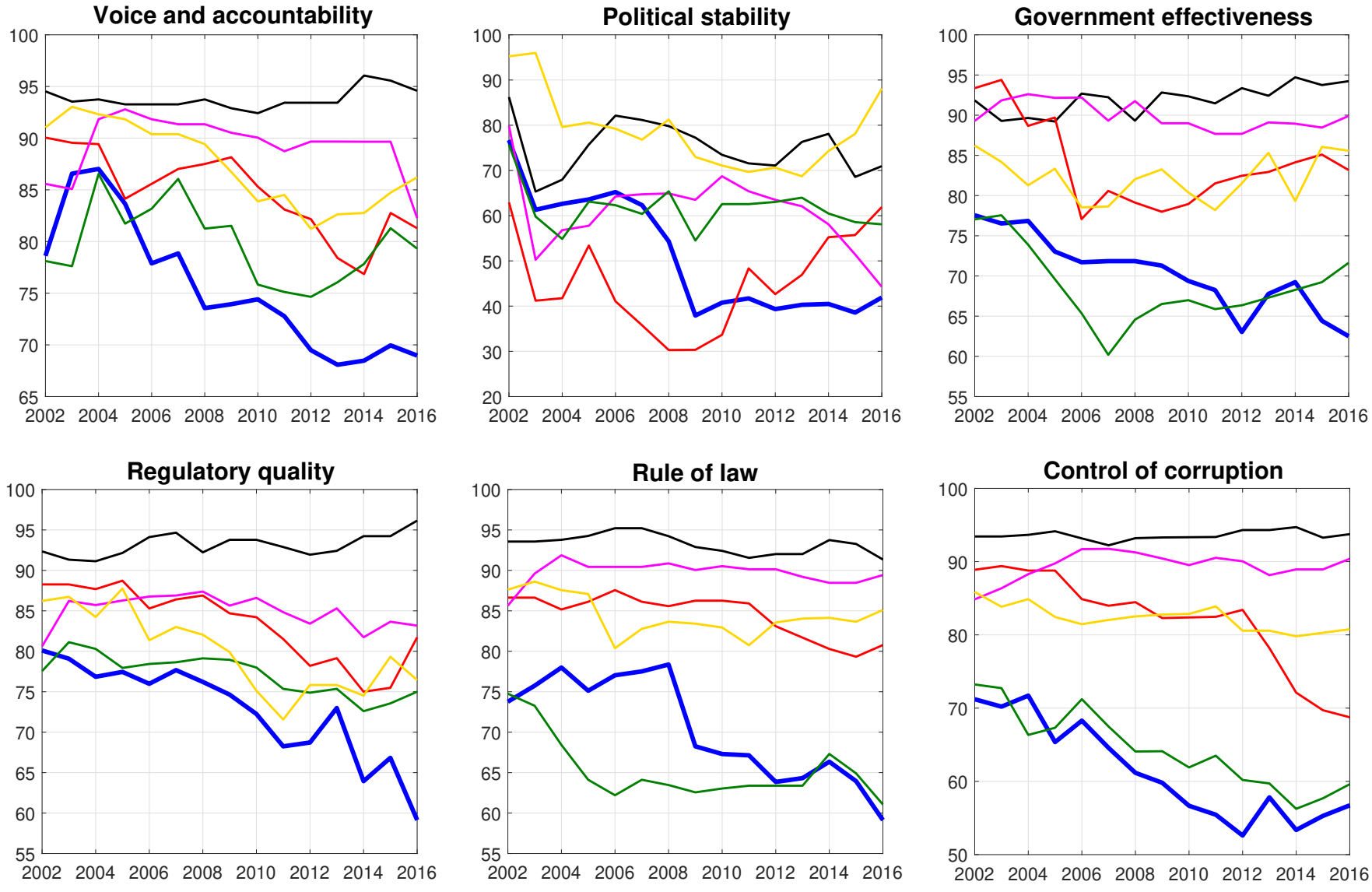
Data: Total factor productivity, USA=1, St. Louis FED



Data: International Country Risk Guide, PRS Group



Data: World Governance Indicators, World Bank



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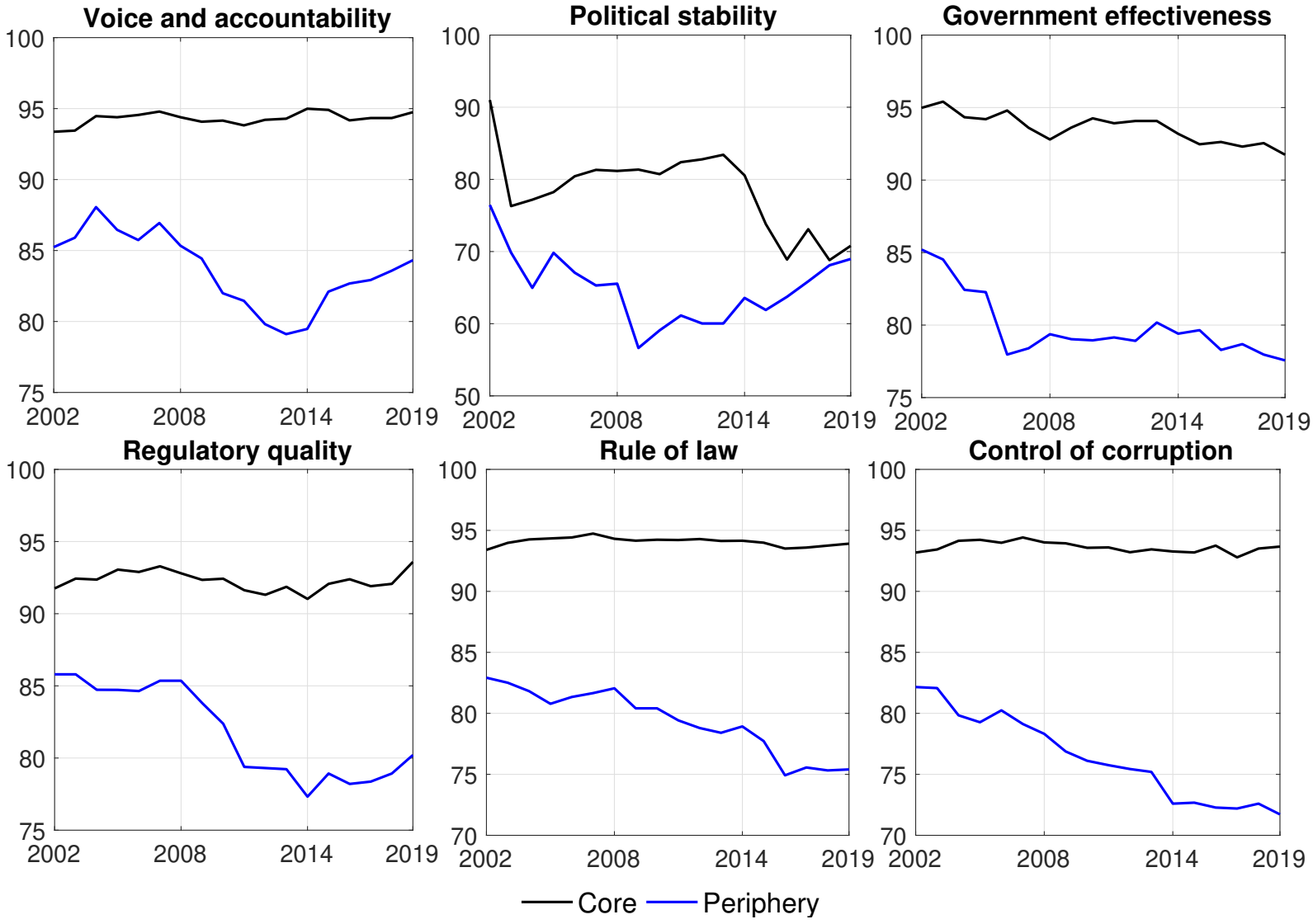
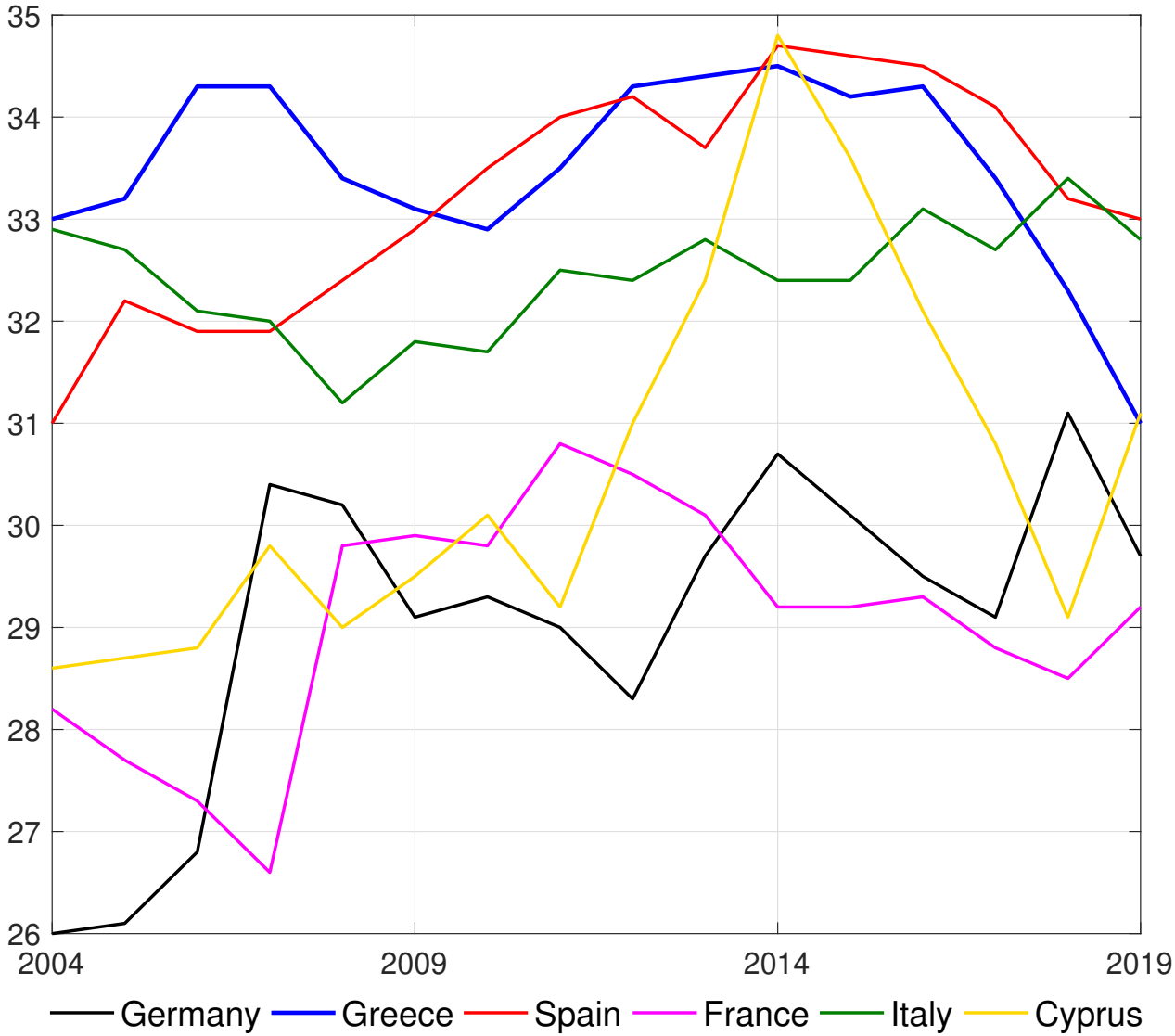
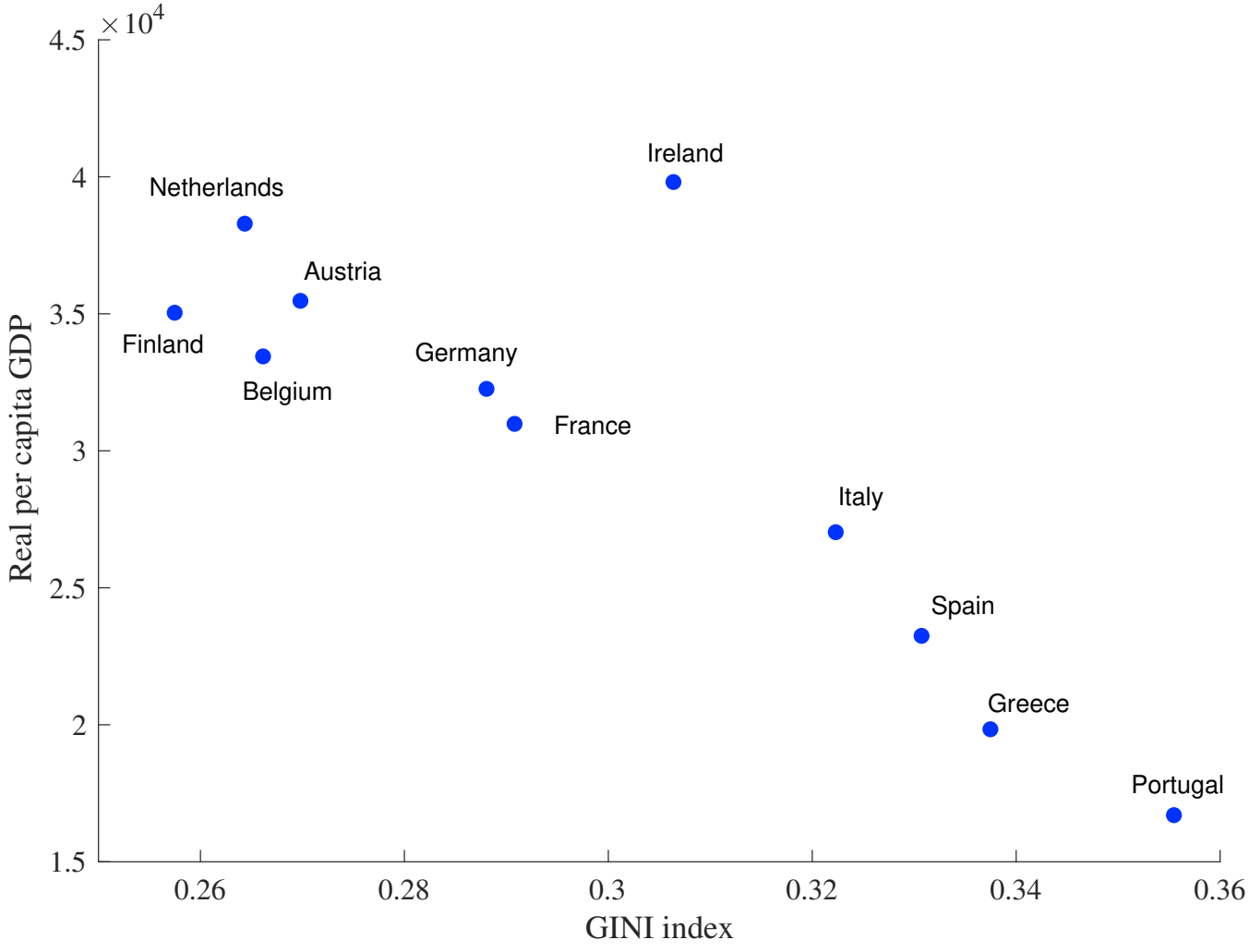


Data: GINI index

Gini index of equivalised disposable income (%), Eurostat (EU-SILC)

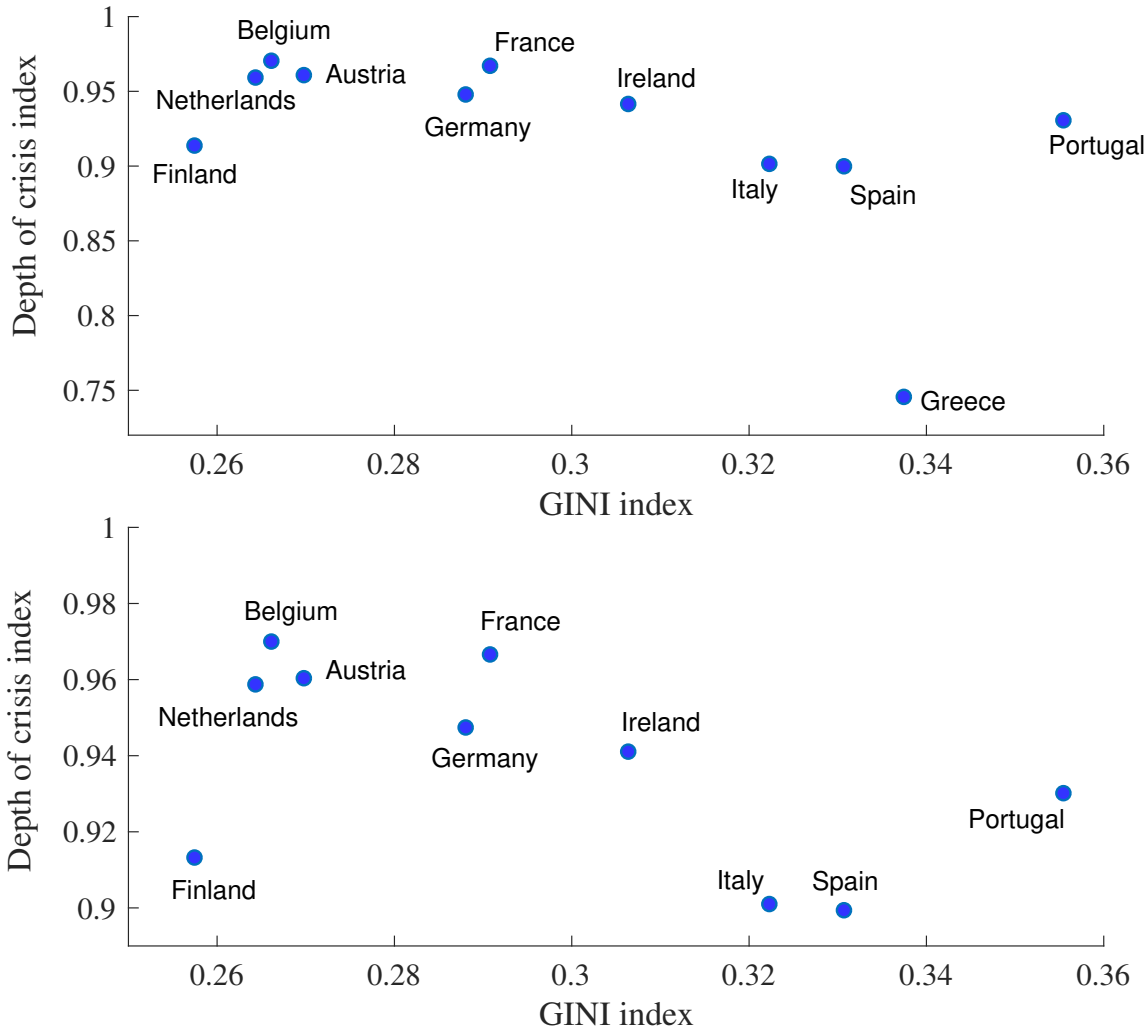


Real per capita GDP vs GINI index

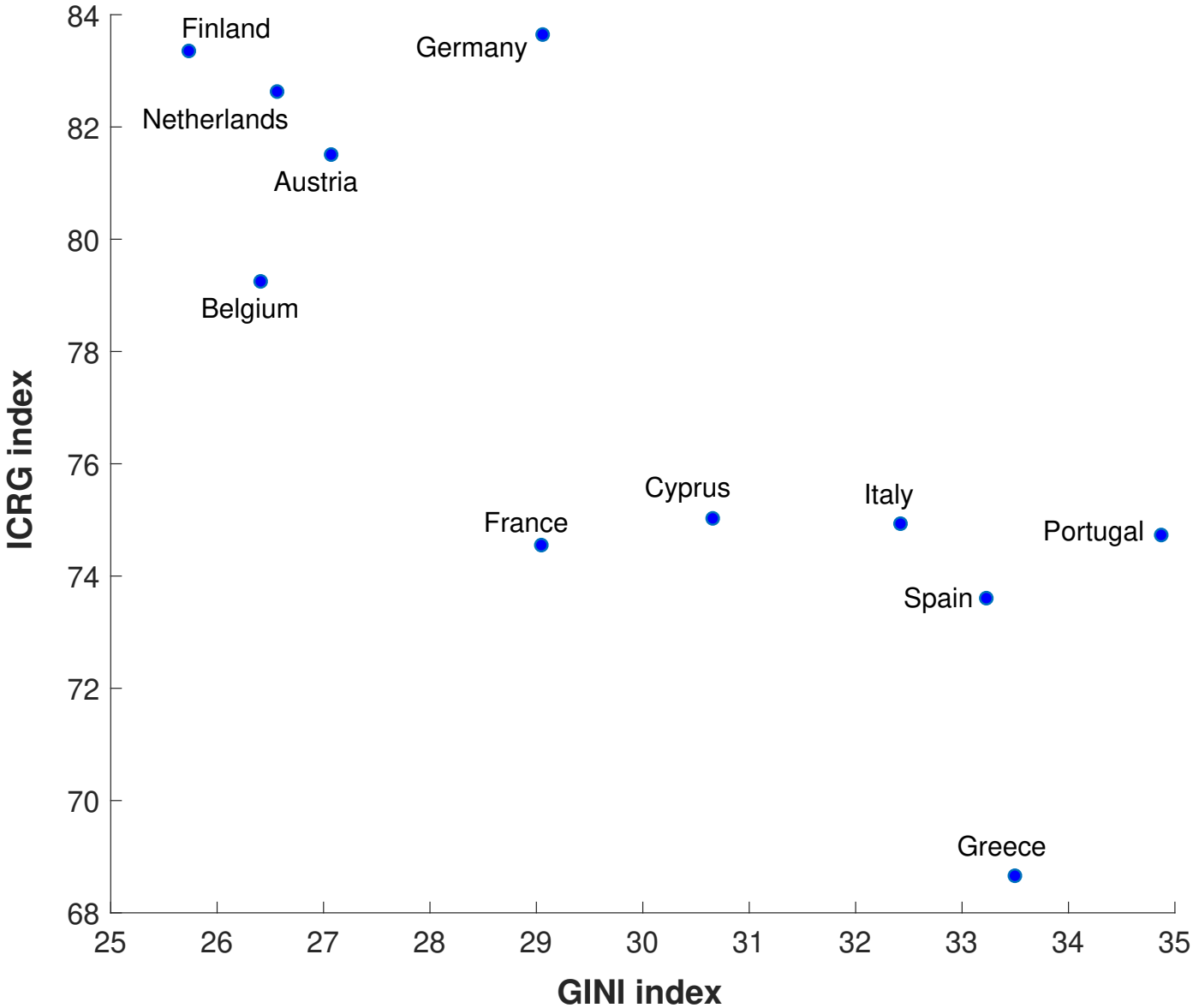


Depth of crisis index vs GINI index

The depth of the crisis index provides an indication on how deep was the effect of the crisis on real per capita GDP.



ICRG index vs GINI index



Motivation

- There are distinct differences between Eurozone countries, especially between countries in the core and the periphery of the Eurozone.
- A well-known example is the different way in which the 2008 global financial crisis affected these countries; the economic downturn was deeper and lasted longer in Southern European countries than in the rest.
- Looking at Total Factor Productivity we observe that periphery countries are less efficient compared to core countries and that periphery countries have experienced a sharper and more persistent decrease in TFP after the economic crisis.
- Moreover, we see differences among countries in terms of income inequality.

Motivation, Cont'd

- We observe that there is a negative relationship between real per capita GDP and the GINI index. Core countries are characterized by lower income inequality and higher real per capita GDP when compared to periphery countries.
- Also, there seems to be a positive relationship among the depth of the crisis index and income inequality.
- Furthermore, we see that there is a negative relationship between the GINI index and institutional quality. Periphery countries are characterized by low institutional quality and high income inequality in contrast to core countries.

Motivation

- Thus, differences are reflected upon both outcomes (e.g. in GDP) and fundamentals that shape these outcomes.
- An important fundamental is the quality of institutions.
  - Institutions are broadly defined as rules, laws, regulations and policies that shape private incentives.
  - Weak institutions discourage people from working, investing, innovating, saving or solving problems of collective action.
  - Weak institutions, in the form of weak property rights, also create rent-seeking opportunities so that those with more aggressive behaviour and/or the right connections extract extra benefits at the expense of the society.

Literature

- There is ample evidence in the literature that institutions matter for macroeconomic performance (Acemoglu et al. (2005), Aron (2000), North (1990), Besley et al. (2010)).
- Moreover, there is also a growing literature on the rise in inequality and on populism (Bourguignon (2018)).
- An important element of institutions is the protection of property rights and the enforcement of contracts (Brunt, 2007).

Literature, Cont'd

- One commonly used way of modeling institutions and weak property rights is to assume that private and/or communal properties are "common pools".
- A popular way of working is through the concept of rent seeking, i.e. assuming that individuals allocate private resources in order to become the beneficiaries of the common pool by competing against other individuals.
- Regarding the common pool (or contestable prize), the literature has mostly used public assets, natural resources or total GDP.

Contestable prize

- Christou et al. (2021) incorporate institutions through rent seeking activities in a homogeneous agents RBC model so as to account for macroeconomic differences in 12 EZ countries:
  - Institutions matter and are fundamental causes of cross-country asymmetries in trends and cycles.
  - Including weak institutions helps the model vis-à-vis the data more in the periphery than in the core of the Eurozone
  - Institutional failures, and their adverse effects on incentives, are worse in periphery countries which contributes to explaining lower long-term growth and higher output volatility in these countries
  - The same shock affects different countries differently depending on their institutional structure and the mix of fiscal policies
  - Counter-factual scenarios imply that periphery countries can gain a lot had their institutional quality been like that in the core.
- We now extent this work to investigate what happens when the contestable prize is the "income of the others".

Motivation and research questions

The negative relationship between the GINI index and institutional quality serves as a motivation to extend our analysis in the heterogeneous agents framework, which will allow us to address distributional issues.

Thus, we augment a **heterogeneous agents RBC model** with weak institutions in order to answer the following questions:

1. How does the introduction of rent seeking in a model with heterogeneous agents affect its behaviour in terms of wedges, second moment properties and impulse response functions?
2. What are the implications in terms of second moment properties and impulse response functions from moving from a representative agent model with rent seeking activities to a heterogeneous agents model with rent seeking activities.

Model

Our model is a standard RBC model with two types of agents, workers and capitalists, with rent seeking activities as in Angelopoulos, Philippopoulos, Vassilatos (2009), Angelopoulos, Economides, Vassilatos (2011) and Christou et al (2021).

In this model we assume that the contestable prize is the "income of the others", i.e. the contestable prize for workers is a fraction of the income of capitalists and the contestable prize of capitalists is fraction of the income of workers.

The choice of this specific contestable prize may also reflect issues related to populism and redistribution.

Model in words

We choose a simple RBC model with distortionary taxation and heterogeneous agents with the following three blocks:

- Households
  - Workers: choose $\{C_t^w, H_t^w, \eta_t^w\}_{t=0}^{\infty}$ in order to solve a standard utility maximization problem.
  - Capitalists: choose $\{C_t^k, H_t^k, \eta_t^k, K_{t+1}^k, B_{t+1}^k\}_{t=0}^{\infty}$ in order to solve a standard utility maximization problem.
- Firms: choose $\{K_t^f, Q_t^{f,w}, Q_t^{f,k}\}_{t=0}^{\infty}$ in order to solve a standard profit maximization problem.
- Government: uses tax revenue and new bonds in order to finance government transfers and government consumption.

Modeling rent seeking behavior

- The household allocates one unit of time in each period to either leisure, L_t^h, or non-leisure time, H_t^h, $h = w, k$:

$$L_t^h + H_t^h = 1 \tag{1}$$

- To incorporate rent seeking behavior we assume that the household further divides its non-leisure time, H_t^h, between productive work, $\eta_t^h H_t^h$, and rent-extracting or seeking activities, $(1 - \eta_t^h)H_t^h$.
- Here, η_t denotes the fraction of non-leisure time allocated to productive work, with the remaining $(1 - \eta_t)$ allocated in rent seeking activites.

Thus, in each period non-leisure time is:

$$H_t^h = \eta_t^h H_t^h + (1 - \eta_t^h)H_t^h \tag{2}$$

Modeling institutional problems

- We assume that a fraction, θ_t, of the total income of each household-type, is the contestable prize that atomistic agents of the opposite household-type compete in order to get a share of, in a Tullock-type redistributive contest.
- The share of the contestable prize extracted by each agent of $h = w, c$ is proportional to the agent's rent seeking time relative to the total rent seeking time allocated by all agents of its specific household-type.
- Thus, the HBC of each household includes the extra income term:

$$\frac{(1-\eta_t^h)H_t^h}{\sum_{h=1}^{N_t}(1-\eta_t^h)H_t^h}\theta_t Y_t^{w,c} \tag{3}$$

- $Y_t^{w,c}$: income of workers or capitalists
- $0 \leq \theta_t < 1$: measure of institutional quality
  - low θ_t indicates better institutions
  - $\theta_t = 0$: no common pool, i.e. property rights are fully secured.

Introduction of rent seeking

$$\textit{Workers} : \theta_t \left[\frac{(1-\eta_t^w)H_t^w}{\sum_{w=1}^{N_t^w}(1-\eta_t^w)H_t^w} \sum_{k=1}^{N_t^k}(W_t^k \eta_t^k H_t^k + r_t^k K_t^k + \Pi_t^k) - W_t^w \eta_t^w H_t^w \right]$$

$$\textit{Capitalists} : \theta_t \left[\frac{(1-\eta_t^k)H_t^k}{\sum_{k=1}^{N_t^k}(1-\eta_t^k)H_t^k} \sum_{w=1}^{N_t^w}(W_t^w \eta_t^w H_t^w) - (W_t^k \eta_t^k H_t^k + r_t^k K_t^k + \Pi_t^k) \right]$$

Rent seeking affects the following equations:

- Household budget constraint Workers Capitalists
  1. Negatively, as a fraction θ_t of the households income is extracted
  2. Positively as the household increases its income by engaging in rent seeking activities to extract a fraction θ_t of the contestable prize, i.e. the income of the other type of household.

- FOC wrt $\eta_t^w, \eta_t^k, h_t^w, h_t^k, k_{t+1}^k$ and the production function
  η_t^w η_t^k h_t^w h_t^k k_{t+1}^k y_t

Wedges

- The introduction of frictions (i.e. distortionary taxation, market power, sticky prices and sticky wages) in the simple RBC model manifests itself in the terminology of Chari et al. (2007) as wedges affecting labor, investment and government consumption.

- Rent seeking in our model introduces an additional friction that induces a labor, an investment and a production wedge which are richer compared to the simple RBC model with distortionary taxation and heterogeneous agents and depend not only on distortionary taxation but also on the level of institutional quality.

Parameterization Table

Given the lack of sufficient data on sectoral variables, we do not proceed to a formal calibration but we set each parameter equal to the average of the respective parameter value for the countries selected in Christou et al (2021), i.e. Austria, Belgium, Germany, France, Finland, Netherlands, Cyprus, Greece, Ireland, Italy, Portugal and Spain.

Long-run solution LRS Sensitivity analysis

- The introduction of the rent seeking activities friction in the heterogeneous agents framework has a **negative impact** on the macroeconomy as output, consumption, investment and capital, both on the economy-wide and sectoral level fall, with the exception of non-leisure time which remains more or less unaffected.
- In contrast, inequality measured by a coefficient of variation-type index, decreases. I^{CW}
- That is, in the presence of rent seeking activities, the economy finds itself in a situation where all agents are worse off but the distribution is more equal.
- In terms of long-run welfare the absence of rent seeking would be Pareto improving for both workers and capitalists despite the increase in inequality index.

Second moment properties

1. Comparison among:
   - RBC with heterogeneous agents (labelled as CW)
   - RBC with heterogeneous agents and rent seeking (labelled as CWRS)

   Question: How does the introduction of rent seeking in a model with heterogeneous agents affect its behaviour?

2. Comparison among:
   - Data
   - RBC with homogeneous agents and rent seeking (labelled as RBCRS)
   - RBC with heterogeneous agents and rent seeking (labelled as CWRS)

   Question: What are the implications from moving from a representative agent model with rent seeking activities to a heterogeneous agents model with rent seeking activities?

Second moment properties: CW vs CWRS

Rel. Volatility | Persistence | Co-movement

Comparison of the dynamic characteristics among heterogeneous agents model with and without rent seeking activities reveals a similar qualitative behaviour on the economy-wide level while differences are observed on the distributional level.

Second moment properties: Data vs RBCRS and CWRS

Rel. Volatility | Persistence | Co-movement

Comparing the two models, focusing on economy-wide variables only, with the data we find that they behave more or less in a similar qualitative way.

Looking at relative volatility, the series generated for consumption is closely matched in the model with CWRS, whereas the relative volatility of investment, non-leisure time and capital is closely matched by RBCRS.

Persistence of the series generated by both models is closely matched with the data.

The picture for co-movement with output in both models is similar to the data.

Impulse response functions A_t ϕ_t θ_t

In order to investigate the dynamic implications of the introduction of rent seeking activities in a heterogeneous agents model we compute impulse responses to the key *economy-wide* and *sectoral* variables for the heterogeneous agents model with and without rent seeking activities.

We find that the two models share similar qualitative characteristics overall, yet *looking at sectoral variables* reveals a more interesting picture as quantitative and qualitative differences arise.

For example, in the existence of rent seeking activities non-leisure time of workers and capitalists reacts in a different way after a positive shock in total factor productivity. This reflects the distortion caused by rent seeking in the incentives of workers and capitalists. h η

Conclusion

- Rent seeking is an additional friction to the simple RBC model with heterogeneous agents that induces wedges which depend on the level of institutional quality.
- The introduction of rent seeking activities in the heterogeneous agents framework has a negative impact on the macroeconomy.
- Overall, moving from a representative agent model to a heterogeneous agents model implies similar qualitative behaviour on economy-wide variables.
- By the same token, comparison of the dynamic characteristics among heterogeneous agents model with and without rent seeking activities reveals a similar qualitative behaviour on the economy-wide level while differences are observed on the distributional level.
- Finally, distinguishing among different type of agents can help us address distributional issues. The heterogeneous agents model reveals differences in the behaviour among sectors.

Thank you

Appendix

Workers

Model

- Households are indexed by $w = 1, 2, \ldots, N_t^w$.
- Expected discounted lifetime utility of household w

$$E_0 \sum_{t=0}^{\infty} \beta^{*t} U(C_t^w + \psi \bar{G}_t^c, L_t^w) \tag{4}$$

- Instantaneous utility function

$$U(C_t^w + \psi \bar{G}_t^c, L_t^w) = \frac{\left((C_t^w + \psi \bar{G}_t^c)^{\mu} (L_t^w)^{1-\mu}\right)^{1-\sigma}}{1-\sigma} \tag{5}$$

where $0 < \mu < 1$ and $\sigma \geq 0$ are parameters.

Workers: Household budget constraint

Given the model with heterogeneous agents, the HBC of workers changes:

$$(1+\tau_t^c)C_t^w = (1-\tau_t^y)W_t^w H_t^w + \bar{G}_t^{t,w} \qquad \text{(3.3-CW)}$$

$$(1+\tau_t^c)C_t^w = (1-\theta_t-\tau_t^y)W_t^w \eta_t^w H_t^w + \bar{G}_t^{t,w} + \frac{(1-\eta_t^w)H_t^w}{\sum_{w=1}^{N_t^w}(1-\eta_t^w)H_t^w}\theta_t \sum_{k=1}^{N_t^k}(W_t^k \eta_t^k H_t^k + r_t^k K_t^k + \Pi_t^k) \qquad \text{(3.3-CWRS)}$$

Capitalists Model

- Households are indexed by $k = 1, 2, \ldots, N_t^k$.
- Expected discounted lifetime utility of household k

$$E_0 \sum_{t=0}^{\infty} \beta^{*^t} U(C_t^k + \psi \bar{G}_t^c, L_t^k) \tag{6}$$

- Instantaneous utility function

$$U(C_t^k + \psi \bar{G}_t^c, L_t^k) = \frac{\left((C_t^k + \psi \bar{G}_t^c)^{\mu} (L_t^k)^{1-\mu}\right)^{1-\sigma}}{1-\sigma} \tag{7}$$

where $0 < \mu < 1$ and $\sigma \geq 0$ are parameters.

Capitalists: Household budget constraint

Given the model with heterogeneous agents, the HBC of workers changes:

$$(1+\tau_t^c)C_t^k + I_t^k + D_t^k = (1-\tau_t^y)(W_t^k H_t^k + r_t^k K_t^k + \Pi_t^k) + r_t^b B_t^k + \bar{G}_t^{t,k} \quad \text{(3.7-CW)}$$

$$(1+\tau_t^c)C_t^k + I_t^k + D_t^k = (1-\theta_t-\tau_t^y)(W_t^k \eta_t^k H_t^k + r_t^k K_t^k + \Pi_t^k) + r_t^b B_t^k + \bar{G}_t^{t,k} + \\ + \frac{(1-\eta_t^k)H_t^k}{\sum_{k=1}^{N_t^k}(1-\eta_t^k)H_t^k}\theta_t \sum_{w=1}^{N_t^w} W_t^w \eta_t^w H_t^w \quad \text{(3.8-CWRS)}$$

Capitalists: Other constraints

- Private holding of government bonds

$$B^k_{t+1} = B^k_t + D^k_t \tag{6}$$

where the initial B^k_0 is given.

- Law of motion of private holding of capital

$$K^h_{t+1} = (1-\delta)K^k_t + I^k_t \tag{7}$$

where the parameter $0 < \delta < 1$ is a depreciation rate and the initial K^k_0 is given.

Households

Thus, each household h acts competitively by taking prices, government policy and economy-wide variables as given and chooses $\{C_t^h, H_t^h, \eta_t^h, K_{t+1}^h, B_{t+1}^h\}_{t=0}^{\infty}$ to maximize lifetime utility Eq.(3) given the definition of instantaneous utility Eq.(4) and subject to the relevant budget constraint depending on the contestable prize (i.e. either (3-I), (3-II) or (3-III)), the time constraints (1) and (2), and K_0^h, B_0^h given.

Firms Model

- Firms are indexed by $f = 1, 2, \ldots, N_t^f$.
- Production function

$$Y_t^f = A_t (K_t^f)^{\alpha} (Q_t^{f,w} + \phi_t Q_t^{f,k})^{1-\alpha} \qquad \text{(3.13-CW)}$$

where $0 < \alpha < 1$ is a parameter.

- Profit function

$$\Pi_t^f = Y_t^f - r_t^k K_t^f - W_t^w Q_t^{f,w} - W_t^k Q_t^{f,k} \qquad \text{(3.14-CW)}$$

Government budget constraint

Model

The government taxes consumption of workers and capitalists at the rate $0 \leq \tau_t^c < 1$ and income of workers and capitalists at the rate $0 \leq \tau_t^y < 1$, and uses these revenue as to finance lump-sum transfers to workers, $G_t^{t,w}$, and capitalists, $G_t^{t,k}$. Thus the government budget constraint is the following:

$$G_t^c + G_t^t + (1 + r_t^b) B_t = B_{t+1} + \tau_t^c (N_t^w C_t^w + N_t^k C_t^k) + \tau_t^y Y_t \quad \text{(3.20-CWRS)}$$

Decentralized Competitive Equilibrium

Model

Given market prices $(w_t^w, w_t^k, r_t^k, r_t^b)$, government policy $(s_t^c, s_t^t, \tau_t^c, \tau_t^y)$ and economy-wide variables (A_t, θ_t):

- Each individual household of type worker, $w = 1, 2, \ldots, N_t^w$, solves its problem as previously defined,
- Each individual household of type capitalist, $k = 1, 2, \ldots, N_t^k$, solves its problem as previously defined,
- Each individual firm, $f = 1, 2, \ldots, N_t^f$, solves its problem as previously defined,
- All markets clear and all constraints are satisfied.

We express the DCE in terms of variables expressed in per capita and efficient labor units (per capita in the case of labor).

This is a system of fourteen equations in fourteen unknown endogenous variables $y_t, c_t^w, c_t^k, h_t^w, h_t^k, \eta_t^w, \eta_t^k, i_t, w_t^w, w_t^k, r_t^k, r_t^b, b_{t+1}$ and k_{t+1}, given $s_t^c, s_t^t, \tau_t^c, \tau_t^y$ and the paths for A_t, θ_t.

First order condition wrt effort, η_t^w and η_t^k Rent seeking Wedges

$$\theta_t(w_t^k \eta_t^k v^k h_t^k + r_t^k k_t) = (1-\theta_t-\tau_t^y)(1-\eta_t^w) w_t^w v^w h_t^w \quad \text{(3.36-CWRS)}$$

$$\theta_t w_t^w \eta_t^w v^w h_t^w = (1-\theta_t-\tau_t^y) w_t^k (1-\eta_t^k) v^k h_t^k \quad \text{(3.37-CWRS)}$$

- In the case of $\theta_t = 0$, no rent seeking activites exist $(\eta_t = 1)$ it is evident that the existence of rent seeking activities affects the first order condition with respect to the effort level of workers and capitalists.

Production function

Rent seeking | Wedges

$$y_t = A_t k_t^{\alpha} (v^w h_t^w + v^k \phi_t h_t^k)^{1-\alpha} \qquad \text{(3.26-CW)}$$

$$y_t = A_t k_t^{\alpha} (v^w \eta_t^w h_t^w + v^k \phi_t \eta_t^k h_t^k)^{1-\alpha} \qquad \text{(3.26-CWRS)}$$

Workers: Household budget constraint

Rent seeking | Wedges

$$(1+\tau_t^c)v^w c_t^w = (1-\tau_t^y)w_t^w v^w h_t^w + v^w s_t^t y_t \qquad \text{(3.24-CW)}$$

$$(1+\tau_t^c)v^w c_t^w =$$
$$(1-\tau_t^y)w_t^w \eta_t^w v^w h_t^w + v^w s_t^t y_t + \theta_t(w_t^k \eta_t^k v^k h_t^k + r_t^k k_t - w_t^w \eta_t^w v^w h_t^w) \qquad \text{(3.24-CWRS)}$$

Rent seeking via θ_t affects both household budget constraints in two directions:

- Negatively as a fraction θ_t of the households income is extracted
- Positively as the household increases its income in engaging in rent seeking activities and this way manages to extract a fraction θ_t of the contestable prize, i.e. the income of the other type of household.

Capitalists: Household budget constraint

Rent seeking | Wedges

$$(1+\tau_t^c)v^k c_t^k + i_t + \gamma_n\gamma_z b_{t+1} = (1-\tau_t^y)(w_t^k v^k h_t^k + r_t^k k_t) + (1+r_t^b)b_t + v^k s_t^t y_t \quad \text{(3.25-CW)}$$

$$(1+\tau_t^c)v^k c_t^k + i_t + \gamma_n\gamma_z b_{t+1} = (1-\tau_t^y)(w_t^k \eta_t^k v^k h_t^k + r_t^k k_t) + (1+r_t^b)b_t + v^k s_t^t y_t + \theta_t(w_t^w \eta_t^w v^w h_t^w - w_t^k \eta_t^k v^k h_t^k - r_t^k k_t) \quad \text{(3.25-CWRS)}$$

Rent seeking via θ_t affects both household budget constraints in two directions:

- Negatively as a fraction θ_t of the households income is extracted
- Positively as the household increases its income in engaging in rent seeking activities and this way manages to extract a fraction θ_t of the contestable prize, i.e. the income of the other type of household.

First order condition wrt non-leisure time, h_t^w

Rent seeking | Wedges

The introduction of rent seeking distorts the marginal rate of substitution between consumption and leisure.

$$\frac{1-\mu}{\mu}\frac{(c_t^w + \psi s_t^c y_t)}{1-h_t^w} = \frac{1-\tau_t^y}{1+\tau_t^c} w_t^w \qquad \text{(3.27-CW)}$$

$$\frac{1-\mu}{\mu}\frac{(c_t^w + \psi s_t^c y_t)}{1-h_t^w} = \frac{1-\tau_t^y}{1+\tau_t^c} w_t^w \eta_t^w + \frac{\theta_t}{(1+\tau_t^c) v^w h_t^w}(w_t^k \eta_t^k v^k h_t^k + r_t^k k_t - w_t^w \eta_t^w v^w h_t^w) \qquad \text{(3.27-CWRS)}$$

First order condition wrt non-leisure time, h_t^k

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First order condition wrt capital, k_{t+1} Rent seeking Wedges

$$\left(\frac{c^k_{t+1}+\psi s^c_{t+1} y_{t+1}}{c^k_t+\psi s^c_t y_t}\right)^{1-\mu(1-\sigma)}\left(\frac{1-h^k_t}{1-h_{t+1}}\right)^{(1-\mu)(1-\sigma)} =$$

$$\beta E_t\left(\frac{1+\tau^c_t}{1+\tau^c_{t+1}}\right)\left(1-\delta+(1-\tau^y_{t+1})r^k_{t+1}\right) \quad \text{(3.29-CW)}$$

$$\left(\frac{c^k_{t+1}+\psi s^c_{t+1} y_{t+1}}{c^k_t+\psi s^c_t y_t}\right)^{1-\mu(1-\sigma)}\left(\frac{1-h^k_t}{1-h_{t+1}}\right)^{(1-\mu)(1-\sigma)} =$$

$$\beta E_t\left(\frac{1+\tau^c_t}{1+\tau^c_{t+1}}\right)\left(1-\delta+(1-\tau^y_{t+1})r^k_{t+1}\right) - \beta E_t\left(\frac{1+\tau^c_t}{1+\tau^c_{t+1}}\right)\theta_{t+1} r^k_{t+1}$$

(3.29-CWRS)

Parameterization

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Parameters	Description	Value
v^w	Worker's share in population	0.80
v^k	Capitalist's share in population	0.20
θ	Long-run value of the economy-wide degree of rent extraction	0.0418
μ	Consumption weight in utility function	0.4449
α	Capital share in production	0.3486
β	Discount factor	0.9656
N_0	Total population initial level	1
γ_z	Growth rate of labor-augmenting technology	1.0240
γ_n	Growth rate of population	1.0074
Z^w	Workers Labor-augmenting technology initial level	1
Z^k	Capitalists labor-augmenting technology initial level	2
A	Long-run aggregate productivity	0.8879
δ	Depreciation rate	0.0562
s^t	Share of government transfers	0.1923
τ_t^c	Consumption tax rate	0.2082
τ_t^y	Total income tax rate	0.3467
σ	Curvature parameter in utility function	2

Long-run solution

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Variable	Descrption	CW	CWRS
y	Output	0.5701	0.5018
y^w/y^k	Sectoral income ratio	0.8559	0.8970
y^w	Income of workers	0.2021	0.1819
y^k	Income of capitalists	0.2362	0.2028
I^{CW}	Inequality index	0.0133	0.0057
c	Consumption	0.2980	0.2681
c^w	Consumption of workers	0.2527	0.2273
c^k	Consumption of capitalists	0.4793	0.4312
k	Capital	1.4139	1.1650
i	Investment	0.1241	0.1023
η	Fraction of non-leisure time allocated to productive work	1	0.9096
η^w	Fraction of non-leisure time of workers allocated to productive work	1	0.9154
η^k	Fraction of non-leisure time of capitalists allocated to productive work	1	0.8862
s^c	Share of government consumption	0.2596	0.2620
h	Non-leisure time	0.3461	0.3489
h^w	Non-leisure time of workers	0.3393	0.3421
h^k	Non-leisure time of capitalists	0.3733	0.3760
w^w	Wage rate of workers	0.8824	0.8518
w^k	Wage rate of capitalists	1.7649	1.7035
r^k	Return on capital	0.1406	0.1502
r^b	Return on bonds	0.0356	0.0356

Long-run solution (CWRS): Sensitivity analysis with respect to θ, v^k and ϕ

Back

	$\theta = 0.05$	$\theta = 0.1$	$v^k = 0.2$	$v^k = 0.4$	$\phi = 2$	$\phi = 3$
$I^{C,W}$	0.0046	0.0007	0.0057	0.3595	0.0057	0.0650
y	0.4891	0.4156	0.5018	0.5855	0.5018	0.5855
y^w	0.1780	0.1551	0.1819	0.1400	0.1819	0.1866
y^k	0.1966	0.1620	0.2028	0.3088	0.2028	0.2621
c	0.2624	0.2287	0.2681	0.3128	0.2681	0.3128
h	0.3494	0.3524	0.3489	0.3448	0.3489	0.3382
η	0.8926	0.7946	0.9096	0.8743	0.9096	0.8902
c^w	0.2225	0.1939	0.2273	0.2333	0.2273	0.2333
c^k	0.4220	0.3677	0.4312	0.4321	0.4312	0.6309
h^w	0.3426	0.3456	0.3421	0.3249	0.3421	0.3249
h^k	0.3766	0.3796	0.3760	0.3747	0.3760	0.3913
η^w	0.8997	0.8099	0.9154	0.8147	0.9154	0.8793
η^k	0.8643	0.7334	0.8862	0.9638	0.8862	0.9335

- Coefficient of variation-type inequality index: $I^{CW} = \frac{(y^w - y^k)^2}{y^w} + \frac{(y^w - y^k)^2}{y^k} + \frac{(y^w - y^k)^2}{y^w + y^k}$.
- The introduction of rent seeking reduces inequality. However, in the presence of rent seeking although the inequality gap among workers and capitalists narrows, both types of agents enjoy lower income, consumption and leisure time.
- The economy therefore is characterized by a situation where all agents are worse off but the distribution is more equal.
- In terms of long-run welfare the absence of rent seeking would be Pareto improving for both workers and capitalists despite the increase in inequality.

Relative volatility: CW vs CWRS

Back

Table: Relative volatility, $x \equiv s_x/s_y$

x	CW	CWRS	x	CW	CWRS
c	0.8307	0.8376	y^w	0.9046	0.9928
i	1.4107	1.4333	y^k	1.6844	2.0093
h	0.0547	0.1023	c^w	0.9046	0.8635
k	0.2290	0.2314	c^k	0.7129	0.8401
η	Na	0.1306	h^w	0.0553	0.1459
σ^y	0.0252	0.0252	h^k	0.3916	0.2988
			η^w	Na	0.1091
			η^k	Na	0.2382

Persistence: CW vs CWRS

Back

Table: Persistence, $\rho(x_t, x_{t-1})$

x	CW	CWRS	x	CW	CWRS
y	0.4822	0.4769	y^w	0.4854	0.4791
c	0.4890	0.4829	y^k	0.2100	0.0780
i	0.4744	0.4693	c^w	0.4854	0.4799
h	0.4651	0.4643	c^k	0.4974	0.4878
k	0.8484	0.8462	h^w	0.4651	0.4686
η	Na	0.4646	h^k	0.4645	0.4627
			η^w	Na	0.4656
			η^k	Na	0.4636

Co-movement with output: CW vs CWRS

Back

Table: Contemporaneous co-movement with output, $\rho(y_t, x_{t+1})$

x	CW	CWRS	x	CW	CWRS
c	0.9992	0.9986	y^w	0.9927	0.9851
i	0.9983	0.9968	y^k	0.9332	0.7951
h	0.9474	0.8057	c^w	0.9927	0.9901
k	-0.0648	-0.0685	c^k	0.9631	0.9494
η	Na	0.0642	h^w	-0.6828	0.3540
			h^k	0.9646	0.6511
			η^w	Na	0.0043
			η^k	Na	0.1680

Relative volatility: Data vs RBCRS and CWRS

Back

Table: Relative volatility, $x \equiv s_x/s_y$

x	Data	RBCRS	CWRS
c	0.8548	0.7537	0.8376
i	3.0691	1.6573	1.4333
h	0.3458	0.1641	0.1023
k	0.3718	0.2664	0.2314
η	Na	0.0367	0.1306
σ^y	0.0252	0.0252	0.0252

Persistence: Data vs RBCRS and CWRS

Back

Table: Persistence, $\rho(x_t, x_{t-1})$

x	Data	RBCRS	CWRS
y	0.8054	0.4805	0.4769
c	0.5501	0.4963	0.4829
i	0.4504	0.4667	0.4693
h	0.5496	0.4570	0.4643
k	0.3456	0.8454	0.8462
η	Na	0.4685	0.4646

Co-movement with output: Data vs RBCRS and CWRS

Back

Table: Contemporaneous co-movement with output, $\rho(y_t, x_{t+1})$

x	Data	RBCRS	CWRS
c	0.5171	0.9972	0.9986
i	0.8789	0.9961	0.9968
h	0.3578	0.9769	0.8057
k	0.3446	-0.0366	-0.0685
η_t	Na	-0.0244	0.0642

Impulse response functions of a shock in A_t Back

Table: Positive shock in A_t: Response on impact

Variables	CW	CWRS	Variables	CW	CWRS
y	1.0759	1.0643	y^w	1.0142	1.2065
c	0.8965	0.9109	y^k	1.3674	1.1995
h	0.0566	0.1294	c^w	0.9780	0.8721
k	0.1282	0.1295	c^k	0.7246	0.9926
i	1.5066	1.5221	h^w	-0.0362	0.1770
η	Na	0.0128	h^k	0.3941	-0.0441
w^w	0.9594	0.9656	η^w	Na	0.0398
w^k	0.9594	0.9656	η^k	Na	-0.0948
r^k	1.0759	1.0643			

IRFs: A positive shock in A_t, response of η^w and η^k Back

- The behavior of the η^w and η^k after an increase in A_t is different. η^w increases while η^k decreases.
- A possible explanation of the behavior of the opposite response to an increase in At in the effort of capitalists and workers is that the bigger contestable prize provides an incentive to capitalists to increase rent seeking effort.

IRFs: A positive shock in A_t, response of h_t^w and h_t^k Back

- A positive shock in At in the absence of rent seeking reduces non-leisure time of workers and increases the non-leisure time of capitalists while the opposite happens in the presence of rent seeking.
- Given the increase in productivity, non-leisure time of capitalists increases **in the model without rent seeking activities**, yet the income effect for workers dominates and non-leisure time of workers decreases.
- **In the model with rent seeking activities**, the observed fall in non-leisure time of capitalists and increase in investment and in the return on capital implies that in the presence of rent seeking, capitalists take advantage of the increased productivity by focusing on the source of income from capital.
- On the other hand, the only way workers can take advantage of increased productivity is via increasing effort and non-leisure time.

Impulse response functions of a shock in ϕ_t Back

Table: Positive shock in ϕ_t: Response on impact

Variables	CW	CWRS	Variables	CW	CWRS
y	0.2520	0.2496	y^w	-0.0586	0.0666
c	0.1696	0.1721	y^k	0.6034	0.5318
h	-0.0277	0.0289	c^w	-0.0730	-0.1490
k	0.0383	0.0409	c^k	0.6811	0.8495
i	0.4499	0.4808	h^w	-0.1203	0.0293
w^w	-0.1349	-0.1336	h^k	0.3089	0.0276
w^k	0.8651	0.8664	η^w	Na	-0.1795
r^k	0.2520	0.2496	η^k	Na	0.4281
η	Na	-0.0580			

Impulse response functions of a shock in θ_t Back

	Periods						
Variables	1	2	3	10	20	30	100
θ	1	0.9900	0.9801	0.9135	0.8262	0.7472	0.3697
y	-0.1681	-0.1776	-0.1861	-0.2258	-0.2437	-0.2391	-0.1284
c	-0.0898	-0.1020	-0.1131	-0.1669	-0.1973	-0.2004	-0.1111
h	0.0587	0.0581	0.0576	0.0537	0.0485	0.0439	0.0217
k	0	-0.0342	-0.0656	-0.2224	-0.3226	-0.3494	-0.2040
i	-0.4018	-0.4031	-0.4040	-0.4016	-0.3821	-0.3546	-0.1803
η	-0.2121	-0.2105	-0.2088	-0.1971	-0.1801	-0.1637	-0.0815
y^w	0.0016	-0.0111	-0.0226	-0.0806	-0.1177	-0.1277	-0.0747
y^k	-0.3737	-0.3745	-0.3750	-0.3710	-0.3516	-0.3257	-0.1653
c^w	-0.1712	-0.1808	-0.1895	-0.2301	-0.2484	-0.2437	-0.1309
c^k	0.0817	0.0642	0.0481	-0.0337	-0.0896	-0.1091	-0.0691
h^w	0.1523	0.1488	0.1455	0.1266	0.1076	0.0941	0.0448
h^k	-0.2819	-0.2721	-0.2628	-0.2119	-0.1666	-0.1389	-0.0623
η^w	-0.1302	-0.1305	-0.1307	-0.1294	-0.1227	-0.1137	-0.0577
η^k	-0.5396	-0.5304	-0.5215	-0.4680	-0.4096	-0.3640	-0.1766
w^w	0.0900	0.0767	0.0645	0.0018	-0.0422	-0.0590	-0.0405
w^k	0.0900	0.0767	0.0645	0.0018	-0.0422	-0.0590	-0.0405
r^k	-0.1681	-0.1434	-0.1205	-0.0034	0.0789	0.1103	0.0756