A two country HANK model for Eurozone

Xiaoshan Chen
(University of Durham)

Spyridon Lazarakis
(Lancaster University)

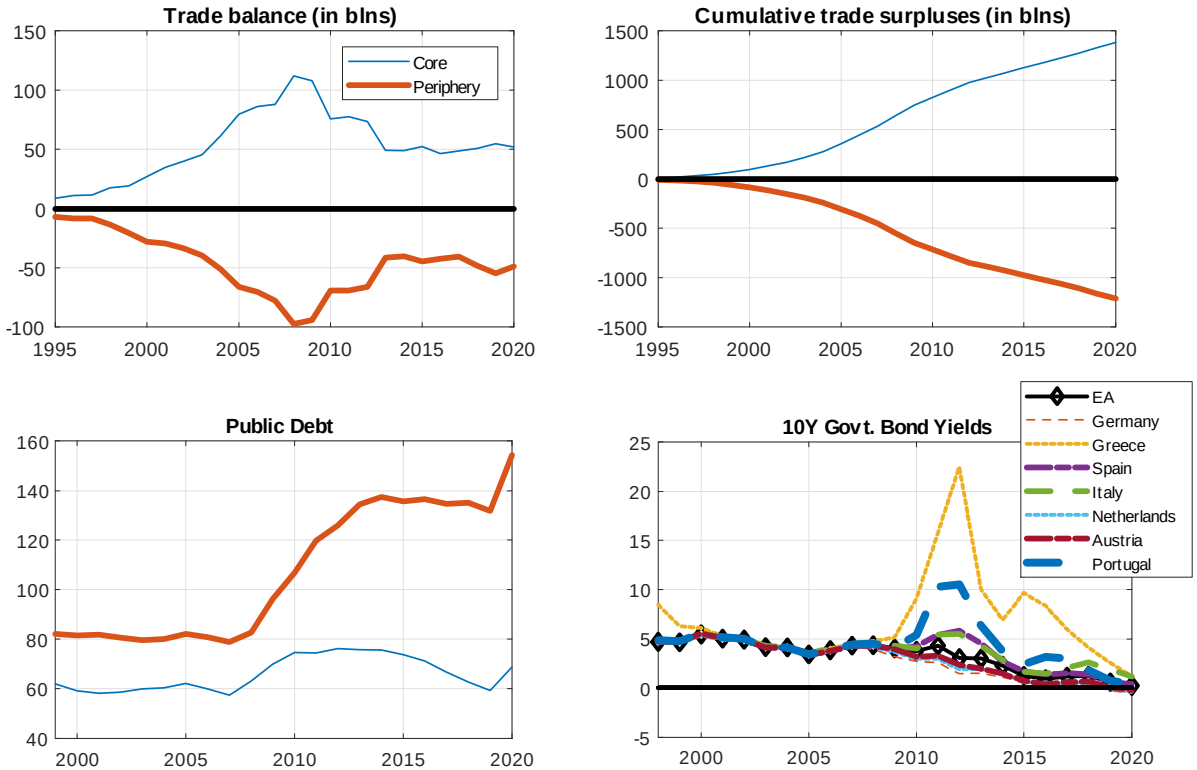
Petros Varthalitis
(Athens University of Economics and Business)

The *20th Conference on Research on Economic Theory and Econometrics*, July 11th-15th, 2022

Motivation

- **Euro Area**, since its formation in 1999, is usually divided into two regions based on their underlying macroeconomic imbalances.
- The **EA Periphery** with high public debt coupled with current account and trade deficits,
- Mostly financed by the **EA Core** with low public debt and current account/trade balance surpluses.

Figure 1: EA Imbalances

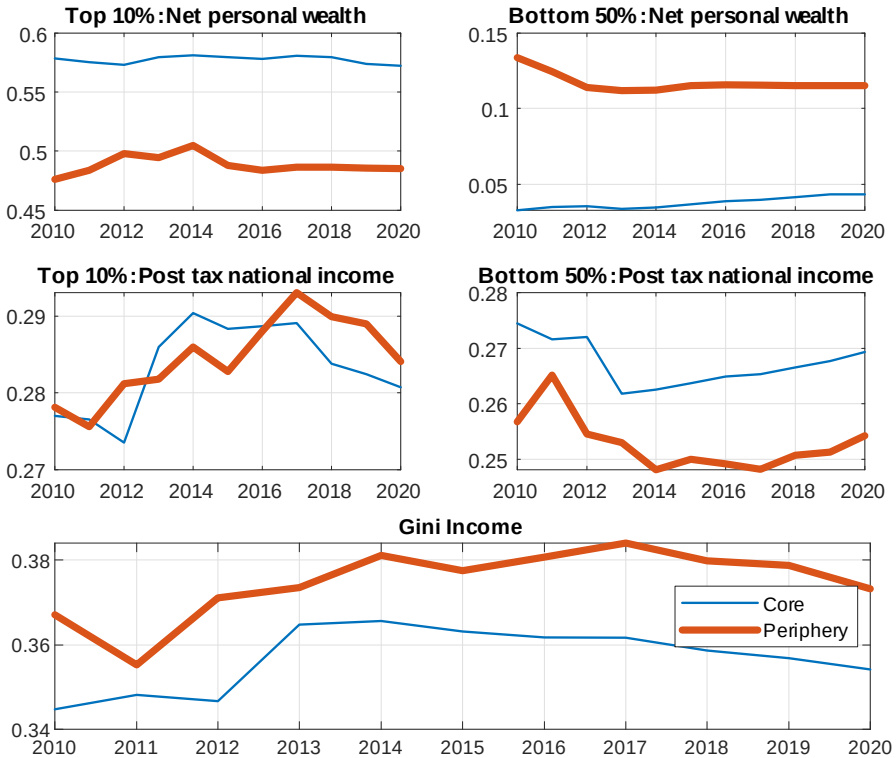


Sources: WITS and Eurostat. Notes: The Core is defined as the weighted average of Austria, Germany and Netherlands while the Periphery is defined as the weighted average of Spain, Italy, Portugal and Greece.

Motivation (cont'ed)

- Cross-country heterogeneity in EA coexists with disparities within each EA country member.
- Since 1999, the EA Periphery performs consistently "**worse**" than EA Core in measures of **income inequality**.
- At the same time, the EA Periphery performs consistently "**better**" than EA Core in measures of **wealth inequality**.
- Although, the Core-Periphery imbalances have received much attention by academics and policymakers the last two decades.
- Their **link to within-country inequalities** is still an open and important issue.

Figure 2: Inequality in the EA



Source: World Inequality Database. Notes: As in Figure 1.

Research aim

The purpose of this paper is twofold:

- To develop a model that captures key features of cross- and within-country heterogeneity in the EA.
- Use it as a vehicle to study debated policy issues in EA, i.e. fiscal consolidation.
  - Is there a scope for changing EA fiscal (debt) targets (see e.g., Blanchard et al. 2021)?
  - Are there any winners/losers from such reforms (welfare ranking)?
  - Does the CB's stance against inflation affect our replies to these questions?
  - Whom would benefit from a Core expansion while the Periphery consolidates?

Preview of results

- The public debt imbalances in the Union can explain part of the **within country wealth and income inequality in EA**.
- Meeting the **debt targets** implied by the **MT** generates **significant welfare losses** esp. for the **Periphery** and the **Poorer** households in the Union.
- **Changing the EA debt targets** closer to the current levels of debt-output ratios mitigates the welfare losses from debt consolidation across and within countries (and the union), i.e., **does not generate a conflict of interest**.

Preview of results (cont'ed)

- A more **aggressive CB's reaction** towards **inflation** *would benefit the relatively Richer*, while it *reduces the benefits* from a change in EA debt targets for *the relatively Poorer*.

- An **expansion** of the **Core** while the **Periphery consolidates** is not necessarily more desirable for the Poorer households in the Union from a simple change in the Periphery's debt target closer to its current debt-output ratio.

Related literature

- **HANK (closed and open economy) models:** HANK closed economy models and monetary policy such as McKay et al. (2016), Kaplan et al. (2018), Hagedorn et al. (2019), Auclert et al. (2021). Distributional implications in small open economies such as De Ferra et al. (2020), Giagheddu (2020), Auclert et al. (2021), Aggrawal et al. 2022, Guo et al. (2021), Oskolkov (2022).

- **Currency union models:** Benigno and Benigno (2006, 2008), Coenen et al. (2008), Forni et al. (2010), Clinton et al. (2011), Cogan et al. (2013), Erceg and Linde (2013), Gali and Monacelli (2008), Fahri and Werning (2017), Philippopoulos et al. (2017), Bianchi et al. (2021).

Description of the model

- The model consists of two countries that participate in a currency union.
- Within each country:
  - Heterogeneous households (Belew-Hugget-Aiyagari type).
  - Final and intermediate good firms (standard NK nominal rigidities).
  - Government
- Policy:
  - **Single** monetary authority.
  - **Independent** national fiscal policies.
- Financial markets:
  - **Segmented international financial markets** (as in Itskhoski and Mukhin (2021).
  - International borrowing/lending takes place via a **financial intermediary**.

Heterogeneity and its sources

- **Cross-country heterogeneity:**
  - Public debt imbalances lead to external imbalances.
  - The Core acts as a net lender while the Periphery acts as a net borrower.
- **Within-country heterogeneity:**
  - Households face uninsured idionsyncratic shocks, and,
  - since the markets are incomplete; three types of inequality emerge:
    - Wealth inequality,
    - Net income inequality, and,
    - Consumption inequality.

Notation

- The **Core** is referred to as the **creditor** country while the **Periphery** is referred to as the **debtor** country.
- The Core's variables are denoted with *.

Model in equations

- Periphery or the debtor country:
  - Households:
    - ▸ Prefences and constraints
    - ▸ Households problem
  - Firms:
    - ▸ Final good firms
    - ▸ Intermediate good firms
  - ▸ Government Budget Constraint
  - ▸ Fisher Equation, ▸ Local Financial Markets
- Core or the creditor country (similar structure with the Periphery): ▸ Financial Intermediary
- ▸ International Financial Market
- Single monetary authority
- National fiscal policy rules
- ▸ Stationary Recursive General Equilibrium

Exchange rate regime and simplifying assumptions

- To mimic the EA: the two countries fix the nominal exchange rate and abandon monetary policy independence (see below).
- Households in the Core/Periphery have identical preferences for home/foreign goods, i.e. *PPP* holds and $Q_t = \frac{S_t P_t^*}{P_t} = 1$.
- Consequently, there is only one inflation rate in the monetary union.

Modified Uncovered Interest Parity

Assuming a monetary union regime, the profit maximization of the financial intermediary yields:

$$(1 + i_{t-1}) = (1 + i^*_{t-1}) + \theta \left(\exp \left(\frac{NFA_{t-1}}{Y_{t-1}} \right) - 1 \right) \frac{1}{Y_{t-1}} \qquad (1)$$

Thus, if home country is a net debtor, i.e., $\frac{NFA_{t-1}}{Y_{t-1}} > 0$, the debtor country borrows with a premium with respect to the creditor country, i.e., $i_{t-1} > i^*_{t-1}$.

Monetary policy

- Since we solve for a monetary union regime, the two countries fix the nominal exchange rate, thus, one of the nominal rates should become an endogenous variable, say i_t, while the common monetary authority sets the other following a Taylor rule:

$$i_t^* = \max\left\{0, i^* + \phi_\pi\left(\pi_t - \overline{\pi}\right)\right\} \tag{2}$$

- where $\phi_\pi \geq 0$ is feedback monetary policy coefficient on union inflation from its target. Finally, variables without time subscript denote policy targets.

National fiscal policies

- The two countries can follow independent national fiscal policies.
- We focus on simple feedback fiscal rules:

$$\tau_t^l = \overline{\tau}^l + \gamma\left(\frac{B_{t-1}}{Y_{t-1}} - \frac{B}{Y}\right)$$

$$\tau_t^{l,*} = \overline{\tau}^{l,*} + \gamma^*\left(\frac{B_{t-1}^*}{Y_{t-1}^*} - \frac{B^*}{Y^*}\right)$$

where $\gamma \geq 0$, $\gamma^* \geq 0$ are feedback policy coefficients on public debt to GDP ratio in debtor and creditor country respectively and variables without time subscript denote fiscal targets.

Solution Method

- The Stationary Recursive Equilibria are solved using a non linear solver.

- For the transition paths we follow Auclert et al (2021):
  - First-order perturbation solution in the sequence space.
  - Find the Jacobian of the sequence of the equilibrium conditions "in the sequence space" and use it in a quasi Newton method to get the solution of the path.

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.
  - Within country heterogeneity (see Table 4).

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.
  - Within country heterogeneity (see Table 4).
- We study reforms of EA fiscal targets, specifically, **debt targets**.

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.
  - Within country heterogeneity (see Table 4).
- We study reforms of EA fiscal targets, specifically, **debt targets**.
- Three reformed economies:

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.
  - Within country heterogeneity (see Table 4).
- We study reforms of EA fiscal targets, specifically, **debt targets**.
- Three reformed economies:
  - **"Maastricht Treaty"** (MT): Core and Periphery 60%.

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.
  - Within country heterogeneity (see Table 4).
- We study reforms of EA fiscal targets, specifically, **debt targets**.
- Three reformed economies:
  - "**Maastricht Treaty**" (MT): Core and Periphery 60%.
  - "**Realistic Scenario**" (RS): Core 70% and Periphery 100%.

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.
  - Within country heterogeneity (see Table 4).
- We study reforms of EA fiscal targets, specifically, **debt targets**.
- Three reformed economies:
  - "**Maastricht Treaty**" (MT): Core and Periphery 60%.
  - "**Realistic Scenario**" (RS): Core 70% and Periphery 100%.
  - "**North goes South**" (NGS): Core and Periphery 100%.

Roadmap of the results

- Stationary Recursive Equilibrium that captures some salient features of the 2010-2020 period:
  - Debt asymmetries (say Core 70%/Periphery 150%) that lead to external imbalances.
  - Within country heterogeneity (see Table 4).
- We study reforms of EA fiscal targets, specifically, **debt targets**.
- Three reformed economies:
  - "**Maastricht Treaty**" (MT): Core and Periphery 60%.
  - "**Realistic Scenario**" (RS): Core 70% and Periphery 100%.
  - "**North goes South**" (NGS): Core and Periphery 100%.
- To capture current inflation hike we implement a union wide mark up shock which generates 9% inflation on impact in the MT.

Calibration

Table 1: Externally Calibrated Parameters

parameter	core value	periphery value	Source
σ^*, σ	2	2	standard value
ϕ^*, ϕ	1	1	like e.g. McKay et al. (2016)
η^*, η	2	2	like e.g. McKay et al. (2016)
μ^*, μ	1.20	1.20	like e.g. McKay et al. (2016)
ρ^*, ρ	0.966	0.966	like e.g. McKay et al. (2016)
σ_e^*, σ_e	0.5568	0.5568	Vacas-Soriano et al. (2020)
Z^*/Z	1		
θ	0.01		
$\overline{\pi}_0$	0.0025		average 2010-2020 ($\frac{1\%}{4}$)
$G^*/Y^*, G/Y$	0.33	0.33	
$\mathbf{B^*/Y^*, B/Y}$	**4*0.7**	**4*1.5**	Annualised debt to GDP ratio

Calibration

Table 2a: Internally Calibrated Parameters

	core	periphery	
parameter	value	value	target
β, β^*	0.9911	0.9911	$i^* = 0$ (current ECB rate)
Z, Z^*	0.9771	0.9771	$Y = 1$ (normalisation)

Table 2b: Feedback policy coefficients

parameter	description	value
ϕ_π	Central Bank's reaction to Union inflation	1.3
γ, γ^*	Labour taxes reaction to debt-output deviations from target	[a]

[a] $\gamma, \gamma^* = [0.024, 0.025, 0.026]$, are set to target a debt consolidation half-life equal to 55 qrts, i.e., the time by which half of the reduction in the debt-output ratio is accomplished.

Stationary Equilibrium: EA 2010-2020

Table 3: Initial Stationary Equilibrium (key macro aggregates)

Variable	Value	Variable	Value
i^*	0.0000	Y^*	1.001
i	0.0041	Y	1
$i - i^*$	0.0041	B^*	2.803
r^*	-0.0025	B	6
r	0.0016	A^* / Y^*	3.142
$\tau^{l,*}$	0.388	A / Y	5.658
τ^l	0.407	NFA / Y	0.350
w^*	0.814	C^*	0.680
w	0.814	C	0.670

Stationary Equilibrium: EA 2010-2020

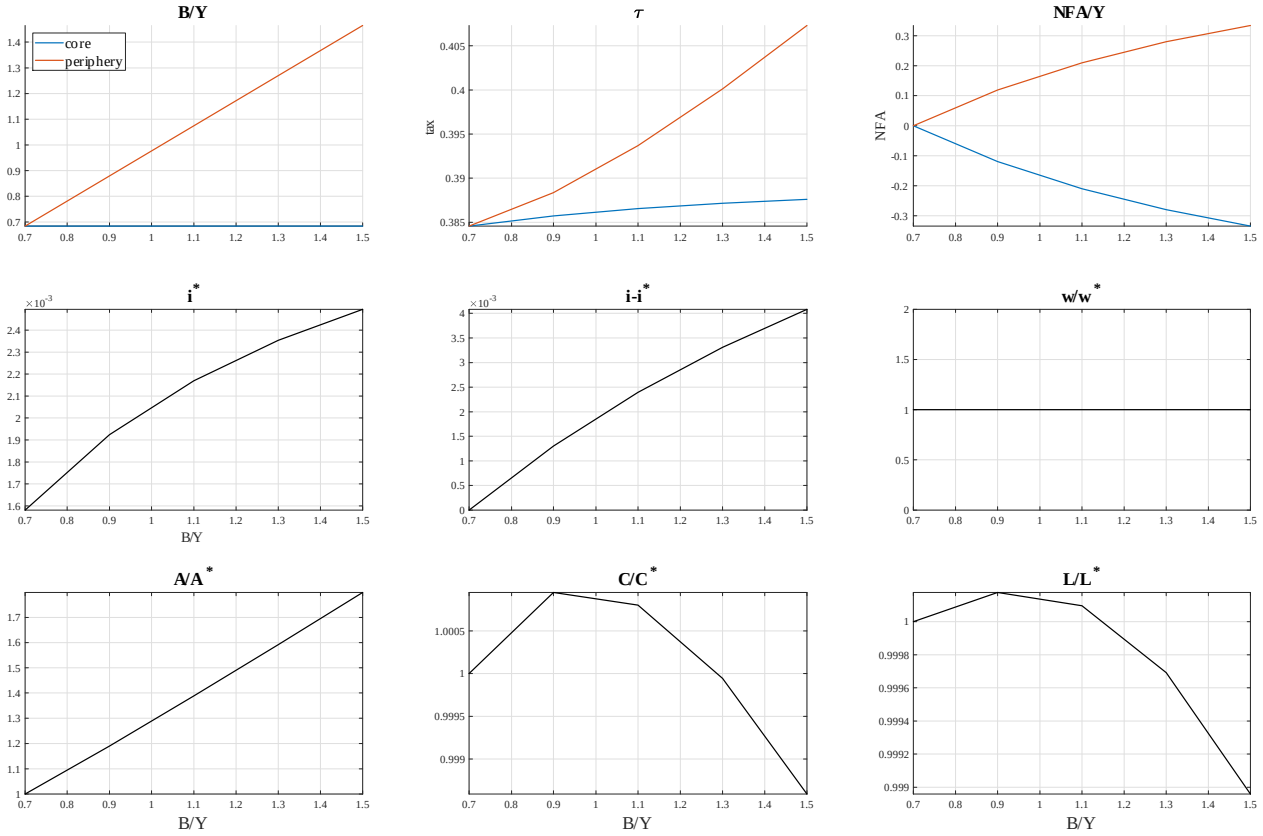
Table 4: Initial Stationary equilibrium (within country distributional variables)

Variable	Model	Data (2010-20)	Variable	Model	Data (2010-20)
Gini(a^*)	0.67	0.74[a]	Gini(y^*)	0.22	0.36[b]
Gini(a)	0.60	0.60[a]	Gini(y)	0.23	0.38[b]
$B_{50\%}(a^*)$	0.02	0.04[b]	$B_{50\%}(y^*)$	0.35	0.26[b]
$B_{50\%}(a)$	0.06	0.12[b]	$B_{50\%}(y)$	0.34	0.25[b]
$T_{10\%}(a^*)$	0.37	0.58[b]	$T_{10\%}(y^*)$	0.176	0.28[b]
$T_{10\%}(a)$	0.34	0.49[b]	$T_{10\%}(y)$	0.180	0.29[b]

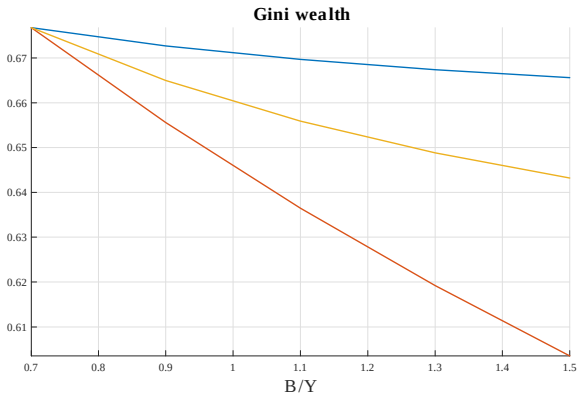
[a] Cowell and Van Kerm (2015) and they data only for 2010 or early 2011

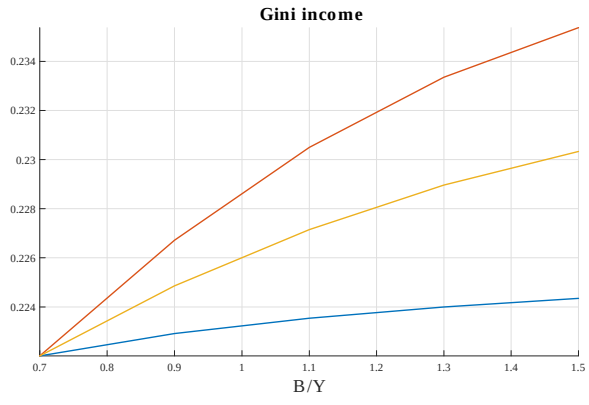
[b] Wealth Inequality Database

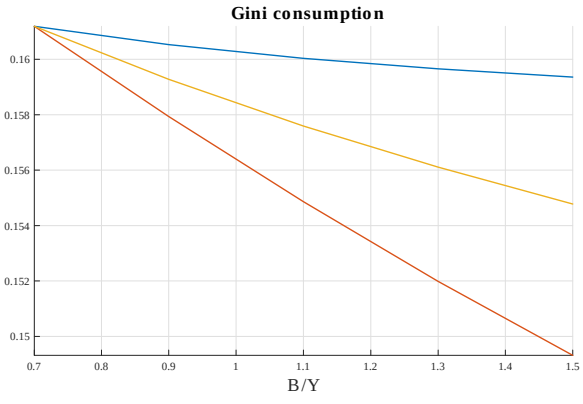
The role of debt asymmetries to inequality

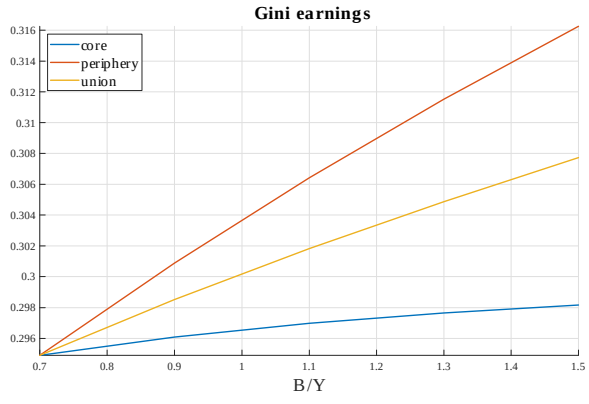


The role of debt asymmetries to inequality









Discussion

- In a world where public debt-output ratio is higher in the debtor country, intra-union imbalances emerge.
- Interest rates are higher in the Periphery vis-à-vis the Core. Higher interest rates imply higher asset accumulation.
- Income taxes are higher in the Periphery to sustain the higher public debt-output ratio.
- Households save more and consume less in the Periphery.

Debt Consolidation: Reformed EA economies

Table 5: Reformed Stationary Equilibria

	"Maastricht Treaty"	"Realistic Scenario"	"North goes South"
i^*	0.0004	0.0021	0.0042
i	0.0004	0.0039	0.0042
$i - i^*$	0	0.0019	0
r^*	-0.0046	-0.0029	-0.0008
r	-0.0046	-0.0011	-0.0008
π_T	0.0050	0.0050	0.0050
$\tau^{l,*}$	0.383	0.386	0.392
τ^l	0.383	0.391	0.392
$w = w^*$	0.814	0.814	0.814
NFA/Y	0	0.172	0
Gini(a^*)	0.69	0.67	0.64
Gini(a)	0.69	0.65	0.64

Debt Consolidation under various debt targets

Table 6: Welfare gains in % LCE

	"Maastricht Treaty"	"Realistic Scenario"	"North goes South"
Core	-0.24	-0.03	0.07
Periphery	-0.57	-0.14	-0.10
Union	-0.41	-0.08	-0.02
"half life" in qrts	55	55	55

Note: Welfare gains are measured in lifetime consumption equivalents (LCE) w.r.t. a stationary equilibrium w/out debt consolidation.

Debt Consolidation under various debt targets (cont'ed)

- Debt consolidation is relatively more (less) harmful for the Periphery (Core).
- The welfare losses are larger when the Union adopts fiscal targets implied by the "Maastricht Treaty" (i.e. 60%).

Is there a scope for changing EA fiscal targets?

- The EA can mitigate the welfare losses by adopting debt targets closer to the current levels of public debt-output ratios (e.g., compare "MT" with "RS").

Is there a scope for changing EA fiscal targets?

- The EA can mitigate the welfare losses by adopting debt targets closer to the current levels of public debt-output ratios (e.g., compare "MT" with "RS").
- The reduction in welfare losses would be higher for the Periphery than the Core.

Is there a scope for changing EA fiscal targets?

- The EA can mitigate the welfare losses by adopting debt targets closer to the current levels of public debt-output ratios (e.g., compare "MT" with "RS").
- The reduction in welfare losses would be higher for the Periphery than the Core.
- A scenario in which the Core expands (via labour tax cuts) while the Periphery consolidates, like "NGS", would be beneficial for the Core and least harmful for the Periphery.

Delving deeper into heterogeneous effects

Table 7: Welfare gains in % LCE

	Percentiles	"Maastricht Treaty"	"Realistic Scenario"	"North goes South"
Union	P^u_{10}	-0.62	-0.14	-0.23
	P^u_{50}	-0.26	-0.08	-0.02
	P^u_{90}	-0.24	-0.01	0.17
Core	P^*_{10}	-0.25	-0.04	-0.02
	P^*_{50}	-0.24	-0.04	-0.01
	P^*_{90}	-0.23	0.01	0.28
Periphery	P_{10}	-0.74	-0.17	-0.24
	P_{50}	-0.52	-0.14	-0.14
	P_{90}	-0.50	-0.11	0.09

Note: Percentiles are computed using the distribution of wealth in the initial stationary equilibrium.

Delving deeper into heterogeneous effects (cont'ed)

- Debt consolidation is relatively more harmful for the poorest households in the Union (esp. in the Periphery), i.e. P_{10}^{u} and P_{10}.

Delving deeper into heterogeneous effects (cont'ed)

- Debt consolidation is relatively more harmful for the poorest households in the Union (esp. in the Periphery), i.e. P_{10}^{u} and P_{10}.

- Changing the EA debt targets closer to current levels of debt-output ratios (i.e. from "MT" to the "RS") would not generate a conflict of interest,

Delving deeper into heterogeneous effects (cont'ed)

- Debt consolidation is relatively more harmful for the poorest households in the Union (esp. in the Periphery), i.e. P_{10}^{u} and P_{10}.

- Changing the EA debt targets closer to current levels of debt-output ratios (i.e. from "MT" to the "RS") would not generate a conflict of interest,
  - i.e., it would benefit all but relatively more the poorest households in the union (esp. in the Periphery).

Delving deeper into heterogeneous effects (cont'ed)

- Debt consolidation is relatively more harmful for the poorest households in the Union (esp. in the Periphery), i.e. P_{10}^{u} and P_{10}.

- Changing the EA debt targets closer to current levels of debt-output ratios (i.e. from "MT" to the "RS") would not generate a conflict of interest,
  - i.e., it would benefit all but relatively more the poorest households in the union (esp. in the Periphery).

- Going further, i.e., from the "RS" to "NGS" generates a conflict of interest,

Delving deeper into heterogeneous effects (cont'ed)

- Debt consolidation is relatively more harmful for the poorest households in the Union (esp. in the Periphery), i.e. P^u_{10} and P_{10}.

- Changing the EA debt targets closer to current levels of debt-output ratios (i.e. from "MT" to the "RS") would not generate a conflict of interest,
  - i.e., it would benefit all but relatively more the poorest households in the union (esp. in the Periphery).

- Going further, i.e., from the "RS" to "NGS" generates a conflict of interest,
  - i.e., would benefit the relatively richer households in the Union (w.r.t the "RS"), i.e. P^*_{90}, P_{90} and P^u_{90}, while,

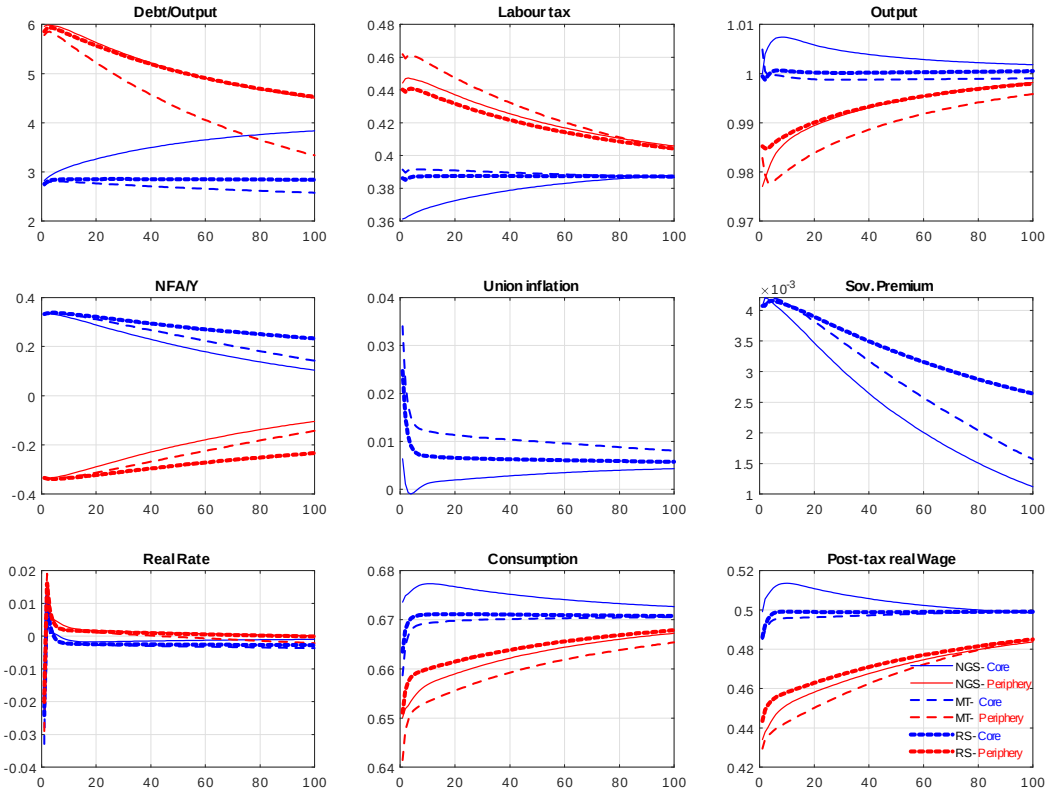
Delving deeper into heterogeneous effects (cont'ed)

- Debt consolidation is relatively more harmful for the poorest households in the Union (esp. in the Periphery), i.e. P^u_{10} and P_{10}.

- Changing the EA debt targets closer to current levels of debt-output ratios (i.e. from "MT" to the "RS") would not generate a conflict of interest,
  - i.e., it would benefit all but relatively more the poorest households in the union (esp. in the Periphery).

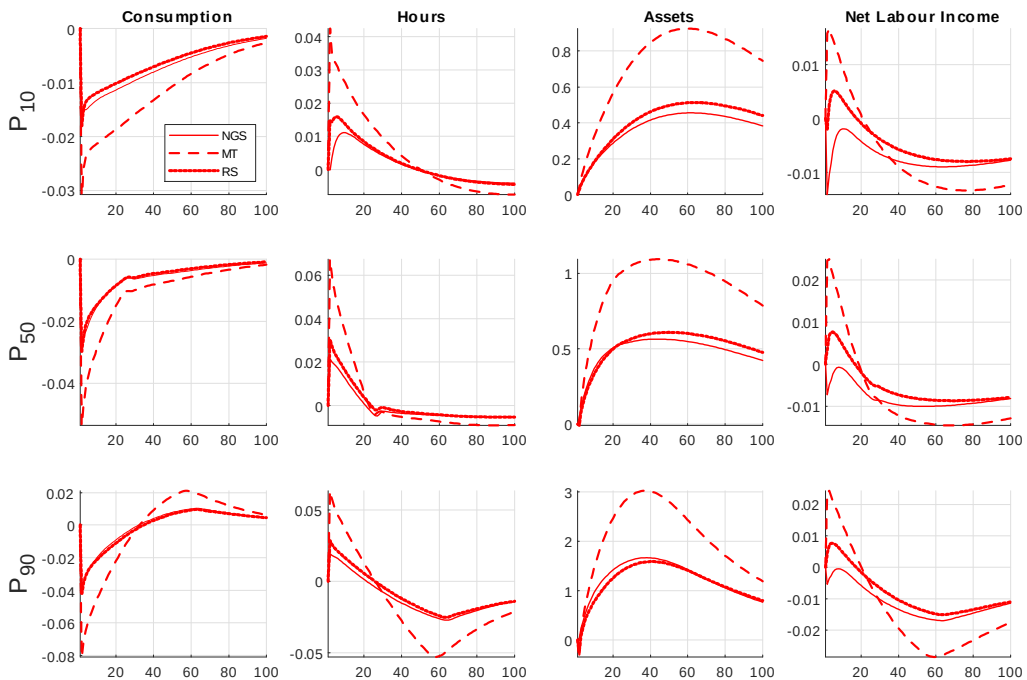
- Going further, i.e., from the "RS" to "NGS" generates a conflict of interest,
  - i.e., would benefit the relatively richer households in the Union (w.r.t the "RS"), i.e. P^*_{90}, P_{90} and P^u_{90}, while,
  - it makes worse the poorest in the Periphery, i.e., P_{10} (w.r.t. the "RS").

Figure 3: Dynamic responses of key macroeconomic aggregates



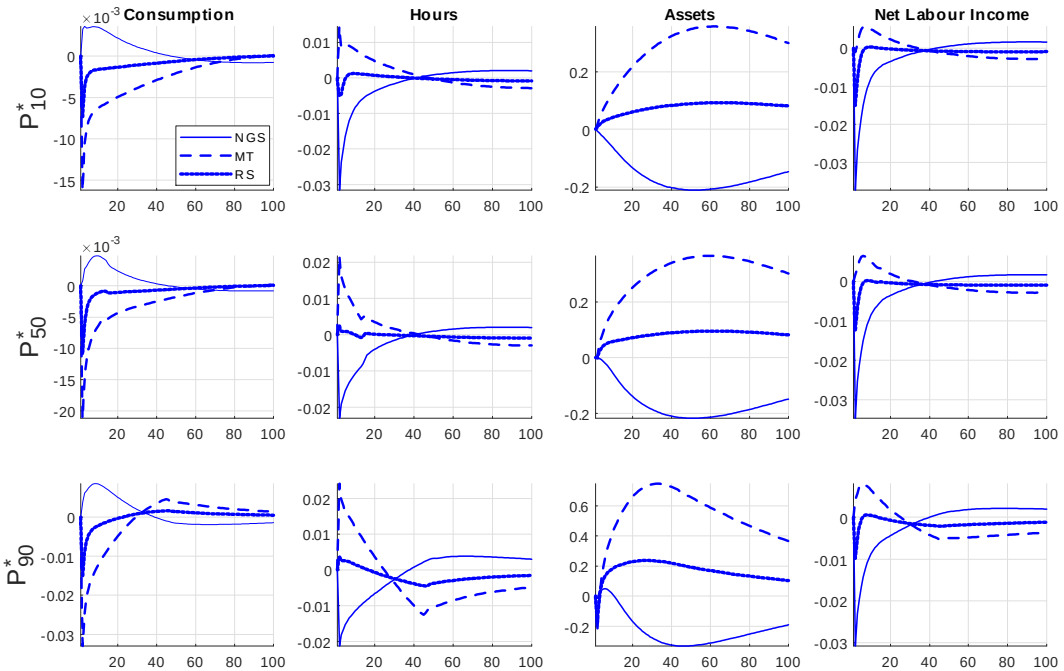
Note: Deviations from the associated stationary equilibrium w/out debt consolidation and the union-wide markup shock.

Figure 4: Dynamic responses of key endogenous variables conditional on the relative position in the initial wealth distribution in the Periphery



Note: As in Fig. 3.

Figure 5: Dynamic responses of key endogenous variables conditional on the relative position in the initial wealth distribution in the Core



Note: As in Fig. 3.

Why debt consolidation is more harmful for the poorer percentiles?

- The poorest households, i.e., P_{10} and P_{50}, rely more heavily on labour income than income from assets.

Why debt consolidation is more harmful for the poorer percentiles?

- The poorest households, i.e., P_{10} and P_{50}, rely more heavily on labour income than income from assets.
- Debt consolidation induces a hike in labour taxes and subsequently a reduction in post-tax real wage.

Why debt consolidation is more harmful for the poorer percentiles?

- The poorest households, i.e., P_{10} and P_{50}, rely more heavily on labour income than income from assets.
- Debt consolidation induces a hike in labour taxes and subsequently a reduction in post-tax real wage.
- Thus, poorer households reduce consumption and increase hours worked along the whole transition path. Both lead to a deterioration of their lifetime welfare.

Why debt consolidation is more harmful for the poorer percentiles?

- The poorest households, i.e., P_{10} and P_{50}, rely more heavily on labour income than income from assets.
- Debt consolidation induces a hike in labour taxes and subsequently a reduction in post-tax real wage.
- Thus, poorer households reduce consumption and increase hours worked along the whole transition path. Both lead to a deterioration of their lifetime welfare.
- At the same time, monetary response to inflation induces real interest rates to rise.

Why debt consolidation is more harmful for the poorer percentiles?

- The poorest households, i.e., P_{10} and P_{50}, rely more heavily on labour income than income from assets.
- Debt consolidation induces a hike in labour taxes and subsequently a reduction in post-tax real wage.
- Thus, poorer households reduce consumption and increase hours worked along the whole transition path. Both lead to a deterioration of their lifetime welfare.
- At the same time, monetary response to inflation induces real interest rates to rise.
- This rise in real rates reinforces a reduction in current consumption. However, the asset accumulation of the poorest is not enough to generate a higher level of consumption in the medium run.

Why debt consolidation is less harmful for the richer percentiles?

- On the contrary the richest households, i.e., P_{90} and P_{90}^{*}, own more wealth earn more asset income and thus rely less on labour income.

Why debt consolidation is less harmful for the richer percentiles?

- On the contrary the richest households, i.e., P_{90} and P_{90}^{*}, own more wealth earn more asset income and thus rely less on labour income.

- The rise in real rates allow richer households to subsitute current with future consumption by accumulating assets and work more in the short-run.

Why debt consolidation is less harmful for the richer percentiles?

- On the contrary the richest households, i.e., P_{90} and P_{90}^{*}, own more wealth earn more asset income and thus rely less on labour income.

- The rise in real rates allow richer households to subsitute current with future consumption by accumulating assets and work more in the short-run.

- Although the short run fall in consumption and the rise in hours worked deteriorate welfare, the medium run consumption recovers and hours worked drop which improves welfare.

Why debt consolidation is less harmful for the richer percentiles?

- On the contrary the richest households, i.e., P_{90} and P_{90}^{*}, own more wealth earn more asset income and thus rely less on labour income.

- The rise in real rates allow richer households to subsitute current with future consumption by accumulating assets and work more in the short-run.

- Although the short run fall in consumption and the rise in hours worked deteriorate welfare, the medium run consumption recovers and hours worked drop which improves welfare.

- The exploitation of the intertemporal subsitution allow richer households to mitigate the losses in their lifetime welfare.

Why changing the fiscal targets makes debt consolidation less costly for the relatively poorer?

- A milder labour tax increase induces a smaller decrease (rise) in consumption (hours worked) for the Poorest households, i.e P_{10} and P_{50}.
- Since poorer rely more on labour income than richer households, they would benefit relatively more from a change in fiscal targets.

Expansion in the North does not make the poorer in the Periphery better off w.r.t. the "RS"

- Surprisingly, under the "NGS", the Poorest household in the Periphery become worse off w.r.t the "RS".

Expansion in the North does not make the poorer in the Periphery better off w.r.t. the "RS"

- Surprisingly, under the "NGS", the Poorest household in the Periphery become worse off w.r.t the "RS".
- Why? the Core's government expansion (via labour tax cuts) requires funding, this reduces the available external funding for the Periphery (see NFA/Y in Fig. 3).

Expansion in the North does not make the poorer in the Periphery better off w.r.t. the "RS"

- Surprisingly, under the "NGS", the Poorest household in the Periphery become worse off w.r.t the "RS".
- Why? the Core's government expansion (via labour tax cuts) requires funding, this reduces the available external funding for the Periphery (see NFA/Y in Fig. 3).
- Any benefits from asset accumulation in the Periphery for the Poorer becomes even smaller.

The role of monetary policy

A more aggressive response w.r.t. inflation (say ϕ_π from 1.3 to 3):

- would benefit the richer households across all scenarios, e.g. welfare in % LCE for P^u_{90} rises from -0.24 to 0.07 in the "MT".

The role of monetary policy

A more aggressive response w.r.t. inflation (say ϕ_π from 1.3 to 3):

- would benefit the richer households across all scenarios, e.g. welfare in % LCE for P^u_{90} rises from -0.24 to 0.07 in the "MT".
- on the other hand, it would reduce the welfare gains from a change in EA fiscal targets, i.e., welfare in % LCE for P^u_{10} decreases from -.0.14 to -0.33 in the "RS".

The role of monetary policy

A more aggressive response w.r.t. inflation (say ϕ_π from 1.3 to 3):

- would benefit the richer households across all scenarios, e.g. welfare in % LCE for P^u_{90} rises from -0.24 to 0.07 in the "MT".
- on the other hand, it would reduce the welfare gains from a change in EA fiscal targets, i.e., welfare in % LCE for P^u_{10} decreases from -.0.14 to -0.33 in the "RS".
- see results ▸ Heterogeneous effects and monetary policy

Extensions

- Richer cross-country heterogeneity:
  - The role of relative prices:
    - Home bias.
    - Non-tradables.
  - Progressivity of labour taxes.
- The role of physical capital.
- Structural reforms which affect within country heterogeneity.

Appendix A: Model Equations

Preferences

The economy consists of a continuum of agents indexed by i normalized to measure 1 who are ex-ante homogeneous, and have CRRA preferences over consumption of home and foreign goods and leisure:

$$E\left[\sum_{t=0}^{\infty}\beta^{t}\left(\frac{\left(c_{i,t}\right)^{1-\gamma}}{1-\gamma}-\varphi\frac{\left(l_{i,t}\right)^{1+\eta}}{1+\eta}\right)\right]$$

where $\beta\in(0,1)$ is the households' subjective discount factor, $\frac{1}{\eta}$ is the Frisch elasticity of labor supply, and c_t^i is a CES aggregate of home and foreign goods with elasticity of substitution θ:

$$c_{i,t}=\left[(\chi)^{\frac{1}{\theta}}\left(c_{H,i,t}\right)^{\frac{\theta-1}{\theta}}+(1-\chi)^{\frac{1}{\theta}}\left(c_{F,i,t}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

where χ is the weight of *home* good in consumption ($1-\chi$ is the share of the *imported* good).

Constraints

Each household i chooses $c_{H,i,t}$ and $c_{F,i,t}$ to minimizes total consumption expenditure given by:

$$P_t c_{i,t} = P_{H,t} c_{H,i,t} + P_{F,t} c_{F,i,t}$$

where $P_{H,t}$ and $P_{F,t}$ are the nominal prices of home produced and *imported* foreign goods, respectively. The demand for home and foreign goods are given by:

$$c_{H,i,t} = \chi \left[\frac{P_{H,t}}{P_t} \right]^{-\theta} c_{i,t}$$

and

$$c_{F,i,t} = (1-\chi) \left[\frac{P_{F,t}}{P_t} \right]^{-\theta} c_{i,t}$$

while P_t is the CPI that is given by:

$$P_t = \left[\chi (P_{H,t})^{1-\theta} + (1-\chi)(P_{F,t})^{1-\theta} \right]^{\frac{1}{1-\theta}}$$

Debtor country: Households

$$
\begin{aligned}
& v_{i,t}\left(a_{i,t-1}, s_{i,t}\right) = \\
& = \max_{\substack{a_{i,t} \geq 0 \\ c_{i,t} \geq 0 \\ l_{i,t} \geq 0}} \left\{ \begin{array}{c} \frac{\left(c_{i,t}\right)^{1-\gamma}}{1-\gamma} - \varphi \frac{\left(l_{i,t}\right)^{1+\eta}}{1+\eta} \\ +\beta E\left[v_{i,t+1}\left(a_{i,t}, s_{i,t+1}\right) \mid s_{i,t}\right] \end{array} \right\}
\end{aligned} \tag{3}
$$

subject to the period-by-period household budget constraint expressed in real terms:

$$
c_{i,t} + a_{i,t} = \left(1 + i_{t-1}\right) \frac{P_{t-1}}{P_t} a_{i,t-1} + \left(1 - \tau_t^l\right) w_t s_{i,t} l_{i,t} + d_t \tag{4}
$$

▸ Model equations

Debtor country: Intermediate good firms

- There is a continuum of identical firms that produce differentiated home traded goods hiring labour services from domestic households.
- Each intermediate firm j faces the following technology:

$$y_{H,j,t} = Z_t n_{jt} \tag{5}$$

- where $y_{H,j,t}$ is the intermediate output of firm j which is produced using labour services n_{jt}, while Z_t is the aggregate labour productivity in period t. To preserve symmetry, we assume that firm employs a representative workforce.

▸ Model equations

Debtor country: Intermediate good firms (cont'ed)

- Firms face Rotemberg type price adjustment costs
$$\psi_{H,j,t} \equiv \frac{\mu_t}{\mu_t - 1} \frac{1}{2\kappa} \left[\ln\left(\frac{p_{H,j,t}}{p_{H,j,t-1}}\right) - \ln\left(1 + \pi_H\right) \right]^2 Y_{Ht}.$$

- Firms problem yields a standard New Keynesian Phillips curve:

$$\ln\left(\frac{1+\pi_{H,t}}{1+\pi_H}\right) = \kappa\left(\frac{w_t}{Z_t} - \frac{1}{\mu_t}\right) + \frac{1}{1+i_t}\frac{P_{H,t+1}}{P_{H,t}}\frac{\mu_t - 1}{\mu_t}\frac{\mu_{t+1}}{\mu_{t+1}-1}\frac{Y_{H,t+1}}{Y_{H,t}}\ln\left(\frac{1+\pi_{H,t+1}}{1+\pi_H}\right) \tag{6}$$

- where $\pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}} - 1$ denotes inflation rate in home country, and π_H is steady state inflation rate.

▸ Model equations

Debtor country: Government budget constraint

The period-by-period Government budget constraint expressed in nominal terms in the debtor country is given by :

$$B_t + \tau_t^l w_t L_t = (1 + i_{t-1}) \frac{P_{t-1}}{P_t} B_{t-1} + \frac{P_{H,t}}{P_t} G_{H,t} \qquad (7)$$

- where B_t is the end-of-period domestic government bonds in real terms,
- $P_{H,t} G_{H,t}$ is nominal government spending entirely on home goods..
- The Government in the debtor country borrows at rate i_t from domestic and/or the world financial intermediary.
- Finally, $\tau_t^l w_t L_t$ are tax revenues from labour income.

▸ Model equations

Debtor country: Fisher equation

- The usual Fisher equation in the debtor country implies:

$$1 + r_t = \frac{1 + i_{t-1}}{1 + \pi_t} \tag{8}$$

- where $\pi_t \equiv \frac{P_t}{P_{t-1}} - 1$ denotes the CPI inflation in home country. r_t is the real returns in terms of the CPI index.

▸ Model equations

Debtor country: Local financial markets

- The Government in the debtor country can borrow, $P_t B_t$, from domestic households, $P_t A_t$, and/or,

from the world financial intermediary, $P_t NFA_t \geq 0$, thus:

$$P_t B_t = P_t A_t + P_t NFA_t \tag{9}$$

- Combining the aggregate household budget constraint with the government budget constraint and subsituting the definition for profits and market clearing conditions in the goods and labour markets, we obtain the evolution of external debt in the debtor country:

$$NFA_t = \left(\frac{1+i_{t-1}}{1+\pi_t}\right) NFA_{t-1} - \left(\frac{P_{H,t}}{P_t} C^*_{H,t} - \frac{P_{F,t}}{P_t} C_{F,t}\right) \tag{10}$$

▸ Model equations

Creditor country: Local financial markets

Foreign households invest their assets, $P_t^* A_t^*$ to foreign government bonds, $P_t^* B_t^*$, and any excess assets, $P_t^* NFA_t^* \leq 0$, are invested in the financial intermediary, i.e.:

$$P_t^* NFA_t^* = P_t^* \left(B_t^* - A_t^* \right) \tag{11}$$

The evolution of international assets in the creditor country:

$$NFA_t^* = \left(1 + i_{t-1}^*\right) \frac{P_{t-1}^*}{P_t^*} NFA_{t-1}^* - \left(\frac{P_{F,t}^*}{P_t^*} C_{F,t} - \frac{P_{H,t}^*}{P_t^*} C_{H,t}^* \right) - \frac{\Xi_t^*}{P_t^*} \tag{12}$$

International financial market

- The international financial market is segmented, i.e. home and foreign households cannot directly trade assets with each other.
- As in Itskhoski and Mukhin (*JPE*, 2021), their international asset holdings are intermediated by a financial intermediary which is located in the creditor country.
- The financial intermediary faces operational costs and this gives rise to deviations from the uncovered interest parity in equilibrium.

Problem of the financial intermediary

- Nominal profits of the financial intermediary denominated in foreign currency are:

$$\Xi_t^* \equiv (1+i_{t-1})\frac{P_{t-1}}{S_t}NFA_{t-1} - \left(1+i_{t-1}^*\right)P_{t-1}^*\left(-NFA_{t-1}^*\right) - \frac{\theta}{2}P_{t-1}^*\left[\exp\left(\frac{(NFA_{t-1})}{Y_{t-1}}\right)-1\right]^2 \tag{13}$$

- where the term $\frac{\theta}{2}P_{t-1}\left[\exp\left(\frac{(NFA_{t-1})}{Y_{t-1}}\right)-1\right]^2$ reflects operational costs of the financial intermediary,
- S_t denotes the nominal exchange rate. Since we assume that both debtor and creditor countries are inside a monetary union, the nominal exchange rate is permanently fixed, say $S=1$.
- When $\theta > 0$, the financial intermediary makes profits when the foreign (creditor) country lends excess funds to home (debtor) country (i.e. $NFA_{t-1} > 0$).

Modified Uncovered Interest Parity

- The profit maximization of the financial intermediary yields:

$$(1 + i_{t-1}) = (1 + i^*_{t-1}) + \theta \left(\exp \left(\frac{NFA_{t-1}}{Y_{t-1}} \right) - 1 \right) \frac{1}{Y_{t-1}} \quad (14)$$

- Thus, if home country is a net debtor, i.e., $\frac{NFA_{t-1}}{Y_{t-1}} > 0$, the debtor country borrows with a premium with respect to the creditor country, i.e., $i_{t-1} > i^*_{t-1}$.

▸ Model equations

World market clearing conditions

Clearing market condition in home (debtor) country produced good:

$$Y_{H,t} = C_{H,t} + C^*_{H,t} + G_{H,t} + \psi_{H,t}$$

Clearing market condition in foreign (creditor) country produced good:

$$Y_{F,t} = C_{F,t} + C^*_{F,t} + G_{F,t} + \psi_{F,t}$$

World financial market is:

$$NFA_t + Q_t NFA^*_t = 0$$

The world goods market equilibrium implies:

$$P_{H,t}Y_{H,t} + P_{F,t}Y_{F,t} = P_{H,t}\left(C_{H,t} + C^*_{H,t} + G_{H,t} + \psi_{H,t}\right) + P_{F,t}\left(C_{F,t} + C^*_{F,t} + G_{F,t} + \psi_{F,t}\right)$$

▸ Model equations

World Stationary Recursive General Equilibrium

The stationary recursive general equilibrium of the world economy is defined as:

- The stationary distributions, $D\left(A \times S\right)$, $D^{*}\left(A^{*} \times S^{*}\right)$, policy functions $a_{h,t} = q_a\left(a_{h,t-1}, s_{h,t}\right)$, $l_{h,t} = q_l\left(a_{h,t-1}, s_{h,t}\right)$ and $c_{h,t} = q_c\left(a_{h,t-1}, s_{h,t}\right)$, $a^{*}_{h,t} = q^{*}_a\left(a^{*}_{h,t-1}, s^{*}_{h,t}\right)$, $l^{*}_{h,t} = q^{*}_l\left(a^{*}_{h,t-1}, s^{*}_{h,t}\right)$, $c^{*}_{h,t} = q^{*}_c\left(a^{*}_{h,t-1}, s^{*}_{h,t}\right)$, and value functions for home and foreign country respectively.
- The sixteen aggregate endogenous variables, π_t, w_t, Y_t , NFA_t, B_t, d_t, r_t, i_t, π^{*}_t, w^{*}_t, Y^{*}_t , NFA^{*}_t, B^{*}_t, d^{*}_t, r^{*}_t, $\widetilde{\Xi}^{*}_t$, that satisfy sixteen equations of the world equilibrium system such that:
- firms maximize profits, the policy functions solve the household's maximization problem given prices, aggregate quantities, the exchange rate regime, national fiscal policies and all local and world markets clear.

▸ Model equations

Appendix B: Tables and Figures

The role of monetary policy

Table A1: Welfare gains in % LCE			
	"Maastricht Treaty"	"Realistic Scenario"	"North goes South"
Core	-0.07	0.03	0.08
Periphery	-0.45	-0.12	-0.10
Union	-0.26	-0.04	-0.01
"half life" in qrts	55	55	55

$\gamma = \gamma^*, \phi_\pi = 3$

Heterogeneous effects and the role of monetary policy

Table A2: Welfare gains/losses in % LCE

	Percentiles	"Maastricht Treaty"	"Realistic Scenario"	"North goes South"
Union	P^u_{10}	-0.63	-0.33	-0.33
	P^u_{50}	-0.20	-0.07	-0.05
	P^u_{90}	0.07	0.25	0.31
Core	P^*_{10}	-0.17	-0.08	-0.06
	P^*_{50}	-0.14	-0.05	-0.03
	P^*_{90}	0.15	0.27	0.38
Periphery	P_{10}	-0.64	-0.35	-0.34
	P_{50}	-0.47	-0.18	-0.17
	P_{90}	-0.22	0.23	0.26

$\gamma = \gamma^*, \phi_\pi = 3$

Note: Percentiles are computed using the distribution of wealth in the initial stationary equilibrium.

Debt Consolidation: without mark up shock

Table A3: Welfare gains in % LCE			
	"Maastricht Treaty"	"Realistic Scenario"	"North goes South"
Core	-0.23	-0.03	0.05
Periphery	-0.55	-0.14	-0.12
Union	-0.39	-0.09	-0.03
"half life" in qrts	55	55	55

Note: i^* jumps immediatelly to the terminal i_T^*

$\gamma = \gamma^*$, $\phi_\pi = 1.3$

at period

$i^* i_T^* t = 4$

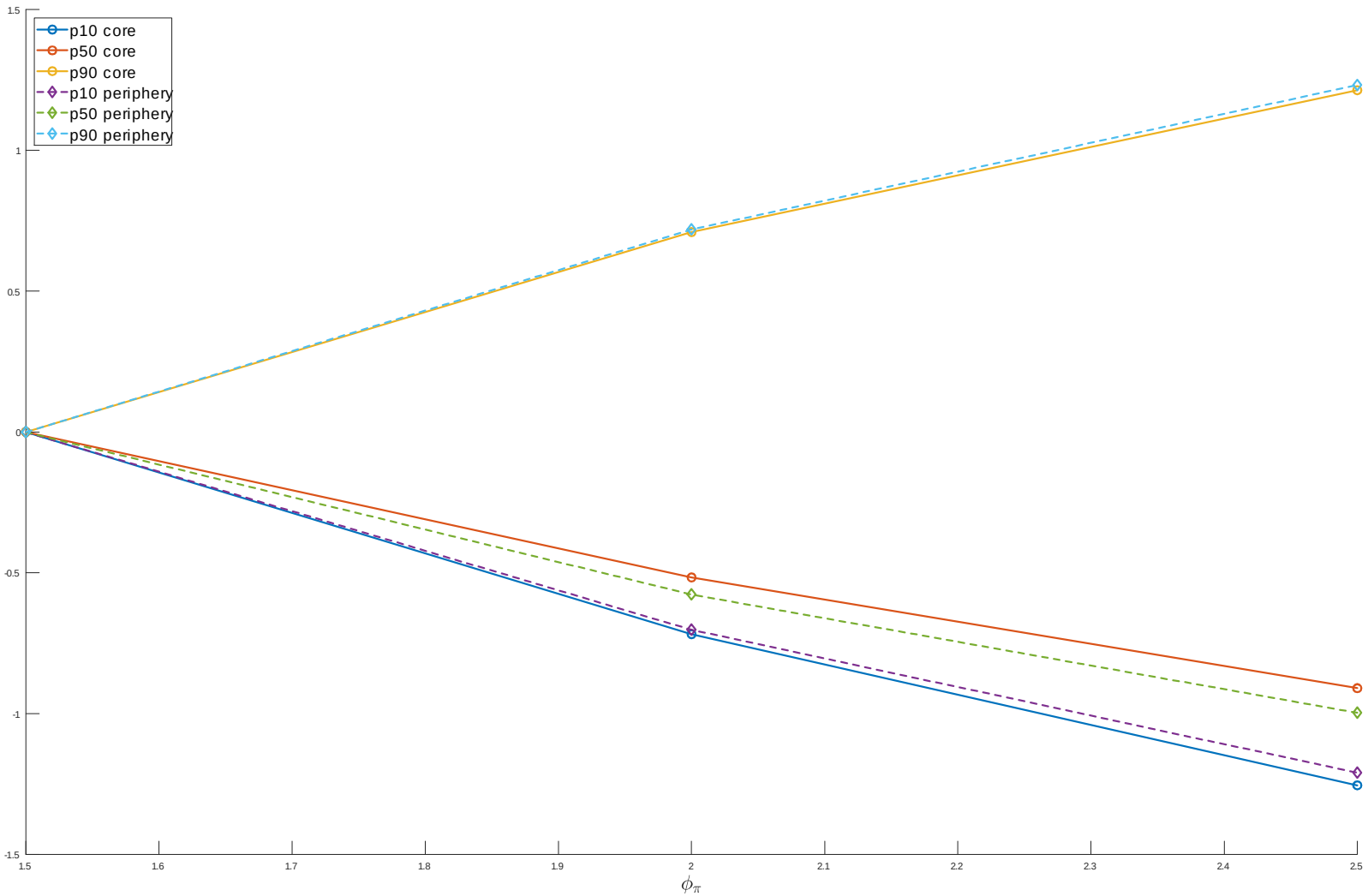
Table A4: Welfare gains in % LCE

	"Maastricht Treaty"	"Realistic Scenario"	"North goes South"
Core	-0.24	-0.04	-0.06
Periphery	-0.58	-0.15	-0.10
Union	-0.41	-0.09	-0.02
"half life" in qrts	55	55	55

Note: i^* jumps to the terminal i_T^* at period $t = 4$

$\gamma = \gamma^*, \phi_\pi = 1.3$

Welfare costs of a positive markup shock (w/o debt consol.)



Welfare costs of a positive markup shock (w/o debt consol.)