Inequality and Imbalances: an Open-Economy Agent-Based Model *

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Abstract

Our paper investigates the impact of rising inequality in a two-country macroeconomic model with an agent-based household sector and a stock-flow consistent structure. In particular, we build upon Cardaci and Saraceno (2016) in order to highlight the role of inequality in determining diverging balance of payments dynamics within a currency union. Growing inequality interacts with expenditure cascades and financialisation, resulting in two different growth patterns: an export-led regime emerges in the country with excess savings and depressed domestic demand; whereas the country with higher desired consumption evolves into a debt-led regime with capital inflows and booming household debt. Eventually, a crisis emerges endogenously due to the sudden-stop of capital flows from the net lending country, triggered by the excessive risk associated to the dramatic amount of private debt accumulated by households in the net borrowing country. Monte Carlo simulations for a wide range of calibration confirm the robustness of our results.

Keywords: Inequality, Current Account Imbalances, Agent-Based Models, Stock-Flow Consistency

JEL Classification: C63, D31, E21, F32, F43,

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1 Introduction

Kumhof et al. (2012) recently argued that current account deficits in developed economies are often accompanied by a dramatic increase in income inequality. More specifically, based on their data and econometric analysis, they point out that the rise in income disparities accounts for a major part of the large current account deficits in countries like the United States or the United Kingdom. The authors further stress the role of financial liberalisation: in order to alleviate the living conditions of the lower segments of society that are mostly affected by widening income disparities, policy makers rarely draw on the use of fiscal polices that tackle the structural source of inequality. Instead, the predominant approach typically relies on facilitating access to credit markets, that is on financial liberalisation, thus increasing the likelihood of building up household debt (Cardaci and Saraceno, 2016; Fitoussi and Saraceno, 2011; Kumhof et al., 2012). The major consequence is a debt-driven consumption boom that sustains aggregate demand for a while at the price of growing economic instability. The shaky foundations of this type of growth lie in the heavy debt burden that spreads in the system, which eventually triggers a series of defaults and a recession. Symmetrically, income inequality can also explain large current account surpluses as these occur in the presence of a low degree of financialisation that does not allow poorer households to access credit markets to borrow. The consequence, in this case, is sluggish internal demand and stagnating imports (Stockhammer, 2015).

In line with this view, we build a two-country macroeconomic model with an agent-based household sector and a stock-flow consistent structure aimed at showing how the rise of inequality in a financialised open economy leads to the emergence of current account imbalances. In fact, the impact of inequality drives the two countries into different growth patterns: where peer effects in consumption interact with higher credit availability from both the national and the foreign banking sector, rising income inequality leads to the emergence of a debt-led growth. Yet, in the country where social norms determine weaker emulation and a more parsimonious consumption behaviour, jointly with net capital outflows, an export-led regime arises. This results in boom-and-bust cycles in the two economies, together with symmetrically different dynamics in the balance of payments.

The situation depicted in our model is similar to the one that the European economy experienced following the introduction of the Euro. As Baldwin and Giavazzi (2015) point out, the key driver of current account imbalances in the Eurozone is to be found in the fact that, broadly speaking, the core nations (e.g. Germany and the Netherlands) had above-average savings, while the GIIPS (Greece, Italy, Ireland, Portugal, Spain) had below-average savings. As a consequence, in the period 2000-2007, core countries lent to the peripheral ones thus allowing the latter to run increasingly large

current account deficits.[1] Hence, Baldwin and Giavazzi highlight the imbalances between such two groups of countries as the key element of fragility in the Eurozone economy. Eventually, the global financial crisis triggered a sudden stop in private capital flows, regarding in particular the positions of both secured and unsecured interbank markets, holdings of foreign public debt, as well as deposits (Auer, 2014). The persistence of current account deficits in the periphery, despite capital flying back to the core, was the main reason behind the dramatic expansion of the net Target 2 position of the Bundesbank (Auer, 2014; Cecchetti et al., 2012; Cesaratto, 2013).[2]

The paper is organised as follows: Section 2 introduces our model, providing a description of the sequence of events and the key mechanisms at work; Section 3 discusses our main findings regarding model results and the sensitivity analysis; Finally, Section 4 concludes.

2 The Model

Our work builds upon Cardaci and Saraceno (2016) by extending the macroeconomic agent-based model developed therein to a two-country economy in order to emphasise the role of inequality in determining diverging balance of payments dynamics within a currency union. Our modelling strategy still relies on the *KISS* (Keep It Simple, Stupid!) principle, in that our assumptions aim at accounting only for the relevant elements of the story we want to describe, thus discarding other features which would certainly enrich the model but would also increase its complexity.

Each country, denoted by the subscript $c = A, B$, has the same number of heterogeneous households ($h = 1, ..., H$), a commercial bank (b), a firm (f), a government (g) and a national central bank (cb). We assume the two economies belong to a currency union and, as such, we include a common supranational central bank (ccb). Thus, in an extremely simplified manner, the framework of our model replicates the general setting of the Eurozone, featuring the European System of Central Banks (ESCB) and including a rather stylised version of the Target 2 mechanism. The essential features of our open economy are as follow:

- Each country has one representative firm only, which is owned by all households, and distributes all its earnings thus retaining zero profits. Also, there is no investment in capital goods. The supply side of

[1] "By 2007, Germany was, on net, lending almost $250 billion per year to other EZ nations. [...] Spain was by far the largest net borrower, with its capital inflows reaching $150 in the year before the crisis" (Baldwin and Giavazzi, 2015, p. 27).

[2] Appendix A elaborates on the functioning of Target 2 and its relationship with external imbalances in the Eurozone. There, we also describe the simple approach to simulate Target 2 in our model.

the economy is simplified to a feedback mechanism that mechanically reacts to changes in aggregate demand.

- Heterogeneous households' desired consumption is based on imitative behaviour, in line with the Expenditure Cascades hypothesis (Frank, 2014).
- Income distribution is based on constant individual income shares drawn from a Pareto distribution, which is identical in the two countries. This is consistent with empirical evidence suggesting that income is generally distributed according to a power-law distribution and, more specifically, to a Pareto, particularly at top of the income scale Clementi and Gallegati (2005); Jones (2015).
- Households can allocate consumption between domestic and foreign goods so that international trade occurs in the economy.
- Each country has a representative commercial bank that extends non-collateralised loans to households.

The sequence of events within each period t follows Cardaci and Saraceno (2016), with the inclusion of the choice of consumption allocation between the two countries and the formation of international loan transactions. Hence:

1. **Production.** Firms in the two countries produce homogenous perishable goods using domestic labour as the only input.
2. **Distribution.** Each firm distributes wages to households in the same country. If the two commercial banks have positive net worth, they distribute the entire amount of profits to domestic households. This process is based on the above-mentioned individual income shares.
3. **Bail out.** In case of a negative net worth, each commercial bank is bailed out by the national central bank of the corresponding country via a transfer of assets (called reserves), so that its net worth at the end of this phase is equal to zero. Thus, we rule out banking crises, and we focus on household debt as a trigger of financial instability.
4. **Government revenues and debt.** Households pay taxes on income based on an exogenous progressive taxation system. Collected taxes add up to the government deposit account held by each national central bank. The government then pays back its principal and interest on bonds to each household, based on the repayment schedule set in the previous period.

5. **Desired consumption and financial assessment.** Each household in the two countries computes her desired consumption based on imitative behaviour, and assesses her own financial position. This latter may be positive, if internal resources are higher than desired consumption and due debt, or negative, otherwise. Households with a positive financial position use the exceeding amount of internal resources to demand government bonds, whereas households with a negative financial position ask for a loan. Note that households can demand loans in order to finance desired consumption as well as to rollover their debt, that is, to pay back the debt from the previous period.

6. **Policy targets.** Policy institutions decide their targets: the supranational central bank sets the policy interest rate while national governments set their desired public expenditure. Both decisions follow an counter-cyclical rule based on the value of the "demand gap" in the previous period.

7. **Bond market.** The bond market opens: if desired public expenditure exceeds collected taxes and past deposits, governments need to borrow from domestic households, thereby computing their supply of bonds. Total bond demand simply equals the sum of individual bond demand by each household in the country, as mentioned in point 5. Note that the bond market may be in disequilibrium since total supply and demand are the result of independent decisions.

8. **First pay-back-phase (PBP).** The pay-back phase (PBP) begins: households pay back the loan (principal plus interest) from the previous period. This does not include borrowers who need to perform debt rollover, as they do not have the internal resources to meet their debt obligations entirely. Hence, they will enter the credit market trying to obtain a new loan and, afterwards, they will go through a second PBP in order to repay the old one.

9. **Credit market.** The commercial banks in the two countries set their total available credit supply as a fraction of total credit demand and rank households in ascending order based on their financial soundness. Loan applications, computed by households at step 5, are satisfied until the banks run out of total credit supply. This implies that credit-rationing may occur in the market: more financially fragile households may not obtain any loan from the commercial banks. Credit-rationed households will not be able to finance their desired consumption entirely and to perform debt rollover. Hence they go bankrupt and as such they are not allowed to apply for a new loan for a number of periods.

10. **Second PBP.** Households who needed debt rollover and successfully got a new loan in the credit market, can now pay back the loan from the previous period.

11. **Goods market.** Based on the ratio between domestic and foreign prices, households decide how to allocate their desired consumption between the two countries. For simplicity, we assume that national governments only buy domestic goods, based on their desired level of expenditure. If the output produced by each firm at the beginning of each period is lower than demand, rationing takes place. On the contrary, in case of excess supply, we assume the firm gets rid of the unsold amount of its perishable goods at no cost.

12. **Macroeconomic closure.** Finally, all macroeconomic variables (e.g. GDP, public and private debt, balance of payments) are updated. Disequilibria trigger changes in prices and in potential output.

2.1 Stocks and Flows

Figure 1 provides a graphical representation of all the transaction flows in our economy, as described by the sequence reported above.

Like in Cardaci and Saraceno (2016), each agent is endowed with a balance sheet that tracks the levels of all stock variables at any point in time. This is meant to guarantee stock-flow consistency, meaning that any transaction that takes place in the economy is matched by an identical change in the stocks held in the balance sheets of the agents involved.

Table 1 represents the balance sheets for each typology of agent in our open economy, with the following stock variables for each country c: household deposits ($D_{t,h,c}$), loans ($L_{t,h,c}$), government deposits ($D_{t,g,c}$), government bonds ($B_{t,g,c}$), reserves ($R_{t,c}$), firm deposits ($D_{t,f,c}$), central bank loans ($LCB_{t,c}$), Target 2 claims for the national central bank ($T2A_{t,c}$), Target 2 liabilities for the national central bank ($T2L_{t,c}$).

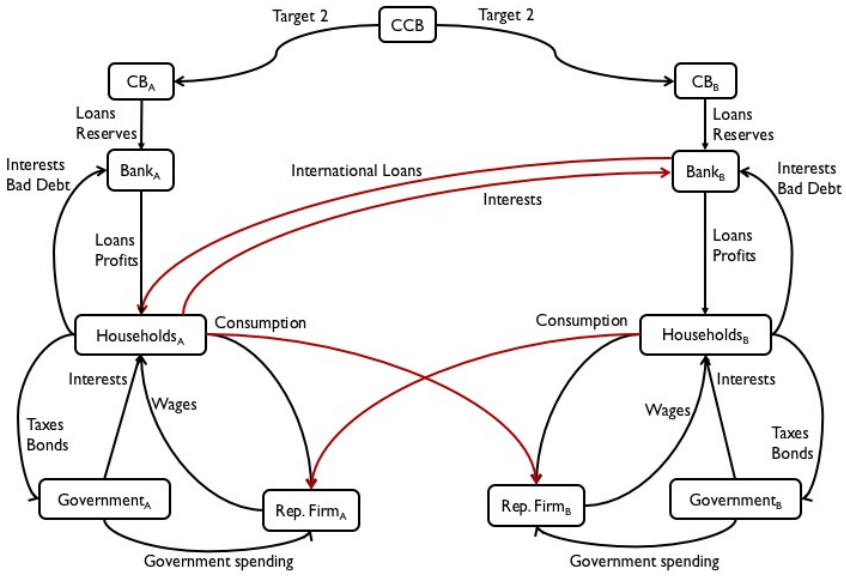

Figure 1: Transaction flows in our economy.

$Households_A$	
Assets	Liabilities
$D_{t,h,A}$	$L_{t,h,A}$
$B_{t,g,A}$	

$Bank_A$	
Assets	Liabilities
$L_{t,h,A}$	$D_{t,h,A}$
$R_{t,A}$	$D_{t,f,A}$
	$LCB_{t,A}$

$Firm_A$	
Assets	Liabilities
$D_{t,f,A}$	

$Government_A$	
Assets	Liabilities
$D_{t,g,A}$	$B_{t,g,A}$

$CentralBank_A$	
Assets	Liabilities
$T2A_{t,A}$	$T2L_{t,A}$
$LCB_{t,A}$	$R_{t,A}$
	$D_{t,g,A}$

$Households_B$	
Assets	Liabilities
$D_{t,h,B}$	$L_{t,h,B}$
$B_{t,g,B}$	

$Bank_B$	
Assets	Liabilities
$L_{t,h,B}$	$D_{t,h,B}$
$R_{t,B}$	$D_{t,f,B}$
	$LCB_{t,B}$

$Firm_B$	
Assets	Liabilities
$D_{t,f,B}$	

$Government_B$	
Assets	Liabilities
$D_{t,g,B}$	$B_{t,g,B}$

$CentralBank_B$	
Assets	Liabilities
$T2A_{t,B}$	$T2L_{t,B}$
$LCB_{t,B}$	$R_{t,B}$
	$D_{t,g,B}$

CCB	
Assets	Liabilities
$T2L_{t,A}$	$T2A_{t,A}$
$T2L_{t,A}$	$T2A_{t,B}$

Table 1: Agents balance sheets in our economy.

We make a number of hypotheses about the functioning of our artificial economy. First, note that central banks usually lend secured to commercial banks, thereby taking collateral to protect against the possibility of loss due to credit and market risk (Rule, 2015). However, in line with Cardaci and Saraceno (2016), our simplistic framework implies that bailout operations do not require any collateral or reimbursement so that the national central bank does not receive any asset in exchange for the transfer of reserves to the commercial bank. In addition, the accumulation of $LCB_{t,c}$, as well as $T2A_{t,c}$ and $T2B_{t,c}$, are due to the inclusion of a stylised version of the Target 2 mechanism in our model. The framework we have adopted is based on a post-crisis setting, as described in Appendix A. That is, for simplicity we assume there is no interbank lending in our economy. This has two major consequences: 1) whenever a country records a current account deficit, this is matched by changes in T2 positions, unless the CA deficit is outbalanced by a capital inflow in the form of deposits arising from household debt with the foreign bank; 2) a current account deficit does not change the reserve account of the commercial bank of the deficit country because any loss of reserves is entirely matched by a refinancing operation by the national central bank, in that the national central bank provides the commercial bank with an unsecured loan ($LCB_{t,c}$). Indeed, since we assume that banks do not provide any collateral when they borrow from the corresponding national central banks, there is no limit to the changes in the net Target 2 position of a country.

We also make two further important assumptions:

1. Households in country A are assumed to have stronger imitation effects compared to households in B;

2. The banking sector of B is willing to provide credit both at home and abroad, whereas the commercial bank in A only lends at the domestic households.

Thus, we expect peer effects and greater credit availability to lead country A towards a less parsimonious consumption pattern; on the contrary, country B should experience higher savings and a capital outflow in the form of household loans. As such, these two assumptions are meant to replicate the above-mentioned core features of the European economy, as reported by Baldwin and Giavazzi (2015).

2.2 Households

Individual disposable income is the sum of wages ($w_{t,h,c}$), profits from the commercial bank of the country ($\pi_{t,h,c}$) and the repayment schedule on government bonds from the previous period ($iB_{t-1,h,c}$), net of the due amount of taxes ($T_{t,h,c}$).

$$yd_{t,h,c} = w_{t,h,c} + \pi_{t,h,c} + iB_{t-1,h,c} - T_{t,h,c} \tag{1}$$

Wages are distributed by the firm at the beginning of each period t. In particular, the firm allocates the entire amount of revenues ($D_{t-1,F}$) to all households based on constant individual income shares that are drawn from a Pareto distribution (Figure 2). The distribution is designed to provide an income share of 29.68% for the top 10% in the two countries, a value in line with the 1970 mean for the countries reported in Cardaci and Saraceno (2016).

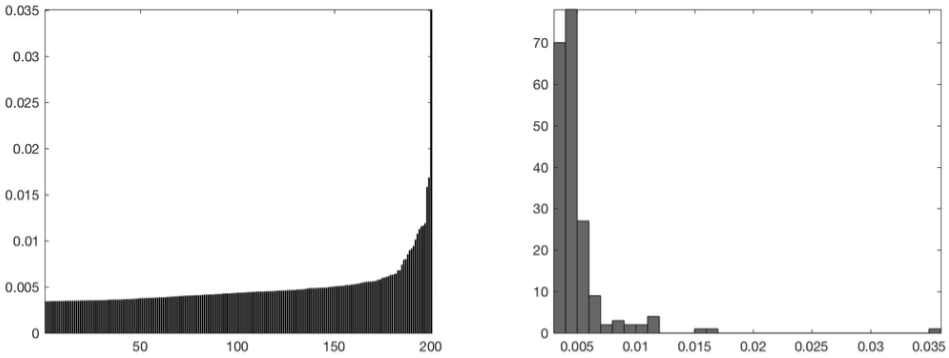

Figure 2: Individual income shares: bar chart (left) and histogram (right).

The distribution of bank's profits in t is based on the same individual income shares and it occurs only in case the bank records positive net worth at the end of $t-1$.

Finally, $iB_{t-1,h,c}$ is not distributed according to fixed individual shares. Instead, it depends on the stock of bonds held by each household and, as such, it might allow the income distribution to change endogenously. However, as discussed later in Section 3, our simulations show that the supply of bonds is always equal to zero, so that $iB_{t-1,h,c} = 0 \quad \forall h, c$ and the income distribution is always exogenous.

Consumption behaviour in our model is based on peer effects and imitation. This is consistent with the empirical literature on behavioural economics, as reported in Frank (2014) (see also Cardaci, 2016; Fazzari and Cynamon, 2013).

$$C^d_{t,h,c} = k\, yd_{t,h,c} + a_c\, C_{t-1,j,c} \tag{2}$$

Equation 2 describes h's desired consumption as a function of her disposable income ($yd_{t,h}$) and the actual previous-period consumption of j, who is the household ranking just above h in the income scale (i.e. $j = h+1$,

based on ascending disposable income ranking). k is a parameter unrelated to permanent income level or rank (Frank, 2014), while a is a sensitivity parameter such that $0 \leq a \leq 1$. When $a = 1$, h fully mimics j's consumption; whereas when $a = 0$, h does not consider j's consumption.

Actual individual demand for consumption is defined as the minimum between desired consumption and household deposits, $min(C^d_{t,h,c}, D_{t,h,c})$, due to the fact that each household might be credit-rationed and, as such, she might not be able to finance her desired consumption in full. In this case, individual household spending for consumption would be constrained by the amount of her deposit.

All households also allocate individual demand at home and abroad ($DC^c_{t,h,c}$ and $DC^{-c}_{t,h,c}$ respectively), based on the ratio between domestic and foreign prices ($P_{t,c}/P_{t,-c}$) multiplied by a sensitivity parameter (γ) (Equations 3 and 4).[3]

$$DC^c_{t,h,c} = \left(1 - \gamma \frac{P_{t,c}}{P_{t,-c}}\right) \cdot min(C^d_{t,h,c}, D_{t,h,c}) \tag{3}$$

$$DC^{-c}_{t,h,c} = \left(\gamma \frac{P_{t,c}}{P_{t,-c}}\right) \cdot min(C^d_{t,h,c}, D_{t,h,c}) \tag{4}$$

Eventually, households compare their expected expenditures with their internal resources in order to assess their financial position. In particular, if the sum of desired consumption and the repayment schedule on home and foreign loans from the previous period ($RS^c_{t-1,h,c} + RS^{-c}_{t-1,h,c}$) is greater than the sum of her disposable income and past deposits, household h applies for a loan to the banking sector.[4] That is, h has a negative financial position and a positive loan demand ($L^d_{t,h}$) as a consequence.

$$\begin{aligned} if \quad & C^d_{t,h,c} + RS^c_{t-1,h,c} + RS^{-c}_{t-1,h,c} > yd_{t,h,c} + D_{t-1,h,c} \\ then \quad & L^d_{t,h,c} = C^d_{t,h,c} + RS_{t-1,h,c} + RS^{-c}_{t-1,h,c} - yd_{t,h,c} - D_{t-1,h,c} \end{aligned} \tag{5}$$

Households in A are assumed to have a home bias, such that they first apply for a loan to the banking sector in their country. Eventually, only in case of rationing in the domestic credit market, households in A will send their loan applications abroad to the commercial bank in B.

On the contrary, households with enough internal resources to finance desired expenditures, are willing to lend their excess resources to the government by demanding government bonds ($B^d_{t,h,c}$).

[3] Notice that γ is a positive parameter such that $1 - \gamma \frac{P_{t,c}}{P_{t,-c}} \geq 0$ and $\gamma \frac{P_{t,c}}{P_{t,-c}} \geq 0$, that is individual demand (at home or abroad) cannot be negative.

[4] The repayment schedule on both home and foreign loans is defined in section 2.5.

$$
\begin{aligned}
if \quad & C^d_{t,h,c} + RS_{t-1,h,c} + RS^{-c}_{t-1,h,c} \leq yd_{t,h,c} + D_{t-1,h,c} \\
then \quad & B^d_{t,h,c} = yd_{t,h,c} + D_{t-1,h,c} - C^d_{t,h,c} - RS_{t-1,h,c} - RS^{-c}_{t-1,h,c}
\end{aligned} \tag{6}
$$

2.3 Firms

In order to keep the structure of the model as simple as possible, we have implemented a relatively simple production sector in each country, with a representative firm owned by the domestic population. Each firm distributes wages to the household sector based upon the already mentioned individual Pareto shares.

The two firms also set total production ($Q_{t,c}$) and prices ($P_{t,c}$) by reacting to disequilibria in the goods market, as described by Equations 7 and 8. That is, production at time t ($Q_{t,c}$), as well as prices ($P_{t,c}$), depend on their previous period level and on a sensitivity parameter ($\phi_{Q,c}$ and $\phi_{P,c}$ respectively) multiplied by the previous period demand gap ($gap_{t-1,c}$). This is consistent with empirical evidence suggesting that income is generally distributed according to a power-law distribution and, more specifically, to a Pareto, particularly at top of the income scale (Clementi and Gallegati, 2005; Jones, 2015).

$$
Q_{t,c} = Q_{t-1,c}\left(1 + \phi_{Q,c} \cdot gap_{t-1,c}\right) \tag{7}
$$

$$
P_{t,c} = P_{t-1,c}\left(1 + \phi_{P,c} \cdot gap_{t-1,c}\right) \tag{8}
$$

The demand gap measures the real term excess demand or supply in the past and it is defined as the difference between aggregate demand ($AD_{t,c}$) and production, divided by production itself (Equation 9).

$$
gap_{t,c} = \frac{AD_{t,c} - Q_{t,c}}{Q_{t,c}} \tag{9}
$$

Aggregate demand (Equation 10) is the sum of private desired consumption, government spending ($G^d_{t,c}$, defined in the next section) and exports, which are computed as the sum of individual demand for goods by foreign households.

$$
AD_{t,c} = \sum_{h \in c} DC^c_{t,h,c} + G^d_{t,c} + \sum_{h \in -c} DC^c_{t,h,-c} \tag{10}
$$

2.4 Government

Based on a counter-cyclical rule, the two governments set the ratio of public spending over GDP at the beginning of each period. In particular, each

national government deviates from the initial value of such ratio $\left(\overline{\frac{G^d}{GDP}}\right)$, based on its sensitivity (ϕ_G) to the demand gap in the previous period:

$$\frac{G^d_{t,c}}{GDP_{t-1,c}} = \overline{\frac{G^d_c}{GDP_c}} - \phi_G \cdot gap_{t-1,c} \tag{11}$$

Like households, the two governments assess their financial situation as the difference between expected expenditure (the sum of desired public expenditure and the repayment schedule on public bonds issued in the previous period, $RSG_{t-1,c}$) and available internal resources (the sum of past deposits and the amount of taxes collected, $T_{t,c}$). Only in case this difference is negative the government issues new public bonds in order to finance its expenditure (Equation 12).

$$BS_{t,c} = G^d_{t,c} + RSG_{t,c} - D_{t-1,g,c} + T_{t,c} \tag{12}$$

For simplicity:

- Bonds are one period debt contracts between domestic households and the national government. That is, we make the simplifying assumption that each of the two governments can borrow only from households in the same country. Hence, in each t, the government pays back $RSG_{t,c}$, which includes both principal and interests.
- The interest rate on bonds is equal to the policy rate set by the supranational central bank (as described in section Section 2.5), as in Cardaci and Saraceno (2016).

We want to stress that there is no mechanism that guarantees that the bond market is in equilibrium. In other words, as the formulation of bond demand and supply in each country are based on independent decisions by households and the government, rationing may take place in the bond market. Indeed, if supply exceeds demand, all lenders obtain the desired amount of bonds, while being rationed in the opposite case so that the amount of bonds they obtain is equal to $min\left(1, \frac{BS_{t,c}}{BD_{t,c}}\right) B^d_{t,h,c}$, where $BD_{t,c} = \sum_{h \in c} B^d_{t,h,c}$ is total demand for bonds.

As already mentioned, the amount of collected taxes is always enough to finance the desired level of expenditure by the government in our simulations. Hence, *de facto*, the bond market never opens. In this case, household savings that cannot be invested into bonds simply take the form of zero interest rate deposits.

2.5 Banks

As pointed out in Section 2.2, only households with a negative financial position are allowed to enter the credit market. We distinguish two types of borrowers: consumption borrowers (CB) and borrowers in financial distress (FDB). The former have enough own resources to pay back the repayment schedule on the loan from the previous period and, as such, they enter the credit market only to finance their desired consumption.[5] On the contrary, FDB ask for a new loan not only to finance consumption but also to pay back the previous-period loan. Hence, FDB demand credit with the purpose of rolling over their debt.

The rule of behaviour for the formation of credit supply follows the mechanism described in Cardaci and Saraceno (2016): the commercial bank in A sets the maximum allowable credit supply as a fraction ($v_{t,A}$) of total credit demand from domestic households,

$$LS_{t,A} = v_{t,A} \sum_{h \in A} L^d_{t,h,A} \tag{13}$$

whereas the bank in B sets its total supply as a fraction of total credit demand by all households in the economy

$$LS_{t,B} = v_{t,B} \left(\sum_{h \in A} L^d_{t,h,A} + \sum_{h \in B} L^d_{t,h,B} \right) \tag{14}$$

This differentiation is due to the fact that, as already pointed out, we allow the banking sector in country B to lend internationally.

Note that $v_{t,c} \in [v_{min}, v_{max}]$. That is, each commercial bank endogenously changes the value of $v_{t,c}$ within two boundaries (v_{min} and v_{max}) that are exogenously set in the initialisation phase of the model (Conditions 15 and 16). In particular, $v_{t,c}$ evolves as a function of systemic risk which is proxied by the household debt-to-GDP ratio in the previous period: the commercial bank in A focuses on the debt ratio in A only $\left(\frac{debt_{t-1,A}}{GDP_{t-1,A}}\right)$, since it supplies loans exclusively to households in the same country:

$$\text{if} \quad \frac{debt_{t-1,A}}{GDP_{t-1,A}} > threshold \quad \text{then} \quad v_{t,A} = v_{t-1,A} + \phi_v(v_{min} - v_{t-1,A}) \tag{15}$$

$$\text{if} \quad \frac{debt_{t-1,A}}{GDP_{t-1,A}} < threshold \quad \text{then} \quad v_{t,A} = v_{t-1,A} + \phi_v(v_{max} - v_{t-1,A}) \tag{16}$$

Bank B on the other hand, evaluates the mean of the debt ratio in the two countries $\left(\frac{debt_{t-1}}{GDP_{t-1}}\right)$, as its credit supply targets households of both A and

[5] CB also includes households with zero repayment schedule, that is, those who did not take any loan in $t-1$.

B:

$$\text{if} \quad \overline{\frac{debt_{t-1}}{GDP_{t-1}}} > threshold \quad \text{then} \quad v_{t,B} = v_{t-1,B} + \phi_v(v_{min} - v_{t-1,B}) \tag{17}$$

$$\text{if} \quad \overline{\frac{debt_{t-1}}{GDP_{t-1}}} < threshold \quad \text{then} \quad v_{t,B} = v_{t-1,B} + \phi_v(v_{max} - v_{t-1,B}) \tag{18}$$

The two commercial banks are assumed to have the same sensitivity threshold (identified by the parameter *threshold*) to households' debt-to-GDP ratio, so that if the ratio is higher (lower) than the threshold, the commercial bank decreases (increases) $v_{t,c}$.

Each commercial bank ranks households in ascending order based on a measure of their financial soundness - namely the total debt service ratio (TDS), defined as the ratio between household repayment schedule and disposable income - and supplies credit by matching each individual demand until it exhausts its credit supply. As already mentioned, households in A apply for a loan to the commercial bank of the same country. Once its credit supply falls down to zero, households eventually send their loan applications to the foreign bank in B. This circumstance takes place whenever $v_{t,A} < 1$: in this case less financially sound applicants, that is households with a higher TDS, will be rationed on the domestic credit market thus getting no loans at all. As a result, they apply for a loan at the commercial bank in B. If $v_{t,B} < 1$, households will be credit rationed also in B and, as a consequence, they will not be able to pay back their previous loan and, in some cases, finance their desired consumption entirely. Therefore, they will go bankrupt, thus being excluded from the credit market for a limited number of periods (identified by the parameter $freeze$.).

Similar to bonds, we assume each loan is a one-period debt contract corresponding to a repayment schedule defined as $RS_{t,h,c} = L_{t,h,c}(1 + r^L_{t,h,c})$, to be paid back entirely in the following period. In line with Cardaci (2016), Cardaci and Saraceno (2016) and Russo et al. (2016), the interest rate on loans is made up of three components, as described by Equation 19.

$$r^L_{t,h,c} = \overline{r_t} + \widehat{r_{t,c}} + r_{t,h,c} \tag{19}$$

$\widehat{r_t}$ is a system-specific component that reflects the sensitivity (ρ) of the bank to the household debt-to-GDP ratio of the economy, so that $\widehat{r_{t,A}} = \rho\frac{debt_{t-1,A}}{GDP_{t-1,A}}$ and $\widehat{r_{t,B}} = \rho\overline{\frac{debt_{t-1}}{GDP_{t-1}}}$. $r_{t,h,c}$ is a household-specific component equal to $\mu TDS_{t,h,c}$, where μ is the bank sensitivity to the household total debt service ratio. Finally, $\overline{r_t}$ is the policy rate set by the central bank at the beginning of each period. Equation 20 indeed describes the central bank's reaction to changes in the average demand gap of the economy ($gap_{t-1,AB}$).[6]

[6]Notice that as we focus on demand fluctuations, quantities and prices move in the same direction, so that the supranational central bank is implicitly targeting inflation as well.

$$\overline{r}_t = \overline{r}_{t-1} + \phi_{CB} \cdot gap_{t-1,AB} \tag{20}$$

After completing all the transactions in the credit market, all FDB enter a second pay back phase: those who successfully obtained a loan can now pay back their due debt $RS_{t-1,h,c}$. On the contrary, FDB who could not obtain a new loan in order to perform debt rollover eventually go bankrupt and, as already pointed out, their access to credit market will be denied for a few periods.

3 Model Results

By means of computer simulations, we investigate the micro and macro properties in order to identify the main mechanisms that drive model dynamics. To this purpose we analyse three main scenarios and a set of policy experiments. In particular we replicate the following:

- Baseline scenario (BS): individual income shares remain constant through the simulations;
- Rising-inequality scenario (RS): income shares exogenously change over time in both countries in order to simulate increasing income disparities;
- Credit-inequality scenario (CS): the maximum propensity to lend of the banking sector increases in both countries together with the rise of inequality as in RS.

The policy experiments include fiscal policies that are simulated with and without coordination between the two countries. In particular we replicate:

- a *Keynesian* policy consisting of a bolder reaction of desired government spending to the demand gap in RS;
- a *Progressive* policy implemented through changes in the marginal tax rates towards a more progressive tax system in RS and CS.

Additionally, we test the ability of the model to replicate some key micro and macro empirical regularities by looking at distributions, cross-correlations and other relevant statistics.[7] Finally, we perform both univariate and multivariate sensitivity analysis thus testing the robustness of model results to changes in parameter values.

[7] Notice that our modelling framework does not include many real world features, such as investment in capital goods, employment dynamics in the labour market, innovation and progress. As such, we do not carry out a full-scale empirical validation. Rather, we investigate whether our simple framework captures some essential facts about inequality and credit.

Parameter		Value
T	Number of periods	4000
H	Number of households in each country	200
k	Propensity to consume for $h = 1 : H - 1$	0.8
k_H	Propensity to consume for $h = H$	0.6
a_A	Sensitivity parameter to j's past consumption in A	0.6
a_B	Sensitivity parameter to j's past consumption in B	0.2
v_{max}	Maximum propensity to lend	0.3
v_{min}	Minimum propensity to lend	0.1
ρ	Bank sensitivity to debt/gdp ratio	0.005
μ	Bank sensitivity to TDS	0.005
$\phi_Q A$	Output sensitivity to output gap in A	0.01
$\phi_Q B$	Output sensitivity to output gap in B	0.01
$\phi_P A$	Price sensitivity to output gap	0.1
$\phi_P B$	Price sensitivity to output gap	0.01
ϕ_G	Government sensitivity to output gap	0.05
ϕ_{CB}	Central bank sensitivity to output gap	0.05
ϕ_v	Speed of adjustment for credit supply	0.05
$freeze$	Number of "freezing" periods for bankrupt borrowers	5
$threshold$	Bank threshold for debt-to-GDP ratio	0.5
γ	Sensitivity parameter to relative prices	0.6

Table 2: Model calibration

The model is calibrated as reported in Table 2. When possible, parameter values are the same as in Cardaci and Saraceno (2016). Exceptions include a_A and a_B, whose values are in line with those reported in Belabed et al. (2013). In all the scenarios, the model starts with the same income distribution, already discussed in Section 2.2.

Simulations are replicated by means of Monte Carlo (MC) analysis, selecting a different random seed at each run, in line with the prevailing approach in the macroeconomic agent-based literature (Cardaci, 2016; Delli Gatti et al., 2011; Russo et al., 2016). In particular, we perform 20 MC repetitions for each scenario and we compute the cross-simulation mean. Hence, each of the graphs reported in this section features the average of the time series across the 20 MC repetitions for each of the three scenarios. Also notice that we drop the first 200 periods, the so-called *transients*, that is the stabilisation phase of the model. Graphs only show the remaining 3800 periods for this reason. Finally, we also represent the key data series as simple moving averages so as to smooth the cyclical fluctuations.

3.1 Scenario analysis

The individual income shares remain constant in BS, while RS and CS replicate the following permanent shocks to the distribution of income:

- **Rising Inequality:** the income share of the top 10% increases gradually (from period 301 to period 600) from 29.68% to 36.84% in both countries, a value which corresponds to the 2007 mean for the countries reported in Cardaci and Saraceno (2016).
- **Credit-Inequality:** Additionally, in CS, v_{max} rises from 0.3 to 0.65 in period 401.

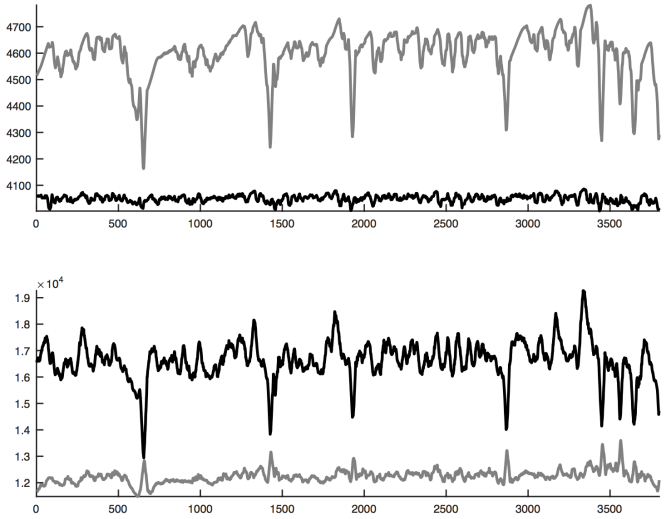

Figure 3: Top: real GDP in BS in country A (black) and B (grey); bottom: desired consumption spending in BS in country A (black) and B (grey).

All the key time series (e.g. real GDP and aggregate desired consumption in Figure 3) show minor oscillations along a rather stationary trend in BS, although country B seems to have a slightly more irregular pattern compared to A's economy (as confirmed by the key statistics reported in the Table in Appendix B). In particular, both actual and desired consumption are highly stable at aggregate level in BS.

Consumption patterns can be analysed also at the individual level. Figure 4 shows the distribution of desired consumption over time in the two countries in BS. As expected, when moving from the bottom to the top of the income distribution, individual desired consumption rises while remaining roughly stable over time for any household h.

Also notice the rather different shape of the two mesh graphs: this shows that desired consumption is more unequally distributed in country A, rather

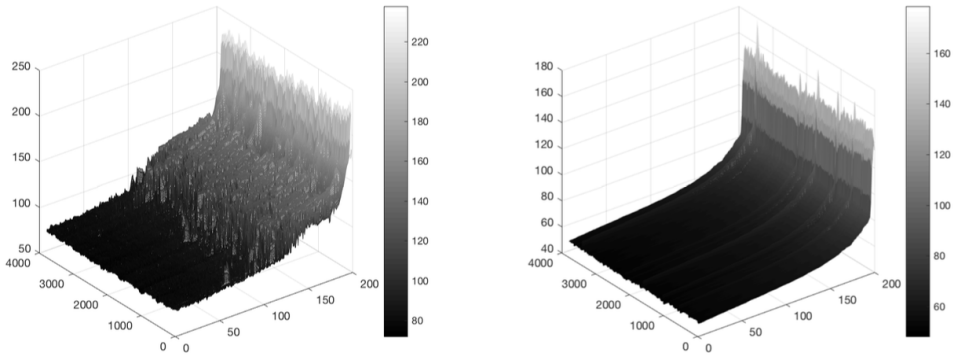

Figure 4: Distribution of individual desired consumption over time in country A (left) and B (right) in BS.

than in B. This is due to the presence of stronger peer effects in A, which, due to the Pareto distribution of income, result in a more even distribution of desired consumption. This is confirmed also by the ratio between desired consumption at the richest 20% and at the poorest 20% of the population, which equals 1.76 in A and 1.54 in B, as well as by the Gini coefficient for desired consumption, which is equal (on average) to 0.13 in A and 0.09 in B (Table 3).

Variable	Scenario	Average 20/20 ratio		Average Gini coefficient	
		A	B	A	B
Individual consumption	BS	2.03	1.53	0.25	0.09
	RS	4.57	3.29	0.39	0.27
	CS	5.84	3.38	0.41	0.29
Individual desired consumption	BS	1.76	1.54	0.13	0.09
	RS	3.95	3.35	0.31	0.27
	CS	4.71	3.48	0.35	0.29
Desired consumption ratio	BS	1.14	0.99	0.09	0.08
	RS	1.21	1.01	0.12	0.09
	CS	1.33	1.11	0.15	0.11

Table 3: Different measures of (actual and desired) consumption inequality in A and B in the three scenarios.

We now discuss impact of growing income inequality with and without changes in the degree of financialisation of the two countries.

RS *scenario.* The impact of rising inequality on the economy of the two countries is roughly similar, in that higher income disparities with unchanged credit conditions eventually lead to falling aggregate desired consumption and GDP in both countries (Figure 5).

It is interesting to analyse the distribution of actual and desired consumption following the increase in inequality in RS. In fact, Figure 6 shows

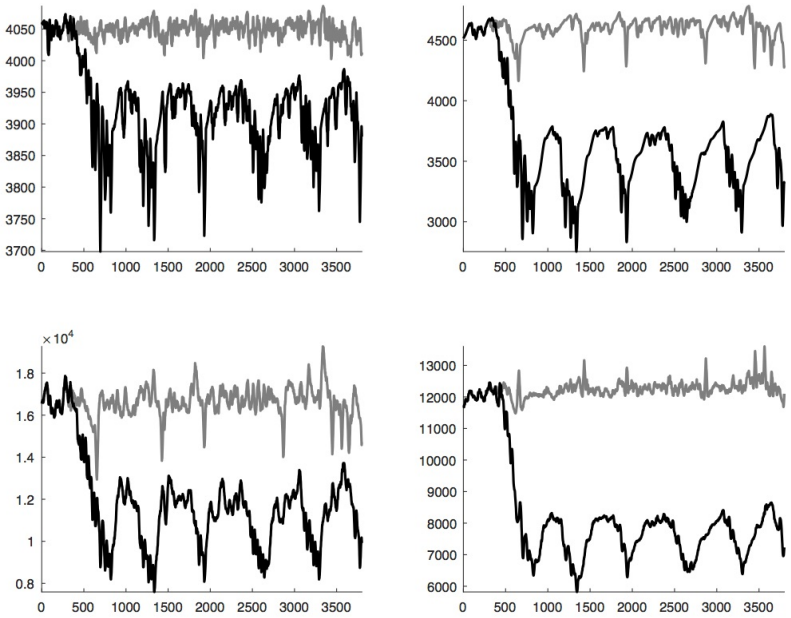

Figure 5: Top: real GDP in RS (black) compared to BS (grey) in country A (left) and B (right); bottom: aggregate desired consumption in RS (black) compared to BS (grey) in country A (left) and B (right).

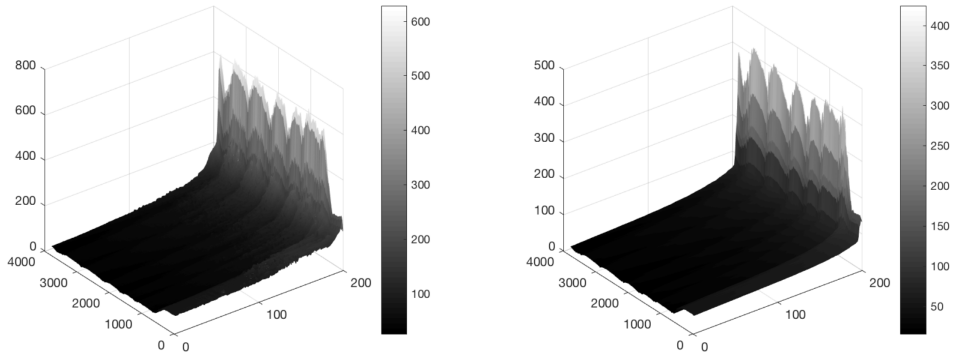

Figure 6: Distribution of individual desired consumption over time in country A (left) and B (right) in RS.

that individual desired consumption is, on average, much higher for households at the top of the income distribution, while it is lower for those at the bottom. Table 3 shows that both the average 20/20 ratio and the Gini coefficient increase in RS compared to BS in both A and B, thus indicating that rising income inequality also results in greater consumption inequality. Our finding supports the recent empirical result that consumption inequality tracks income inequality (Aguiar and Bils, 2015; Attanasio et al., 2014).

As in Cardaci (2016), it is possible to better understand the economic pressure that rising inequality under peer effects has on poorer households, by analysing the change in the distribution of the desired consumption ratio, that is the ratio between individual desired consumption and income at the beginning of each period. Our analysis shows that such measures increases for all households, even though it is more unevenly distributed in CS compared to BS, as the corresponding average 20/20 ratio increases from 1.14 in BS to 1.33 in CS. Also the average Gini coefficient increases in CS compared to BS. This suggests that rising inequality in a poorly financialised context worsens the performance of the economy as the increase in desired consumption by richer individuals does not compensate for the fall by poorer households. As such, the economy enters a recession in both countries.

However, for the sake of completeness, a slightly different pattern arises in the two countries: country A has barely higher internal consumption but lower exports, whereas country B experiences the opposite situation (Figure 7).

CS *scenario.* Rising inequality with greater financialisation leads to the emergence of endogenous business cycle oscillations around a roughly constant trend (Figure 8). It is possible to identify three major phases of each business cycle, corresponding to the expansion of the economy, the turning point and, in the end, the recession.

- *Economic expansion.* Growing income disparities impact on desired consumption which rises dramatically in both countries (Figure 8). Also in CS, it is possible to evaluate the distribution of desired consumption (Figure 9). Table 3 shows that both the average 20/20 ratio and the average Gini coefficient for actual, as well as desired, consumption are larger in CS, in country A and in B. Such measures of inequality increase also for the desired consumption ratio in both countries.

  However, in the initial phase, credit demand rises only in A (Figure 10) due to stronger peer effects in consumption compared to country B. Hence, a greater number of people at the bottom of the distribution in country A need external finance to pay for the increased desired consumption. On the contrary, in country B, the minor rise in credit demand after the shock emerges from a positive demand for loans by a

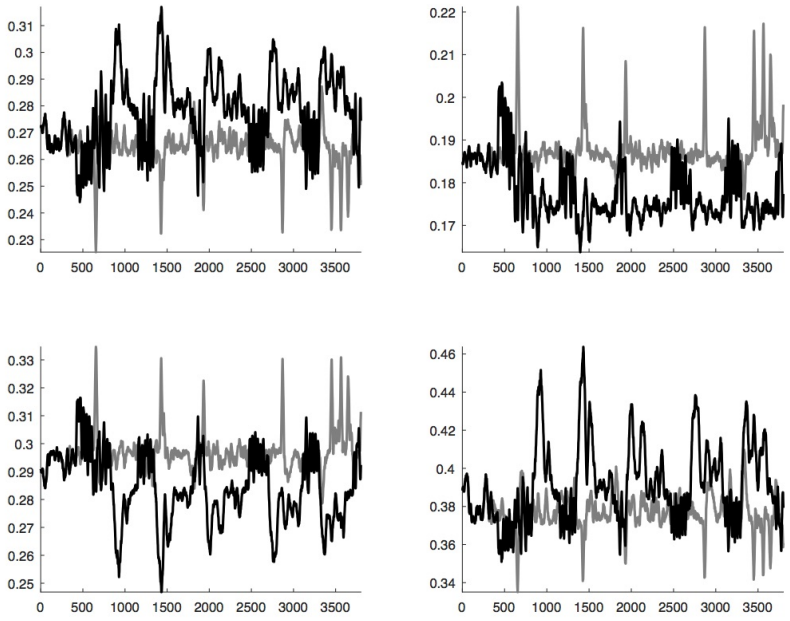

Figure 7: Top: real domestic consumption relative to GDP in RS (black) compared to BS (grey) in country A (left) and B (right); bottom: real exports relative to GDP in RS (black) compared to BS (grey) in country A (left) and B (right).

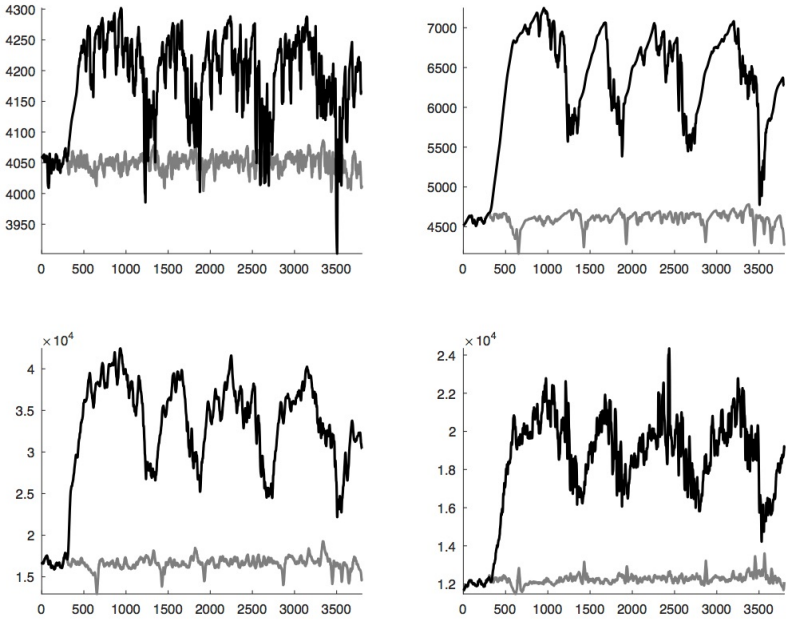

Figure 8: Top: real GDP in CS (black) compared to BS (grey) in country A (left) and B (right); bottom: Desired consumption spending in CS (black) compared to BS (grey) in country A (left) and B (right).

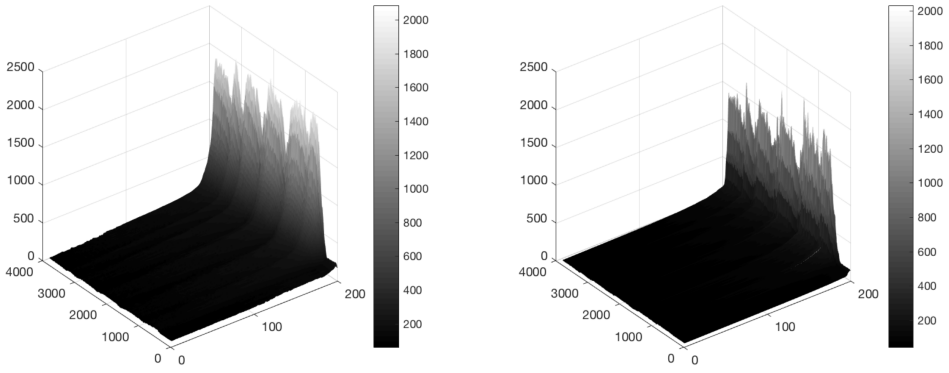

Figure 9: Distribution of individual desired consumption over time in country A (left) and B (right) in CS.

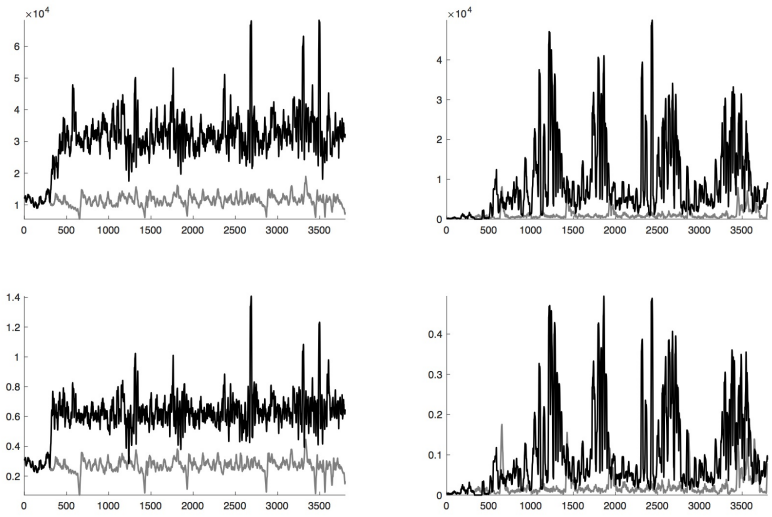

Figure 10: Top: total credit demand in CS (black) compared to BS (grey) in country A (left) and B (right); bottom: household debt relative to GDP in CS (black) compared to BS (grey) in country A (left) and B (right).

small number of richer households. Indeed, when income is distributed based on a Power-Law, a low value of the imitation parameter implies that rising inequality impacts mostly households at the top 10%, i.e. the decile where income disparities are wider.

The most striking implication of rising inequality with a higher degree of financialisation is that household debt skyrockets in A, so that the ratio of household debt relative to GDP exceeds the sensitivity threshold set by the banking sector in A (Figure 10). In particular, Figure 11 shows that aggregate desired consumption is positively correlated with aggregate consumption loans in both A and B (particularly at lag 0, 1 and 2). This result suggests that rising inequality results in greater expenditure cascades trigger higher credit demand in the present and in future periods.

Eventually bank A cuts the fraction of credit demand that it is willing to supply, that is $v_{t,A}$ falls, as shown in the top graph in Figure 12. Consequently, a rising fraction of households become credit-rationed at home, thereby sending their loan applications abroad to the commercial bank in B (bottom graph, Figure 12). Notice that, even though a greater number of households from A get a loan in B (from roughly 40% to almost 80%) and household debt in A keeps on rising, the banking sector in B is still willing to provide an increasing fraction

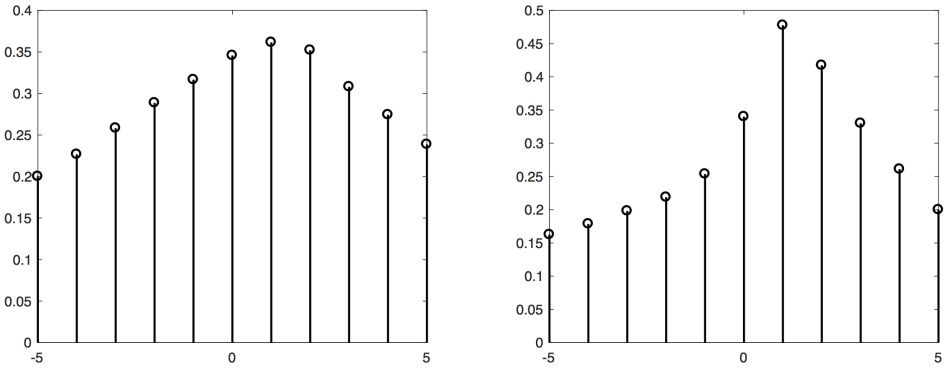

Figure 11: Cross-correlation between aggregate desired consumption and demand for consumption loans.

of credit (top graph in Figure 12). The reason why $v_{t,B}$ does not fall following a rise of household debt in A is that the commercial bank in B sets its sensitivity threshold based on the average value of household debt to GDP in the overall economy (as pointed out in Section 2.5). That is, since households in B are still poorly indebted, the banking sector in B is prone to lend.

Rather different patterns emerge in the two countries during the ascending phase of the business cycle: country A evolves into a debt-driven economy with higher real household consumption relative to GDP, while country B shifts to an export-led pattern with depressed real internal consumption (Figure 13). These remarkable differences between the two economies arise from the heterogeneity in the imitation parameters, as well as from the greater financialisation of the overall economy. In other words, households in A increase their consumption faster than production due to the increased credit availability from the banking sector in B.

This drives the dynamics of both the current account and the financial account: households in A borrow a greater amount of loans from the commercial bank in B in order to import goods from the firm of that same country (Figure 14). Indeed, the financial account of country B becomes negative, thus recording the outflow of credit-capital, whereas its current account turns positive as a result of rising real exports relative to GDP. Also notice that the net T2 position of A is always slightly positive thus meaning that country A receives a greater amount of capital (i.e. consumption loans) than needed to import goods from B. In other words, households in A use consumption loans from B also to finance a small fraction of domestic spending.

- *Turning point.* After a number of periods, also the level of household

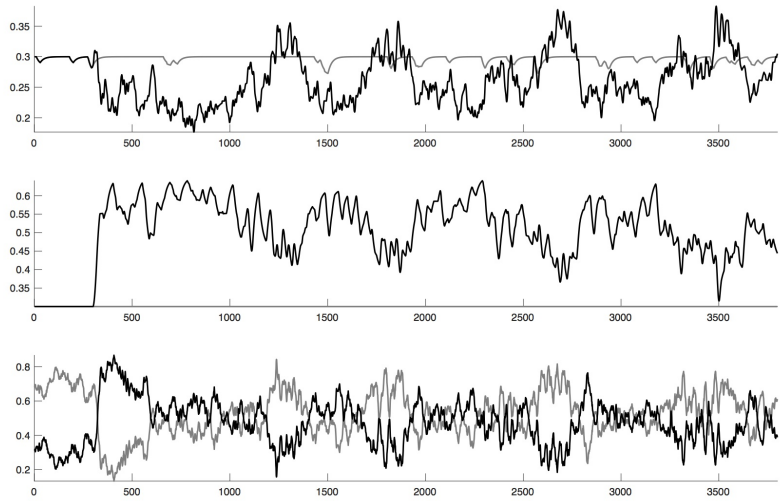

Figure 12: Top: willingness to lend of bank A in CS (black) compared to BS (grey); middle: willingness to lend of bank B in CS (black) compared to BS (grey); bottom: percentage of households from A who get a loan from bank A (grey) and bank B (black) in CS.

debt in B starts to rise, in particular in correspondence to the peak of GDP in the same country. Thus, the average household debt to GDP in the overall economy rises above the sensitivity threshold set by the commercial bank in B, so that credit availability in B shrinks. Since the banking sector in B lends almost exclusively to households from A, the increasing shortage of credit supply affects mostly foreign households, leading to the following major consequences: 1) the percentage of successful credit applicants among households in A starts to fall, from almost 90% to roughly 65%, so that household debt in A decreases and the willingness to lend of the commercial bank of A improves; 2) a growing percentage of households from A, from approximately 40% to almost 80%, send their loan applications back to the commercial bank in the same country.

- *Bust.* The whole process of credit contraction generates a dramatic fall of aggregate demand in A, since households have more limited opportunities to find external resources to finance consumption. On the other hand, A's import drop so that its current account improves even though the economy never records a surplus. The financial account of A, instead, falls as a result of the lower amount of loans from the foreign banking system. Country B has opposite dynamics compared to

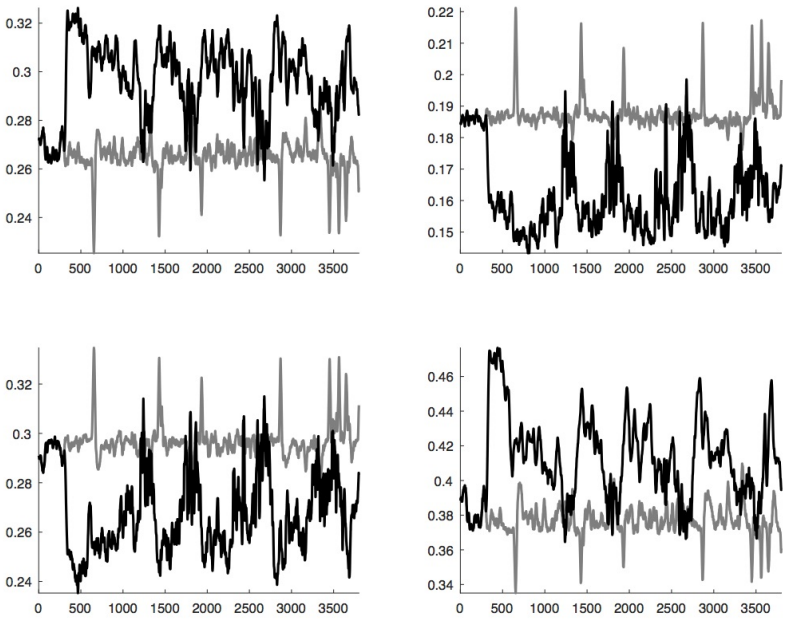

Figure 13: Top: real domestic consumption relative to GDP in CS (black) compared to BS (grey) in country A (left) and B (right); bottom: real exports relative to GDP in CS (black) compared to BS (grey) in country A (left) and B (right).

A, as its real household consumption relative to GDP improves, even though its real exports (equal to A's imports) plunge. Notice that all dynamics revert, such that a new business cycle starts again whenever the commercial bank in B restores its willingness to lend.

3.2 Policy responses

In addition to the three scenarios analysed above, we analyse how model dynamics change when policy makers react to rising inequality by implementing a coordinated fiscal policy in the two countries. In particular, first we assess the effectiveness of a *Keynesian* type of policy consisting in a bolder reaction of desired government spending to the demand gap. Eventually, we analyse the consequences of a change in the tax system into a more progressive one. Similar to the closed economy version of the model, also in this case our results suggest that the second type of policy has a clearer and stronger effect on the overall economy with respect to an intervention of the first type.

The simulation procedure is the same as in Cardaci and Saraceno (2016),

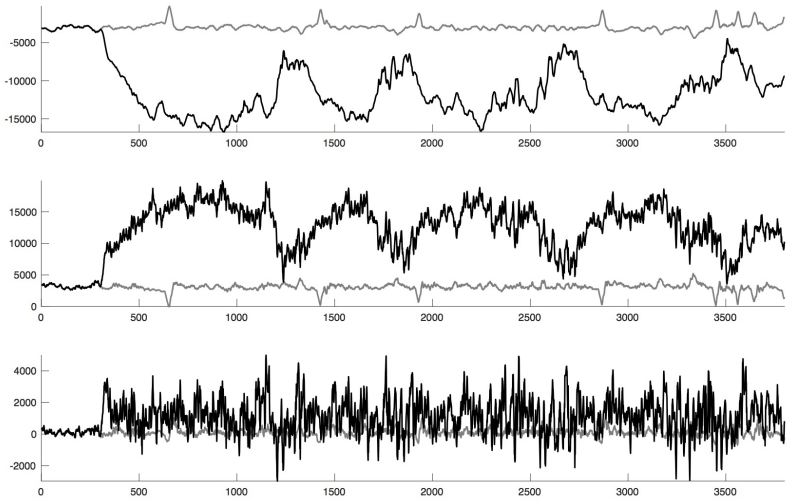

Figure 14: Top: current account of A in CS (black) compared to BS (grey); middle: financial account of A in CS (black) compared to BS (grey); bottom: variation in the Target 2 position of A in CS (black) compared to BS (grey).

as we randomly draw 20 different values for ϕ_G and for each of them we also perform 20 MC repetitions in each of the three scenarios (hence, we perform 1200 computer simulations in total). Our results indicate that a bolder fiscal policy does not prevent the economy from entering a recession in both countries in RS, and its implications are also non-tangible in the CS scenario as the time series of all the key variables do not show any significant difference in terms of magnitude, duration and volatility of the boom and bust cycles.

The second kind of fiscal policy consists in changing the marginal tax rates in a way such that the system becomes more progressive. In particular, we simulate 10 different compositions of the marginal tax rates (equal in both countries) and we run 20 Monte Carlo repetitions for each of them (thus having 200 simulations in total).

Our results show that such policy has a positive impact on the overall economy. In particular, a more progressive tax system manages to counterbalance (at least partially) the negative effect of rising inequality in RS.[8]

Table 4 shows that when the marginal tax rates change, thus becoming more progressive in both countries, the average GDP is higher. It is

[8]The degree of progressivity is measured as follows: first, for each class of income we calculate the percentage change in the corresponding marginal tax rate in each simulated tax composition. Eventually, we calculate the mean of such percentage changes and we consider this as the change in the degree of progressivity.

Progressivity variation (%)	*Average GDP*	GDP variation (%)	*Coefficient of variation*
base	3914.73		0.014
	3577.77		0.091
+4.89	3943.11	0.72	0.010
	3778.67	5.61	0.071
+7.49	3949.64	0.89	0.008
	3815.68	6.65	0.063
+17.8	3962.48	1.22	0.005
	3904.39	9.13	0.035
+23.69	3969.12	1.39	0.004
	3951.10	9.42	0.032

Table 4: The impact of progressive taxation for different degrees of progressivity.

also worth noticing that a more progressive tax system corresponds to lower volatility, as the coefficient of variation is lower for higher progressivity variations.

Hence, a more progressive tax system allows a greater share of poorer households to rely on internal financial resources, thus implying also lower levels of debt accumulation and a more stable economy. As such, our simulations confirm the positive impact of a progressive tax system also in the context of an open economy (within a currency union). Notice, however, that GDP still remains below the baseline value in both countries and this result holds true for any of the 10 simulated tax systems.

We point out that our rather simplified modelling framework does not allow to take into account the possible distortionary effects that greater progressivity may have on other aspects of the economy, such as the functioning of labour markets or firm profits and investment decisions. The interpretation of our results should therefore be limited to considering that an increase in progressivity is more efficient than macroeconomic policies in tackling the expenditure cascades that follow a rise in inequality. Any further interpretation would be unwarranted given the simplified structure of our model.

3.3 Sensitivity Analysis

The purpose of univariate and multivariate sensitivity analysis is to assess the robustness of our results by running the simulations under different calibrations. In other words, we want to understand whether the main findings of our model are biased by the choice of our parameter vector.

Univariate analysis allows to look at variations in the outcome of the model while changing one parameter at a time, leaving all the other constant. Eventually, "the model is then believed to be good if the output values of interest do not vary significantly despite significant changes in the input

values" (Delli Gatti et al., 2011, p. 77). Hence, we follow the same approach adopted for the robustness check of the closed-economy version of this model reported in Cardaci and Saraceno (2016): we select 15 parameters and we randomly draw 20 values within a reasonable *min-max* interval for each individual parameter at a time, leaving all the other ones unchanged. For each of the 20 parameter values, we run the usual 20 Monte Carlo repetitions, each with a different random seed, in all the three scenarios (i.e. BS, RS and CS). As such, for each single parameter, the univariate analysis results in 1200 simulations. Since we explore 15 parameters, we run 18000 simulations in total.

Parameter	*Variation in parameter (%)*	*Variation in GDP-BS at t 500 (%)*	*Variation in GDP-RS at t 1000 (%)*	*Variation in GDP-CS at t 1000 (%)*
k	45.89	4.29 29.36	10.78 111.95	8.67 75.13
a_A	113.31	4.12 36.12	9.31 82.66	6.22 58.48
a_B	154.14	3.87 28.01	10.04 87.98	9.33 90.93
ρ	3325.3	0.89 6.29	2.29 17.91	3.54 23.86
μ	3466.94	1.48 5.29	4.10 23.63	3.35 20.33
$\phi_Q A$	866.31	14.31 8.93	20.11 24.59	18.47 24.58
$\phi_Q B$	287.84	1.12 15.02	7.08 62.43	2.79 32.96
γ	227.46	2.73 7.62	7.16 32.07	6.20 28.19
$\phi_P A$	166.47	1.41 3.48	4.39 21.63	5.53 30.07
$\phi_P B$	837.36	2.18 14.29	10.15 30.85	3.43 16.54
ϕ_G	737.71	1.31 5.43	4.35 26.06	3.67 18.67
$\phi_C B$	838.14	1.09 6.34	5.72 32.69	2.94 17.75
ϕ_V	360.01	1.08 6.81	6.02 29.12	3.19 20.79
$threshold$	471.85	0.73 8.24	4.53 26.97	7.31 71.63
$freeze$	596.13	2.38 22.21	3.01 35.21	4.47 27.44

Table 5: *Min-max* variations in parameter values for univariate sensitivity analysis, together with corresponding cross-series variation in GDP at time 500 in BS and at time 1000 in RS and CS, for both country A and B.

The results of our univariate analysis highlight the robustness of our model. In fact, in most cases, output variations are greatly smaller than the

variations in the parameters. Table 5 reports the variation for each parameter between its minimum and maximum value in the sensitivity analysis and the corresponding cross-series variation in GDP at time 500 for BS and at time 1000 for RS and CS for both country A and B. Results also confirm that country A is less sensitive to changes in model parameters compared to country B since, for any change in the calibration of the model, min-max variations in model output are larger in country B (with the exception of the univariate analysis of $\phi_Q A$ in BS). Among the most relevant parameters, in terms of impact on model dynamics, the univariate analysis seems to confirm the primary role of the consumption parameters k, a_A and a_B. Compared to the closed economy model (Cardaci and Saraceno, 2016), the *min-max* cross-series variation in GDP is larger in RS than in CS in most cases, such as for univariate changes of k, μ, γ, etc.

Another robustness check that we perform consists in computing the percentage of successful simulations for each of the parameters tested in the univariate analysis. To this purpose, we calculate the mean and the variance of selected key variables (i.e. GDP, desired consumption, household debt, credit demand and household default rate) along the entire time span in the three scenarios for each of the two countries. Eventually, we compare these values, obtained under the different calibrations used in the sensitivity analysis, with the same values obtained with the standard calibration reported in Table 2.

Parameter	*Successful simulations (%)*	*Parameter*	*Successful simulations (%)*
k	80.83	$\phi_P A$	95.83
a_A	95.5	$\phi_P B$	93.3
a_B	85.5	ϕ_G	94.16
ρ	98.3	$\phi_C B$	95.83
μ	95.3	ϕ_V	90
$\phi_Q A$	97.2	$threshold$	93.05
$\phi_Q B$	66.7	$freeze$	94.72
γ	93.05		
		Average	91.28

Table 6: Percentage of successful simulations in the univariate sensitivity analysis.

For example, based on the standard calibration, both the mean and the variance of GDP are lower in RS and higher in CS, compared to the baseline values, in both A and B. As such, we check whether GDP has the same qualitative behaviour in terms of mean and variance in any other univariate simulation. For instance, we find that, *ceteris paribus*, most of the randomly

selected values of k imply that both the mean and the variance of GDP are lower in RS and higher in CS. In particular, we claim that 80.83% of the univariate simulations for k are successful.

After repeating this experiment for all the parameters tested in the univariate analysis (Table 6), we find that, on average, 91.28% of univariate simulations are successful, based on the criterion mentioned above.

Multivariate analysis consists in analysing model results under different calibrations of model parameters. In this case, we build 20 vectors for our parameters and we randomly draw each value in the vector within a reasonable interval. Eventually, for each of the 20 vectors, we perform 20 MC repetitions, each with a different random seed. We do so in the three scenarios, thereby running a total amount of 1200 simulations.

Also the multivariate analysis shows that the behaviour of the model is robust to parameter changes. Indeed, we compute the percentage of successful simulations also for the multivariate analysis. Based on the same criteria described above, our test identifies 73.3% of successful simulations in the multivariate case, thus leading us to conclude that the model is robust also to multivariate changes in model parameters.

4 Conclusions

Our paper extends Cardaci and Saraceno (2016) by developing a two-country currency union model that resembles the functioning of the Economic and Monetary Union. This allows us to capture the major role that inequality plays in determining large balance of payments imbalances, in line with Kumhof et al. (2012). Indeed, our model results suggest that rising inequality with greater financialisation leads to the emergence of a debt-led consumption regime in the country with stronger peer effects, while resulting in an export-led regime in the country that experiences sluggish internal demand growth, as suggested by Stockhammer (2015). Hence, the former country records a current account deficit, whereas the the latter has a symmetrical surplus. Through the inclusion of international loans from the banking sector of the surplus country to the household sector of the deficit country, our model captures the flow of capital that finances the imbalances over the expanding phase of the economy. Eventually, a crisis emerges endogenously as a consequence of booming household debt relative to GDP that triggers a change in the perception of system risk on behalf of the banking sector of the lending country. As such, a sudden stop occurs, in that the representative commercial bank in this country cuts its credit supply thereby forcing households in the deficit country to dramatically lower their domestic consumption and imports. This conclusion is in line with the work by Baldwin and Giavazzi (2015), who claim that in the period between the introduction of the common currency and the outburst of the

recent financial crisis, the Eurozone accumulated a remarkable amount of cross-country capital flows from the core countries to the GIIPS. That is, the peripheral nations relied heavily on intra-Eurozone foreign lending to finance their current account deficits.

A Appendix - Balance of Payments and Target 2 Imbalances

Target 2 (T2) is the Trans-European Automated Real-Time Gross Settlement Express Transfer System, a system of payments among European banks aimed at facilitating private sector transactions without causing any gains or losses to the public organisations involved (Whelan, 2014).

T2 plays a key role in real times transactions as it is one of the three largest wholesale payment systems in the world with an average daily amount of transactions equal to 2.4 trillion of Euro, equivalent to 1/4 of the Eurozone annual GDP. In order to explain how T2 works, we replicate the simple example reported in Cecchetti et al. (2012) (and later in Whelan, 2014).

Suppose a household in country A buys 100 Euros of goods from a firm in country B (Figure 15): she requests that 100 Euros be transferred from her deposit account at a commercial bank in A (bank A, for simplicity) to that of the firm held at a commercial bank in B (bank B). Therefore, bank A records a reduction of 100 Euros in its liabilities to the household but it also records a 100 Euros reduction in its assets, as the "actual transfer of money" to bank B occurs by informing Central Bank A (CB_A) to deduct this amount from its reserve account. Hence, CB_A asks the ECB to credit 100 Euros to Central Bank B (CB_B). This is a standard procedure: transfers between commercial banks are made via an exchange of reserves through the central banks (Cesaratto, 2013). Thus, bank B has increased assets as its account with CB_B is credited with 100 Euros of new reserves from CB_A. Also its liabilities increase by the same amount since it adjusts the firm's deposit account accordingly. Assuming that no other transactions take place, the net capital positions of the two central banks have changed: CB_A has a positive variation of its net worth (i.e. same assets but lower liabilities), while CB_B has a negative one (i.e. increased assets, same liabilities). Such changes in the net position of the central banks may be compensated by a transfer of assets from the central bank with increased net worth (CB_A, in our case) to that with reduced net worth (CB_B), so that their net positions are eventually unchanged. But this is not the case in the Eurozone due to technical difficulties.[9] Hence, the compensation runs through Target 2: "the system works by providing national central banks with credits and debits in the form of a bilateral position vis-a-vis the ECB, usually recorded on

[9]Indeed, "a complication with a procedure of this type is it would require a protocol on which kinds of assets could be used in these transfers" (Whelan, 2014, p. 7)

the balance sheets as either *Intra-Eurosystem Claims* or *Intra-Eurosystem Assets*" (Whelan, 2014, p. 7). So, in our example, CB_A gets a new T2 liability ("owed to ECB") of 100 Euros, while CB_B has a new T2 asset ("owed from ECB") of 100 Euros.

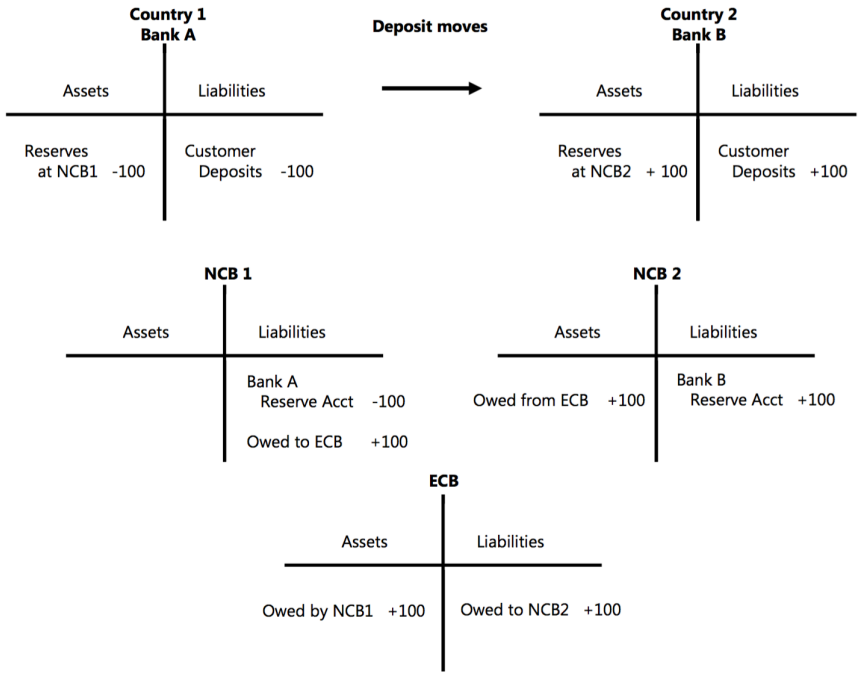

Figure 15: One household in country A buys 100 Euros of goods from a firm in country B. Source: Cecchetti et al. (2012).

Notice, however, that our example implies that any transactions between the two countries change the amount of reserves that bank A has in its account at the national central bank. In order to recover from the reserve-loss, bank A might borrow on the interbank market directly from bank B (the typical pre-2008 solution in the Eurozone). This would clear the net Target 2 positions of the two countries since there is a cross-country payment going from A to B, that is in the opposite direction with respect to the goods. Yet, suppose that interbank borrowing becomes difficult so that the market breaks down, as it has after the 2008 crisis (Cesaratto, 2013). In this case, bank A would not be able to receive any loans from bank B and, as a consequence, it does not recover from the loss of reserves. Hence, the solution is that CB_A replenishes bank A's reserve account with 100 Euros through a short or long term refinancing operation (Figure 16). That is, CB_A supplies a loan to bank A. This operation does not change the net T2 position of the country. Such post-crisis framework corresponds to the one we adopt in our model.

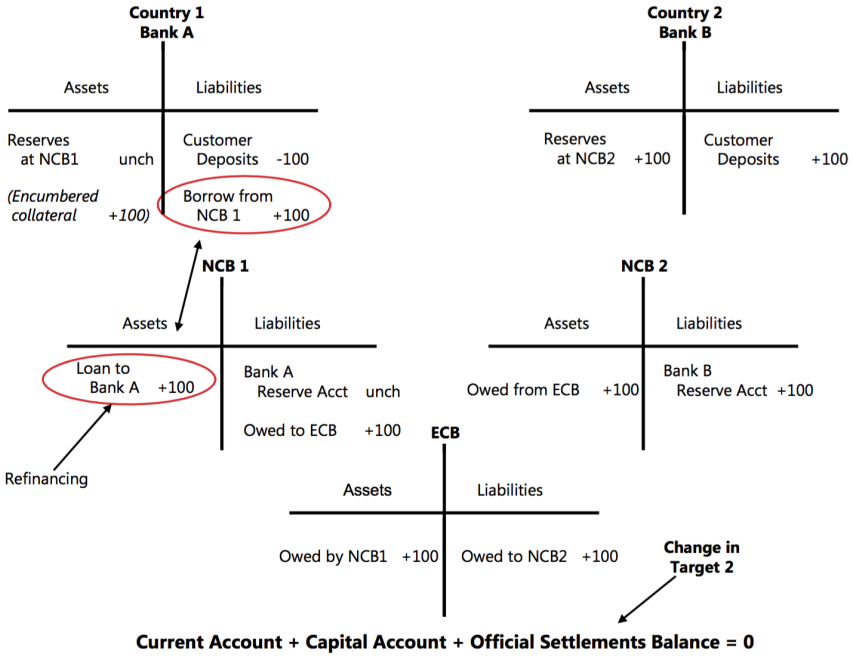

Figure 16: T2 mechanism with full refinancing operations. Source: Cecchetti et al. (2012).

Having explained how T2 works in a rather simplified way, let us now trace the link between T2 imbalances and variations in the balance of payments of a country. This is an accounting identity defined as Current Account (CA) + Capital Account (KA) + Official Settlements Balance $\equiv 0$. The example introduced above shows how T2 positions change when variations in the current account are not matched by movements of capital of any kind (neither in the form of interbank lending, nor in the form of foreign loans to the household sector). Indeed, as seen in the example, if country A has no inflow of private capital (so that KA does not vary), its current account deficit is entirely financed through changes in the Target 2 position. This is recorded in the third term of the balance of payments, that is the Official Settlements Balance. After all, the balance of payments describes precisely the difference in payments that has to be covered by transactions in foreign reserves, which in the European case are given by Target 2 positions (Cecchetti et al., 2012).

In general, any time the sum of CA and KA is different from zero in a fixed exchange rate regime, central banks act on their stock of foreign reserves in order to finance the disequilibrium in the the balance of payments. For example, if a country has a CA deficit that is not exactly matched by a surplus of the capital account, then the central bank will sell its foreign reserves in order to finance net payments. Similarly, when a country experi-

ences a capital flow reversal, the outflows are limited by the amount of the country's foreign reserves (Cecchetti et al., 2012).

Within the Euro system the balancing mechanism works in a similar way: the net Target 2 position of a country changes automatically in order to match the gap between CA and KA, so that a current account deficit (surplus) that is not matched by a KA surplus (deficit) is going to be matched by a negative (positive) variation of the T2 position of the country, that is the country acquires more T2 liabilities (assets) than assets (liabilities) vis-a-vis the ECB.

The mechanism highlighted above has a major implication: Target 2 might avoid balance of payment crises in the Eurozone. Outside the Eurozone, if a country with a fixed exchange rate regime and a CA deficit happens to experience a so-called "sudden stop" (e.g. a capital account reversal because of a confidence loss by investors), the country will have a depletion of foreign reserves. Yet, this is obviously limited by the amount of foreign reserves owned by the national central bank. In order to avoid loosing all of its foreign reserves, the country has no other option than devaluating its currency or allowing to let it float on the open market.

In the Euro area, "Target 2 does a job similar to creating foreign exchange reserves for the country that is suffering the balance of payments crisis. The only limit on capital outflows, and the only limit on the liability that the country's central bank can amass with respect to the remainder of the Eurosystem, is the collateral that the country's banks have available to bring to the refinancing operation. But since the system operates automatically, there is no natural break" (Cecchetti et al., 2012, p. 5). In essence, this is what happened after the 2009-2010 sudden stop that occurred in the Euro periphery: if these countries had not been euro-area members, they would have likely suffered a harsh current account adjustment through a currency crisis. Instead, "these countries remained in the euro area and continued to run current account deficits, despite rapidly falling private capital inflows, and, in some cases, capital flight" (Hale, 2013, p. 4).

A relevant case that led to a huge debate is the impressive accumulation of T2 claims by the German Bundesbank in the aftermath of the 2008 financial crisis. Currently, there are two major interpretations of this phenomenon. One is that Germany had been financing *de facto* the large and persistent current account deficits of the peripheral Eurozone economies (Sinn and Wollmershäuser, 2012). Yet, according to Cecchetti et al. (2012), this was not the case until 2009: data only support this interpretation in the period starting from 2010. Also Auer (2014) finds that the evolution of CA balances and T2 balances were entirely unrelated before the onset of the financial crisis. The other view argues that T2 balances were actually financing the flight of private capital from the periphery to the core that was due to the sudden stop triggered by the global financial crisis. Cecchetti et al. (2012) finds that, starting from 2012, the relationship between cur-

rent accounts and T2 balances strongly favours this interpretation, since the changes in T2 balances substantially exceeded the value of current accounts. Hence, he concludes that "Eurosystem credit was and is doing more than simply financing ongoing deficits. It was also redistributing existing stocks of claims from the private sector to the public sector" (Cecchetti et al., 2012, p. 8). Also Auer (2014) points out that changes in T2 balances simply reflected the fact that the financing of CA deficits changed with the onset of the financial crisis, due to the reversal of capital flows. As reported in (Cesaratto, 2013, p. 371), this interpretation confirms "the concurrency of repatriation of German private funds lent before the crisis to the periphery and expansion of German T2 claims along with the support of further CA deficit during the crisis".

B Statistics

Table 7 reports some key statistics for real GDP in BS in the 20 Monte Carlo simulations for both country A and B.

Simulation	*Average growth rate (%)*	*Mean*	*Variance*	*Standard Deviation*
1	0.16	4048.22	182.57	13.51
	1.51	4588.11	7769.98	88.15
2	0.39	4053.17	163.04	12.76
	1.65	4623.78	4645.17	68.16
3	-0.17	4049.95	253.98	15.93
	-3.43	4605.41	8752.45	93.55
4	-0.39	4056.49	200.75	14.16
	-1.46	4660.78	6151.97	78.44
5	0.03	4047.85	341.73	18.48
	0.64	4605.03	11975.74	109.43
6	-0.41	4052.81	163.14	12.77
	-0.67	4627.56	6546.06	80.91
7	0.29	4049.75	228.06	15.10
	2.23	4599.38	5289.35	72.73
8	0.16	4053.23	143.12	11.96
	0.41	4619.35	4029.61	63.48
9	0.21	4052.47	208.58	14.44
	0.36	4623.44	6911.51	83.13
10	-0.68	4051.05	187.05	13.67
	-1.11	4615.72	4569.84	67.61
11	0.22	4053.19	219.33	14.80
	1.21	4627.87	8121.79	90.12
12	0.45	4041.99	228.69	15.12
	0.21	4537.09	7989.72	89.41
13	-0.39	4057.25	172.96	13.15
	0.41	4656.71	5620.11	74.96
14	0.19	4049.45	288.67	16.99
	2.47	4625.21	8588.63	92.68
15	-0.37	4055.74	174.27	13.20
	-0.41	4650.49	6423.94	80.14
16	-0.32	4051.51	127.11	11.27
	-0.65	4587.74	3507.88	59.23
17	-0.17	4056.20	221.10	14.86
	0.71	4668.22	6645.28	81.51
18	0.18	4057.36	225.02	15.01
	2.19	4662.81	7975.25	89.30
19	0.16	4053.09	172.24	13.12
	-0.11	4626.58	5000.11	70.71
20	0.06	4053.49	157.49	12.54
	0.96	4623.44	4963.44	70.45

Table 7: Key statistics for BS-GDP in the 20 MC simulations for country A and B.

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