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**Working Paper**

## A prototype regional stock-flow consistent model

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## **Working Paper No. 1005**

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### **A Prototype Regional Stock-Flow Consistent Model**

by

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## **ABSTRACT**

Starting from the seminal works of Wynne Godley (1999; Godley and Lavoie 2005, 2007a, 2007b), the literature adopting stock-flow consistent (SFC) models for two or more countries has been flourishing, showing that consistently taking into account real and financial markets of two open economies will generate different results with respect to more traditional open economy models. However, few contributions, if any, have modeled two regions in the same country, and our paper aims at filling this gap. When considering a regional context, most of the adjustment mechanisms at work in open economy models—such as exchange rate movements, or changes in interest on public debt—are simply not present, as they are controlled by “external” authorities. So, what are the adjustment mechanisms at work?

To answer this question, we adapt the framework suggested in Godley and Lavoie (2007a) to consider two regions that share the same monetary, fiscal, and exchange rate policies. We loosely calibrate our model to Italian data, where the South (Mezzogiorno) has both a lower level of real income per capita and a lower growth rate than the North. We also introduce a fragmented labor market, as discouraged workers in the South will move North in hopes of finding commuting jobs.

Our model replicates some key features of the Italian economy and sheds light on the interactions between financial and real markets in regional economies with “current account” imbalances.

**KEYWORDS:** Stock-Flow Consistent; Regional Labor Mobility; Regional Economic Activity and Development

**JEL CLASSIFICATIONS:** E12; J61; R12

## INTRODUCTION

Our approach is grounded in the fast-developing strand of literature on macroeconomic models that adopt an accounting framework that connects real and financial markets, known as the stock-flow consistent (SFC) approach.<sup>1</sup>

SFC models are particularly suitable for analyzing open-economy issues, especially those related to real and financial imbalances and their effects on growth. With its focus on the interdependencies between real and financial markets, as well as how the evolution of stocks affects monetary flows paid/received by the different sectors—which ultimately determines aggregate demand and growth—the SFC approach to open-economy macroeconomics has always paid special attention to monetary issues, exchange rate movements, and financial and trade imbalances, and how these may affect real flows, agents’ behavior, and debt sustainability.

At first, open-economy SFC models showed how a watertight accounting framework alongside a *complete* description of interrelated stocks and flows between countries could provide additional answers to questions in international monetary and trade theory with respect to mainstream models.

In this sense, Godley and Lavoie’s OPENFLEX model (Godley and Lavoie 2005, 2007b)—which was a revised and extended version of Godley (1999) and is considered the cornerstone of open-economy SFC macro—challenged the Mundell-Fleming-type open-economy model prevailing in neoclassical trade theory. It shows that, in the case of a fixed exchange rate and endogenous reserves, “sterilization” becomes endogenous when central banks fix interest rates, and that changes in liquidity preference or in interest rates—though they may have large and immediate consequences for the exchange rate and hence on levels of activity—seem to have effects that are self-reversing, implying a major role in the medium and long run for the feedbacks tied to trade. A smaller version of the OPENFLEX model is presented in Carnevali (2021)—which is meant to represent a new, simpler pedagogical tool for undergraduate macro, as he managed to reduce the number of equations by 60 percent while replicating most of the original results and major model dynamics.

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<sup>1</sup> Godley and Lavoie (2007b) is the main reference. See Nikiforos and Zezza (2017) for an introduction and a survey of the main contributions to the SFC approach.

Several works have dealt with models where a country relies upon a foreign currency—usually the US dollar—to assess how imbalances generate movements in exchange rates, interest rates, and financial flows, and how monetary and fiscal policy may be constrained by dollarization (Bortz 2014; Izurieta 2003; Missaglia 2021; Nalin and Yajima 2021).

Three- and four-country models have been developed to study how countries with different monetary systems behave in the world economy and how the different adjustment mechanisms affect the dynamics of their individual economies (Lavoie and Zhao 2010; Mazier and Tiou-Tagba Aliti 2012; Mazier and Valdecantos 2019; Valdecantos and Zezza 2015).

Last but not least, open-economy SFC frameworks have been used to integrate macroeconomic and environmental analysis, as well as to investigate the relationship between climate change and economic policies (Berg, Hartley, and Richters 2015; Carnevali et al. 2020; Dafermos, Nikolaidi, and Galanis 2017, 2018).

However, few contributions—if any—have attempted modeling two regions in the same country,<sup>2</sup> and our paper aims at filling this gap. When considering a regional context, most of the rebalancing mechanisms in open-economy models—such as exchange rate movements or changes in interest on public debt—are simply not present, as they are in control of “external” authorities. So, what are the adjustment mechanisms at work? To answer this question, we adapt the framework suggested in Godley and Lavoie (2007a) to consider two regions that share the same monetary, fiscal, and exchange rate policies. We loosely calibrate our model to Italian data, where the South (Mezzogiorno) has both a lower level of real income per capita and a lower growth rate than the North. We also introduce a fragmented labor market, as unemployed and discouraged workers in the South will move North with the hope of finding jobs.

A key difference between our model and that of Godley and Lavoie (2007a) is that we do not explicitly represent the third region, i.e., the rest of the world (RoW), assuming that the two regions of our model are small enough not to imply significant impacts on it.

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<sup>2</sup> The only regional SFC model in the literature so far is the macroeconometric model presented in Canelli, Realfonzo, and Zezza (2022), which deals with a single region, assuming a “small-country hypothesis.”

Our contribution is not limited to methodological applications: various countries (for instance Italy, Germany, the United Kingdom, and Spain) experience strong regional gaps that require specific policies, for which a model should identify the determinants of demand and output, the sources of finance for growth, and the consequences of such policies for both real and financial markets.

The rest of the paper is organized as follows. Section I presents some stylized facts regarding the recent dynamics in macroeconomic variables for Italian regions. Section II introduces the balance sheet and transaction matrices and then presents the model's equations. Section III presents the results from steady-state analysis. Section IV concludes.

## **I. SOME STYLIZED FACTS ABOUT ITALY'S REGIONAL DIVERGENCE**

Since its unification 160 years ago, the Italian economy has been characterized by a dual pattern of growth, emphasized by significant regional imbalances between the center-north and the South (the so-called Mezzogiorno). Some convergence took place during the postwar "economic miracle" (from 1950s to 1970s), led by a particularly incisive set of public policy programs (Graziani 1975, 1979, 2000; Iuzzolino et al. 2013). Starting from the 1980s—and at a higher pace since the start of privatizations and the shift toward antiinflationary policies, culminating in the Maastricht Treaty and the adoption of the common currency—the process inverted and divergence accelerated again after the double-dip recessions of 2008–9 and 2011–12.

Between 1995 and 2019, real GDP's growth rate averaged 0.1 percent in the Mezzogiorno, against the 0.7 percent registered in the center-north regions, increasing the already large regional gap in income and wealth. But what contributed to this divergence in GDP growth? Looking at the components of aggregate demand, public investment in both regions remained at a very low level throughout the period (at 2.1 percent and 3 percent of local GDP for the center-north and the Mezzogiorno, respectively), while private investment was slightly lower in the Mezzogiorno (16.5 percent of GDP against 17.4 percent in the center-north). Another difference lies in the dynamics of final consumption expenditures in the private and public sectors, which averaged in the South 72.3 percent and 26.8

percent of GDP, respectively, against 56.9 percent and 15.7 percent in the center-north. However, the first real driver of the divergence was the dynamic of trade, shown in figure 1.<sup>3</sup>

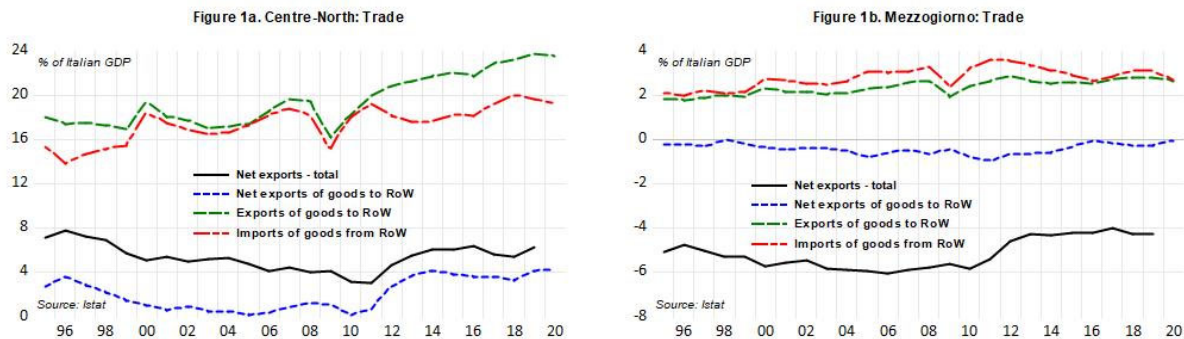
Between 1995 and 2018, the center-north registered an average surplus in total net imports equal to 7 percent of local GDP (96.1 billion euro in 2018), mirrored by a deficit in the Mezzogiorno of 22 percent of local GDP (75.7 billion euro in 2018). Similarly, while the center-north had an average surplus of 2.5 percent of GDP in the trade balance against the RoW (58.2 billion euro in 2018), the Mezzogiorno registered a deficit of 2 percent (5.2 billion euro in 2018). The deficit in the Mezzogiorno has been declining since 2010 due to the reduction in imports—from both other regions and the RoW—caused by the collapse in disposable incomes after the financial crisis. The volumes traded in the two areas are however completely different: while exports and imports in the center-north accounted for 25 percent and 22.5 percent of GDP (411.5 billion and 353.4 billion euro in 2018, respectively), for the Mezzogiorno they were only 9.9 percent and 11.9 percent (49.7 billion and 54.9 billion euro in 2018, respectively).

The fact that final demand has averaged *above GDP* in the Mezzogiorno over the last 25 years implies that this deficit must have been financed by other sectors—represented here mainly by the public sector through the sustained transfers from the central authority to households (via pensions, unemployment schemes, poverty aid, etc.), firms (through tax reductions, subsidies for investment and hirings, etc.), and local authorities (which also receive net transfers from the EU).

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<sup>3</sup> In the Regional Economic Accounts, available at annual frequency from 1995 to 2020, Istat only provides data on *net total imports of goods and services*, which thus includes interregional trade. Regional statistics on exports and imports are published in coeweb, at quarterly frequency from 1991 to 2021, with a large country/goods decomposition. However, it only registers trade in goods.

**Figure 1. Trade in Italy as a Percentage of GDP**



The lower growth in the Mezzogiorno over the last 30 years also exacerbated another crucial problem of Italy's economy: the increasing inequality in the concentration of wealth between social classes and generations, and also within the country. Brandolini, Gambacorta, and Rosolia (2018), using national accounts and income and wealth survey data from 1989 to 2013, show that inequality, as measured by the Gini coefficient, rose sharply during the recession of the early 1990s, and less so in the double-dip recessions of 2008–9 and 2011–12. They also find that, compared to previous episodes, during the last recession, the gap in wealth between the young and the elderly widened.

Albareto et al. (2008), regionalizing financial accounts data, provide new estimates of the real and financial wealth of Italian households by region from 1998 to 2005, which confirms the highly uneven distribution of per capita wealth between regions found in previous studies. They found that the personal net wealth of Italian households in the Mezzogiorno in 2005 was less than half the figure for northern regions (83,000 euro in Mezzogiorno against 133,500 euro in the North).

Acciari, Alvaredo, and Morelli (2021), using microdata on inheritance tax files, find that since the mid-1990s there has been a strong increase in wealth concentration and inequality. While the figures for wealth concentration in Italy appear to be similar to those of other European countries, the time trend resembles the US experience. Moreover, Italy had the largest decline in the wealth share of the bottom half of the observed adult population.



Finally, another key feature of the Italian economy in recent years has been the reemergence of South–North migration flows. Svimez (2019) certified that between 2002 and 2019, 800,000 people, mostly young and with a higher degree, migrated from the South to the North. Moreover, the net outflow to the rest of the EU (notably the United Kingdom, Germany, and Spain) has been more pronounced in the Mezzogiorno than in the North. The inflows of migrants from Mediterranean countries to the South, which also usually represents their first port of arrival, not only does not even remotely compensate for the outflow of youngsters (as the numbers are small, and most continue to move toward northern European countries), but also radically alters the competencies of the labor force. Combined with the national decline in the birth rate, the exodus of the most vital forces from the Mezzogiorno further weakened the demographic structure in the area. This has compromised the fate not only of small centers and rural areas (a problem common also to regions in central Italy), but also of the peripheries of metropolitan areas, which indeed represent the highest sources of South–North migration.

## II. THE MODEL

In this section we present our model, starting with a description of its key structure, depicted in the balance sheet and transaction matrices. We then introduce, in section II.I, the equations of the model, sector by sector.

We consider three regions, loosely related to the Italian South (Mezzogiorno), the North, and the eurozone (RoW), which we will identify with the superscript S, N, and W, respectively, when coding variables in the model’s equations.<sup>4</sup> Output is produced by firms in both regions using capital and labor.

In the current version of the model, to keep things simple, we chose to adopt the “small country” hypothesis, i.e., we neglect the feedbacks from the RoW that would be generated from shocks arising in

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<sup>4</sup> When multiple superscripts are present, they correspond to “from/to” when talking of flows (i.e.,  $WB^{NS}$  are the wages generated in N going to workers from S, while  $WB^{NN}$  are instead the wages generated in N but paid to workers from N), and “issued/held” when considering stocks (i.e.,  $EQ^{SN}$  are the equities issued by firms in S held by households in N).

Italy. In other words, we specify the RoW sector's behavior only with reference to the flows of goods, services, and financial assets with the two Italian regions.

Following the approach suggested in Zezza and Zezza (2019), we start to lay out the model by identifying the minimum amount of financial assets for the institutional sectors of the economy. We used our quarterly SFC model of the Italian economy<sup>5</sup> to identify the most relevant stocks of assets and liabilities and calibrate the local balance sheet entries according to the regional shares in Italian GDP. In the current stage, we consolidate households and nonfinancial businesses into a private nonfinancial sector, although we model consumption and investment separately. On the other hand, we separate the private financial sector from the rest of the economy and consider it as an “external” institution, i.e., we assume that the localization of financial institutions in a specific region is of little relevance to the analysis. This hypothesis can also be relaxed in future work: in the traditional banking model, local banks were more likely to provide credit to local businesses and households, but since banks started to collateralize their loans, and with the adoption of the Basel rules, the relevance of local banks has decreased. We believe, anyway, that it will not be complicated to extend our model to consider the localization of financial institutions.

We assume the two regions to have different *financial complexity*, meaning that the South has fewer assets and liabilities on their balance sheet and thus fewer options for allocating their wealth. More precisely, the private sector in the S region only holds cash ( $M^S$ ), bank deposits ( $D^S$ ), and government bonds ( $B^S$ ) as assets (which are a liability of the central bank, banks, and the central government, respectively), and loans ( $L^S$ ) and equities issued by local firms ( $EQ^S$ ) as liabilities. In contrast, the private sector in the N region also holds as assets the bonds issued by banks ( $BB^N$ ) and the equities issued by firms in the S ( $EQ^{SN}$ ) and the RoW ( $EQ^W$ ).

We assume that local governments must balance their books, considering transfers from the central government, so that they will not hold financial assets or issue debt. Finally, we assume that the central bank distributes all of its profits, having government bonds ( $B^{CB}$ ), foreign reserves ( $FR$ ), and advances to banks ( $ADV$ ) on the asset side of its balance sheet.

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<sup>5</sup> See Zezza and Zezza (2020).

Under these hypotheses, we chose to simplify the balance sheet of the two regions, as in table 1. We distinguish eight sectors: private and public sectors in S and N, banks, the central government, the central bank, and the foreign sector. Entries with a plus sign represent assets, while those reported with a negative sign represent liabilities.

**Table 1. Balance Sheet Matrix**

	South		North		Banks	Gov.	C.B.	RoW	Tot
	Private nonfin.	Local auth.	Private nonfin.	Local auth.					
Cash+reserves	$+M^S$		$+M^N$		$+RES$		$-M - RES$		0
Foreign reserves							$+FR$	$-FR$	0
Advances					$-ADV$		$+ADV$		0
Bank deposits	$+D^S$		$+D^N$		$-D$				0
Loans	$-L^S$		$-L^N$		$+L$				0
Bank bonds			$+BB^N$		$-BB$			$+BB^W$	0
Public bonds	$+B^S$		$+B^N$		$+B^F$	$-B$	$+B^{CB}$	$+B^W$	0
Equities S	$-EQ^S$		$+EQ^{SN}$					$+EQ^{SW}$	0
Equities N			$-EQ^N$					$+EQ^{NW}$	0
Equities W			$+EQ^{WN}$					$-EQ^W$	0
Foreign bonds					$+FB$			$-FB$	0
Net wealth	$+NW^S$	0	$+NW^N$	0	0	$-B$	0	$+NW^W$	

It should be remembered that in table 1 we consolidate the household sector with the nonfinancial business sector, so that the equities issued by the business sector and held by the household sector in the same region are netted out, and the table reports only the equities issued by a region and held by other regions.

Table 2 reports the transactions arising in the economy. Entries with a plus sign record “sources” of income, while negative values report “uses” of income. We added a “production” column in both regions, which highlights the two sides of the national income identity, i.e., GDP as the sum of the incomes generated in production—wages, profits, and taxes on production and imports—and as the sum of the components of aggregate demand.

Inherited stocks in the model generate payments and receipts of interest and dividends, recorded in the central part of the matrix, which generate income from capital in future periods.

The difference between disposable income and expenditures determines the net acquisition of financial assets of the sectors: if positive/negative, it implies that the relative sector is *increasing/decreasing* its stock of financial wealth (by either acquiring assets or reducing liabilities).

**Table 2. Transaction Matrix**

	South			North			Banks	Gov.	CB	RoW	Tot
	Prod.	Private nonfin.	Local auth.	Prod.	Private nonfin.	Local auth.					
Wages South	$-WB^S$	$+WB^{SS}$			$+WB^{SN}$						0
Wages North		$+WB^{NS}$		$-WB^N$	$+WB^{NN}$						0
Profits South	$-OPS^S$	$+OPS^{SS}$			$+OPS^{SN}$					$+OPS^{SW}$	0
Profits North				$-OPS^N$	$+OPS^{NN}$					$+OPS^{NW}$	0
Net indirect taxes	$-INDT^S$			$-INDT^N$				$+INDT$			0
Imports	$-MGS^S$			$-MSG^N$						$+MGS$	0
Exports	$+XGS^S$			$+XGS^N$						$-XGS$	0
Trade S->N	$+XGS^{SN}$			$-MGS^{NS}$							0
Trade N->S	$-MGS^{SN}$			$+XGS^{NS}$							0
Interest on advances							$-r^{ADV}$ $* ADV_{t-1}$		$+r^{ADV}$ $* ADV_{t-1}$		0
Int. on deposits		$+r^D * D_{t-1}^S$			$+r^D * D_{t-1}^N$		$-r^D * D_{t-1}$				0
Int. on loans		$-r^L * L_{t-1}^S$			$-r^L * L_{t-1}^N$		$+r^L * L_{t-1}$				0
Int. on gov. Bonds		$+r^B * B_{t-1}^S$			$+r^B * B_{t-1}^N$		$+r^B * B_{t-1}^F$	$-r^B * B_{t-1}$	$+r^B * B_{t-1}^{CB}$	$+r^B * B_{t-1}^W$	0
Int. on bank bonds					$+r^{BB} * BB^N$		$-r^{BB} * BB_{t-1}$			$+r^{BB} * BB_{t-1}^W$	0
Int. on f. bonds							$+r^F * F_{t-1}$			$-r^F * F_{t-1}$	0
Dividends S		$-DIV^S$			$+DIV^{SN}$					$+DIV^{SW}$	0
Dividends N					$-DIV^N$					$+DIV^{NW}$	0
Dividends W					$+DIV^W$					$-DIV^W$	0
Dividends banks					$+DIV^{BN}$		$-DIV^{BN}$				0
Primary income		$YP^S$			$YP^N$		$YP^F$			$YP^W$	
Taxes		$-TAX^S$			$-TAX^N$		$-TAX^F$	$+TAX$			0
Local taxes		$-LTAX^S$	$+LTAX^S$		$-LTAX^N$	$+LTAX^N$					0

Transfers from C.G. to L			$+TR^{GS}$			$+TR^{GN}$		$-TR^G$		0
Pension payments		$+PENS^S$			$+PENS^N$			$-PENS$		0
Social contribution		$-SOCCON^S$			$-SOCCON^N$			$+SOCCON$		0
Seignorage								$+TR^{CBG}$	$-TR^{CBG}$	0
Disposable income		$YD^S$			$YD^N$			$YD^G$		
Expenditure	$+PX^S$ $+G^S$	$-PX^S$	$-G^S$	$+PX^N + G^N$	$-PX^N$	$-G^N$				0
NAFA	0	$+NAFA^S$	0	0	$+NAFA^N$	0	0	$+NAFA^G$	0	$+NAFA^W$ 0
<hr/>										
<i>Flow of Funds</i>										
ΔCash+reserves		$+\Delta M^S$			$+\Delta M^N$		$+\Delta RES$		$-\Delta M - \Delta RES$	0
ΔForeign reserves									$+\Delta FR$	$-\Delta FR$ 0
ΔAdvances							$-\Delta ADV$		$+\Delta ADV$	0
ΔBank deposits		$+\Delta D^S$			$+\Delta D^S$		$-\Delta D$			0
ΔLoans		$-\Delta L^S$			$-\Delta L^N$		$+\Delta L$			0
ΔBank bonds					$+\Delta BB^N$		$-\Delta BB$			$+\Delta BB^W$ 0
ΔPublic bonds		$+\Delta B^S$			$+\Delta B^N$		$+\Delta B^F$	$-\Delta B$	$+\Delta B^{CB}$	$+\Delta B^W$ 0
ΔEquities S		$-\Delta EQ^S$			$+\Delta EQ^{SN}$					$+\Delta EQ^{SW}$ 0
ΔEquities N					$-\Delta EQ^N$					$+\Delta EQ^{NW}$ 0
ΔEquities W					$+\Delta EQ^W$					$-\Delta EQ^W$ 0
ΔForeign bonds							$+\Delta FB$			$-\Delta FB$ 0
Total	0	0	0	0	0	0	0	0	0	0

## II.I Model Equations

**Output, employment, and income distribution:** Output in the model is determined by aggregate demand, which is the sum of private sector final demand ( $PX^i$ ),<sup>6</sup> government expenditures ( $G^i$ ), and exports (to the other region,  $XGS^{ij}$ , and to the RoW,  $XGS^{iw}$ ) minus imports (from the other region,  $XGS^{ji}$ , and from the RoW,  $XGS^{wi}$ ), as reported in the first column of table 1.<sup>7</sup>

$$GDP^i = PX^i + G^i + XGS^{iw} + XGS^{ij} - XGS^{wi} - XGS^{ji} \quad (1-2)$$

On the income side, the functional distribution of income is obtained as follows: the total level of employment in each region will depend on the level of output and average labor productivity (eq. 3–4) The total wage bill paid in each region (eq. 5–6) is determined by the average regional wage times the level of employment. Firms employ workers coming from both regions and thus the total wage bill is split between wages paid to local workers (eq. 7–8) and those paid to workers from the other region (eq. 9) based on the number of people employed multiplied by the current regional wage.<sup>8</sup> Another fraction of the income generated in production is paid to the central government as net indirect taxes (eq. 10–11), depending on a given tax rate ( $\tau_i$ ). The residual represents the operating surplus generated in each region (eq. 12–13).

$$N^i = GDP^i / \pi^i \quad (3-4)$$

$$WB^i = w^i \cdot N^i \quad (5-6)$$

$$WB^{ii} = w^i \cdot N^{ii} \quad (7-8)$$

$$WB^{NS} = w^N \cdot N^{SN} \quad (9)$$

$$NIT^i = \tau_i \cdot GDP^i \quad (10-11)$$

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<sup>6</sup> When equations are the same for both regions, we will use the suffixes i,j to denote region S and N for the first equation, and regions N and S for the next.

<sup>7</sup> A list of model parameter values is available upon request, along with the Eviews code.

<sup>8</sup> We assume the unit wage in both regions to be exogenous and to grow in line with the productivity level (at 2 percent in both regions). This assumption will be relaxed in future version of the model.

$$OPS^i = GDP^i - (WB^i + NIT^i) \quad (12-13)$$

The next block of equations describes the functioning of the labor market. In this version of the model, population is exogenous and grows at 0.025 percent, while the number of retired people is given by a share in the total population. The working age population is thus given residually (eq. 14–15). Total employment is determined by the dynamic of local GDP and the level of productivity (eq. 3–4).

As we will discuss later, labor migration is one of the mechanisms of convergence between the two regions. For simplicity, we will assume that only workers from the S region will move to the N region following an increase in the demand for labor; we neglect migration in the other direction. We don't explicitly model migration to other regions/countries, which is approximated in the current version of the model by a negative growth rate in total population.

Employment of local workers in the S region will therefore be given by the regional demand for labor (eq. 16), while firms in the N region will employ both local and migrant workers<sup>9</sup> on the basis of a percentage ( $\Omega$ ), which is fixed in the current model version (eq. 17).

Commuting from S to N is assumed to depend upon the change in the employment level in the two regions (eq. 19) and it will impact the level of unemployment in both regions (eq. 20–21). Note that our measure of migration can assume negative values when the increase in employment in the S region exceeds that of N, generating a return of S workers to their region. We also consider a discouraged-worker effect through a ( $\Phi^i$ ) parameter in both regions.

The following equations (22–27) conventionally endogenize the labor force ( $LF$ ), those out of the labor force ( $IN$ ), and the unemployment rate ( $ur$ ).

$$POPWA^i = POP^i - RET^i \quad (14-15)$$

$$N^{SS} = N^S \quad (16)$$

---

<sup>9</sup> In the current version of the model, we assume that workers from the S region who find a job in the N region will commute rather than migrate permanently to the other region, so that the population level in the two regions does not depend on labor movements. Extensions of the model to properly model migration will be addressed in future research.



$$N^{NN} = \Omega \cdot N^N \quad (17)$$

$$N^{SN} = N^N - N^{NN} \quad (18)$$

$$NM^{SN} = \Phi^{SN} \cdot (\Delta N_{t-1}^{SN} - \Delta N_{t-1}^{SS}) \quad (19)$$

$$U^S = U_{t-1}^S - NM^{SN} - \Phi^S \cdot \Delta N_{t-1}^{SS} \quad (20)$$

$$U^N = U_{t-1}^N + NM^{SN} - \Phi^N \cdot \Delta N_{t-1}^{NN} \quad (21)$$

$$LF^i = N^i + U^i \quad (22-23)$$

$$IN^i = POPWA^i - LF^i \quad (24-25)$$

$$ur^i = U^i / LF^i \quad (26-27)$$

**Disposable income, expenditure, and saving:** The central block of the transaction matrix in table 2 records the payments and receipts relative to incomes from capital (i.e., interest and dividends payments/receipts). These, together with the incomes generated in production, determine private sector primary income (eq. 28–29). We assume that a fraction ( $\eta$ ) of the salary corresponding to S residents working in the N region is spent in the S region. Rather than modifying the consumption equation, for simplicity we chose to include this assumption in the determination of income.

We assume that only N residents receive dividends from banks and from the RoW (eq. 29).

As is common in SFC models, interest payments/receipts on the stocks held are determined by the relative current interest rate times the opening stock. The private sector dividends to shareholders (eq. 30–31) are an exogenous share of profits. The dividends paid from S to N and W, and from N to W, will be a fraction of total dividends equal to the share of equities held by the other region (eq. 32–37). Finally, we assume that only the N region holds foreign equities receiving dividends (eq. 38).

$$YP^S = [WB^{SS} + \eta \cdot WB^{NS} + OPS^S] + [r^D \cdot DEPS_{t-1}^S + r^B \cdot B_{t-1}^S - r^{LS} \cdot L_{t-1}^S - (DIV^{SN} + DIV^{SW})] \quad (28)$$

$$YP^N = [WB^{NN} + (1 - \eta) \cdot WB^{NS} + OPS^N] + [(r^D \cdot DEPS_{t-1}^N + r^B \cdot B_{t-1}^N + r^{BB} \cdot BB_{t-1}^N - r^{LN} \cdot L_{t-1}^N) + (DIV^F + DIV^W + DIV^{SN} - DIV^{NW})] \quad (29)$$

$$DIV^i = \zeta^i \cdot OPS^{ii} \quad (30-31)$$

$$DIV^{SN} = DIV^S \cdot \psi^{SN} EQ_{t-1}^{SN} / EQ_{t-1}^S \quad (32)$$

$$DIV^{iW} = DIV^i \cdot \psi^{iW} \quad (33-34)$$

$$\psi^{ij} = EQ_{t-1}^{ij} / EQ_{t-1}^i \quad (35-37)$$

$$DIV^W = re^W \cdot EQ_{t-1}^W \quad (38)$$

The third block of the transaction matrix reports the formation of secondary income—taking into account taxes and other public transfers—which brings about the disposable income of the private sector (eq. 39–40). The private sector receives pension payments (eq. 41–42), pays social contributions on the wages received (eq. 43–44), and pays taxes to the local and central government, depending on the relative tax rates (eq. 45–48).

$$YD^i = YP^i + PENS^i - TAX^i - LTAX^i - SOCCON^i \quad (39-40)$$

$$PENS^i = \tau^p \cdot w^i \cdot RET^i \quad (41-42)$$

$$SOCCON^S = \tau^{SC} \cdot (WB^{NS} + WB^{SS}) \quad (43)$$

$$SOCCON^N = \tau^{SC} \cdot WB^{NN} \quad (44)$$

$$LTAX^i = \tau^{DR} \cdot (YP^i + PENS^i) \quad (45-46)$$

$$TAX^i = \tau^D \cdot (YP^i + PENS^i) \quad (47-48)$$

Private expenditure (eq. 49–50) has a simple specification. As is standard in the SFC literature, household consumption depends on disposable income and the opening stock of net wealth (eq. 51–52). Firms' investment is based on a simple accumulation function, which is positively linked to animal spirits and the rate of capacity utilization in the previous period (proxied here by the output–capital ratio) and negatively on the interest rate on loans (eq. 53–56), as in Godley and Lavoie (2007b: ch.11). The stock of capital (eq. 57–58) increases over time with net investment. We assume a higher propensity to consume in the S region, while the parameters in the accumulation function are assumed to be the same in both regions.

$$PX^i = C^i + I^i \quad (49-50)$$

$$C^i = \alpha_0^i + \alpha_1^i \cdot YD^i + \alpha_2^i \cdot NW_{t-1}^i \quad (51-52)$$

$$I^i = (gk + \delta) \cdot K_{t-1}^i \quad (53-54)$$

$$gk^i = \beta_0 + \beta_1 \frac{GDP_{t-1}^i}{K_{t-2}^i} - \beta_2 r_{t-1}^{Li} \quad (55-56)$$

$$K^i = K_{t-1}^i \cdot (1 - \delta) + I^i \quad (57-58)$$

The net acquisition of financial assets (*NAFA*, eq. 59–60) is given by the difference between disposable income and expenditure, and determines the accumulation of net financial wealth (eq. 61–62). We neglect in this version the possible role of net capital gains.

$$NAFA^i = YD^i - PX^i \quad (59-60)$$

$$NW^i = NW_{t-1}^i + NAFA^i \quad (61-62)$$

Next we present the equations related to trade. We model imports from W (eq. 63–64) and intraregional trade (eq. 65–66), leaving exports to W exogenous. We assume both regions to have the same elasticity

of GDP to imports (from W and the other region,  $\gamma$  and  $\sigma$ , respectively) and assume instead different autonomous components for interregional exports—to reflect the higher reliance of S region firms on intermediate goods from the N region.

$$MGS^i = \gamma_0^i + \gamma \cdot GDP^i \quad (65-66)$$

$$XGS^{NS} = x^S + \sigma^S \cdot GDP^S \quad (67)$$

$$XGS^{SN} = x^N + \sigma^N \cdot GDP^N \quad (68)$$

To complete the analysis of the top part of our transaction matrix in table 2, we need to specify our assumptions about payments and receipts of local and central governments, banks, and the foreign sector. It must be the case that the net acquisition of financial assets for all sectors is zero.

**Government expenditures and receipts:** As specified earlier, the central government levies indirect taxes on production (eq. 69) and direct taxes on incomes (eq. 70). Pension payments to both regions depend on the local wage rate and the number of retired people (eq. 45–46).

Government expenditure, which is exogenously determined, is carried out by local governments that balance their budget, meaning that the possible fiscal residual, i.e., the difference between expenditures and revenues, is financed by the central government (eq. 71–72).

The determination of the government net borrowing/lending ( $NAFA^G$ , eq. 73) is completed by adding to the revenues the seigniorage received from the central bank (eq. 74) and subtracting interest paid on the existing stock of debt.

$$NIT = NIT^S + NIT^N \quad (69)$$

$$T = T^S + T^N \quad (70)$$

$$TR^{Gi} = G^i - LTAX^i \quad (71-72)$$

$$NAFA^G = (NIT + T) + (SC^S + SC^N) + (TR^{CBG}) - (r^B \cdot B_{t-1}) - (TR^{GS} + TR^{GN}) - (PENS^S + PENS^N) \quad (73)$$

$$TR^{CBG} = r^{ADV} \cdot ADV_{t-1} + r^B \cdot B_{t-1} \quad (74)$$

**Net lending of banks and the foreign sector:** The role of banks in this version of the model is to accommodate the demand for deposits and credit coming from the domestic economy. Even though we model banks separately from the regional economies, we assume that they distribute all profits to households in the N region in the form of dividends (eq. 52) so that their net wealth is zero.

$$DIV^F = (r^{LS} \cdot L_{t-1}^S + r^{LN} \cdot L_{t-1}^N + r^B \cdot B_{t-1}^F + r^{FB} \cdot FB_{t-1}) - (r^{ADV} \cdot ADV_{t-1} + r^D \cdot D_{t-1} + r^{BB} \cdot BB_{t-1}) \quad (75)$$

To obtain the net lending of the foreign sector ( $NAFA$ ) we consider interest paid abroad on government and bank bonds, and interest received on domestic ownership of foreign assets, as well as dividends paid (eq. 76).

$$NAFA^W = (MGS^S + MGS^N) - (XGS^S + XGS^N) + (r^B \cdot B_{t-1} + r^{BB} \cdot BB_{t-1} - r^{FB} \cdot FB_{t-1}) + (DIV^{SW} + DIV^{NW} - DIV^W) \quad (76)$$

Consistent accounting ensures that the sum of the net lending of all sectors is zero: an accounting constraint that will be respected by the model without the need to add the equation explicitly.

$$NAFA^S + NAFA^N + NAFA^G + NAFA^W = 0$$

This equation is central to our analysis, in that it shows that a deficit (i.e. net borrowing) in a region must be matched by a surplus (i.e., net lending) in one or more other regions.

**Flow of funds and balance sheets:** We chose to have a simpler portfolio for the S region with respect to the N region, so we will discuss their portfolio decisions separately, while the demand for loans—as well as the supply of equities—is assumed to follow common rules in the two regions.

With respect to the demand for loans, we assume the private sector to ask for loans only if they are needed to finance the gap between: a) consumption and the sum of (local) wages and pensions, which reflects the households' channel (eq. 77–78); and b) the difference between investment and profits (net of dividends), which reflects the firms' channel (eq. 79–80). Thus, the stock of loans evolves according to equation (81–84), with a constraint to avoid negative stocks of loans.

Firms finance a portion of their investment by issuing shares (eq. 87–88) that are sold to N and W from the S region (eq. 89) and only to W for the N region (eq. 90). The stock of equities held locally is then residually determined by the difference between total equities issued and foreign demand.

The return on equities depends on the flow of dividends paid to shareholders (eq. 91–92).<sup>10</sup>

$$dLh^i = v_1^i \cdot [C^i - (WB^{ii} + PENS^i)] \quad (77-78)$$

$$dLf^i = v_2^i \cdot [I^i - (OPS^{ii} - DIV^i)] \quad (79-80)$$

$$Lh^i = \begin{cases} Lh_{t-1}^i + dLh^i; & \text{if } (Lh_{t-1}^i + dLh^i) \geq 0 \\ Lh_{t-1}^i; & \text{if } (Lh_{t-1}^i + dLh^i) < 0 \end{cases} \quad (81-82)$$

$$Lf^i = \begin{cases} Lf_{t-1}^i + dLf^i; & \text{if } (Lf_{t-1}^i + dLf^i) \geq 0 \\ Lf_{t-1}^i; & \text{if } (Lf_{t-1}^i + dLf^i) < 0 \end{cases} \quad (83-84)$$

$$L^i = Lh^i + Lf^i \quad (85-86)$$

$$EQ^i = EQ_{t-1}^i + \xi^i * I_{t-1}^i \quad (87-88)$$

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<sup>10</sup> Since we consolidate the household and business sectors in each region, dividends paid by firms to equity owners in the same region cancel out when determining the disposable income of the private sector as a whole. For this reason, it is simpler to compute the return on equities on the basis of dividends paid externally.

$$EQ^{SS} = EQ^S - EQ^{SN} - EQ^{SW} \quad (89)$$

$$EQ^{NN} = EQ^N - EQ^{NW} \quad (90)$$

$$re^S = (DIV^{SN} + DIV^{SW}) / (EQ_{t-1}^{SN} + EQ_{t-1}^{SW}) \quad (91)$$

$$re^N = DIV^{NW} / EQ_{t-1}^{NW} \quad (92)$$

The allocation of wealth between assets and liabilities in the S region reflects the lower complexity of its portfolio. The demand for liquidity (cash and deposits) is transactional, depending on the evolution of final demand (eq. 93–94).

The buffer stock is here represented by government bonds, which are determined residually as the difference between assets and liabilities (eq. 95), so that the determination of the net lending/borrowing position from the income side is made consistent with the allocation of financial wealth and the demand for credit on the financial side.

$$M^S = M_{t-1}^S + \mu_1^S \cdot (PX^S - PX_{t-1}^S) \quad (93)$$

$$D^S = D_{t-1}^S + \mu_2^S \cdot (PX^S - PX_{t-1}^S) \quad (94)$$

$$B^S = NW^S + (EQ^{SN} + EQ^{SW} + L^S) - (M^S + D^S) \quad (95)$$

The private sector in the N region has a richer financial portfolio, as presented in table 1. We therefore need to determine the stock of its financial assets and its allocation to cash, deposits, bonds, etc., from the identity defining financial net wealth (eq. 96).

$$FA^N = NW^N + L^N + EQ^{NW} \quad (96)$$

While the demand for liabilities in the N region follows the same rules as the ones for S—although with different parameters—the rest of the demand for assets is very different. Given the higher complexity of their balance sheet, we model private sector portfolio choices in the N region by

adopting the approaches of Brainard and Tobin (1968), Tobin (1969, 1982) and Godley and Lavoie (2007b).

In this framework, households want to hold a certain share ( $\lambda_{i0}$ ) of their wealth in the form of asset  $i$ , but this proportion is modified by the expected rate of return on this asset and by the level of expected (regular) disposable income. When making their portfolio allocations, households are concerned about the interest rates relative to the different assets ( $r^i$ ), which will generate the future interest payments, and by the expected return on bonds and equities. In matrix form:

$$\begin{bmatrix} D^N / FAe^N \\ BB^N / FAe^N \\ B^N / FAe^N \\ EQ^{SN} / FAe^N \\ EQ^W / FAe^N \end{bmatrix} = \begin{bmatrix} \lambda_{10} \\ \lambda_{20} \\ \lambda_{30} \\ \lambda_{40} \\ \lambda_{50} \end{bmatrix} + \begin{bmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} & \lambda_{14} & \lambda_{15} \\ \lambda_{21} & \lambda_{22} & \lambda_{23} & \lambda_{24} & \lambda_{25} \\ \lambda_{31} & \lambda_{32} & \lambda_{33} & \lambda_{34} & \lambda_{35} \\ \lambda_{41} & \lambda_{42} & \lambda_{43} & \lambda_{44} & \lambda_{45} \\ \lambda_{51} & \lambda_{52} & \lambda_{53} & \lambda_{54} & \lambda_{55} \end{bmatrix} \begin{bmatrix} r^D \\ r^{BB} \\ r^B \\ RE^{SN} \\ RE^W \end{bmatrix} + \begin{bmatrix} \lambda_{16} \\ \lambda_{26} \\ \lambda_{36} \\ \lambda_{46} \\ \lambda_{56} \end{bmatrix} YDe^N / FAe^N \quad (97-101)$$

As agents in this framework are supposed to make consistent decisions on wealth allocation, the coefficients in the matrix must respect several constraints, which however assure the logical and economic consistency of this class of models:

- The sum of the constants must be unity, as the decision to hold one asset implies the decision to hold the remaining wealth in the other two.
- The sum of the coefficients with respect to each argument of the portfolio equations must be zero: if, following a change in interest (or income) people wish to hold a higher proportion of their assets in bonds, it implies that they want to hold a lower proportion of cash, deposits, and equities.

This is the so-called “adding-up constraint”: if there are  $m$  assets, one needs to specify  $m-1$  demand function (the last one being implied by others), thus assuring that any increase in a stock implies a corresponding decrease in some other, and the same applies to the relative rate of returns (i.e., an increase in one rate implies that, at least, there is a specular change in another). Finally, cash balances represent the buffer stock in the N region (eq. 102).



$$M^N = FA^N - (D^N + BB^N + B^N + EQ^{SN} + EQ^W) \quad (102)$$

The expected end-of-period values for financial assets and disposable income are projected based on the previous growth rate in GDP (eq. 103–104).

$$FAe^N = FA_{t-1}^N \cdot (GDP_{t-1}^N / GDP_{t-2}^N) \quad (103)$$

$$YDe^N = YD_{t-1}^N \cdot (GDP_{t-1}^N / GDP_{t-2}^N) \quad (104)$$

**Banks:** Banks supply deposits and loans on demand (eq. 105–106),<sup>11</sup> and issue bonds to partly cover their exposure (eq. 107).

The stock of reserves (eq. 108) evolves according to a reserve ratio on deposits, while the demand for government and foreign bonds (eq. 107 and eq. 108) also depends on deposits plus an exogenous parameter that reflects banks' willingness to diversify their portfolio. Finally, their demand for advances, which is accommodated by the central bank, is determined residually from the balance sheet adjustments (eq. 109).

$$D = D^S + D^N \quad (105)$$

$$L = L^S + L^N \quad (106)$$

$$BB = BB_{t-1} + \varphi \cdot (L_{t-1} - L_{t-2}) \quad (107)$$

$$RES = RES_{t-1} + \varsigma \cdot (D_{t-1} - D_{t-2}) \quad (108)$$

$$B^F = B_{t-1}^F + v_1 \cdot (D_{t-1} - D_{t-2}) \quad (109)$$

$$FB = FB_{t-1} + v_2 \cdot (D_{t-1} - D_{t-2}) \quad (110)$$

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<sup>11</sup> In future work the model could be expanded to include credit restrictions that arise when banks consider that a portion of investment may not be profitable.

$$ADV = ADV_{t-1} + \Delta(RES + B^F + F + L - D) \quad (111)$$

**Government and the central bank:** At the present stage, our main interest is in analyzing the mechanisms driving regional divergence and how local systems react to these forces, rather than studying monetary and fiscal policies to curtail them. Thus, we choose to simplify as much as possible our discussion of government and the monetary authority, which we defer to future research.

The government issues bonds to finance its deficit (eq. 112).

$$B = B_{t-1} - NAFA^G \quad (112)$$

The central bank supplies cash on demand (eq. 113), as well as reserves and advances to banks, and absorbs a portion of the public bonds issued (in the previous period) for monetary policy purposes (eq. 114).

$$M = M^S + M^N \quad (113)$$

$$B^{CB} = B_{t-1}^{CB} + \vartheta \cdot \Delta(B_{t-1}) \quad (114)$$

The consistency of the model requires that the value of foreign reserves held by the central bank summed up to the other central bank assets be equal to the central bank liabilities. There is no need to include this equation explicitly, since the model consistency will imply that it is respected:

$$M + RES = FR + B^{CB} + ADV$$

**The foreign sector:** Following our “small country” hypothesis, we do not model the foreign sector’s behavior in detail, which is thus the residual buyer for some of the asset in the economy, namely banks’ bonds (eq. 116) and public debt (eq. 117), while the demand for equities of the S and N regions are given by fixed exogenous shares in total issues (eq. 118–119). Finally, the stock of foreign reserves closes the balance sheet structure (eq. 120) i.e., is the buffer stock in the net investment position of the country.

$$NW^W = NW_{t-1}^W + NAFA^W \quad (115)$$

$$BB^W = BB - BB^N \quad (116)$$

$$B^W = B - (B^S + B^N + B^{CB} + B^F) \quad (117)$$

$$EQ^{SW} = EQ_{t-1}^{SW} + \xi^{SW} \cdot \Delta EQ_{t-1}^S \quad (118)$$

$$EQ^{NW} = EQ_{t-1}^{NW} + \xi^{NW} \cdot \Delta EQ_{t-1}^N \quad (119)$$

$$FR = (BB^W + B^W + EQ^{SW} + EQ^{NW} - EQ^W - FB) - NW^W \quad (120)$$

#### IV. MODEL FEATURES AND RESPONSES TO SHOCKS

This section discusses the properties of the baseline solution of the model and how it responds to exogenous shocks.

To obtain a baseline solution we assume that:

- government spending grows at 2 percent in both regions;
- exports to the RoW grow at 2 percent in both regions;
- population grows at 0.25 percent, while the shares of youths and retired people within that population are stable;

- the employment and participation rates in both regions are stable; and
- productivity grows at 2.5 percent in both regions.

Given our assumptions, the calibration for balance sheet entries, and the chosen values for parameters, the model replicates some key features of the Italian economy and sheds light on some of the major dynamics at work.

In particular:

- The gap in GDP per capita in the two regions tends to be reduced very slowly, with the growth rate in the South being slightly higher (at 2.4 percent) than the North's growth rate of 2.3 percent.
- The South region exhibits a deficit against the other two regions. Given that the GDP per capita in the S region is around 54 percent of that in the N region and tax rates are the same in both regions, the model predicts a large automatic fiscal transfer from the North to the South, which completely finances the "current account" deficit of the South.
- As long as the growth rate in the South is lower than that in the North, the model predicts migration to the North, which is reversed when the South starts to converge toward the North's levels of GDP per capita;
- For our choice of parameters, in the South region, since fiscal transfers are sufficient to sustain income, there is no need to increase borrowing either for consumption or investment purposes, and the stock of loans declines. In the North region, on the contrary, we have assumed a larger profit share. Since our hypothesis is that households borrow to finance consumption in excess of income from wages and pension payments, thus excluding income from capital, the stock of loans does not decline, but stabilizes with respect to GDP.
- The total stock of public debt fluctuates in a plausible range with respect to GDP.
- The balance of payments for the country as a whole is relatively stable relative to GDP and in a surplus position.

**Figure 2: Balance of Payments of the South Region**

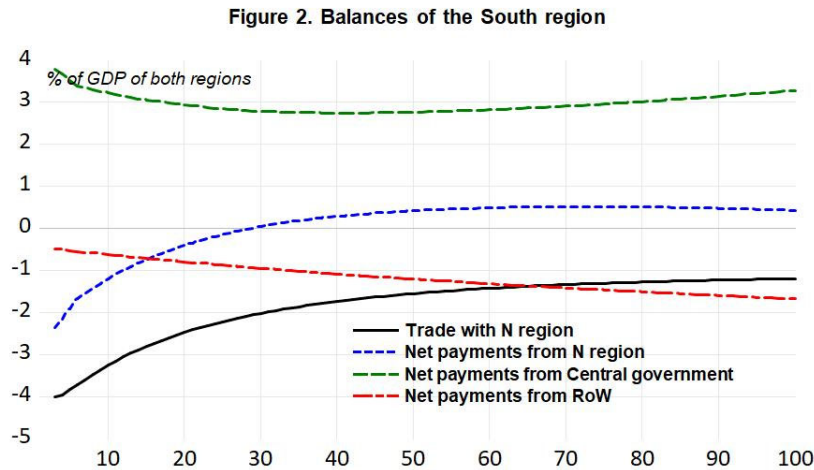


Figure 2 reports the net balances of the South with the other sectors, summarizing these results. It is important to stress that the gap between net payments with the North from trade and the overall net payments with the North are due to wages earned by residents from the South commuting to the North. With our choice of parameters, the role of dividends paid by firms in the South to rentiers in the North is less relevant.

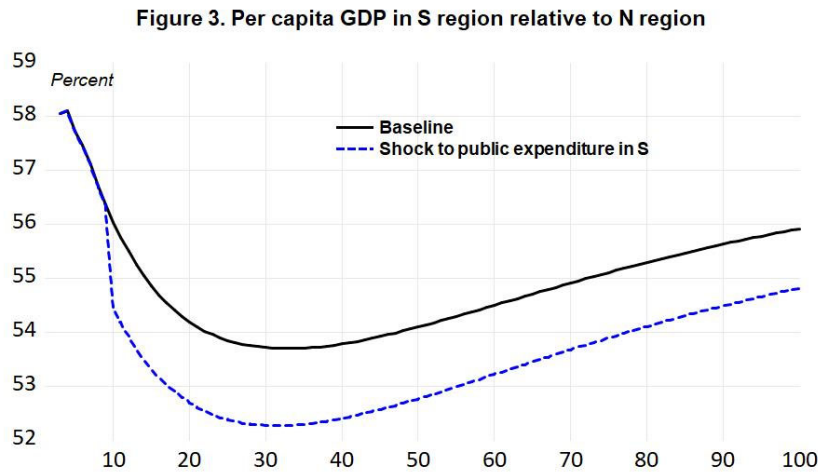
#### IV.I Response to a Shock

Given that the main adjustment mechanism in the model depends on fiscal transfers, it is interesting to explore the consequences of a public expenditure reduction in the South region, which should imply a lower net fiscal transfer.

We drop public expenditure in the S region by 10 percent in period ten, which is about 2 percent of the region's GDP. The impact on the relative GDP per capita of the S region against the N region is reported in figure 3.

The impact multiplier in the S region is greater than one, implying a fall of 3.1 percent of GDP. This in turn implies a reduction in imports from the other region and GDP in the N falls by 0.3 percent. The reduction in disposable income in the S region also implies a fall in the stock of net wealth, which falls by more than 3 percent after about twenty simulation periods, contributing to a further fall in the region's consumption.

**Figure 3: Per Capita GDP in the South Region Relative to the North Region**



With our choice of parameters, net migration from S to N increases to a negligible extent and only in the period of the shock. Consumption falls less than wages in the S region, implying a temporary increase in borrowing.

Summing up our results, there are no mechanisms in the model that will imply an automatic reduction in the regional gap after the shock, so that appropriate policies are needed if convergence is considered to be a desirable social goal.

## V. CONCLUSIONS

We have presented a stock-flow consistent model of two regions that share a central government and a central bank, contributing to the SFC literature modeling open economies by introducing the treatment of workers' migration, as well as the transfers of ownership of firms across regions. The model has been calibrated on Italian data, but can easily be modified to be applied to other countries who exhibit relevant regional gaps in income per capita. The purpose of our exercise was not to deploy a detailed model for a specific country, but rather to provide a skeleton for future expansions of the analysis.

A relevant missing feature of the current model version is the endogenization of the dynamics of prices and wages in the two regions, which should imply an additional effect on migration arising from differences in real wages, as well as the impact of price competitiveness on trade. The analysis of these phenomena is left to future work.

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