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From abstract to concrete: some tips for developing an empirical stock–flow consistent model

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The main purpose of this paper is to show how a simple (medium-scale) empirical stock–flow consistent dynamic model can be developed from scratch. Eurostat data and conventional statistical packages (notably EViews, Excel and R) are used. On the theoretical side, the work builds upon the pioneering work of Godley/Lavoie (2007). Sectoral transactions–flow matrices and balance sheets are explicitly modelled and their evolution over time under different scenarios is analysed. On the empirical side, the model draws upon the applied work of Burgess et al. (2016). The case of Italy is considered, but the model can be replicated for other countries. Eurostat annual data (from 1995 to 2016) are used to estimate or calibrate most model parameter values (for example, consumption function and housing investment parameters). Remaining parameters are borrowed from the available literature or taken from a range of realistic values (for example, weight on past errors in agents' expectations). The model is then used to impose and compare alternative scenarios for Italian sectoral financial balances, based on different shocks to government spending.

Keywords: *sectoral balances, flow of funds, macro modelling, Italian economy*

JEL codes: *E21, E22, E25, E37*

1 INTRODUCTION

The main purpose of this paper is pedagogical. It is aimed at showing how a simple (medium-scale) empirical stock–flow consistent macroeconometric model can be developed from scratch. Eurostat data and conventional statistical packages (notably EViews, Excel and R) are used to implement a theory-constrained but data-driven modelling method. The key features of the model are as follows. First, the model belongs to the class of 'stock–flow consistent' models (SFCMs hereafter), as it is inspired by the pioneering theoretical work by Godley/Lavoie (2007).[1] Second, it is an 'empirical macroeconometric' model, as its structure is developed by building upon macroeconomic principles and available time series for macro variables, rather than 'classical' microeconomics' first principles.

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1. See Nikiforos/Zezza (2017) for a recent survey on stock–flow consistent approach literature.

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As such, the model presented here shows a clear resemblance to a recent work released by the Bank of England (Burgess et al. 2016).

Another distinctive feature of the model is that no dynamic optimisation technique is used to derive the system of macroeconomic equations, for it is recognised that modern economies should be regarded as complex monetary systems of production. Their emerging behaviour cannot be traced back to the choices made by an individual representative agent in a Saturday evening's 'village fair'. As a result, their system-wide dynamics should be analysed either through a heterogeneous interacting agents micro-founded model or through a macro-monetary accounting approach. The second method is chosen here. Accordingly, sectoral transactions–flow matrices and balance sheets of the economy are explicitly modelled. Their evolution over time under different scenarios is analysed. Available time series for Italy are used, but the model can be replicated for other countries. More precisely, Eurostat annual data (from 1995 to 2016) are employed to estimate or calibrate most model parameter values (for example, consumption function and housing investment parameters). Remaining parameters are borrowed from the available literature or taken from a range of realistic values (for example, weight on past errors in agents' expectations). The model is then run to impose and compare alternative scenarios for Italy's sectoral financial balances, based on different government spending patterns.

To sum up, the aim of the paper is to show how to develop a structural macroeconometric model that enables us to account consistently for the evolution of financial stocks and flows across sectors (households, non-financial corporations, government, financial institutions and the foreign sector). For this purpose, the rest of the work is organised as follows. Section 2 provides a detailed description of the method used to reclassify and aggregate Eurostat data, and create sectoral balance sheets and the transactions–flow matrix. Section 3 presents the theoretical model, equation by equation, highlighting advantages and possible controversies. How to estimate model parameters and how to forecast relevant time series are briefly discussed. A few tips about software technicalities are also given. Section 4 presents some simple dynamic comparative exercises. More precisely, different hypothetical (future) scenarios are imposed and compared to test the reaction of key endogenous macroeconomic variables following shocks to government spending. Some further remarks on pros, cons and possible future developments of the model are made at the end of Section 4 and then in Section 5.

2 RECLASSIFICATION OF EUROSTAT ENTRIES

The research question this paper aims at addressing is not 'theoretical', but a quite practical one. Since the publication of *Monetary Economics* by Wynne Godley and Marc Lavoie in 2007, a growing army of early-career researchers, 'dissenting' economists and practitioners have been using SFCMs to perform a variety of dynamic simulation exercises. The widespread availability of statistical software, along with the high flexibility of SFCMs, have contributed to their increasing popularity among PhD students as well. SFCMs have been cross-bred with input–output and agent-based modelling approaches, giving rise to super-models whose potential is yet to be fully discovered. While qualitative findings from SFCMs are usually obtained through numerical simulation techniques, only a few empirically calibrated SFCMs have been developed so far.[2] The reason is likely to be the absence of a well-established method to match the standard theoretical framework used by stock–flow consistent (SFC) modellers with the System

2. The reader is referred again to the complete survey by Nikiforos/Zezza (2017).

of National Accounts (SNA).[3] Attributing values to model parameters and exogenous variables is not trivial. The aim of this paper is to help bridge this gap. For this purpose, the model discussed here is built upon Eurostat data. There are three reasons for that. First, Eurostat series are freely accessible online and can be downloaded through a specific *R* package named *pdfetch*. Second, the Eurostat dataset is uniform across countries, allowing for clear and consistent cross-country comparisons. Third, a useful reclassification of Eurostat entries has been proposed by Godin (2016). This works draws strongly on that reclassification.

As mentioned, the first step to be taken is to match the transactions–flow matrix (TFM hereafter) to the chosen country's national accounting provided by Eurostat. The full TFM for Italy (at current prices) is shown in Table 1, which displays the Excel sheet used to take a snapshot of payments and other transactions across sectors in 2015. The related balance sheet (BS) is displayed in Table 4. Focusing on Table 1, one feature and three possible issues are apparent. First, five macro-sectors are considered: (i) the household sector, marked by the subscript H in the model, including both households (named S14 in Eurostat classification) and non-profit firms serving households (S15); (ii) the firms sector, marked by the subscript F in the model, including all non-financial corporations (S11); (iii) the government sector, marked by the subscript G in the model, including both central and local governments (S13); (iv) the financial sector, marked by the subscript B in the model, including both commercial banks and other financial institutions (S12); and (v) the foreign sector, marked by the subscript RoW in the model, including the rest of the world's stocks and flows (S2, as opposed to total domestic economy, S1). Second, the central bank is implicitly consolidated with the rest of the banking and financial sector. This simplification should be addressed in a more advanced SFC model for Italy or other euro-area member states. The point is that the Bank of Italy does not operate like a 'normal' central bank issuing its own currency. On the contrary, this is a special privilege of the European Central Bank (ECB). Third, lines 6 to 9 (and 1 to 5) of the full TFM do not sum up to zero. The fact is that there is no information about 'who pays whom', that is, about cross-sector transactions, in the Eurostat basic data set. Consequently, an assumption must be made about the way output is produced and distributed. Fourth, the TFM's entries are numerous and 'dense'. This makes the task of identifying the model's identities from columns and multiple-entry rows quite complicated.[4] These entries should be reduced to avoid dealing with an excessive number of variables and equations when developing the model.

To address the last two issues, the full TFM can be narrowed down into two steps. First, it can be assumed that everything is produced by non-financial corporations upon the request of other sectors. Strong though it may seem, this assumption allows us to meet the stock–flow consistency conditions for production entries in a simple way, so that each row's total amounts to zero. Table 2 shows the reduced TFM, where some rows have been consolidated. Second, the TFM can be further simplified by merging together some entries (rows). In this paper it was chosen to merge all tax entries (except for subsidies on products, which must be kept separated to calculate each sector's and the total GDPs), all transfers (including subsidies, benefits and other transfers from the government sector), and other heterogeneous entries (labelled 'change in funds'). Table 3

3. The SNA is the internationally agreed set of recommendations to be adopted by national accounting offices. The SNA suggests the methods to build consistent transactions–flow matrices, flow of funds and balance sheets for real economies. For detailed information, see https://unstats.un.org/unsd/nationalaccount/sna.asp.
4. See Dafermos/Nikolaidi (2017) for a short but clear description of the steps in developing an SFCM.

Table 1 The full TFM (Italy, 2015, current prices, millions €)

Entries (Italy, 2015)	Eurostat code	Non-financial corporation S11	Financial corporation S12	Government S13	Households S14_S15	Rest of world S2	Total economy (row total) S1
Gross output	P1	2095694	130440	306245	580440	0	3112819
Intermediate consumption	P2	−1360170	−54429	−90092	−129658	0	−1634349
Taxes on product	D21	0	0	189354	0	2251	191605
Subsidies on products	D31	0	0	−24469	0	−167	−24636
Memo: GDP		*735524*	*76011*	*381038*	*450782*	*2084*	*1645439*
Consumption	P3	0	0	−311639	−1001014		−1312653
Exports	P6	0	0	0	0	−493934	−493934
Imports	P7	0	0	0	0	446042	446042
Investment	P5(G)	−149558	−4429	−36959	−93949		−284895
Total production		*585966*	*71582*	*32440*	*−644181*	*−45808*	*0*
Wages	D1	−411085	−32356	−161998	609723	−4284	0
Taxes on production and imports	D2***	−26528	−5735	240236	−18620	−189354	0
Subsidies on production	D3	4347	4	−28481	3929	20201	0
Dividends	D42	−109941	−1633	4271	114625	−7322	0
Interests payments	D41	−5209	18574	−65237	30759	21113	0
Other property income	D4G*	−11995	−17221	3924	23481	1812	0
Taxes on income and wealth	D5	−27869	−6022	241582	−206485	−1206	0
Social benefits (net of social contribution)	D6**	1273	2461	−113732	112607	−2609	0
Other current transfers	D7	−5061	−1075	−6476	−6232	18844	0
Adjustments in pension funds	D8	−1272	−2461	0	3733	0	0
Capital transfers	D9	18031	8294	−25421	2889	−3792	0
Total transfers		*−575309*	*−37170*	*88668*	*670409*	*−146597*	*0*
Sum production and transfers		*10657*	*34412*	*121108*	*26228*	*−192405*	*0*
Acquisition less consumption of NPNFP	NP	−1535	−18	−420	789	1184	0
Tax – subsidies on product	−D21 +D31	0	0	−164885	0	164885	0
Computed net lending position		*9123*	*34394*	*−44197*	*27017*	*−26336*	*0*
Net lending position	B9	9123	34394	−44197	27017	−26336	0
Total by sector (column total)		0	0	0	0	0	0

Notes: * $D43 + D44 + D45$; ** Government = $D61 - D62$, Households = $D61 + D62$; *** RoW = $-S1.D21 + S2.D2$.

Table 2 The simplified TFM (Italy, 2015, current prices, millions €)

Entries (Italy, 2015)	Eurostat code	Non-financial corporation S11	(capital)	Financial corporation S12	Government S13	Households S14_S15	Rest of world S2	Total economy (row total) S1
Gross output	P1	2095694		130440	306245	580440	0	3112819
Intermediate consumption	P2	−1360170		−54429	−90092	−129658	0	−1634349
Taxes on product	D21	0		0	189354	0	2251	191605
Subsidies on products	D31	0		0	−24469	0	−167	−24636
Memo: GDP per sector		*735524*		*76011*	*381038*	*450782*	*2084*	*1645440*
Memo: total GDP		*1645440*						
GDP redistribution		*−909915*	$=-\sum$	*76011*	*381038*	*450782*	*2084*	*0*
Consumption	P3	1312653		0	−311639	−1001014	0	0
Exports	P6	493934		0	0	0	−493934	0
Imports	P7	−446042		0	0	0	446042	0
Investment	P5 (G)	284895	−149558	−4429	−36959	−93949	0	0
Wages	D1	−411085		−32356	−161998	609723	−4284	0
Taxes on production and imports	D2	−26528		−5735	240236	−18620	−189354	0
Subsidies on production	D3	4347		4	−28481	3929	20201	0
Dividends	D42	−109941		−1633	4271	114625	−7322	0
Interests payments	D41	−5209		18574	−65237	30759	21113	0
Other property income	D4G	−11995		−17221	3924	23481	1812	0
Taxes on income and wealth	D5	−27869		−6022	241582	−206485	−1203	0
Social benefits (net of social contributions)	D6	1273		2461	−113732	112607	−2609	0
Other current transfers	D7	−5061		−1075	−6476	−6232	18844	0
Adjustments in pension funds	D8	−1272		−2461	0	3733	0	0
Capital transfers	D9	18031		8294	−25421	2889	−3792	0
Acquisition less consumption of NPNFP	NP	−1535		−18	−420	789	1184	0
Tax – subsidies on product	−D21 +D31	0		0	−164885	0	164885	0
Computed net lending position		*9123*		*34394*	*−44197*	*27017*	*−26336*	*0*
Net lending position	B9	9123		34394	−44197	27017	−26336	0
Total by sector (column total)		0		0	0	0	0	0

Table 3 The super-simplified TFM (Italy, 2015, current prices, millions €)

Entries (Italy, 2015)	Eurostat code	Non-financial corporation S11	(capital)	Financial corporation S12	Government S13	Households S14_S15	Rest of world S2	Total economy (row total) S1
Memo: GDP		*1645440*						
GDP redistribution		*−909915*	$-\sum$	*76011*	*381038*	*450782*	*2084*	0
Consumption	P3	1312653		0	−311639	−1001014	0	0
Exports	P6	493934		0	0	0	−493934	0
Imports	P7	−446042		0	0	0	446042	0
Investment	P5 (G)	284895	−149558	−4429	−36959	−93949	0	0
Wages	D1	−411085		−32356	−161998	609723	−4284	0
Total taxes	D2+D5−D21	−54397		−11757	292464	−225105	−1206	0
Dividends	D42	−109941		−1633	4291	114625	−7322	0
Interests payments	D41	−5209		18574	−65237	30759	21113	0
Other property income	D4G	−11995		−17221	3924	23481	1812	0
Transfers (subsidies, benefits, etc.)	D3+D6+D7−D31	559		1390	−124220	110304	11967	0
(Change in) funds	D8+D9+NP	15224		5815	−25841	7411	−2608	0
Computed net lending position		*9123*		*34394*	*−44197*	*27017*	*−26336*	*0*
Net lending position	B9	9123		34394	−44197	27017	−26336	0
Total by sector (row total)		0		0	0	0	0	0

Table 4 Sectoral balance sheets (Italy, 2015, current prices, millions €)

Entries (Italy, 2015)	Eurostat code	Non-financial corporations			Financial corporations			Government			Households		
		Assets	Liabilities	Net	Assets	Liabilities	Net	Assets	Liabilities	Net	Assets	Liabilities	Net
Non-financial assets (dwellings)	N1N +N2N	180,249.6	0.0	180,249.6	4,781.2	0.0	4,781.2	54,401.6	0.0	54,401.6	2,518,103.0	0.0	2,518,103.0
Currency and deposits	F2	308,930.0	32,763.0	276,167.0	326,009.0	2,027611.0	−1,701602.0	75,877.0	239,722.0	−163,845.0	1,273045.0	0.0	1,273045.0
Securities other than shares	F3	57,048.0	145,902.0	−88,854.0	1,675684.0	540,827.0	1,134857.0	27,908.0	2,097250.0	−2,069342.0	413,008.0	0.0	1,273,045.0
Loans	F4	18,947.0	1,067,001.0	−1,048,054.0	1,823,350.0	109,846.0	1,713,504.0	94,284.0	177,240.0	−82,956.0	13,707.0	691,961.0	−678,254.0
Shares and other equity	F5	525,651.0	1,666,671.0	−1,141,020.0	632,959.0	475,692.0	157,261.0	128,934.0	0.0	128,934.0	1,447,540.0	0.0	1,447,540.0
Other financial assets													
–Insurance technical reserves	F6	16,896.0	101,556.0	−84,660.0	6,358.0	758,730.0	−752,372.0	1,278.0	3,803.0	−2,525.0	862,639.0	0.0	862,636.0
–Derivatives and empl. stock options	F7	15,425.0	14,307.0	1,118.0	125,954.0	138,737.0	−12,783.0	0.0	31,899.0	−31,899.0	738.0	68.0	670.0
–Other account receivables/ payable	F8	147,171.0	91,326.0	55,845.0	26,448.0	5,664.0	20,784.0	115,005.0	74,245.0	40,760.0	13,286.0	93,518.0	−80,232.0
Net worth	BF90			−1,849,208.4			564,430.2			−2,126,471.4			5,756,516.0

Note: Foreign sector not included.

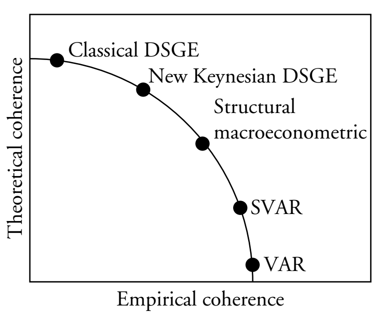
displays the super-simplified TFM that provides the accounting structure which the theoretical model presented in Section 3 is built upon. Notice that, unlike the TFM, the BS does not need a deep reclassification. For the sake of simplicity, insurance technical reserves, derivatives and other accounts were grouped together and named 'other financial assets' in the model. Currency and deposits were also merged, so that the amended or reclassified BS is made up of four types of assets and liabilities: produced non-financial assets (including dwellings), currency and deposits, securities, loans, shares, and other financial assets (see Table 4).

3 DEVELOPING THE MODEL

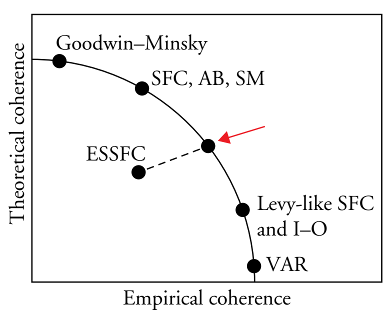
3.1 The system of difference equations

3.1.1 Key features and assumptions

The model proposed here is a discrete-time, medium-scale, dynamic macroeconometric model, based on both theoretical principles and data availability. It will be referred to as ESSFC (EuroStat-based Stock–Flow Consistent model) hereafter. The position occupied by ESSFC along the Pagan (2003) frontier of models is displayed in Figure 1. It shows the trade-off between theoretical and empirical coherence that macro modellers usually face. At the two ends of the curve are the models that have never been calibrated or estimated using historical data (purely theoretical models) and those that have perfect fit but have hardly any theoretical structure (purely empirical models), respectively. Quadrant (a) shows that conventional models can be classified in classical dynamic stochastic general equilibrium (DSGE), Keynesian DSGE, structural macroeconometric, structural vector autoregression (SVAR) and vector autoregression (VAR) models, moving from the most 'theoretical' to the most 'empirical' model. Similarly, Minsky–Goodwin non-linear models can be regarded as the most theoretical option for heterodox macroeconomists – see quadrant (b). Numerical SFC, agent-based (AB) and super-multiplier (SM) models also have a strong theoretical structure, but they can be bent to empirical purposes. Finally, input–output (I–O) and policy-oriented SFC models, like the one developed by researchers at the Levy Institute, are usually preferred over both structural and non-structural VAR models at a higher level of empirical detail. In a sense, ESSFC is aimed at bridging the gap between numerical or theoretical SFC models and Levy-like models. However, since the model is still being developed, it is unlikely to be on the optimal frontier yet.



(a) Conventional or orthodox models



(b) Unconventional or heterodox models

Figure 1 ESSFC position along Pagan's 'best practice' frontier of models

ESSFC's main assumptions and features are listed below.

1. ESSFC aims at using and manipulating Eurostat classifications, while assuring full stock–flow consistency.
2. It is assumed that the economy is demand-led both in the short and long run. Total production and the employment level are determined by aggregate demand. A production function has been added to the basic set of equations, but it does not anchor ESSFC long-run dynamics.[5] Rather, the latter is 'tied down' by the accounting consistency constraints of the model.
3. Unless otherwise stated, stock and flow variables are expressed at constant prices and national currency (euros). More precisely, variables have all been taken at current prices and then changed to 2010 prices. For the sake of simplicity, the GDP deflator has been used for all GDP components and financial stock variables as well.[6] Some asset prices, the general price level (GDP deflator) and the capital deflator are then endogenously determined by the model.
4. Total gross output is assumed to be produced by non-financial firms only, on behalf of other sectors.[7]
5. Distribution and hence sectoral GDPs are determined by institutional, political, social and historical factors. For the sake of simplicity, these factors are embodied in coefficients named 'beta' (β_j, where the subscript j denotes the sector), which can be calculated as moving averages (see Subsection 3.2). Table 5 shows the complete key to symbols.
6. Each sector is marked by either a portfolio investment function or a simplified financial investment rule.
7. Net stocks of financial assets and liabilities, rather than gross stocks, are usually taken into consideration. This is a remarkable limitation that should be addressed in a more advanced version of the model. One of the main reasons is that portfolio choices of households are modelled according to the Tobinesque principle. Using net financial stocks, instead of gross ones, can severely affect the relationship between return rates on assets and portfolio adjustments.
8. Since there is no available information about 'who pays whom', some simplifying hypotheses about sectoral portfolio compositions are used, based on observation of available data.
9. In practice, all (net) dividends are paid by non-financial firms and received by households, while almost all securities are issued by the government. Interest is paid by government and non-financial firms to banks, households and the rest of the world.
10. Commercial banks and other financial institutions are regarded as an integrated and consolidated sector. This is not a major simplification for the Italian system, as the financial sector is dominated by a few banks.

5. Along with the absence of the 'representative agent' type of microfoundations, this is the most remarkable difference with a DSGE model. The point is that the multiplicity of possible macroeconomic equilibria is at odds with the use of a harmonic oscillator mechanism.
6. Clearly, a more accurate model would use a different deflator for each different GDP component. The same goes for financial stock variables.
7. As a result, there is only one production function to be defined.

Table 5 Key to symbols

Symbol	Description	Type
Household sector		
ANN_H	Household net (received) annuities	En
ANN_H	Household net (received) other property income	En
c_0	Autonomous or shock component of household consumption	X
c_1	Marginal propensity to consume out of income	X
c_2	Marginal propensity to consume out of wealth	X
c_3	Parameter defining smoothing or inertial component of household consumption	X
C_H	Household total consumption	En
CG_H	Total capital gains recorded by households	En
CG_H^{RES}	Capital gains recorded by households on other financial assets	En
GDP_H	Household GDP	En
$NFUNDS_H$	Adjustment in household funds	En
NL_H	Household net lending	En
T_H	Household net (received) transfers	En
WB	Household net received wages	En
YD	Household disposable income	En
$\alpha_{H,FU}$	Adjustment in household funds to disposable income ratio	X*
$\alpha_{H,P}$	Other property income received by households as a % of wages	X*
$\alpha_{H,T}$	Transfers received by households as a % of wages	X*
β_H	Household-GDP-to-total-GDP ratio	X*
η_i	Parameters in housing investment function $(i = 1, 2, ..., 5)$	X
θ_H	Taxes paid by households as a % of wages	X*
$\iota_{1,j}^H$	Parameters in received interest function $(j = 0, 1, ..., 7)$	
$\iota_{2,j}^H$	Parameters in interest payment function $(j = 0, 1, ..., 7)$	X
$\lambda_{i,j}^H$	Parameters in household portfolio equations $(i = 1, 2, 3, 4$ and $j = 0, 1, 2, 3)$	
σ_H^1	Housing depreciation rate	X
σ_H^2	% of household non-housing investment	X
σ_H^{CG}	Percentage of capital gains realised by households on other financial assets	X*
τ_H	Taxes paid by households	En
υ_i	Parameters in return rate on equity and shares function $(i = 1, 2)$	X
ϕ_i	Parameters in loans-to-households function $(i = 1, 2, 3)$	X
ω_H	Wage share to GDP	X*
ω_S	Share of wages paid by NPISH to total wages	X*
Non-financial corporations		
c_{INT}	Intermediate consumption as a share of total output	X*
CG_F	Capital gains recorded by NFCs	En
$CONS_{INT}$	Intermediate consumption	En
GDP	Total gross domestic product	En
GDP_F	GDP attributed to NFCs	En

Symbol	Description	Type
g_K	Growth rate of capital stock	En
g_n	Potential output growth rate	En
g_{PROD}	Labour productivity growth rate	En
INV	Total investment	En
N	Number of labour units (employment)	En
$NFUNDS_F$	Adjustment in NFC funds	En
NL_F	NFC net lending	En
NPL	% non-performing loans	En
$PROD_L$	Product per unit of labour	En
$PROP_F$	Other property income received by NFCs	En
s_F	NFC profit retention rate	X*
T_F	Transfers received by NFCs	En
WB_{OTHER}	Wage paid by non-productive sectors	En
Y	Total output	En
Y_{AD}	Aggregate demand	En
YD_F	NFC disposable income	En
Y_n	Potential output	En
Y_n^K	Potential output as a function of capital only	En
Y_n^L	Potential output as a function of labour only	En
$\alpha_{F,FU}$	NFC change in funds-to-profit ratio	X*
$\alpha_{F,O}$	NFC other property income-to-profit ratio	X*
β_F	NFC GDP share-to-total-GDP ratio	X*
γ_R	Sensitivity of growth rate to interest rate on loans	X
γ_U	Sensitivity of growth rate to utilisation rate	X
γ_Y	Autonomous component of capital growth rate	X
γ_Z	Sensitivity of growth rate to free-risk interest rate	X
γ_Π	Sensitivity of growth rate to profit rate	X
δ_F	% of investment attributed to NFCs (to total investment)	X*
δ_K	Depreciation rate of capital stock	X*
η_F	Extra-growth of NFC deposits compared with GDP	X*
θ_F	NFC tax rate	X*
μ_i	Parameters in import function ($i = 1, 2, 3$)	X
μ_i^K	Parameters in capital deflator ($i = 1, 2, 3, 4$)	X
μ_i^Y	Parameters in output price level ($i = 1, 2, 3, 4$)	X
$\nu_{H,F}$	NFC produced NFA as a % of net wealth	X*
ξ_B	% of non-performing bank loans	X*
ξ_F	% of NPBL turning into NFC loans write-offs	X
Π_F	NFC profit	En
Π_{FU}	NFC retained profit	En
ρ_i	Parameters in labour productivity growth rate function ($i = 1, 2, 3, 4$)	X
σ_{CG}^F	Capital gains realised by NFCs a % of net wealth	X*
τ_F	Taxes paid by NFCs	En
τ_P^{NET}	Total taxes on products net of subsidies	En
υ_i^K	Capital parameters in potential output function ($i = 0, 1, 2$)	X
υ_i^L	Labour parameters in potential output function ($i = 0, 1, 2$)	X

(continues overleaf)

Table 5 (continued)

Symbol	Description	Type
ψ	% of investment funded by new shares	X*
ω_L	Labour income share to total income	X*
ω_O	Other-wages-to-total-wages ratio	X*
Ω	Non-labour income share to total income	En
Government sector		
CG_G	Capital gains recorded by government	En
$CONS_G$	Government spending: final consumption	En
DEG^G	Government debt-to-GDP ratio	En
DEF^G	Government deficit-to-GDP ratio	En
GDP_G	GDP attributed to government sector	En
GOV_{REV}	Government revenues	En
GOV_{SP}	Government spending	En
INV_G	Government investment	En
NL_G	Government net lending	En
$NFUNDS_G$	Government change in funds	En
$PROP_G$	Government other property income	En
T_{TOT}	Total transfers	En
WB_G	Wages paid by government	En
α_G^C	Government consumption as a % to GDP	X*
α_G^{FU}	Government change in funds as a % to GDP	X*
α_G^P	Government other property income as a % to GDP	X*
α_G^V	Government equity and shares holdings as a % to GDP	X*
β_G	Government GDP to total GDP ratio	X*
ζ_G	Shock to government spending	X
η_D^G	Deposits from/to government as a % of net wealth	X*
η_L^G	Loans from/to government as a % of net wealth	X*
θ_{TOT}	TTPNS as a % of total output	X*
σ_{CG}^G	Capital gains realised by government a % of net wealth	X*
τ_{TOT}	Total tax revenue	En
τ_{TOT}^{NET}	Total taxes on products net of subsidies (TTPNS)	En
ω_G	Government wages as a % to GDP	X*
Banks and financial intermediaries		
CG_B	Capital gains recorded by financial sector	En
GDP_B	GDP attributed to financial sector	En
INV_B	Productive investment attributed to financial sector	En
$NFUNDS_B$	Financial sector change in funds	En
NL_B	Financial sector net lending	En
$PROP_B$	Financial sector other property income	En
s_B	Financial sector profit retention rate	X*
T_B	Transfers received by financial sector	En
WB_B	Wages paid by financial sector	En
α_B^{FU}	Financial sector change in funds as a % of profit	X*
α_B^{INV}	Financial sector investment to total investment	X*

Symbol	Description	Type
α_B^P	Financial sector property income as a % of profit	X*
α_B^T	Financial sector transfers as a % of profit	X*
β_B	Financial-sector-GDP-to-total-GDP ratio	En
θ_B	Tax rate on financial sector profit	X*
$\lambda_{i,j}^B$	Parameters in financial sector portfolio equations ($i = 1, 2$ and $j = 0, 1, 2, 3$)	X
$\nu_{H,B}$	Financial sector produced NFA as a % of net wealth	X*
Π_B	Financial sector profit	En
σ_{CG}^B	Capital gains realised by financial sector as a % of net wealth	X*
τ_B	Taxes paid by financial sector	En
ω_B	Financial sector wages as a % of GDP	X*
Foreign sector		
EXP	Export value	En
GDP_{RoW}	Residual GDP attributed to foreign sector	En
IMP	Import value	En
NL_{RoW}	Foreign sector net lending	En
T_{RoW}	Transfers attributed to foreign sector	En
α_{RoW}^T	Transfers attributed to foreign sector as a % of GDP	En
θ_{RoW}	Taxes attributed to foreign sector as a % of GDP	En
μ_i	Parameters in import function ($i = 1, 2, 3$)	X
μ_i^X	Parameters in export function ($i = 1, 2, \ldots, 4$)	X
τ_{RoW}	Taxes attributed to foreign sector	En
Φ_D^i	Parameters in foreign sector deposits function ($i = 1, 2, \ldots, 6$)	X
Φ_L^i	Parameters in foreign sector loans function ($i = 1, 2, \ldots, 6$)	X
Φ_{RoW}^i	Parameters in foreign sector securities function	
Assets and liabilities		
B_B	Stock of securities held by financial sector	En
B_F	Net stock of securities issued by NFCs	En
$B_{F,B}$	Stock of NFC securities held by financial sector	En
$B_{F,H}$	Stock of NFC securities held by households	En
$B_{F,RoW}$	Stock of NFC securities held by foreign sector	En
b_G	Real supply of government bonds	En
B_G	Total (demanded) stock of government bonds	En
$B_{G,B}$	Stock of government bonds held by financial sector	En
$B_{G,F}$	Stock of government bonds held by NFCs	En
$B_{G,H}$	Stock of government bonds held by households	En
$B_{G,RoW}$	Stock of government bonds held by foreign sector	En
B_H	Stock of securities held by households	En
B_{RoW}	Stock of securities held by foreign sector	En
BOT	Nominal supply of government bills (BOT)	En
D_B	Total stock of bank deposits	En
D_F	Stock of deposits and cash held by NFCs	En
D_H	Stock of deposits and cash held by households	En
D_G	Net stock of deposits and cash held by government	En

(continues overleaf)

Table 5 (continued)

Symbol	Description	Type
D_{RoW}	Net stock of deposits and cash held by foreign sector	En
$HOUSE_B$	Financial sector produced non-financial assets	En
$HOUSE_F$	NFC produced non-financial assets	En
$HOUSE_H$	Housing stock (dwellings)	En
K	Total stock of capital	En
L_B	Total stock of bank loans	En
L_F	Bank loans obtained by NFCs	En
L_H	Bank loans (mortgages) to households	En
L_G	Net loans to/from government	En
L_{RoW}	Net loans to/from foreign sector	En
NFW_B	Financial sector net financial wealth	En
NFW_F	NFC net financial wealth	En
NFW_H	Household net financial wealth	En
NW_B	Financial sector net wealth (or worth)	En
NW_F	NFC net wealth (or worth)	En
NW_H	Household net wealth (or worth)	En
NW_G	Government net wealth (or worth)	En
$OFIN_B$	Net stock of other financial assets held by financial sector	En
$OFIN_F$	Net stock of other financial assets held by NFCs	En
$OFIN_H$	Net stock of other financial assets held by households	En
$OFIN_G$	Net stock of other financial assets held by government	En
v_F	Real volume of NFC equity to fund investment	En
V_B	Net total equity and shares issued/held by financial sector	En
V_B^{PUR}	Gross equity and shares purchased by financial sector	En
V_B^{ISS}	Gross equity and shares issued by financial sector	En
$V_{B,G}$	Financial sector equity and shares held by households	En
$V_{B,H}$	Financial sector equity and shares held by government	En
V_F	Total equity and shares issued by NFCs	En
$V_{F,B}$	NFC equity held by financial sector	En
$V_{F,G}$	NFC equity held by government	En
$V_{F,H}$	NFC equity held by households	En
V_H	Stock of equity and shares held by households	En
V_G	Stock of equity and shares held by government	En
V_{RoW}	Net stock of equity and shares issued by foreign sector	En
V_{RoW}^{PUR}	Gross stock of equity and shares purchased by foreign sector	En
$V_{RoW,B}$	Foreign sector equity and shares held by financial sector	En
$V_{RoW,G}$	Foreign sector equity and shares held by households	En
$V_{RoW,H}$	Foreign sector equity and shares held by government	En
V_{TOT}	Total stock of equity and shares	En
Dividends and interest payments		
DIV_B	Net dividends received by financial sector	En
DIV_B^{PAID}	Gross dividends paid by financial sector	En
DIV_B^{RECV}	Gross dividends received by financial sector	En
$DIV_{B,G}$	Financial sector dividends paid to government	En

Symbol	Description	Type
$DIV_{B,H}$	Financial sector dividends paid to households	En
$DIV_{B,RoW}$	Financial sector dividends paid to foreign sector	En
DIV_F	Net dividends paid by NFC	En
$DIV_{F,B}$	NFC dividends paid to financial sector	En
$DIV_{F,G}$	NFC dividends paid to government	En
$DIV_{F,H}$	NFC dividends paid to households	En
GDP_F	GDP attributed to NFCs	En
$DIV_{F,RoW}$	NFC dividends paid to foreign sector	En
DIV_G	Net dividends received by government	En
DIV_H	Household net (received) dividends	En
DIV_{RoW}^{PAID}	Gross dividends paid by foreign sector	En
DIV_{RoW}^{RECV}	Gross dividends paid by foreign sector	En
$DIV_{RoW,B}$	Foreign sector dividends paid to financial sector	En
$DIV_{RoW,G}$	Foreign sector dividends paid to government	En
$DIV_{RoW,H}$	Foreign sector dividends paid to households	En
DIV_{TOT}	Total dividends paid in the economy	En
INT_B	Net interest received by financial sector	En
INT_B^{RES}	Residual component in financial sector interest payments	X*
INT_F	Net interest payments made by NFCs	En
$INT_{F,B}$	Interest paid by NFCs to financial sector	En
$INT_{F,H}$	Interest paid by NFCs to households	En
$INT_{F,RoW}$	Interest paid by NFCs to foreign sector	En
INT_F^{RES}	Residual interest payments attributed to NFCs	En
INT_G	Net interest payments made by government	En
$INT_{G,B}$	Interest paid by government to financial sector	En
$INT_{G,H}$	Interest paid by government to households	En
$INT_{G,RoW}$	Interest paid by government to foreign sector	En
INT_G^{RES}	Residual component in interest payments made by government	X*
INT_H	Household net (received) interest	En
INT_H^{PAID}	Interest payments made by households	En
INT_H^{RECV}	Interest income received by households	En
INT_{RoW}	Foreign sector net interest income	En
Cross-sector payment coefficients		
ϵ_B	% of accounting dividends received by financial sector	X*
ϵ_G	% of accounting dividends received by government	X*
ϵ_{RoW}	% of accounting dividends received by foreign sector	X*
ι_F	% of NFC interest payments to total interest payments	X*
δ_B^{DIV}	% of total dividends paid by financial sector	X*
δ_F^{DIV}	% of total dividends paid by NFCs	X*
δ_{RoW}^{DIV}	% of total dividends paid by foreign sector	X*
ρ_F	% of NFC securities to total securities	X*
ρ_{GF}	% of government bonds held by NFCs	X*

(continues overleaf)

Table 5 (continued)

Symbol	Description	Type
χ_B	% of financial sector equity to total equity	X*
χ_F	% of NFC equity to total equity	X*
Central-bank stance and interest rates		
NER	Nominal exchange rate	X
r_{BA}	Average return rate on (government) securities	X
r_D	Interest rate on bank deposits	X
r_{ECB}	Policy rate set by the ECB	X
r_H	Return rate on other property income	En
$r_{L,F}$	Interest rate on bank loans to NFCs	En
GDP_F	GDP attributed to NFCs	En
r_V	Return rate on equity and shares (excluding dividends)	En
r_Z	Risk-free interest rate (ten-year German bonds)	X
$SPREAD_A$	Spread between Italian and German bond yields	X*
μ_A	Mark-up of Italian bond rate over German bond rate	En
Prices		
p_B	Unit price of government bonds	En
p_H	Unit price of housing	En
p_K	Capital deflator	En
p_V	Equity and shares price index	En
p_Y	Output price level (GDP deflator)	En

Notes: En = endogenous variable; X = exogenous variable or parameter; * = calculated as a moving average.
Source: This table can be found at http://models.sfc-models.net/.

3.1.2 Household sector

As is well known, Italian households were marked by an exceptional saving rate up until the early 1990s. However, a plurality of economic, institutional and political factors (including several reforms of the labour market and the pension system, the coming into force of the Maastricht Treaty, the launch of the euro, two major financial crises, and the beginning of the 'austerity' era) have significantly affected the financial situation of the household sector ever since. Italian households still exhibit a high saving rate compared to other industrialised or developed countries, but the gap has been narrowing over time. This has gone along with symmetrical changes in other sectoral financial balances.

In formal terms, household disposable income is made up of household gross domestic product (meaning gross output *minus* intermediate consumption) *plus* wages *minus* taxes (on income, wealth, imports and production) *plus* net interest entries *plus* total transfers (including narrowly defined transfers, subsidies and benefits) *plus* annuities (including dividends and other property incomes):

$$YD = GDP_H + WB - \tau_H + INT_H + T_H + ANN_H. \tag{1}$$

Notice that the household sector is here defined in broad terms, as it includes non-profit institutions serving households (NPISH), in addition to small productive units or household unincorporated market enterprises (HUME) recorded by the SNA. This is the reason the disposable income equation includes a (sectoral) GDP component. The latter is assumed to be produced materially by non-financial firms on behalf of NPISH and HUME.

As mentioned, household GDP is taken as a share of total product:

$$GDP_H = \beta_H \cdot GDP. \tag{2}$$

Similarly, net wages are defined as a share of total GDP:

$$WB = \omega_T \cdot GDP. \tag{3}$$

For the sake of simplicity, total taxes paid by households are defined as a share of (past) wages:

$$\tau_H = \theta_H \cdot WB_{-1}. \tag{4}$$

Notice that this is a simplification, as financial incomes perceived by households should be also included in their total taxable income.

Total transfers to households are also defined as a share of wages.[8] The net interest received by households equals interest revenues net of interest payments:

$$INT_H = INT_H^{RECV} - INT_H^{PAID}. \tag{5}$$

The total interest received by households is defined as a linear function of interest earned on bank deposits, incomes from bonds, and other financial instruments. Similarly, the total interest paid by households is the summation of interest payments on mortgages and other payments on loans.[9]

In the SFC literature, household consumption is usually defined as a function of (expected) disposable income and wealth. An autonomous (or shock) component and a smoothing (or inertial) one have also been considered here, so that:

$$C_H = c_0 + c_1 \cdot E(YD) + c_2 \cdot NW_{H,-1} + c_3 \cdot C_{H,-1}, \tag{6}$$

where YD is household disposable income, $E(\cdot)$ stands for 'expected value', and NW_H is households' net wealth. As usual, c_1 and c_2 are the propensities to consume out of income and wealth, respectively, whereas c_0 and c_3 account for stochastic shocks and inertial consumption habits, respectively.[10] Capital gains (or losses) are not included explicitly, but they affect consumption through households' net wealth.

Notice that adaptive expectations are assumed, meaning that $E(x) = x_{-1} + \upsilon \cdot [E(x_{-1}) - x_{-1}]$, with $0 \leq \upsilon \leq 1$. Accordingly, expected household disposable income is:

$$E(YD) = YD_{-1} + \upsilon \cdot [E(YD_{-1}) - YD_{-1}].$$

8. This is another simplification that should be addressed in a more accurate version of the model, as some transfers are discretionary and can hardly be linked with wages.
9. See appendix B, section I, at http://models.sfc-models.net/, for the specific form of household equations. Notice that, since the interest rate on bank deposits is null, the related interest payment has been dropped from INT_H^{RECV}.
10. For the sake of simplicity, the impact of social or class status on propensity to consume is assumed away. Notice that a simple way to account (partially) for it would be to split net wealth into its own components and allow for different consumption coefficients, because portfolio compositions are likely to be quite diverse across different groups of population.

Net wealth in the current period is the net stock of wealth in the previous period *plus* current saving (that is, the portion of disposable income that is not spent for consumption and/or housing investment) *plus* change in funds *plus* wealth revaluation:

$$NW_H = NW_{H,-1} + YD_H - CONS_H - INV_H + NFUNDS_H + CG_H, \qquad (7)$$

where CG_H is the amount of capital gains (or losses) recorded by households, due to the revaluation of their dwellings, bonds, and equity and shares holdings. Capital gains, in turn, can be calculated by accounting for the effect of the change in unit prices of assets on the current value of their stocks. In the case of households, it is:

$$CG_H = \Delta p_H \cdot \frac{HOUSE_{H,-1}}{p_{H,-1}} + \Delta p_B \cdot \frac{B_{H,-1}}{p_{B,-1}} + \Delta p_V \cdot \frac{V_{H,-1}}{p_{V,-1}} + CG_H^{RES}, \qquad (8)$$

where $HOUSE_H, B_H$ and V_H are the stocks of dwellings, government bonds and shares held by households, respectively, while p_H, p_B and p_H are the related unit prices. Finally CG_H^{RES} is an additional component capturing revaluation effects on other financial assets. It is defined using the average value of $\sigma_{CG}^H = CG_H^{RES}/CG_H$ over the period considered.[11]

Households' financial assets holdings can be calculated by subtracting non-financial assets from their net wealth and adding net (received) loans:

$$NFW_H = NW_H - HOUSE_H + L_H. \qquad (9)$$

Household non-financial assets holdings, meaning dwellings, equal past period housing stock (net of depreciation) plus new housing investment:

$$HOUSE_H = (1 - \delta_H^1) \cdot HOUSE_{H,-1} + (1 - \delta_H^2) \cdot INV_H, \qquad (10)$$

where δ_H^1 is the depreciation rate of housing capital, INV_H is the total investment undertaken by households, and δ_H^2 is the (small) share of household investment not devoted to housing.

Portfolio allocation by households is modelled based on Brainard/Tobin (1968) and Godley/Lavoie (2007). For the sake of simplicity, it is assumed that all shares are marked by the same average return rate. Total net equity and shares (stock) held by households is:

$$V_H = \lambda_{1,0}^H \cdot E(NFW_H) + \lambda_{1,1}^H \cdot E(NFW_H) \cdot E(r_V) + \lambda_{1,2}^H \cdot E(YD_H) + \\ + \lambda_{1,3}^H \cdot E(NFW_H) \cdot E(r_{BA}),$$

where $\lambda_{1,j}^H$ coefficients (with $j = 0, 1, 2, 3$) define the proportion of net financial wealth that households wish to hold in the form of equity and shares, based on their expected return rate, securities' interest rates and liquidity needs.[12] Notice that r_V is the (average) return rate on equity and shares, and r_{BA} is the (average) return rate on securities. The

11. See appendix B, section I, at http://models.sfc-models.net/. By contrast, capital gains and losses recorded by other sectors are here simply defined as percentages of the total stock of assets held at time $t-1$, that is: $CG_j = \sigma_{CG}^j \cdot NW_{j,-1}$, where subscript $j = F, B, G$ defines the sector (non-financial firms, financial institutions and government, respectively) and each σ_{CG}^j is calculated as a moving average.

12. It is assumed that bank deposits bear no interest rate. Consequently, deposits (and cash) are mainly demanded for transaction (and hoarding) motives, 'proxied' by households' disposable income level.

latter is defined by equation (44), whereas the former can be calculated as a function of the market price of shares:

$$r_V = v_1 \cdot r_{V,-1} + v_2 \cdot \frac{\Delta p_V}{p_{V,-1}}.$$

The equation above states that the return rate on Italian equity and shares grows as their market value grows, where the causality runs from price to return rate. For the sake of simplicity, dividend payments have been assumed away. However expected dividends influence the return rate through changes in the unit price. The real volume of equity and shares, and their price, are defined by equations (38) and (39), respectively, and are further discussed below. Notice that, while this formulation is used to simulate future scenarios, r_v was taken as an exogenous variable when the model was run on historical values.

Rearranging the V_H equation, household portfolio decisions about equity and shares can be expressed by the ratio below:

$$\frac{V_H}{E(NFW_H)} = \lambda^H_{1,0} + \lambda^H_{1,1} \cdot E(r_V) + \lambda^H_{1,2} \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda^H_{1,3} \cdot E(r_{BA}). \qquad (11)$$

Similarly, the ratio of household demand for securities to net financial wealth is:

$$\frac{B_H}{E(NFW_H)} = \lambda^H_{2,0} + \lambda^H_{2,1} \cdot E(r_V) + \lambda^H_{2,2} \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda^H_{2,3} \cdot E(r_{BA}), \qquad (12)$$

where $\lambda^H_{2,j}$ parameters define households' target or desired bonds' holdings.[13]

Bank deposits and cash held by households are:

$$\frac{D_H}{E(NFW_H)} = \lambda^H_{3,0} + \lambda^H_{3,1} \cdot E(r_V) + \lambda^H_{3,2} \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda^H_{3,3} \cdot E(r_{BA}), \qquad (13)$$

where the $\lambda^H_{3,j}$ parameters embody households' preference for liquidity.

Table 4 shows that households hold other financial assets in addition to shares, securities and deposits. For the sake of simplicity, these assets are assumed to bear no interest rate. Their value can be defined using the well-known adding-up constraints (Godley/Lavoie 2007):

$$\frac{OFIN_H}{E(NFW_H)} = \lambda^H_{4,0} + \lambda^H_{4,1} \cdot E(r_V) + \lambda^H_{4,2} \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda^H_{4,3} \cdot E(r_{BA}),$$

where: $\lambda^H_{4,0} = 1 - (\lambda^H_{1,0} + \lambda^H_{2,0} + \lambda^H_{3,0})$ and $\lambda^H_{4,j} = -(\lambda^H_{1,j} + \lambda^H_{2,j} + \lambda^H_{3,j})$, for $j = 1, 2, 3$.

Alternatively, $OFIN_H$ can be directly defined as the remaining portion of net financial wealth, once deposits, equity and shares, and securities are deducted:

$$OFIN_H = NFW_H - D_H - V_H - B_H. \qquad (14)$$

Turning to liabilities, new loans (mortgages) to households are modelled as a function of household disposable income, their own stock of dwellings, and housing investment:

$$L_H = L_{H,-1} + \phi_1 \cdot YD_{-1} + \phi_2 \cdot HOUSE_{H,-1} + \phi_3 \cdot INV_{H,-1}. \qquad (15)$$

13. Notice that portfolio equations should be specified in terms of gross wealth rather than net wealth, because the latter may well be negative. For the sake of simplicity, this possible issue is ignored hereafter.

Investment is undertaken by households mainly for housing purposes. So, it can be defined as a function of several variables, including past housing investment, household mortgages, the stock of dwellings, household disposable income, and the expected growth rate in property income:

$$INV_H = \vartheta_1 \cdot INV_{H,-1} + \vartheta_2 \cdot L_{H,-1} + \vartheta_3 \cdot HOUSE_{H,-1} + \\ + \vartheta_4 \cdot YD_{H,-1} + \vartheta_5 \cdot E(r_H), \tag{16}$$

where the property income growth rate is simply defined as:

$$r_H = \frac{\Delta PROP_H}{PROP_{H,-1}}. \tag{17}$$

Some additional hints on the housing market are given in Appendix 1.

Net borrowing by households can be defined as households' consumption and investment spending in excess of disposable income and net changes in funds. Conversely, *net lending by households* is:

$$NL_H = YD + NFUNDS_H - CONS_H - INV_H. \tag{18}$$

As mentioned, $NFUNDS_H$ is a quite heterogeneous entry including adjustment in pension funds, capital transfers and non-produced non-financial products (see Table 3). For the sake of simplicity, it is regarded as a linear function of (lagged) disposable income.

3.1.3 Non-financial corporations

Despite facing a long-standing crisis since the mid 1990s or even earlier,[14] Italy remains the second biggest manufacturing economy in the European Union. Around a quarter of Italian GDP is still attributed to (manufacturing) industry.

Eurostat defines GDP as gross output, Y, *minus* intermediate consumption, $CONS_{INT}$, *plus* taxes on products net of subsidies, τ_P^{NET} (see Table 1). In formulas:

$$GDP = Y - CONS_{INT} + \tau_P^{NET}. \tag{19}$$

As mentioned, it is assumed that non-financial corporations (NFCs) produce all output on behalf of the other sectors. However, the amount of GDP associated with NFCs is just a share of total GDP:

$$GDP_F = \beta_F \cdot GDP, \tag{20}$$

where β_F is a parameter depending on several institutional, political and historical factors.

The total stock of fixed capital grows at a rate g_K:

$$K = K_{-1} \cdot (1 + g_K). \tag{21}$$

Total investment must also cover capital depreciation:

$$INV = K_{-1} \cdot (g_K + \delta_K), \tag{22}$$

where δ_K is the capital depreciation rate.

14. The last three decades have witnessed an apparent stagnation in labour productivity, with Italy losing its central position in the global value chain.

The growth rate of capital is defined as a function of the expected capital utilisation rate (proxied by the output-to-capital ratio), the expected profit rate, the risk-free interest rate, and the cost of financing:[15]

$$g_K = \gamma_Y + \gamma_U \cdot E\left(\frac{Y}{K}\right) + \gamma_\Pi \cdot E\left(\frac{\Pi_F}{K}\right) - \gamma_Z \cdot E(r_Z) - \gamma_R \cdot E(r_{L,F}), \qquad (23)$$

where Π_F is NFC profit net of taxes.[16]

While it is assumed that investment decisions are made by firms, only a portion of them (albeit a big one) must be directly attributed to the NFC sector. For the sake of simplicity, narrowly defined NFC investment (including inventories) is defined as a share of total investment:

$$INV_F = \delta_F \cdot INV, \qquad (24)$$

where δ_F is the ratio of NFC investment to total investment.

Data show that deposits held by Italian non-financial corporations have been growing faster than GDP in recent decades. This is a relatively recent phenomenon and is likely to be linked with the 'financialisation' of the Italian productive sector and the need for liquid assets. Accordingly, deposits held by firms are defined as:

$$D_F = (1 + \eta_F) \cdot D_{F,-1} \cdot \frac{GDP}{GDP_{-1}}, \qquad (25)$$

where η_F allows accounting for the extra growth rate of bank deposits.

Aggregate demand is defined as the summation of household consumption, government spending (consumption), investment, intermediate consumption and export, *minus* import and (net) taxes on products:

$$\begin{aligned} Y_{AD} = {} & CONS_H + CONS_G + INV + CONS_{INT} + \\ & + EXP - IMP - \tau_T^{NET}, \end{aligned} \qquad (26)$$

where τ_T^{NET} stands for total taxes on products net of subsidies (see Table 2).

The market-clearing or equilibrium condition between aggregate supply and aggregate demand is:

$$Y = Y_{AD}. \qquad (27)$$

Looking at the supply side, gross potential output can be defined in real terms through a production function. A Leontief function was chosen for the ESSFC.[17] In formal terms:

$$Y_n = min(Y_n^L, Y_n^K), \qquad (28)$$

15. More precisely, g_K is affected by both the risk-free interest rate and the actual rate on loans. Alternatively, it can be modelled as a function of the risk premium only. Furthermore, the risk-free interest rate can be replaced with the ECB policy rate.
16. Actual values, rather than forecast values, are used when running the model on historical values to create Figure 3.
17. This is another difference compared with Burgess et al. (2016), who assume that production and distribution are implicitly defined through a standard Cobb–Douglas production function.

where Y_n^L and Y_n^K are defined, respectively, as:

$$log(Y_n^L) = \nu_0^L + \nu_1^L \cdot log(N) + \nu_2^L \cdot t$$

and:

$$log(Y_n^K) = \nu_0^K + \nu_1^K \cdot log(K) + \nu_2^K \cdot t,$$

where ν_i^L and ν_i^K are empirically estimated coefficients ($\forall i = 0, 1, 2$). These coefficients have been obtained by regressing against output values during 'normal times' only. Potential output is here defined as the level of output predicted using a Leontief production function and based on 1996–2008 data.

Accordingly, the (real) potential growth rate of the economy is approximately:

$$g_n = d\Big(log(Y_n)\Big).$$

Notice that the potential output does not determine the actual output in ESSFC. The actual production level is assumed to be only defined (constrained) by aggregate demand. However, the potential output is used as a proxy for both demand pressure and social conflict to determine the price level of output (GDP deflator). More precisely, output and capital deflators are set as linear functions of several variables, including an inertial component, the wage share, the nominal exchange rate, the output gap (for output price level, p_Y, only) and the rate of utilisation of plants (for capital deflator, p_K, only).[18]

Actual productivity of labour is also regarded as an endogenous variable of the model. Its growth rate is assumed to depend on growth rates of *autonomous* components of aggregate demand. Data show that the impact of government spending is higher than the impact of private investment and the latter is higher than the impact of the next export. This is likely to be due to the structure of the Italian economy, where government spending is chronically low (after two decades of austerity measures) while exports are traditionally driven by low-tech products. So, the productivity growth rate is defined as:[19]

$$\begin{aligned} g_{PROD} = \rho_1 + \rho_2 \cdot d[log(INV_{F,-1})] + \rho_3 \cdot d[log(EXP_{-1})] + \\ + \rho_4 \cdot d[log(CONS_{G,-1})]. \end{aligned} \tag{29}$$

Consequently, labour productivity is:

$$PROD_L = PROD_{L,-1} \cdot (1 + g_{PROD}), \tag{30}$$

while the employment level can be simply defined as:

$$N = \frac{Y}{PROD}. \tag{31}$$

Similarly to Burgess et al. (2016), import dynamics depends on the change in output and the exchange rate:

$$IMP = IMP_{-1} \cdot exp\left[\mu_1 + \mu_2 \cdot ln\left(\frac{Y}{Y_{-1}}\right) + \mu_3 \cdot (NEF - NER_{-1})\right], \tag{32}$$

18. See appendix B, section II, at http://models.sfc-models.net/.
19. A dummy variable is used to address the structural break in productivity that takes place in 2007.

where NER is the nominal exchange rate (see Subsection 3.1.8) and $exp(x)$ is the exponential function of x, that is, e^x.

Profits of non-financial corporations (net of taxes) are defined residually: corporate GDP *minus* wages paid by NFCs (net of other sectors' wages) *minus* taxes *plus* subsidies *plus* net interest payments *plus* change in funds *plus* other property incomes. In formulas:

$$\begin{aligned}\Pi_F = GDP_F - (WB - WB_{OTHER}) - \tau_F + T_F + \\ + INT_F + NFUNDS_F + PROP_F.\end{aligned} \tag{33}$$

NFCs earn interest on their own bank deposits and government bond holdings, and face negative interest payments on bank loans and security issues. An additional component is also included. So, the net interest income earned by NFCs is defined as:

$$\begin{aligned}INT_F = [r_{D,-1} \cdot D_{F,-1}] - r_{L,F} \cdot L_{F,-1} - r_{BA} \cdot (B_{F,-1} - B_{G,F,-1}) + \\ + INT_F^{RES}.\end{aligned} \tag{34}$$

Notice that the additional or residual component is particularly important when considering interest payments accruing on loans obtained by NFCs, because this interest cannot be accurately calculated just by multiplying loans by interest rates. This is a well-known problem for SFC modellers. The fact is that interest payments are proportional to *gross initial* or *ex ante* received loans, which are demanded by NFCs at the *beginning* of each period, based on their own production plans (Graziani 2003). However, one can only use data on *remaining* or *ex post* received loans, as recorded at the *end* of the same period. As a result, one is unlikely to find a simple linear relationship between the stock of bank loans at a certain period and the related flow of interest payments. Notice also that the value of INT_F^{RES} is expected to be negative, as interest payments made by NFCs normally outstrip interest earnings.[20]

Profits earned by NFCs are not entirely reinvested. Retained profits are:

$$\Pi_{FU} = s_F \cdot \Pi_F, \tag{35}$$

where s_F is the average retention rate of NFCs, defining their own self-funding capacity.

Accordingly, NFC distributed profits (dividends) are:

$$DIV_F = (1 - s_F) \cdot \Pi_F. \tag{36}$$

Taxes paid by NFCs are a fixed percentage of *pre-tax* (past) profits:

$$\begin{aligned}\tau_F = \theta_F \cdot [GDP_{F,-,1} - (WB_{-1} - WB_{OTHER,-1}) - INT_{F,-1} + \\ - NFUNDS_{F,-1} - PROP_{F,-1}].\end{aligned} \tag{37}$$

For the sake of simplicity, changes in funds and additional property incomes are defined as a percentage of current profit. Subsidies and transfers are defined in a similar way. In line with the current literature, it is assumed that firms can issue new equity to fund a small percentage of their investment plans (Burgess et al. 2016). The real volume of equity is:

$$v_F = v_{F,-1} + \psi \cdot \frac{INV_{F,-1}}{p_{V,-1}}, \tag{38}$$

20. However, data show that the value of net interest flows have turned positive in the last few years.

where p_V is the unit market value of NFC equity and shares. This is an average price, which can be simply defined as:

$$p_V = \frac{V_F}{v_F}. \tag{39}$$

Notice that Italy is usually regarded as a traditional or 'bank based' system, for financial markets usually do not occupy centre stage. On the contrary, Italian NFCs rely mainly on bank loans to fund their own production and investment plans. In line with SFC literature, new bank loans obtained by firms are determined in residual terms:

$$\begin{aligned} L_F &= L_{F,-1} + INV_F - \Pi_{FU} - NPL - p_V \cdot \Delta v_F \\ &= L_{F,-1} - NL_F - NPL - p_V \cdot \Delta v_F. \end{aligned} \tag{40}$$

Equation (39) shows that the change in bank loans obtained by NFCs equals their own investment plans *minus* retained profits *minus* loans write-offs *minus* issues of new shares.

The model can now be used to determine the *net lending by NFCs*, which is:

$$NL_F = \Pi_{FU} - INV_F. \tag{41}$$

This is the key sectoral magnitude of ESSFC, as it defines the NFC net financial link with the rest of the economy.

3.1.4 Government sector

Both Eurostat and the ECB liken the concept of government 'surplus' ('deficit') with that of government 'net lending' ('net borrowing'). The latter is defined as 'the last balancing item of the non-financial accounts - namely the balancing item of the capital account'.[21] In formal terms, *net lending by the government* arises from revenues net of spending and interest payments:

$$NL_G = GOV_{REV} - GOV_{SP} - INT_G. \tag{42}$$

Interest payments depend on the average return rate on government securities and the amount of outstanding debt (in the form of securities). An additional or residual component is also included, so that:

$$INT_G = r_{BA,-1} \cdot B_{G,-1} + INT_G^{RES}. \tag{43}$$

The average yield of Italian government securities can be defined by adding a mark-up to the risk-free interest rate (that is, the German ten-year government bond yield):[22]

$$r_{BA} = r_Z \cdot (1 + \mu_A). \tag{44}$$

21. See Eurostat Glossary at http://ec.europa.eu/eurostat/statistics-explained/.
22. Government securities issued by the Italian government include Treasury bills (BOT), zero-coupon certificates (CTZ), floating rate notes (CCT), and bonds with other maturities. The average spread between Italian and German bonds can be defined endogenously as a function of the market price of Italian bonds and other institutional factors. However, it is treated as an exogenous variable by ESSFC.

Government total spending is given by the summation of government consumption, investment, total transfers (including subsidies and benefits) and change in funds:

$$GOV_{SP} = CONS_G + INV_G + T_{TOT} + NFUNDS_G. \tag{45}$$

Government total revenue is given by government GDP (that is, the *cost* of goods and services produced by the government) *minus* wage payments, *plus* total taxes, other property incomes and dividends:

$$GOV_{REV} = GDP_G - WB_G + \tau_{TOT} + PROP_G + DIV_G. \tag{46}$$

For the sake of simplicity, government consumption is defined as a share of total GDP *plus* a discretionary component:

$$CONS_G = \alpha_G^C \cdot GDP + \zeta_G. \tag{47}$$

Other government spending and revenue entries are defined in a similar way.[23] Since the model is quite complex, only stochastic shocks to government equations' coefficients are considered here. However, these simplified equations can be redefined to include all sorts of fiscal policy rules and reaction functions.

The total tax revenue is the summation of taxes paid by (domestic) private and foreign sectors:

$$\tau_{TOT} = \tau_H + \tau_F + \tau_B + \tau_{RoW}. \tag{48}$$

Similarly, the amount of total transfers is the summation of transfers paid by the government to (domestic) private and foreign sectors:

$$T_{TOT} = T_H + T_F + T_B + T_{RoW}. \tag{49}$$

The change in the real supply of government bonds (b_G or BTP) is determined by both government borrowing needs and newly issued Treasury bills (BOT):[24]

$$b_G = b_{G,-1} - \frac{-NL_G}{p_{B,-1}} + \frac{BOT_{-1}}{p_{B,-1}}, \tag{50}$$

where p_B is the (average) unit price of Italian Treasury bonds and BOT is the quantity of Treasury bills issued by the government in the current period.

So, the market price of Italian government bonds is:

$$p_B = \frac{B_G}{b_G}. \tag{51}$$

The supply of Treasury bills is:

$$BOT = p_{B,-1} \cdot \Delta b_G - \left(B_G - B_{G,-1} \cdot \frac{p_B}{p_{B,-1}} \right). \tag{52}$$

23. As usual, the reader is referred to appendix B, section III, at http://models.sfc-models.net/, for the whole set of government equations.
24. For the sake of simplicity, government securities other than Treasury bonds and bills are neglected.

In other words, the Italian government is assumed to issue bills (BOT) to deal with temporary cash imbalances.

Clearly, Italian government net wealth is negative as it reflects the accumulated stock of government debt:

$$NW_G = NW_{G,-1} + NL_G + CG_G. \tag{53}$$

Accordingly, government deficit- and debt-to-GDP ratios are defined, respectively, as:

$$DEF_G = \frac{-NL_G}{GDP}$$

$$DEB_G = \frac{-NW_G}{GDP}.$$

Notice that, while Italy's government debt-to-GDP ratio is one of the highest in the EU, its government deficit-to-GDP ratio has been one of the lowest since the early 1990s. The Italian government has been running primary surpluses ever since (except for 2009). However, the debt-to-GDP ratio has begun to grow again since the US financial crisis. The reaction of the ratios above, following exogenous shocks to government spending, is one of the topics analysed in Subection 4.2.

3.1.5 Banks and other financial institutions

Italy's financial sector is dominated by a few large banks (notably Unicredit and Intesa Sanpaolo). Consequently, commercial banks and non-bank financial institutions can be included in the same sector without loss of realism. As usual, the GDP to be attributed to financial institutions as a whole is defined as a percentage, β_B, of total GDP:

$$GDP_B = \beta_B \cdot GDP. \tag{54}$$

The financial sector's GDP is largely given by the spread between the interest rate that financial institutions receive on financial assets and the one they pay on financial liabilities.[25]

Profits made by financial institutions are calculated as the summation of the financial sector's GDP, net dividends, net interest payments and change in funds, *minus* wages paid and taxes net of transfers:

$$\begin{aligned} \Pi_B = {} & GDP_B - WB_B - \tau_B + T_B + DIV_B \\ & + PROP_B + INT_B + NFUNDS_B. \end{aligned} \tag{55}$$

It is possible to derive the *net lending by financial institutions* by subtracting both net dividends and investment spending from profits:

$$NL_B = \Pi_B - DIV_B - INV_B. \tag{56}$$

Total taxes on financial sector profits are defined as:

$$\tau_B = \theta_B \cdot \Pi_{B,-1}. \tag{57}$$

25. The SNA requires the use of this spread as a measure of services provided by the financial sector to the economy, by acting as an 'intermediary'.

The value of total transfers received by financial institutions is determined in a similar way. Financial sector net earning from lending is defined as net interest paid by households *plus* net interest paid by NFCs *plus* an additional component defined by the percentage $\delta^{RES}_{INT,B}$ and accounting for other interest payments:

$$INT_B = (INT^{PAID}_{H} + INF_F) \cdot (1 + \delta^{RES}_{INT,B}). \tag{58}$$

The accounting consistency of interest payments across sectors is then assured by net interest received by the foreign sector being calculated in residual terms.

Financial sector net wealth is:

$$NW_B = NW_{B,-1} + \Pi_B - INV_B + CG_B. \tag{59}$$

The *net* stock of bank loans is the summation of mortgages to households and loans granted to other domestic sectors, net of foreign loans:

$$L_B = L_H + L_F + L_G - L_{RoW}. \tag{60}$$

Similarly, the stock of bank deposits is:

$$D_B = D_H + D_F + D_G + D_{RoW}. \tag{61}$$

The overall amount of financial assets held by banks and other financial institutions is:

$$NFW_B = NW_B - HOUSE_B, \tag{62}$$

where $HOUSE_B$ is the amount of 'produced non-financial assets' held by financial institutions. It is simply defined as a percentage $(\nu_{H,B})$ of the financial sector's net wealth:

$$HOUSE_B = \nu_{H,B} \cdot NW_B. \tag{63}$$

Apart from loans, Italian banks and financial institutions' financial assets are made up of equity and shares, securities, and other instruments. The ratio of financial institutions' equity and shares holdings to net financial wealth is:

$$\frac{V^{PUR}_B}{E(NFW_B)} = \lambda^B_{1,0} + \lambda^B_{1,1} \cdot E(r_V) + \lambda^B_{1,2} \cdot \Pi_B + \lambda^B_{1,3} \cdot E(r_{BA}). \tag{64}$$

The ratio of financial institutions' securities holdings to net financial wealth is:

$$\frac{B_B}{E(NFW_B)} = \lambda^B_{2,0} + \lambda^B_{2,1} \cdot E(r_V) + \lambda^B_{2,2} \cdot \Pi_B + \lambda^B_{2,3} \cdot E(r_{BA}). \tag{65}$$

The ratio of other net financial assets (or liabilities) held by financial institutions to their net financial wealth is:

$$\frac{OFIN_B}{E(NFW_B)} = \lambda^B_{3,0} + \lambda^B_{3,1} \cdot E(r_V) + \lambda^B_{3,2} \cdot \Pi_B + \lambda^B_{3,3} \cdot E(r_{BA}).$$

In the portfolio equations above, the profit level performs the same function that disposable income performs for the households sector, defining financial institutions' liquidity needs for transactions. Notice that $\lambda^B_{i,j}$ coefficients (for $i = 1, 2$ and $j = 0, 1, 2, 3$) are empirically estimated parameters, whereas $\lambda^B_{3,j}$ coefficients (for $j = 0, 1, 2, 3$) are defined in such a way as to meet the portfolio's adding-up constraints. In other words, $OFIN_B$ is the residual portion of the financial institutions' net financial wealth. As such, it can be also simply defined as:

$$OFIN_B = D_B + V_B - L_B + B_B - NW_B + HOUSE_B. \tag{66}$$

Finally, notice that a 'minimalist' way to model commercial banks' and other financial institutions' behaviour has been chosen here. However, a more refined rendition is possible (see, for instance, Le Heron/Mouakil 2008).

3.1.6 Foreign sector

Most foreign sector accounting identities can be derived from other sectors in a residual fashion. The most significant one is *net lending by the rest of the world*, which must match domestic net borrowing:

$$NL_{RoW} = -(NL_H + NL_F + NL_G + NL_B). \tag{67}$$

The latter is nothing but the flipside of the Italian economy's current account. A positive (negative) value of NL_{RoW} shows a deficit (surplus) of Italy towards the rest of the world.

There are still a few stochastic variables to be defined. Loans to (or from) the rest of the world are modelled as a linear function of many factors, notably past loans, ECB target interest rate, GDP attributed to the rest of the world, (nominal) exchange rate, total trade volume, and Italian trade balance. Domestic deposits held by foreign investors are determined in a similar way. Export is defined as a linear function of changes in labour productivity, import and the exchange rate.[26] Total net securities held by the rest of the world are determined by expected return rates on bonds and other financial assets, and the exchange rate. To sum up, the rest of the world's variables are usually defined in residual terms (except for portfolio decisions, foreign loans and export).[27] This helps assure the accounting consistency of the model.

3.1.7 Cross-sector holdings and payments

To complete the model, cross-sector assets and liabilities holdings and payments must be defined. When no information about 'who pays whom' is available, some simplifying hypotheses can help. Arguably, the easiest way to proceed is to take a look at available data. Suppose that the Italian security market is dominated (as it is) by government issues, so that government bonds account for 90 per cent of total securities. It can be assumed that, while sectoral portfolios are different in terms of asset types' composition (shares, securities, deposits), each sector holds the same proportion of government bonds to total securities (that is, 90 per cent). This is coherent with the hypothesis that securities (be they NFC securities or government bonds) all carry the same average return rate. The same method can be applied to other financial assets.

Another problem might arise from the fact that dividends received by each sector seldom mirror the related equity and shares' holdings. This issue is likely to be due to the high aggregation level and other simplifying assumptions. It is tackled in two

26. The price (or wage) level or the inflation rate can also be added to the export equation to account for price competitiveness. In addition, export strongly depends on income of trading partners. This aspect should be considered in a more advanced version of the model.
27. See appendix B, section V, at http://models.sfc-models.net/.

steps here: (i) total dividends received by each 'recipient' sector i have been corrected to fit empirical evidence ($DIV_i = \epsilon_i \cdot DIV_{TOT} \cdot V_i / V_{TOT}$, where ϵ_i is the correction coefficient); and (ii) each 'issuing' sector j has been assumed to pay the same proportion ($\delta_j = DIV_j / DIV_{TOT}$) of total dividends to every other sector (so that dividends paid by j to i are defined as: $DIV_{j,i} = \delta_j \cdot DIV_i$). Interest payments have been modelled in a similar way.[28]

3.1.8 Central-bank stance and interest rates

Since Italy is a member of the euro area, the key policy interest rate(r_{ECB}) is set autonomously by the ECB. Similarly, the exchange rate (*NER*) is an exogenous variable. It is here defined as the effective nominal exchange rate with 42 trading partners.[29] The risk-free interest rate (r_Z) is the return rate on ten-year German bonds, which is also an exogenous variable for Italy. In principle, the mark-up NFCs are charged by commercial banks ($\mu_{L,F} = r_{L,F} - r_{ECB}$) can be defined endogenously, as a function of the leverage ratio of firms and other variables of the model. However, ESSFC treats it as an exogenous when simulations are run on historical values. For the sake of simplicity, the average yield on securities is also defined by adding an exogenous 'spread' to the ten-year German bonds' yields.[30] As mentioned, the return rate on bank deposits (and cash) is set to zero instead. The model is now complete, meaning that the entries in Tables 3 and 4 have all been defined. The next section deals with parameter value estimation and model calibration.

3.2 Data, estimation and calibration

Once the theoretical model is complete, it is necessary to define the value of parameters and exogenous variables, as well as some initial stocks and lagged variables. The latter are simply set at their own historical value at the beginning of the simulation period. In principle, there are several ways to select unknown coefficients in stochastic equations: (i) model coefficients can be estimated through standard econometric techniques; (ii) coefficients can be calibrated based on data observation; (iii) coefficients can be calibrated based on main findings in the literature; (iv) coefficients can also be fine-tuned to allow the model to match actual data or to create a steady (or stationary) state baseline. While theoretical SFCMs are usually set up through methods (iii) and (iv), ESSFC's coefficients are defined empirically, that is, using methods (i) and (ii). There are a few exceptions, notably the return rate on bank deposits (which is assumed to be null), the percentage of non-performing bank loans that are written off, the percentage of investment funded by new shares, and the weight on past errors in agents' expectations. Their values are displayed by Table 6. All the remaining unknown coefficients have been estimated based on Eurostat data.

More precisely, the data set used covers the period from 1996 to 2016 on an annual basis at the sectoral level. Stock and flow variables are taken at constant prices (millions of national currency at 2010). Prices of output, capital and a number of financial assets are

28. See appendix B, section VI, at http://models.sfc-models.net/, for the complete list of equations.
29. Eurostat provides a variety of exchange-rate indexes. So other options are available.
30. See appendix B, section VII, at http://models.sfc-models.net/.

Table 6 Fine-tuned parameters

Description	Parameter values
Weight on past errors in expectations	$\upsilon = 0.000$
% of NPBLs turning into NFC loans write-offs	$\xi_F = 0.700$
% of investment funded by new shares	$\psi = 0.010$
Interest rate on bank deposits	$r_D = 0.000$
Unit price of shares (starting value)	$p_V = 1.000$
Unit price of T-bonds (starting value)	$p_B = 1.000$

Note: NPBLs = non-performing bank loans.
Source: This table can be found at http://models.sfc-models.net/.

determined endogenously.[31] While a higher frequency (or a longer period) would have allowed for a more accurate estimation, the choice of annual data was due to data availability and uniformity reasons. Unfortunately, this means that the number of available observations, 21, is quite low. The presence of several gaps in pre-1996 data does not allow us to extend the sample further. This can affect estimations, especially when focusing on a single country. However, this problem is going to become less and less relevant as new observations are released by Eurostat.[32] For the sake of simplicity, unknown coefficients of key stochastic equations have been estimated one at time by simple equation ordinary least squares (OLS).[33] As is well known, this approach is not totally reliable, as endogeneity and spurious correlation issues may well arise. A possible way to tackle the first issue is to use instrumental variables or system estimation methods. Cointegration techniques can also be employed to deal with the second issue. However, using OLS estimates allows us to simplify the coding work and make a quick preliminary test of the model's operation. So, it can be regarded as an intermediate step in the development of a more accurate empirical model. Finally, key exogenous ratios in 'supplementary' equations (for example, 'beta' parameters, the ratio of wages paid by NFCs to total wages, the ratio of government securities to total securities, etc.) can be calculated as moving averages. In practice, those ratios are usually taken at their actual values (that is, a one-year average) by ESSFC, to avoid shortening time series.

3.3 Software technicalities

SFCMs can be set up and simulated using a variety of statistical packages (for example, Excel, EViews, R) engineering software (for example, Matlab), and also programming

31. In principle, a proper treatment of price deflators is of fundamental importance, because even small changes in the inflation rate (relative to other countries) can affect the economy. However, this aspect is left for future research.
32. One could wonder whether the launch of the euro should be regarded as a structural break for the member states. It is safe to assume that this was not the case for Italy, because the Italian lira (re) joined the European Exchange Rate Mechanism (ERM) in November 1996. In fact, a soft peg with the Deutsche mark was operating between 1996 and 1998. Italy officially adopted the euro in January 1999.
33. This paper aims to provide insights on how to develop an empirical SFC model. It does not aim to perform an accurate analysis of the Italian economy. So, no detailed description of the statistical inference method used to estimate model parameters is provided here. However, both the EViews model program file and the related work file can be provided upon request.

languages (for example, Python).[34] Since SFCMs are usually medium- to large-scale models, numerical findings, rather than analytical solutions, are usually calculated. This is also the method used to solve ESSFC's system of difference equations. As for the data source, all series have been downloaded by R files through the 'pdfetch' package. Each file has fetched transactions-flow matrices' entries at a sectoral level since 1996. Balance sheets' data are collected by separate files. All R files' sectoral data are then grouped together in a single accounting sheet, using a '.xls' file format (but a '.csv' file can do as well). The latter is then imported by an EViews program that uses the data to: (i) estimate model parameters; (ii) create, calibrate and then run the model using estimated and fine-tuned coefficients; (iii) compare historical series with model forecast values; (iv) adjust in-sample simulations to smooth the transition to out-of-sample forecasts; and (v) create alternative scenarios for relevant series to be compared with the baseline.

The programs' structure is sketched in Figure 2. Appendix C at http://models.sfc-models.net/ shows the basic steps to develop the EViews program file, once data have been collected in the form of an Excel or a .csv file.[35] Appendix D displays the R code used to download times series of stock and flow variables from the Eurostat database. The code provided can easily be amended to download and organise other variables. R can also be used to create snapshots of complete transactions-flow matrices and balance sheets in a certain period.[36] The main advantage of this structure is that it enables resetting the model by using different data sets. Time series can be updated just by rerunning the R files (for instance, following most recent releases from Eurostat or including new variables). In principle, other countries' data can also be employed right away. The model will execute automatically points (i) to (v),

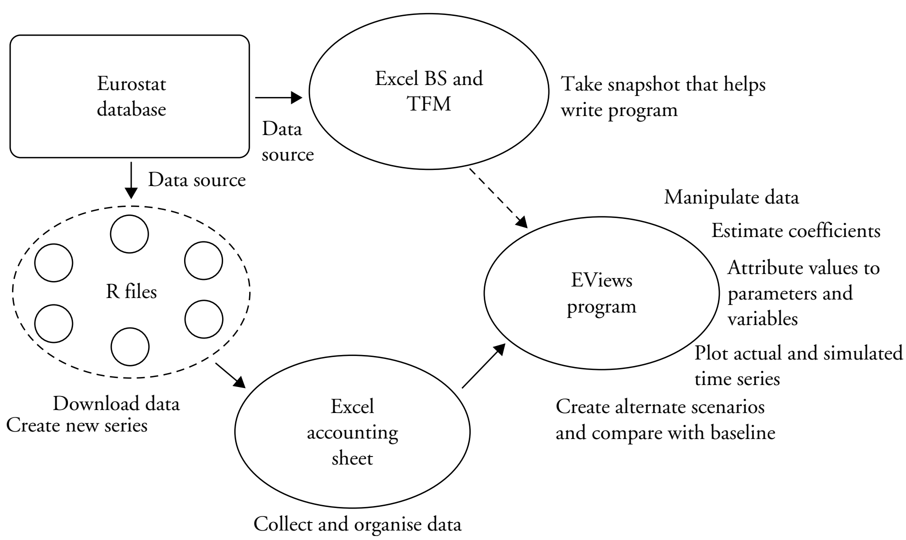


Figure 2 Programs' structure

34. A useful repository for SFCMs' code can be find on the Internet at http://models.sfc-models.net/.
35. As mentioned, the complete EViews program is available upon request.
36. The related code can be provided upon request. However, this step is not necessary to develop the model.

and it will display new solutions. However, it is recommended to check and possibly amend portfolio choices' assumptions and financial sector settings to account for country-specific institutional features. Once the model is set up and run, it allows the user to account explicitly for the impact of stocks on flows and vice versa, highlighting the role of financial agents, assets and cross-sector balances. ESSFC's preliminary simulations are presented in the next section.

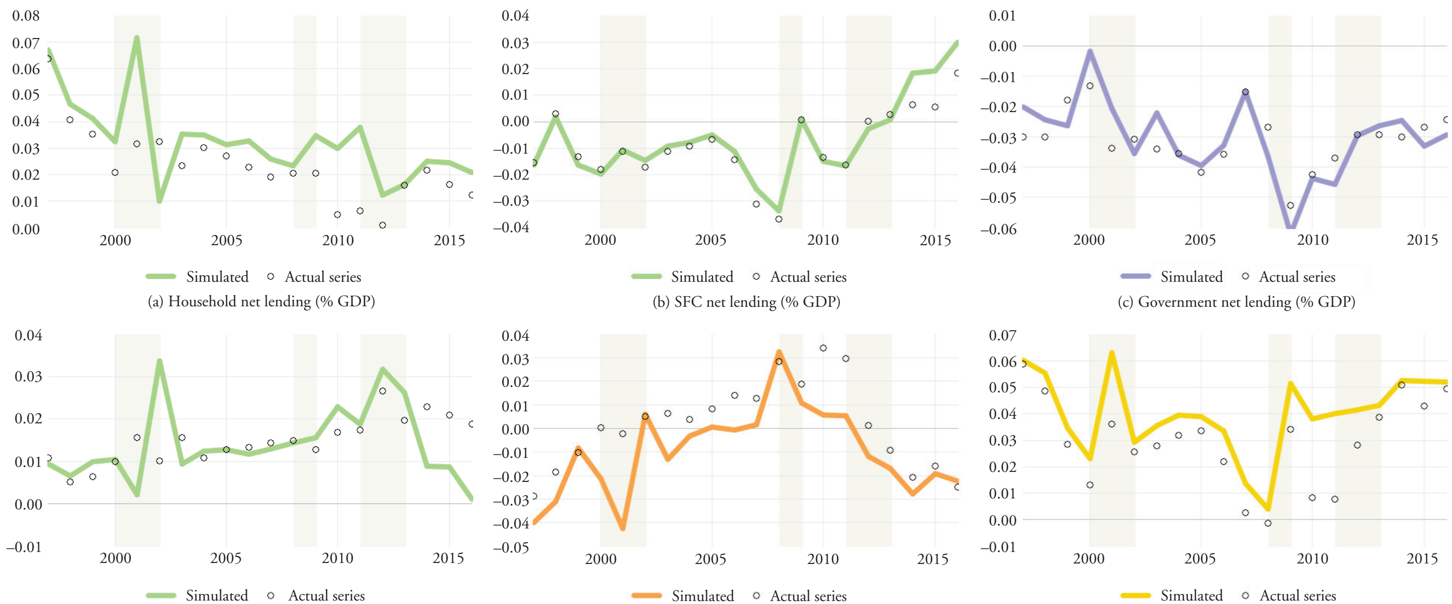
4 RUNNING THE SIMULATIONS

4.1 In-sample and out-of-sample forecasting

While the main goal of ESSFC is to allow the performing of comparative dynamics exercises (that is, testing reactions to shocks under different scenarios) in a financially sophisticated economy, it can also be used to fit past values (in-sample forecast) and predict future values (out-of-sample forecast) of relevant time series. Figure 3 shows the in-sample forecast produced by ESSFC. More precisely, it displays financial balances (net lending ratios) for each Italian macro-sector as a percentage of GDP from 1996 to 2016. Circles are actual series (as recorded by Eurostat), whereas continuous lines show ESSFC forecast or simulated values. Shaded areas highlight the dot-com crisis of 2000–2002, the US financial crisis of 2007–2008 and the European Sovereign Debt Crisis, respectively. Despite the simplified estimation of coefficients, the fit looks accurate enough. As one would expect, each crisis affects negatively the predicting power of the model.[37]

When using a model for out-of-sample forecasts, it is useful to reset endogenous variables of stochastic equations in such a way as to eliminate the residuals.[38] Standard statistical packages usually enable us to adjust forecast results to achieve a perfect fit. For example, EViews allows us to compensate for a poor fit of the (behavioural equations of the) model through the 'Add Factors' function.[39] This function computes the residuals for the in-sample dynamic simulation and adds them to forecast values. As a result, discrepancies from the dynamic simulation over the sample do not affect out-of-sample forecast accuracy. Figure 4 shows financial balances of the Italian economy when model in-sample simulations are corrected to match historical values. Out-of-sample forecast values are displayed after 2016, showing the predicted trend in net lending ratios of Italian sectors. Notice that all model variables are allowed to revert to their model-implied paths starting from the first out-of-sample period (2017). This can lead to a 'jump' or 'break' in the series when model fit is poor. Many mechanisms can be used to smooth the transition from historical data into the forecast period. However, the simplest choice, and arguably the most transparent one, is to try to improve estimations, thus reducing the residuals near the end of the historical (or back) data.

37. This is not a mere static simulation (where values of endogenous variables up to the previous period are used each time the model is solved for the current period). It is a dynamic simulation, because variables' values are 'predicted' based on the *initial estimation* of parameters. However, several key exogenous ratios have been defined using moving averages (or punctual values) for the period considered. This simplification artificially improves the in-sample fit, but may well affect out-of-sample forecasts. To address this issue, key ratios should be modelled as behavioural equations.
38. Residuals are defined as the gap between forecast values generated by the model and observed historical values.
39. See appendix D at http://models.sfc-models.net/ for the details.



(a) Household net lending (% GDP)
(b) SFC net lending (% GDP)
(c) Government net lending (% GDP)
(d) Financial sector net lending (% GDP)
(e) Rest of world net lending (% GDP)
(f) Private sector net lending (% GDP)

Figure 3 Cross-sector financial balances since 1996: in-sample forecast

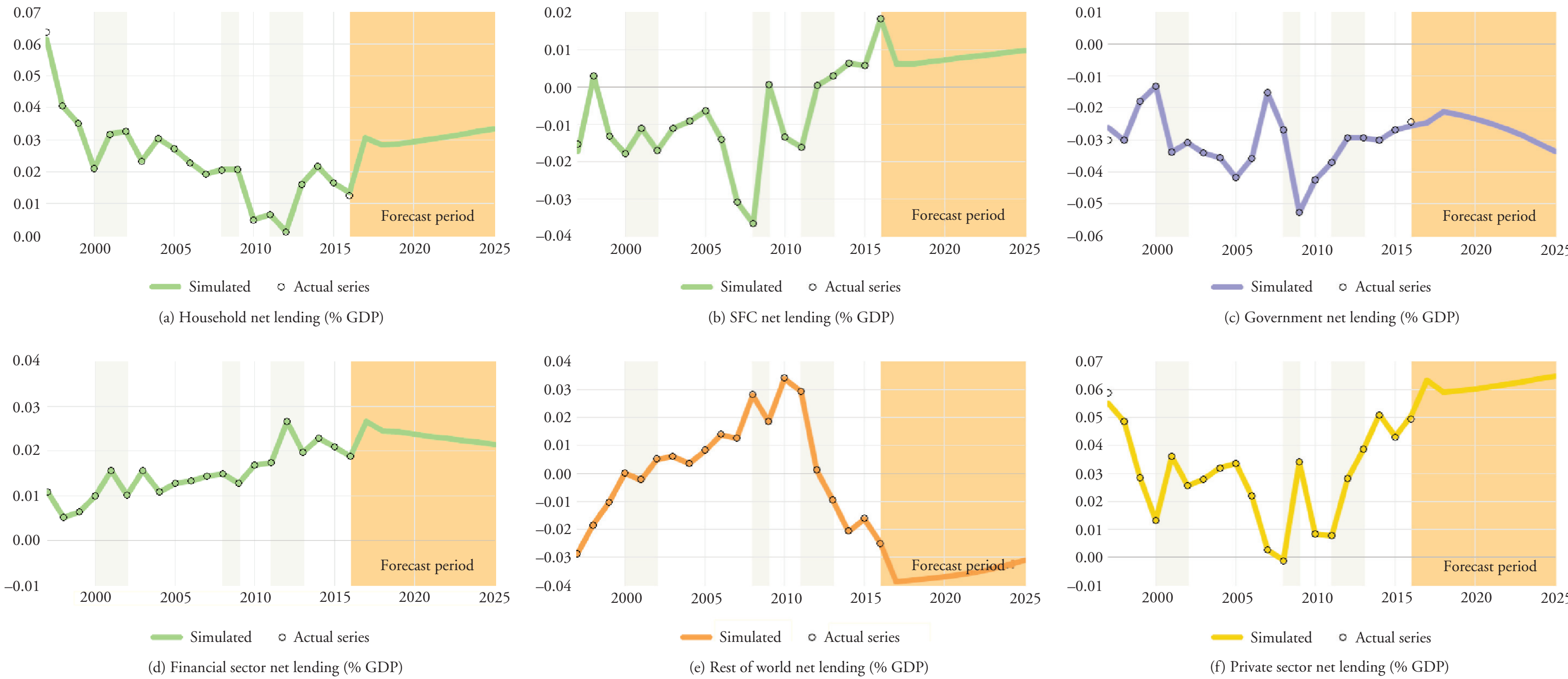


Figure 4 Cross-sector financial balances since 1996: out-of-sample forecast

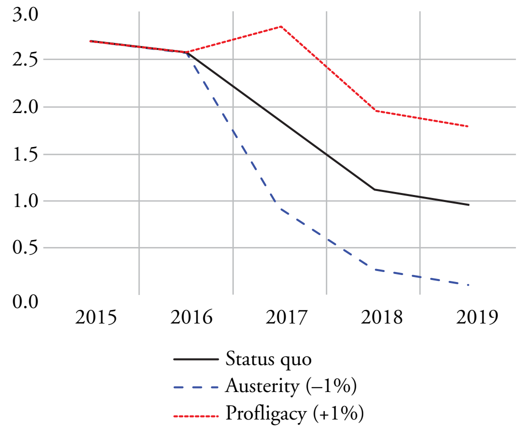
4.2 Creating alternative scenarios

The model is fully set up. It can now be used to create alternative scenarios to be compared with the status quo. In fact, the main goal of ESSFC is to simulate the reaction of endogenous variables to shocks to key parameters. The model's behaviour under the new scenario is then compared with the baseline (that is, the status quo) or alternative scenarios. When shocks are imposed at the last available observation period, the trend displayed by the model with no shock can be used as the baseline. Since the Fiscal Compact and other European treaties require Italian policy-makers to reduce the government debt-to-GDP ratio in the next few years, the impact of a change in government spending was used to test the model. Charts (a) to (d) in Figure 5 contrast government debt and deficit ratios under three alternative scenarios about government consumption: the baseline scenario, where government consumption is assumed to stick to its historical trend (solid line); an 'austerity' scenario, marked by a permanent year-to-year cut in government consumption (–1 per cent of GDP, dashed line); and a 'profligacy' scenario, characterised by an increase in government consumption (+1 per cent of GDP, dotted line). More precisely, charts (a) and (b) show the impact on government annual deficit and stock of debt, respectively, both expressed as percentages of GDP. Charts (c) and (d) display the same variables, but as ratios to the baseline. All in all, while austerity reduces the deficit-to-GDP ratio, it does not reduce the stock-of-debt-to-GDP ratio. On the contrary, the latter increases (compared to the baseline) when government spending is cut. Similarly, a loose fiscal policy increases the deficit, but reduces the debt-to-GDP ratio. The reason is that fiscal policies have a (long-lasting) impact on the denominator, that is, GDP growth. Charts (e), (f) and (g) in Figure 5 show that austerity affects GDP growth both in nominal and real terms.[40] Notice that austerity vs profligacy shocks' effects are perfectly symmetrical. This 'unrealistic' feature of the model is due to its simplified structure. In principle, it can be amended by: (i) introducing asymmetries in behavioural equations and norms; and (ii) using potential output as a ceiling for current output. However, hypothesis (ii) is quite contentious. In fact, it would be questioned by several Keynesian authors. Alternatively, one can assume that output gap impacts on production costs and inflation in a non-linear way. Finally, chart (h) in Figure 5 shows that non-financial corporations (solid line) and households (dashed-and-dotted line) face a reduction in their net lending ratios as government spending reduces. By contrast, banks and other financial institutions (dotted line) slightly benefit from austerity measures. The foreign sector's deficit worsens (dashed line), meaning that net lending by Italy to the rest of the world increases correspondingly. However, the overall impact on the Italian private sector is negative. While these are well-known phenomena in the eyes of non-neoclassical macroeconomics theorists, ESSFC may provide them with a flexible tool giving a new formal, quantitative, guise to the theory.

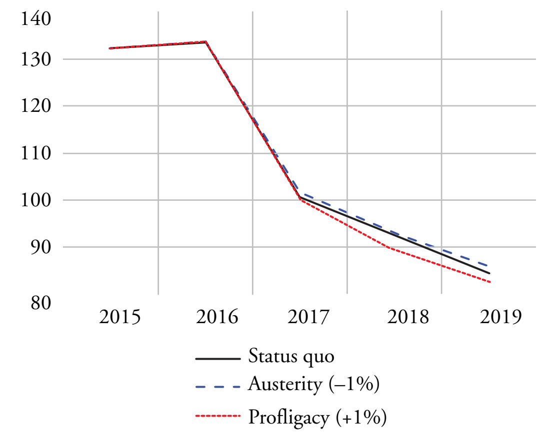
4.3 Limitations and possible developments

The above findings are just preliminary exercises or tests. In no way should they be used to infer conclusions about the Italian economy, let alone for policy purposes. An accurate calibration/estimation of model coefficients and a full specification of hypotheses about

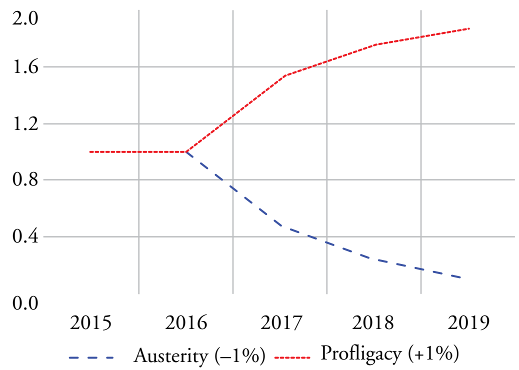
40. Three points are worth stressing here: (i) ESSFC predicts Italy's inflation rate to be very low in the next few years; (ii) forecast inflation seems to be quite insensitive to different policy stances anyway; and (iii) model findings hold even when a less-than-unity value of debt-to-GDP ratio is considered.



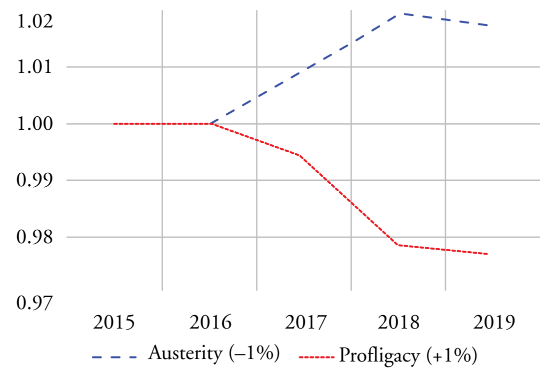
(a) Government deficit (% GDP): alternative scenarios



(b) Government debt (% GDP): alternative scenarios



(c) Government deficit (to baseline): alternative scenarios



(d) Government debt (to baseline): alternative scenarios

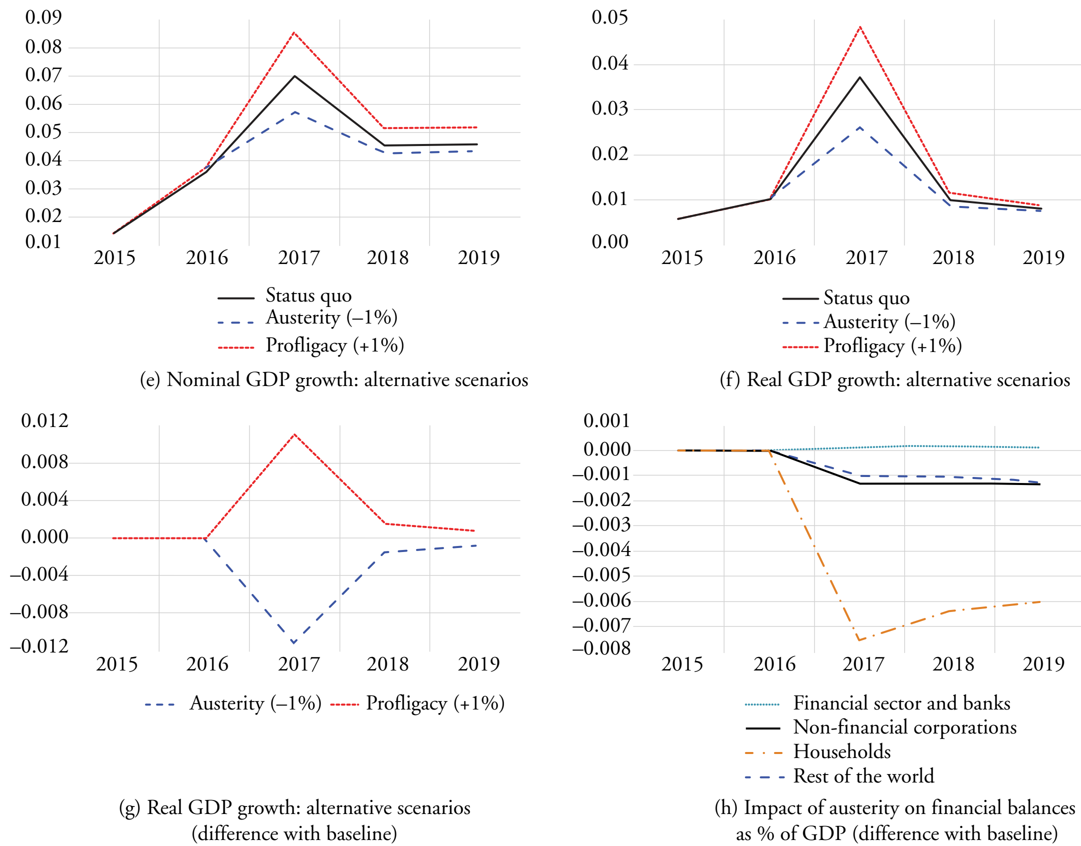


Figure 5 ESSFC reaction following shocks to government spending

exogenous variables' out-of-sample behaviours are necessary to obtain robust findings. Other main limitations of the model can be summarised as follows: (i) annual data can be replaced with quarterly data to increase observations' frequency and improve the predictive power of the model;[41] (ii) cointegration methods (for example, error correction models), instrumental variables and other econometric techniques should be used to improve coefficients' estimation; (iii) net stocks and transactions should be all replaced with gross stocks and transactions; (iv) where possible, the aggregation level of financial assets (liabilities) should be further reduced; and (v) the excessive use of key ratios calculated as 'moving averages' (or 'punctual values') should be avoided, and additional behavioural equations should be used instead. Finally, notice that the model is possibly subject to the well-known Lucas critique when it is used for policy purposes. In principle, several types of microfoundations can be added to the basic structure. For it to be in line with the current mainstream in macroeconomics, additional hypotheses would also be necessary to anchor its dynamics to a somewhat 'natural' long-run equilibrium. However, this would be at odds with the 'disequilibrium' spirit of SFCMs. Furthermore, the idea that the Lucas critique can be addressed through the estimation of invariant deep parameters of a representative agent is rather controversial. A 'heterogeneous interacting agents' type of microfoundations would be more in line with the structure and the philosophy of the model. However, this would increase further the complexity of the code, affecting its tractability and the readability of the results. Despite these limitations, ESSFC can be extended to include a variety of subsectors, variables, shocks and alternative scenarios. In addition, with respect to theoretical or numerical SFC models, it enables coupling qualitative findings with clear quantitative directions. Like other SFC models and unlike 'mainstream' models,[42] ESSFC sheds light on macroeconomic paradoxes, path-dependency and multiple equilibria characterising real-world economies. Furthermore, it allows the monitoring of stock–flow norms, which can possibly help detect early signs of economic–financial fragility and crises.

5 FINAL REMARKS

This paper aims to show how a medium-scale empirical stock–flow consistent macroeconometric model can be developed from scratch. Eurostat data for Italy and conventional statistical packages (notably EViews, Excel and R) have been used to implement a theory-constrained but data-driven modelling method. The key features of the model, named 'ESSFC', are as follows. First, ESSFC belongs to the class of 'stock–flow consistent' models, as it is inspired by the pioneering theoretical work by Godley/Lavoie (2007). Second, ESSFC is an 'empirical macroeconometric' model, as its structure has been developed by building upon macroeconomic principles and available time series for macro variables, rather than microeconomics' first principles. ESSFC has been shown to account consistently for the evolution of financial stocks and flows across Italy's sectors. In fact, despite some obvious limitations, this method allows us to make comparative analyses and conditional forecasts. In this sense, ESSFC can hopefully act as a useful benchmark for PhD students, early-career researchers, non-neoclassical macro modellers, and the practitioners who are eager to expand their own set of analytical tools.

41. Note that this requires addressing seasonality issues.
42. Meaning both DSGE models and conventional macroeconometric models based on a neoclassical production function.

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APPENDIX 1 THE HOUSING MARKET

Arguably, the simplest way to deal with the housing market is to create a housing price index as a function of households' debt-to-income ratio $(m_H = L_H/YD_H)$, their expected disposable income and the stock of housing:

$$p_H = h \cdot m_H \cdot \frac{E(YD_H)}{HOUSE_H}, \tag{68}$$

where the percentage h is an empirically estimated coefficient defining the sensitivity of housing prices to household leverage.[43]

Capital gains/losses on housing can be also calculated:

$$CG_{HOUSE} = HOUSE_{H,-1} \cdot \frac{d(p_H)}{p_{H,-1}}.$$

Housing investment can be now redefined as a function of the housing price index (in addition to households' mortgages and an inertial component):

$$INV_H = \vartheta_0 + \vartheta_1 \cdot INV_{H,-1} + \vartheta_2 \cdot MORT_{H,-1} + \vartheta_3 \cdot p_{H,-1}. \tag{69}$$

Simplified though it is, the equation above allows us to link households' spending decisions with the current conditions of the housing market.

43. Alternatively, one can assume that the stock of housing grows at an exogenous rate. This is the solution adopted by Burgess et al. (2016).