From Abstract to Concrete: Some Tips to Develop an Empirical SFC Model

(*Revised draft*)

by Marco Veronese Passarella*

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Abstract

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 by Godley and Lavoie (2006)[5]. Sectoral transaction flows and balance sheets are explicitly modelled and their evolution over non-ergodic time under different scenarios is analysed. The model also draws upon the applied work by Burgess et al. (2016)[2]. The case of Italy is considered, but the model can be easily extended to other countries. Eurostat annual data (from 1995 to 2016) are used to estimate most of model parameter values (e.g. consumption function and housing investment parameters). Remaining parameters are borrowed from the available literature or taken from a range of realistic values (e.g. 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

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*University of Leeds, Economics Division, m.passarella@leeds.ac.uk

Contents

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 and Lavoie (2006)[5].[1] Second, it is an 'empirical macroeconometric' model, as its structure is developed building upon macroeconomic principles and available time series for macro variables, rather than microeconomics' first principles. As such, the model developed here shows a clear resemblance with a recent work released by the Bank of England (Burgess et al. 2016)[2].

Another distinctive feature of the model is that no dynamic optimisation technique is used to create the system of macroeconomic equations. For it is recognised that a financially-sophisticated country should be rather regarded as a complex monetary economy of production, whose emerging behaviour can be hardly traced back to the choices made by an individual representative agent in a Saturday evening's 'village fair'. As a result, its 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, the sectoral transaction flows and balance sheets of the economy are explicitly modelled and their evolution over non-ergodic time under different scenarios is analysed. Available time series for Italy are used, but the model can be easily extended to other countries. More precisely, Eurostat annual data (from 1995 to 2016) are employed to estimate most of model parameter values (e.g. consumption function and housing investment parameters). Remaining parameters are borrowed from the available literature or taken from a range of realistic values (e.g. 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 accounting consistently for the evolution of financial stocks and flows across sectors (households, non-financial corporations, government, financial institutions, and 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 re-classify and aggregate Eurostat data, construct sectoral balance-sheets and the transactions-flow matrix. Section 3 presents the theoretical model, equation by equation, highlighting advantages and possible controversies. It is explained how to estimate model parameters, and track/forecast relevant time series. Some tips about software technicali-

[1] See Nikiforos and Zezza (2017)[7] for a recent survey on stock-flow consistent approach literature.

ties are also provided. 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 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 2006, 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 also 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 SFC modellers with the System of National Accounts (SNA).[3] Attributing values to model parameters and exogenous variables is also 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 also downloaded through a specific R package (named *pdfetch*). Second, the Eurostat's 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)[4]. This works draws strongly on that reclassification.

As mentioned, the first step to be taken is to match the transaction-flow matrix (TFM hereafter) to the chosen country's national accounting provided by Eurostat. The full TFM for Italy is shown by Figure 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 by Figure 4. Focusing on Figure 1, one feature and two possible issues are apparent. First, five macro-sectors are considered: *a*) 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); *b*) the firms' sector, marked by the subscript F in the model, including all non-financial corporations (S11); *c*) the government sector, marked by the subscript G in

[2] The reader is referred again to the complete survey by Nikiforos and Zezza (2017)[7].

[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*.

the model, including both central and local governments (S13); *d*) the financial sector, marked by the subscript B in the model, including both commercial banks and other financial institutions (S12); *e*) the foreign sector, marked by the subscript RoW in the model, including rest of the world's stocks and flows (S2, as opposed to total domestic economy, S1). Second, lines 6 to 9 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 dataset. Consequently, an assumption must be made about the way output is produced and distributed. Third, TFM's entries are numerous and 'dense'. This makes the task of identifying 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 two issues above, the full TFM can be narrowed down in two steps. First, it can be assumed that everything is produced by non-financial corporations upon request of other sectors. Strong though it may seem, this assumption allows meeting the stock-flow conditions for production entries in a simple way, so that each row total amounts to zero. Figure 2 shows the reduced TFM, where the so-called *quadruple-entry principle* is met. 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 the subsidies on products, which must be kept separated to calculate each sector's and total GDPs), all transfers (including subsidies, benefits and other transfers from the government sector), and other heterogeneous entries (labelled 'adjustment in funds'). Figure 3 displays the super-simplified TFM, which provides the accounting structure 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/liabilities: produced non-financial assets (including dwellings), currency and deposits, securities, loans, shares, and other financial assets (see Figure 4).

3 Developing the model

3.1 The system of difference equations

The model proposed is a discrete-time, medium-scale, dynamic macroeconometric model, based on both theoretical principles and data availability. It will be referred as a ESSFC (EuroStat-based Stock-Flow Consistent model) hereafter.[5] ESSFC's main assumptions and features are listed below.

[4] See Dafermos and Nikolaidi (2017)[3] for a short but clear description of the steps in developing a SFCM.

[5] The position occupied by EESFC along the classical Pagan (2003)[8] frontier of models is shown by Figure 11.

a) ESSFC aims at using and manipulating Eurostat classifications, while assuring full stock-flow consistency.

b) It is assumed that the economy is demand-led both in the short- and long-run. In other words, while a production function has been added to the basic set of equations, ESSFC's dynamics is not anchored by any long-run attractor.[6] Aggregate demand constrains total production and determines the employment level.

c) Unless otherwise stated, stock and flow variables are expressed at constant prices (2010) and national currency (Euro). Both financial assets' prices and the general price level are modeled.

d) Total gross output is assumed to be produced by non-financial firms only, on behalf of other sectors.[7]

e) 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).

f) Each sector is marked by either a portfolio investment function or a simplified financial investment rule.

g) Net stocks of financial assets and liabilities, rather than gross stocks, are usually taken into consideration. This is a limitation that should be addressed in a more advanced version of the model.

h) 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.

i) In practice, all (net) dividends are paid by non-financial firms and received by households, while almost all securities are issued by the government. Interests are paid by government and non-financial firms to banks, households and the rest of the world.

[6] Along with the absence of 'representative agent'-based microfoundations, this is the most remarkable difference with a dynamic stochastic general equilibrium model. The point is that the multiplicity of possible macroeconomic equilibria is at odds with the use of an harmonic oscillator mechanism.

[7] As a result, there is only one production function to be defined. Incidentally, this shows resemblance with the Marxian view that value is created in the (manufacturing) production sphere and then 'distributed' to other sectors through the price setting mechanism (i.e. via market forces and institutional factors). However, this is just a superficial resemblance, as sectors are defined following Eurostat accounting taxonomy, not Marx's theoretical one.

l) 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.

3.1.1 *Household sector*

As is 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 Maastricth Treaty, the launch of the Euro, two major financial crises, and the beginning of the 'austerity' era) have affected remarkably the financial situation of 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 down 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, import 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). This is the reason the disposable income equation includes a (sectoral) gross domestic product component. The latter is assumed to be produced materially by non-financial firms on behalf of NPISH.

As mentioned, household gross domestic product 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:

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

Total transfers to households are also defined as a share of wages, while 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 interests 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.[8]

In the SFC literature, household consumption is usually defined by the Haig-Simons function, so that:

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

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.[9] Capital gains (or losses) are not included explicitly, but they affect consumption through households' net wealth (see subsection 4.1).

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:

$$E(YD) = YD_{-1} + \upsilon \cdot \Big(E(YD_{-1}) - YD_{-1}\Big)$$

Net wealth is the summation of dwellings, currency & deposits, shares & equity, securities and other financial assets held by households, *minus* the stock of mortgage debt:

$$NW_H = HOUSE_H + D_H + V_H + B_H + OFIN_H - L_H \tag{7}$$

where $FUNDS_H$ is a composite variable defined below.

Household financial assets holdings are:

$$NFW_H = NW_H - HOUSE_H + L_H \tag{8}$$

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

$$HOUSE_H = (1 - \delta_H^1) \cdot HOUSE_{H,-1} + \delta_H^2 \cdot INV_H \tag{9}$$

where δ_H^1 is the depreciation rate of housing capital, INV_H is (housing) investment undertaken by household, and δ_H^2 can be regarded as the share of household investment actually devoted to housing.[10]

Portfolio allocation by households is modelled based on Brainard and Tobin (1968)[1] and Godley and Lavoie (2006)[5]. For the sake of simplicity, it is

[8] See Appendix A, Section I, for the specific form of household equations.

[9] When simulating the model, an autonomous component (c_0) and a smoothing one ($c_3 \cdot C_{H,-1}$) have been also added to the consumption function to improve the fit of ESSFC.

[10] When simulating the model, an additional component ($\delta_H^3 \cdot L_{H,-1}$) was added to improve the fit. This allows accounting for the sensitivity of dwellings' market value to the past level of household mortgages.

assumed that all shares are marked by the same average return rate. Total net equity (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 households wish to hold in form of equity & shares, based on their expected return rate, securities' interest rates and liquidity needs.[11] Notice that r_V is the (average) return rate on equity and shares, and r_{BA} is the (average) return rate on securities. The latter is defined by equation (43), whereas the former can be calculated as a function of the market price of shares:

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

Equation above states that the return rate on Italian equity and shares grows as their market price grows. While this formulation can help modelling future scenarios, r_v has been taken as an exogenous variable when the model was run backwards.

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

$$\frac{V_H}{E(NFW_H)} = \lambda_{1,0}^H + \lambda_{1,1}^H \cdot E(r_V) + \lambda_{1,2}^H \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda_{1,3}^H \cdot E(r_{BA}) \qquad (10)$$

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

$$\frac{B_H}{E(NFW_H)} = \lambda_{2,0}^H + \lambda_{2,1}^H \cdot E(r_V) + \lambda_{2,2}^H \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda_{2,3}^H \cdot E(r_{BA}) \qquad (11)$$

where $\lambda_{2,j}^H$ parameters define households' target or desired bonds' holdings.[12]

Bank deposits and cash held by households are:

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

where $\lambda_{3,j}^H$ parameters embody households' preference for liquidity.

Figure 4 shows that households hold other financial assets in addition to shares, securities and deposits. For the sake of simplicity, these assets are

[11] 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.

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

assumed to bear no interest rate. Their value can be defined residually, using the well-known adding-up constraints (Godley and Lavoie 2006)[5]:

$$\frac{OFIN_H}{E(NFW_H)} = \lambda^H_{4,0} + \lambda^H_{4,1} \cdot E(r_V) + \lambda^H_{4,2} \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda^H_{4,3} \cdot E(r_{BA}) \qquad (13)$$

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 $j = 1, 2, 3$.

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:

$$L_H = L_{H,-1} + \phi_1 \cdot YD_{-1} + \phi_2 \cdot HOUSE_{H,-1} + \phi_3 \cdot INV_{H,-1} \qquad (14)$$

Investment undertaken by households is 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:

$$\begin{aligned} INV_H = {} & \vartheta_1 \cdot INV_{H,-1} + \vartheta_2 \cdot L_{H,-1} + \vartheta_3 \cdot HOUSE_{H,-1} + \\ & + \vartheta_4 \cdot YD_{H,-1} + \vartheta_5 \cdot E(r_H) \end{aligned} \qquad (15)$$

where the property income growth rate is simply defined as:

$$r_H = \frac{\Delta PROP_H}{PROP_{H,-1}} \qquad (16)$$

A more accurate modellisation of housing market is provided in the Appendix B.

It is now possible to calculate the net borrowing by households, which can be defined as their own consumption and investment spending (net of changes in funds) in excess of disposable income. *Net lending by households* is therefore:

$$NL_H = YD + FUNDS - CONS_H - INV_H \qquad (17)$$

where 'funds' is a quite heterogeneous entry including adjustment in pension funds, capital transfers and non-produced non-financial products (see figures 1 to 3). For the sake of simplicity, it is regarded as a linear function of (lagged) disposable income.

3.1.2 *Non-financial corporations*

While facing a long-standing crisis since the mid-1990s or even earlier,[13] Italy is still the second biggest manufacturing economy in the European Union. Around a quarter of Italian GDP is still attributed to (manufacturing) industry.

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

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

$$GDP = Y - CONS_{INT} + \tau_P^{NET} \tag{18}$$

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

$$GDP_F = \beta_F \cdot GDP \tag{19}$$

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:

$$K = K_{-1} \cdot (1 + g_K) \tag{20}$$

Total investment must also cover capital depreciation:

$$INV = K_{-1} \cdot (g_K + \delta_K) \tag{21}$$

where δ_K is the capital depreciation rate.

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 actual cost of financing paid by NFCs (including a risk premium):

$$g_K = \gamma_Y + \gamma_U \cdot E\left(\frac{Y}{K}\right) + \gamma_\Pi \cdot E\left(\frac{\Pi_F}{K}\right) - \gamma_Z \cdot E(r_Z) - \gamma_R \cdot E(r_{L,F}) \tag{22}$$

where Π_F is the NFC profit net of taxes.[14]

Narrowly-defined NFC investment, including inventories, is a share of total investment:

$$INV_F = \delta_F \cdot INV \tag{23}$$

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 the GDP in the last 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:

$$D_F = (1 + \eta_F) \cdot D_{F,-1} \cdot \frac{GDP}{GDP_{-1}} \tag{24}$$

[14] Actual values, rather than forecast values, are used up until 2011 when running the model backwards.

where η_F is an estimated parameter 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:

$$\begin{aligned} Y_{AD} = & CONS_H + CONS_G + INV + CONS_{INT} + \\ & + EXP - IMP - \tau_T^{NET} \end{aligned} \tag{25}$$

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

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

$$Y = Y_{AD} \tag{26}$$

Looking at the supply side, gross potential output must be defined in real terms through a production function. A Leontief function was chosen for the ESSFC.[15] In formal terms:

$$Y_n = min(Y_n^L, Y_n^K) \tag{27}$$

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 ($\forall i = 0, 1, 2$).

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

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

Notice that potential output does not determine actual output in ESSFC. The actual production level is assumed to be only defined (constrained) by aggregate demand. However, 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 output gap, the wage share, the nominal exchange rate, and the rate of utilisation of plants (see Appendix A, Section II).

[15] This is a key difference with respect to Burgess et al. (2016)[2], who assume that production and distribution are implicitly defined through a standard Cobb-Douglas production function.

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 (notably, investment, export and government consumption):[16]

$$\begin{aligned} g_{PROD} = g_1 + g_2 \cdot d\big(log(INV_F)\big) + g_3 \cdot d\big(log(EXP)\big) + \\ + g_4 \cdot d\big(log(CONS_G)\big) \end{aligned} \tag{28}$$

Consequently, labour productivity is:

$$PROD_L = PROD_{L,-1} \cdot (1 + g_{PROD}) \tag{29}$$

while the employment level can be simply defined as:

$$N = \frac{Y}{PROD} \tag{30}$$

Similarly to Burgess et al. (2016)[2], import dynamics depends on an autonomous component, the change in output and the exchange rate:

$$IMP = \mu_0 + IMP_{-1} \cdot exp\left(\mu_1 + \mu_2 \cdot ln\left(\frac{Y}{Y_{-1}}\right) + \mu_3 \cdot (NER - NER_{-1})\right) \tag{31}$$

where NER is the nominal exchange rate (see Section 2.6) and $exp(x)$ is the exponential function of x, that is, e^x.

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

$$\begin{aligned} \Pi_F = GDP_F - (WB - WB_{OTHER}) - \tau_F + T_F + \\ + INT_F + FUNDS_F + PROP_F \end{aligned} \tag{32}$$

NFCs earn interests 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:

$$\begin{aligned} INT_F = \big[r_{D,-1} \cdot D_{F,-1}\big] - r_{L,F} \cdot L_{F,-1} - r_{BA} \cdot (B_{F,-1} - B_{G,F,-1}) + \\ + INT_F^{RES} \end{aligned} \tag{33}$$

Notice that the additional or residual component is particularly important when considering interest payments accruing on loans obtained by NFCs. For interest payments cannot be accurately calculated just by multiplying loans by interest rates. This is a well-known problem for SFC modellers. The fact

[16] A dummy variable is added to productivity growth equation when the model is used to fit past data. This allows addressing the apparent structural break in productivity that takes place in 2007.

is that interest payments are proportional to *gross* or *ex-ante* loans, which are demanded by NFCs at the *beginning* of each period based on their own production plans (Graziani 2003)[6]. However, one can only use data on *residual* or *ex-post* loans, as recorded at the *end* of the same period. As a result, it is unlikely to find a simple linear relationship between the stock of bank loans at period t and the flows of interest payments at $t-1$. Notice also that the value of INT_F^{RES} is expected to be negative as interest payments made by NFCs normally outstrip interest earnings.[17]

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

$$\Pi_{FU} = s_F \cdot \Pi_F \tag{34}$$

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

Accordingly, NFC distributed profits (dividends) are:

$$DIV_F = (1 - s_F) \cdot \Pi_F \tag{35}$$

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

$$\begin{aligned} \tau_F = \theta_F \cdot \Big(& GDP_{F,-1} - (WB_{-1} - WB_{OTHER,-1}) - INT_{F,-1} + \\ & - FUNDS_{F,-1} - PROP_{F,-1} \Big) \end{aligned} \tag{36}$$

For the sake of simplicity, adjustment in funds and additional property incomes are defined as a percentage of profit, while subsidies and transfers are regarded as exogenous entries. In line with current literature, it is assumed that firms can issue new equity to fund a small percentage of their investment plans (Burgess et al. 2016[2]). The real volume of equity is:

$$v_F = v_{F,-1} + \psi \cdot \frac{INV_{F,-1}}{p_{V,-1}} \tag{37}$$

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

$$p_V = \frac{V_F}{v_F} \tag{38}$$

Notice that Italy is usually regarded as a traditional or 'bank based' system. For financial markets usually do not occupy center stage. In contrast, 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 as a residual:

$$\begin{aligned} L_F &= L_{F,-1} + INV_F - \Pi_{FU} - NPL - p_V \cdot \Delta v_F + \xi_D \cdot \Delta D_F \\ &= L_{F,-1} - NL_F - NPL - p_V \cdot \Delta v_F + \xi_D \cdot \Delta D_F \end{aligned} \tag{39}$$

[17] However, data show that the value of net interest has turned positive in the last few years.

Equation above 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. There is also a residual term accounting for the small percentage (ξ_D) of loans which are temporarily held as bank deposits.

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

$$NL_F = \Pi_{FU} - INV_F \tag{40}$$

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

3.1.3 *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'.[18] In formal terms, *net lending by the government* arises from revenues net of spending and interest payments:

$$NL_G = GOV_{REV} - GOV_{SP} - INT_G \tag{41}$$

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

$$INT_G = r_{BA,-1} \cdot B_{G,-1} + INT_G^{RES} \tag{42}$$

The average yield from Italian government securities can be defined by adding a mark-up to the risk-free interest rate (i.e. the German 10-year government bond yield):[19]

$$r_{BA} = r_Z \cdot (1 + m_A) \tag{43}$$

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

$$GOV_{SP} = CONS_G + INV_G + WB_G + T_{TOT} + FUNDS_G \tag{44}$$

Government total revenue is given by the summation of government GDP (i.e. the *cost* of goods and services produced by the government), total taxes, property incomes and dividends:

$$GOV_{REV} = GDP_G + \tau_{TOT} + PROP_G + DIV_G \tag{45}$$

[18] See Eurostat Glossary at: http://ec.europa.eu/eurostat/statistics-explained/.

[19] 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.

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

$$CONS_G = \alpha_G^C \cdot GDP + \epsilon_G \tag{46}$$

Other government spending and revenue entries are defined in a similar way.[20] Since the model is quite complex yet (see Figure 7 displaying the dependency graph of ESSFC), only stochastic shocks to government equations' coefficients are considered here. However, these simplified equations can be easily redefined to include all sorts of reaction functions.

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

$$\tau_{TOT} = \tau_H + \tau_F + \tau_B + \tau_{RoW} \tag{47}$$

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

$$T_{TOT} = T_H + T_F + T_B + T_{RoW} \tag{48}$$

Using adaptive expectations, 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):[21]

$$b_G = b_{G,-1} - \frac{-NL_G}{p_{B,-1}} + \frac{BOT_{-1}}{p_{B,-1}} \tag{49}$$

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 current period.

So, the market price of Italian government bonds is:

$$p_B = \frac{B_G}{b_G} \tag{50}$$

The nominal supply of Treasury bills is:

$$BOT = p_{B,-1} \cdot \Delta b_G - \left(B_G - B_{G,-1} \cdot \frac{p_B}{p_{B,-1}} \right) \tag{51}$$

In other words, the Italian government issues bills to deal with temporary cash imbalances.

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

$$NW_G = D_G + V_G - L_G - B_G + OFIN_G \tag{52}$$

[20] As usual, the reader is referred to Appendix A, Section III, for the whole set of government equations.

[21] For the sake of simplicity, government securities other than Treasury bonds and bills are neglected.

Accordingly, the government deficit and debt to GDP ratios are, respectively:

$$DEF_G = -NL_G/GDP$$

$$DEB_G = -NW_G/GDP$$

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), but this has not kept the debt from restarting growing after the US financial crisis. The reaction of the ratios above following exogenous shocks to government spending is one of the topics analysed in Section 4.2.

3.1.4 *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:

$$GDP_B = \beta_B \cdot GDP \tag{53}$$

Financial sector's GDP is largely given by the spread between the interest rate financial institutions receive on financial assets and the one they pay on financial liabilities.[22]

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

$$\begin{aligned}\Pi_B = GDP_B - WB_B - \tau_B + T_B + DIV_B + \\ + PROP_B + INT_B + FUNDS_B\end{aligned} \tag{54}$$

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

$$NL_B = \Pi_B - DIV_B - INV_B \tag{55}$$

Total taxes on financial sector profits are:

$$\tau_B = \theta_B \cdot \Pi_{B,-1} \tag{56}$$

The value of total transfers received by financial institutions is determined as an exogenous instead.

[22] The SNA suggests to use this spread as a measure of services provided by the financial sector to the economy, by acting as an 'intermediary'.

Financial sector net earning from lending is defined as net interest paid by households *plus* net interest paid by NFCs *plus* a residual:

$$INT_B = (INT_H^{PAID} + INT_F) \cdot (1 + perc_{INT,B}^{RES}) \tag{57}$$

where an additional component (expressed in percentage terms) is also included to account for other possible interest flows. Overall accounting consistency is then assured by interests paid/received by foreign sector being calculated as a residual entry.

Financial sector net wealth is:

$$NW_B = V_B + L_B - D_B + B_B - OFIN_B \tag{58}$$

The *net* stock of bank loans is the summation of mortgages to households and loans granted to NFCs, government and foreign agents:

$$L_B = L_H + L_F + L_G + L_{RoW} \tag{59}$$

Similarly, the stock of bank deposits is:

$$D_B = D_H + D_F + D_G + D_{RoW} \tag{60}$$

Turning to financial assets held by banks and other financial institutions, the overall amount is:

$$NFW_B = NW_B - HOUSE_B \tag{61}$$

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 financial sector's net wealth:

$$HOUSE_B = \nu_{H,B} \cdot NW_B \tag{62}$$

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

$$\frac{V_B^{PUR}}{E(NFW_B)} = \lambda_{1,0}^B + \lambda_{1,1}^B \cdot E(r_V) + \lambda_{1,2}^B \cdot \Pi_B + \lambda_{1,3}^B \cdot E(r_{BA}) \tag{63}$$

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

$$\frac{B_B}{E(NFW_B)} = \lambda_{2,0}^B + \lambda_{2,1}^B \cdot E(r_V) + \lambda_{2,2}^B \cdot \Pi_B + \lambda_{2,3}^B \cdot E(r_{BA}) \tag{64}$$

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

$$\frac{OFIN_B}{E(NFW_B)} = \lambda_{3,0}^B + \lambda_{3,1}^B \cdot E(r_V) + \lambda_{3,2}^B \cdot \Pi_B + \lambda_{3,3}^B \cdot E(r_{BA}) \tag{65}$$

In the portfolio equations above, the financial sector's profit (Π_B) is used as a proxy for the 'transactions motive'-led demand for liquidity. Notice that $\lambda_{i,j}^B$ coefficients (for $i = 1, 2$ and $j = 0, 1, 2, 3$) are empirically estimated parameters, whereas $\lambda_{3,j}^B$ coefficients (for $j = 0, 1, 2, 3$) are defined in such a way to meet the portfolio adding-up constraints. In other words, $OFIN_B$ is a residual variable.

3.1.5 *Foreign sector*

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

$$NL_{RoW} = -(NL_H + NL_F + NL_G + NL_B) \tag{66}$$

The latter is nothing but the flip side of the current account for the Italian economy. 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 are modelled as a linear function of many factors, notably, past loans, the ECB target interest rate, the GDP attributed to the rest of the world, the (nominal) exchange rate, the total trade volume, and the 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.[23] 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, rest of the world's variables are usually defined in a residual way, except for portfolio decisions, foreign loans & deposits and export (see Appendix A, Section V). This is required to assure the accounting consistency of the model.

3.1.6 *Cross-sector holdings and payments*

To close the model, cross-sector assets & liabilities holdings and payments must be defined. When no information about 'who pays whom' is available, some simplifying hypotheses can help. The easiest way is 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 ninety percent of total security value. 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, ninety percent). This is coherent with the hypothesis that securities (be they NFC securities or government bonds) carry all the same average return rate. The same method can be applied to other financial assets.

Another problem might arise from the fact that seldom dividends received by each sector mirror its own equity and shares' holdings. This issue is likely

[23] The price (or wage) level or the inflation rate can also be added to export equation to account for price competitiveness.

to be due to the high aggregation level and other simplifying assumptions. It has been tackled in two steps: *a*) total dividends received by each 'recipient' sector i have been corrected to fit empirical evidence ($DIV_i = e_i \cdot DIV_{TOT} \cdot V_i/V_{TOT}$, where e_i is the correction coefficient); *b*) each 'issuing' sector j has been assumed to pay the same proportion ($perc_j = DIV_j/DIV_{TOT}$) of total dividends to every other sector (so that dividends paid by j to i are defined as: $DIV_{j,i} = perc_j \cdot DIV_i$). Interest payments have been modelled in a similar way (see Appendix A, Section VI, for the complete list of equations).

3.1.7 *Central bank stance and interest rates*

Since Italy is a member of the Euro Area, the key discount interest rate (r_{ECB}) is set autonomously by the ECB. Similarly, the exchange rate (NER) is an exogenous, and it is defined as the effective nominal exchange rate with 42 trading partners.[24] The risk-free interest rate (r_Z) is the return rate on 10-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 backwards. For the sake of simplicity, the average yield on securities is also defined by adding an exogenous 'spread' to 10-year German bonds' yield (see Appendix A, section VII). As mentioned, the return rate on bank deposits (and cash) is set to zero instead. The model is now complete, meaning that entries of Figure 1 and Figure 2 have been all defined. Next section deals with parameter value estimation and model calibration.

3.2 Data, estimation and calibration

Once the theoretical model is completed, it is necessary to define the value of parameters & exogenous variables, and some initial stocks & 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: *a*) model coefficients can be estimated through standard econometric techniques; *b*) coefficients can be calibrated based either on data observation or on literature's findings; *c*) coefficients can be also 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 by using methods (*b*) and (*c*), ESSFC's coefficients are (almost) all defined empirically. 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 which are written off, the percentage of investment funded by new shares, and the weights on past errors in agents' expectations. Their values are displayed by Table 1. All the remaining unknown coefficients have been estimated based on Eurostat data.

More precisely, the dataset used covers the period from 1996 to 2016 on

[24] Eurostat provides a variety of exchange rate indexes. So, other options are available.

a 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 determined endogenously.[25] 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. For the sake of simplicity, unknown coefficients of key stochastic equations have been estimated one at time by simple equation OLS. As is 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 be also employed to deal with the second issue. However, using OLS estimates allow simplifying the coding work and making a quick preliminary test of the model's operation. So, it can be regarded as an intermediate step in the development of a more econometrically sophisticated model. Parameter values of 'supplementary' equations (e.g. 'beta' parameters, the ratio of wages paid by NCFs to total wages, the ratio of government securities to total securities, etc.) are calculated as moving averages.

3.3 Software technicalities

SFCMs can be set up and simulated using a variety of statistical packages (e.g. *Excel*, *EViews*, *R*) engineering software (e.g. *Matlab*), and also programming languages (e.g. *Python*).[26] 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 fetches transactions-flow matrix's 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 which: *a*) estimates model parameters; *b*) calibrates the model using estimated (and fine-tuned) parameter values; *c*) improve estimates and smooth transition to forecast values by manipulating the residuals;[27] *d*) compares actual data with 'forecast' values; *e*) create alternative scenarios for relevant series to be compared with baseline values. Programs' structure is sketched in Figure 5.[28] The main advantage of this structure is that it enables resetting the model by using different datasets. Time series can be updated just re-running the *R* files (for instance, following most recent releases from Eurostat or to include new variables). In principle,

[25] Using constant prices is fundamental when dealing with countries characterised by high inflation rates. This is not the case of the country considered here, Italy, which has been marked by a relatively low change in the price level since the end of 1990s and a negligible one in the last five years.

[26] A useful repository for SFCMs' code can be find on the Internet at *http://models.sfc-models.net/*.

[27] Please refer to subsection 4.1.

[28] The complete EViews program, including all estimations of parameter values, can be provided upon request.

other countries' data can be also employed right away. The model will execute automatically points (a) to (d) and display new solutions. However, it is recommended to check and possibly amend portfolio choices' assumptions and financial sector's settings to account for country-specific institutional features. Once the model is set up and run, it allows accounting explicitly for the impact of stocks on flows and *vice versa*, highlighting the role of financial agents, assets and cross-sector balances. ESSFC's simulations are presented in the next section.

4 Running the simulations

4.1 Fitting past data and forecasting

While the main goal of ESSFC is to allow performing comparative dynamics exercises (i.e. testing reactions to shocks under different scenarios) in a financially-sophisticated economy, it can also be used to fit past values and forecast future values of relevant time series. For this purpose, it is appropriate to make an assumption about the way residuals behave.[29] More precisely, it would be useful to eliminate the gap between actual and estimated values at the very last available observation period (or the period in which model variables' reactions to exogenous shocks are tested), call it t_0. While standard statistical packages usually enable to adjust forecast results to compensate for a poor fit,[30] a slightly different method has been chosen here. For residuals are explicitly assumed to reduce steadily (at a rate defined by parameter μ) up until the last observation period, call it t_0, and are unwound afterwards (at the same rate). In formal terms, for $t \leq t_0$, the estimate value of the variable x, corrected to improve the fit, is:

$$x_t^* = e^{-\mu \cdot \frac{t}{t_0 - t}} \cdot (x_t^f - \overline{x}) + \overline{x} \tag{67}$$

where x_t^f is the forecast value of variable x at time t (with $t = 1996, 1997, ..., 2016$) and $\overline{x}$ is either the actual value of x or its average value in the last few periods.

As a result, x_t^* tends to the originally estimated value, x_t^f, for t that tends to 0; while x_t^* tends to $\overline{x}$ (or simply to its actual value, x_t) for t that tends to t_0.

By contrast, for $t > t_0$, the estimate value of the variable x, corrected to smooth the transition, is:

$$x_t^* = e^{-\mu \cdot (t - t_0)} \cdot (\overline{x} - x_t^f) + x_t^f \tag{68}$$

As a result, x_t^* tends to $\overline{x}$ for t that tends to t_0; while x_t^* moves away from $\overline{x}$, and hence tends to x_t^f, for t that tends to $+\infty$. In other words, future (predicted) residuals are allowed to increase gradually, so that model's forecast

[29] Notice that residuals are defined as the gap between forecast and observed values.

[30] For example, EViews does it through the 'Add Factors' function.

value departs gradually from the last observed value (or from the last average value).

This simple mechanism enables creating a moving ceiling for (actual and predicted) residuals, which can be used to: *a*) improve artificially estimates of stochastic variables; *b*) reset the (initial values of) identities of which one wants to monitor the reaction to shocks. Notice that option (*b*) requires identifying a 'residual' or 'buffer' variable to absorb the estimation difference (i.e. $x_t^* - x_t^f$). For instance, ESSFC uses the method above to improve the fit of price, consumption and investment functions, and also to reset the initial value of each sector's net lending ratio. A specific stock variable, that is, 'other financial assets', is then redefined in such a way as to assure the accounting consistency of the model.[31] For the sake of simplicity, possible capital gains/losses (that is, the 'revaluation effect') are assumed away on government bonds. As for other financial and real assets, the revaluation effect is automatically accounted for, as stocks at time t are defined as nominal stocks at time $t-1$ *plus* changes in stocks' value from $t-1$ to t.[32]

4.2 Some simple comparative dynamics exercises

The model is fully set up. It can now be used to: first, check the adherence or fit of forecast values to available series, and predict future developments in main endogenous variables; second, create alternative scenarios to be compared with the *status quo*.

4.2.1 *Data-fitting and forecasting*

Figure 6 shows financial balances (net lending values) 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 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. The fit looks accurate enough. This is no surprise. The residual correction mechanism allows always a perfect match with the last observed value, although forecast errors are still possible (and likely) in previous periods. Sectoral net lending residuals are shown by chart F in Figure 6. As one would expect, each crisis affects negatively the predicting power of the model. This is shown by the pikes in residuals. Notice that ESSFC forecast is neither 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) nor a narrowly-defined dynamic one (where variables' values are all 'forecasted' based on the initial parameters' estimation only). It can be regarded as a middle ground, as a moving ceiling for residuals is put in place for key stochastic equations and most parameter values are defined as moving averages along the period considered. On the one

[31] For the sake of simplicity, households' residual financial assets are simply defined as a percentage of net wealth: $OFIN_H = \sigma^H_{OFIN} \cdot NW_H$. The same goes for other sectors.

[32] For a detailed discussion of this issues, see again Burgess et al. (2016)[2].

hand, ESSFC purpose is to allow setting up and comparing reactions to shocks under different scenarios rather than providing accurate short-run predictions. On the other hand, the model can be used to forecast key variables' behaviour in the medium run. However, some additional hypotheses on main coefficients' expected trends are necessary to prevent ESSFC from relying excessively on last period's values.

4.2.2 *Creating alternative scenarios*

As mentioned, the main goal of ESSFC is to simulate the reaction of endogenous variables to shocks to key parameters. Model's behaviour under the new scenario is then compared with the baseline (i.e. 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. [33] 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 is considered. Charts A to F in Figure 8 contrast government debt ratios and sectoral net lending ratios under three alternative scenarios about government consumption: the baseline scenario, where government consumption is assumed to stick to its historical trend (black line); an 'austerity' scenario, marked by a permanent year-to-year cut in government consumption (-1% of GDP, blue line); and a 'profligacy' scenario, characterised by an increase in government consumption (+1% of GDP, red 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 E and F display the same variables, but as ratios to the baseline. Chart C shows the impact on (real) GDP growth. All in all, while austerity is obviously successful in reducing the deficit to GDP ratio, it does not reduce the stock of debt to GDP. On the contrary, the latter increases (compared to the baseline) when government spending is cut. A loose fiscal policy entails the opposite effect: the deficit increases but the debt to GDP ratio falls, due to a long-lasting increase in the denominator.[34] Charts A and B in figure 9 show that identical findings are found when the GDP at current prices is considered.[35] This again is no surprise. Since Italy's stock of debt is more than unity, a unity multiplier would be sufficient to generate such a seemingly paradoxical effect. However, these findings can be shown to be rather robust, as they keep holding when experiments are re-run starting from a less than unity value of debt to GDP ratio (charts C and D in Figure 9). The reason is that austerity entails a long-lasting depressing effect on GDP growth rate. Furthermore, Chart D in Figure 8 shows that all domestic

[33] This is an advantage compared with computational or purely-theoretical SFC models (like those developed by Godley and Lavoie, 2006[5]), where steady/stationary state values must be calculated (either analytically or through numerical simulations) before testing model's reactions to shocks.

[34] After the initial pike, the GDP growth rate reduces, but its steady-state value remains higher than the baseline.

[35] ESSFC predicts the inflation rate to be very low in the next few years. In addition, inflation seems to be quite insensitive to different policy stances.

private sectors (firms, financial institutions and households) face a worsening in their own financial balances as government spending reduces. This is only partially offset by the raise of a surplus towards the foreign sector (blue line). 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.

4.2.3 *Further developments and limitations*

Simulations shown so far are of deterministic nature. However, the model can be also solved stochastically to obtain a non-deterministic forecast. Figure 10 shows private, government and foreign sectors' net lending ratios. Average values, along with upper and lower boundaries (± 1 standard deviation), are displayed. Unfortunately, the complexity of the model (portrayed by Figure 7) and the high number of behavioural equations make such corridor quite broad. This is the inevitable drawback to accept for a consistent rendition of cross-sector transactions and balance-sheet connections. The other main limitations of the model can be summarised as follows: *a*) annual data should be replaced with quarterly data to increase observations' frequency and improve the predictive power of the model; *b*) cointegration, instrumental variables and other econometric techniques should be used to improve coefficients' estimation; *c*) gross stocks and transactions should be replaced with net stocks and transactions; *d*) where possible, the aggregation level of financial assets (liabilities) should be further reduced; *e*) when used for policy advising purposes, the model is subject to the well-knonw Lucas critique.[36] Despite these limitations, ESSFC can be extended to a variety of sub-sectors, variables, shocks and alternative scenarios. It allows monitoring stock-flow norms, which can possibly help detect early signs of economic-financial fragility and crises.

5 Final remarks

This paper aimed at showing how a medium-scale empirical stock-flow consistent macroeconometric model could be developed from scratch. Eurostat data for Italy and conventional statistical packages (notably EViews, Excel and R) were 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 and Lavoie (2006)[5]. Second, ESSFC is an 'empirical macroeconometric' model, as its structure is developed 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

[36] In principle, microfoundations could be added to the basic model. For it to be in line with current mainstream in macroeconomics, additional hypothesis would be necessary to anchor its dynamics to a natural equilibrium in the long-run. However, this would be at odds with the 'disequilibrium' spirit of SFCMs.

Italy's sectors. In fact, despite some obvious limitations, the method proposed enables for comparative analyses and conditional forecast yet. 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 want to expand their own set of analytical tools.

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A Appendices

Appendix A - The complete model

I. *Household sector*

$$YD = GDP_H + WB - \tau_H + INT_H + T_H + ANN_H \tag{A1}$$

$$ANN_H = DIV_H + PROP_H \tag{A2}$$

$$GDP_H = \beta_H \cdot GDP \tag{A3}$$

$$WB = \omega_T \cdot GDP \tag{A4}$$

$$\omega_L = \frac{INT_H + ANN_H + WB \cdot (1 - \omega_S)}{GDP} \tag{A5}$$

$$\tau_H = \theta_H \cdot WB_{-1} \tag{A6}$$

$$INT_H = INT_H^{RECV} - INT_H^{PAID} \tag{A7}$$

$$\begin{aligned} INT_H^{RECV} = \iota_{10}^H + \iota_{11}^H \cdot INT_{H,-1}^{RECV} + \iota_{12}^H \cdot r_{BA} + \iota_{13}^H \cdot r_{BA,-1} + \iota_{14}^H \cdot B_H + \\ + \iota_{15}^H \cdot B_{H,-1} + \iota_{16}^H \cdot B_H \cdot r_{BA} + \iota_{17}^H \cdot B_{H,-1} \cdot r_{BA,-1} \end{aligned} \tag{A8}$$

$$\begin{aligned} INT_H^{PAID} = \iota_{20}^H + \iota_{21}^H \cdot INT_{H,-1}^{PAID} + \iota_{22}^H \cdot r_{ECB} + \iota_{23}^H \cdot r_{ECB,-1} + \iota_{24}^H \cdot L_H + \\ + \iota_{25}^H \cdot L_{H,-1} + \iota_{26}^H \cdot L_H \cdot r_{ECB} + \iota_{27}^H \cdot L_{H,-1} \cdot r_{ECB,-1} \end{aligned} \tag{A9}$$

$$T_H = \alpha_{H,T} \cdot WB_{-1} \tag{A10}$$

$$PROP_H = \alpha_{H,P} \cdot WB_{-1} \tag{A11}$$

$$C_H = c_1 \cdot E(YD) + c_2 \cdot NW_{H,-1} \tag{A12}$$

$$NW_H = HOUSE_H + D_H + V_H + B_H + OFIN_H - L_H \tag{A13}$$

$$NFW_H = NW_H - HOUSE_H + L_H \tag{A14}$$

$$HOUSE_H = (1 - \delta_H^1) \cdot HOUSE_{H,-1} + \delta_H^2 \cdot INV_H + \delta_H^3 \cdot L_{H,-1} \tag{A15}$$

$$r_V = v_1 \cdot r_{V,-1} + v_2 \cdot \frac{\Delta p_V}{p_{V,-1}} \tag{A16}$$

$$\frac{V_H}{E(NFW_H)} = \lambda_{1,0}^H + \lambda_{1,1}^H \cdot E(r_V) + \lambda_{1,2}^H \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda_{1,3}^H \cdot E(r_{BA}) \tag{A17}$$

$$\frac{B_H}{E(NFW_H)} = \lambda_{2,0}^H + \lambda_{2,1}^H \cdot E(r_V) + \lambda_{2,2}^H \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda_{2,3}^H \cdot E(r_{BA}) \tag{A18}$$

$$\frac{D_H}{E(NFW_H)} = \lambda_{3,0}^H + \lambda_{3,1}^H \cdot E(r_V) + \lambda_{3,2}^H \cdot \frac{E(YD_H)}{E(NFW_H)} + \lambda_{3,3}^H \cdot E(r_{BA}) \tag{A19}$$

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

$$OFIN_H = \sigma^H_{OFIN} \cdot NW_H \tag{A20}$$

$$L_H = L_{H,-1} + \phi_1 \cdot YD_{-1} + \phi_2 \cdot HOUSE_{H,-1} + \phi_3 \cdot INV_{H,-1} \tag{A21}$$

$$\begin{aligned} INV_H = {} & \vartheta_1 \cdot INV_{H,-1} + \vartheta_2 \cdot L_{H,-1} + \vartheta_3 \cdot HOUSE_{H,-1} + \\ & + \vartheta_4 \cdot YD_{H,-1} + \vartheta_5 \cdot E(r_H) \end{aligned} \tag{A22}$$

$$r_H = \frac{\Delta PROP_H}{PROP_{H,-1}} \tag{A23}$$

$$NL_H = YD + FUNDS - CONS_H - INV_H \tag{A24}$$

$$FUNDS_H = \alpha_{H,FU} \cdot YD_{H,-1} \tag{A25}$$

II. *Non-financial corporations*

$$GDP = Y - CONS_{INT} + \tau^{NET}_P \tag{A26}$$

$$GDP_F = \beta_F \cdot GDP \tag{A27}$$

$$CONS_{INT} = c_{INT} \cdot Y \tag{A28}$$

$$K = K_{-1} \cdot (1 + g_K) \tag{A29}$$

$$INV = K_{-1} \cdot (g_K + delta_K) \tag{A30}$$

$$g_K = \gamma_Y + \gamma_U \cdot E\left(\frac{Y}{K}\right) + \gamma_\Pi \cdot E\left(\frac{\Pi_F}{K}\right) - \gamma_Z \cdot r_Z - \gamma_R \cdot r_{L,F} \tag{A31}$$

$$INV_F = \delta_F \cdot INV \tag{A32}$$

$$D_F = (1 + \eta_F) \cdot D_{F,-1} \cdot \frac{GDP}{GDP_{-1}} \tag{A33}$$

$$\begin{aligned} Y_{AD} = {} & CONS_H + CONS_G + INV + CONS_{INT} + \\ & + EXP - IMP - \tau^{NET}_T \end{aligned} \tag{A34}$$

$$Y = Y_{AD} \tag{A35}$$

$$Y_n = min(Y^L_n, Y^K_n) \tag{A36}$$

$$\log(Y^L_n) = \nu^L_0 + \nu^L_1 \cdot \log(N) + \nu^L_2 \cdot t$$

$$\log(Y^K_n) = \nu^K_0 + \nu^K_1 \cdot \log(K) + \nu^K_2 \cdot t$$

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

$$p_Y = \pi^Y_1 \cdot p_{Y,-1} + \pi^Y_2 \cdot (Y_n - Y) + \pi^Y_3 \cdot \frac{WB}{GDP} + \pi^Y_3 \cdot NER \tag{A37}$$

$$p_K = \pi^K_1 \cdot p_{K,-1} + \pi^K_2 \cdot \frac{GDP}{K} + \pi^K_3 \cdot \frac{WB}{GDP} + \pi^K_3 \cdot NER \tag{A38}$$

$$g_{PROD} = g_1 + g_2 \cdot d\big(log(INV_F)\big) + g_3 \cdot d\big(log(EXP)\big) + \\ + g_4 \cdot d\big(log(CONS_G)\big) \tag{A39}$$

$$PROD_L = PROD_{L,-1} \cdot (1 + g_{PROD}) \tag{A40}$$

$$N = \frac{Y}{PROD} \tag{A41}$$

$$IMP = \mu_0 + IMP_{-1} \cdot exp\Big(\mu_1 + \mu_2 \cdot ln\Big(\frac{Y}{Y_{-1}}\Big) + \mu_3 \cdot (NER - NER_{-1})\Big) \tag{A42}$$

$$\Pi_F = GDP_F - (WB - WB_{OTHER}) - \tau_F + T_F + \\ + INT_F + FUNDS_F + PROP_F \tag{A43}$$

$$\zeta = 1 - \omega_L \tag{A44}$$

$$INT_F = r_{D,-1} \cdot D_{F,-1} - r_{L,F} \cdot L_{F,-1} - r_{BA} \cdot (B_{F,-1} - B_{G,F,-1}) + \\ + INT_F^{RES} \tag{A45}$$

$$WB_{OTHER} = \omega_O \cdot WB \tag{A46}$$

$$\Pi_{FU} = s_F \cdot \Pi_F \tag{A47}$$

$$DIV_F = (1 - s_F) \cdot \Pi_F \tag{A48}$$

$$\tau_F = \theta_F \cdot \Big(GDP_{F,-1} - (WB_{-1} - WB_{OTHER,-1}) - INT_{F,-1} - FUNDS_{F,-1} - PROP_{F,-1}\Big) \tag{A49}$$

$$FUNDS_F = \alpha_{F,FU} \cdot \Pi_{F,-1} \tag{A50}$$

$$PROP_F = \alpha_{F,O} \cdot \Pi_{F,-1} \tag{A51}$$

$$v_F = v_{F,-1} + \psi \cdot \frac{INV_{F,-1}}{p_{V,-1}} \tag{A52}$$

$$p_V = \frac{V_F}{v_F} \tag{A53}$$

$$L_F = L_{F,-1} + INV_F - \Pi_{FU} - NPL - p_V \cdot \Delta v_F + \xi_D \cdot \Delta D_F \\ = L_{F,-1} - NL_F - NPL - p_V \cdot \Delta v_F + \xi_D \cdot \Delta D_F \tag{A54}$$

$$NPL = \xi_F \cdot \xi_B \cdot L_{F,-1} \tag{A55}$$

$$NL_F = \Pi_{FU} - INV_F \tag{A56}$$

$$YD_F = \Pi_{FU} - FUNDS_F \tag{A57}$$

$$NW_F = D_F - V_F - L_F - B_F - OFIN_F \tag{A58}$$

$$NFW_F = NW_F - HOUSE_F + L_F + V_F + B_F - B_{G,F} \tag{A59}$$

$$HOUSE_F = \nu_{H,F} \cdot NW_F \tag{A60}$$

$$OFIN_F = \sigma_{OFIN}^F \cdot NW_F \tag{A61}$$

III. *Government sector*

$$r_{BA} = r_Z \cdot (1 + m_A) \tag{A62}$$

$$m_A = \frac{SPREAD_A}{r_Z} \tag{A63}$$

$$NL_G = GOV_{REV} - GOV_{SP} - INT_G \tag{A64}$$

$$INT_G = r_{BA,-1} \cdot B_{G,-1} + INT_G^{RES} \tag{A65}$$

$$GOV_{SP} = CONS_G + INV_G + WB_G + T_{TOT} + FUNDS_G \tag{A66}$$

$$GOV_{REV} = GDP_G + \tau_{TOT} + PROP_G + DIV_G \tag{A67}$$

$$CONS_G = \alpha_G^C \cdot GDP + \epsilon_G \tag{A68}$$

$$INV_G = \alpha_G^I \cdot GDP \tag{A69}$$

$$WB_G = \omega_G \cdot GDP \tag{A70}$$

$$V_G = \alpha_G^V \cdot GDP \tag{A71}$$

$$\tau_{TOT} = \tau_H + \tau_F + \tau_B + \tau_{RoW} \tag{A72}$$

$$T_{TOT} = T_H + T_F + T_B + T_{RoW} \tag{A73}$$

$$GDP_G = \beta_G \cdot GDP \tag{A74}$$

$$PROP_G = \alpha_G^P \cdot GDP \tag{A75}$$

$$FUNDS_G = \alpha_G^{FU} \cdot GDP \tag{A76}$$

$$b_G = b_{G,-1} - \frac{-NL_G}{p_{B,-1}} + \frac{BOT_{-1}}{p_{B,-1}} \tag{A77}$$

$$p_B = \frac{B_G}{b_G} \tag{A78}$$

$$BOT = p_{B,-1} \cdot \Delta b_G - \left(B_G - B_{G,-1} \cdot \frac{p_B}{p_{B,-1}} \right) \tag{A79}$$

$$\tau_{TOT}^{NET} = \theta_{TOT} \cdot Y \tag{A80}$$

$$L_G = NW_G \cdot \eta_L^G \tag{A81}$$

$$D_G = NW_G \cdot \eta_D^G \tag{A82}$$

$$NW^G = D_G + V_G - L_G - B_G + OFIN_G \tag{A83}$$

$$OFIN_G = \sigma_{OFIN}^G \cdot NW_G \tag{A84}$$

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

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

IV. *Financial corporations*

$$GDP_B = \beta_B \cdot GDP \tag{A85}$$

$$\begin{aligned} \Pi_B = {} & GDP_B - WB_B - \tau_B + T_B + DIV_B + \\ & + PROP_B + INT_B + FUNDS_B \end{aligned} \tag{A86}$$

$$NL_B = \Pi_B - DIV_B - INV_B \tag{A87}$$

$$WB_B = \omega_B \cdot GDP \tag{A88}$$

$$\tau_B = \theta_B \cdot \Pi_B \tag{A89}$$

$$PROP_B = \alpha_B^P \cdot \Pi_B \tag{A90}$$

$$FUNDS_B = \alpha_B^{FU} \cdot \Pi_B \tag{A91}$$

$$INT_B = \Big(INT_H^{PAID} + (-INT_F)\Big) + INT_B^{RES} \tag{A92}$$

$$INV_B = \alpha_B^{INV} \cdot INV \tag{A93}$$

$$NW_B = V_B + L_B - D_B + B_B - OFIN_B \tag{A94}$$

$$L_B = L_H + L_F + L_G + L_{RoW} \tag{A95}$$

$$D_B = D_H + D_F + D_G + D_{RoW} \tag{A96}$$

$$NFW_B = NW_B - HOUSE_B \tag{A97}$$

$$HOUSE_B = \nu_{H,B} \cdot NW_B \tag{A98}$$

$$\frac{V_B^{PUR}}{E(NFW_B)} = \lambda_{1,0}^B + \lambda_{1,1}^B \cdot E(r_V) + \lambda_{1,2}^B \cdot \Pi_B + \lambda_{1,3}^B \cdot E(r_{BA}) \tag{A99}$$

$$\frac{B_B}{E(NFW_B)} = \lambda_{2,0}^B + \lambda_{2,1}^B \cdot E(r_V) + \lambda_{2,2}^B \cdot \Pi_B + \lambda_{2,3}^B \cdot E(r_{BA}) \tag{A100}$$

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

$$OFIN_B = \sigma_{OFIN}^B \cdot NW_B \tag{A101}$$

V. *Foreign sector*

$$GDP_{RoW} = GDP - (GDP_H + GDP_F + GDP_G + GDP_B) \tag{A102}$$

$$NL_{RoW} = -(NL_H + NL_F + NL_G + NL_B) \tag{A103}$$

$$\begin{aligned} L_{RoW} = {} & \Phi_L^1 \cdot L_{RoW,-1} + \Phi_L^2 \cdot r_{ECB,-1} + \Phi_L^3 \cdot GDP_{RoW,-1} + \\ & + \Phi_L^4 \cdot NER + \Phi_L^5 \cdot (IMP_{-1} + EXP_{-1}) + \Phi_L^6 \cdot (IMP_{-1} - EXP_{-1}) \end{aligned} \tag{A104}$$

$$D_{RoW} = \Phi_D^1 \cdot L_{RoW,-1} + \Phi_D^2 \cdot GDP_{RoW,-1} + \Phi_D^3 \cdot (IMP_{-1} + EXP_{-1}) + \\ + \Phi_D^4 \cdot (IMP_{-1} - EXP_{-1}) + \Phi_D^5 \cdot r_{BA,-1} + \Phi_D^6 \cdot GDP_{-1} \tag{A105}$$

$$EXP = \mu_1^X \cdot EXP_{-1} + \mu_2^X \cdot d(PROD_L) + \mu_3^X \cdot d(IMP) + \mu_4^X \cdot d(NER) \tag{A106}$$

$$B_{RoW} = s^1 \cdot r_Z + s^2 \cdot r_{ECB} + s^3 \cdot r_{BA} + s^4 \cdot NER + s^5 \cdot r_V \tag{A107}$$

$$V_{RoW} = V_H + V_G - (V_F + V_B) \tag{A108}$$

$$INT_{RoW} = INT_H + INT_B - (INT_F + INT_G) \tag{A109}$$

$$T_{RoW} = \alpha_{RoW}^T \cdot GDP \tag{A110}$$

$$\tau_{RoW} = \theta_{RoW} \cdot GDP \tag{A111}$$

VI. *Cross-sector holdings and payments*

VI.1 *Equity and shares issued by NFCs*

$$V_F = V_{F,H} + V_{F,G} + V_{F,B} \tag{A112}$$

$$V_{F,B} = x_F \cdot V_B^{PUR} \tag{A113}$$

$$V_{F,H} = x_F \cdot V_H \tag{A114}$$

$$V_{F,G} = x_F \cdot V_G \tag{A115}$$

Note: $x_F = \%$ of NFC equity to total equity.

VI.2 *Equity and shares issued by financial sector*

$$V_B = V_B^{PUR} - V_B^{ISS} \tag{A116}$$

$$V_B^{ISS} = V_{B,H} + V_{B,G} \tag{A117}$$

$$V_{B,H} = x_B \cdot V_H \tag{A118}$$

$$V_{B,G} = x_B \cdot V_G \tag{A119}$$

Note: $x_B = \%$ of financial sector's equity to total equity.

VI.3 *Equity and shares issued by foreign sector*

$$V_{ROW,H} = (1 - x_F - x_B) \cdot V_H \tag{A120}$$

$$V_{ROW,G} = (1 - x_F - x_B) \cdot V_G \tag{A121}$$

$$V_{ROW,B} = x_B \cdot V_{ROW} \tag{A122}$$

VI.4 *Total equity and shares issues*

$$V_{TOT} = V_F + V_B^{ISS} + V_{ROW} \tag{A123}$$

VI.5 *Dividends received by households*

$$DIV_H = DIV_{TOT} - DIV_{F,G} - DIV_{F,B} - DIV_{F,ROW} \tag{A124}$$

$$DIV_{TOT} = DIV_F + (-DIV_B^{PAID}) + (-DIV_{ROW}^{PAID}) \tag{A125}$$

$$DIV_{F,H} = DIV_F - DIV_{F,G} - DIV_{F,B} - DIV_{F,ROW} \tag{A126}$$

$$DIV_{B,H} = -DIV_B^{PAID} - DIV_{B,ROW} \tag{A127}$$

$$DIV_{ROW,H} = -perc_{ROW}^{DIV} \cdot DIV_H \tag{A128}$$

Note: $perc_{ROW}^{DIV}$ = % of of total dividends paid by foreign sector.

VI.6 *Dividends received by government*

$$DIV_G = e_G \cdot \frac{V_G}{V_{TOT}} \tag{A129}$$

$$DIV_{F,G} = perc_F^{DIV} \cdot DIV_G \tag{A130}$$

$$DIV_{ROW,G} = perc_{ROW}^{DIV} \cdot DIV_G \tag{A131}$$

$$DIV_{B,G} = perc_B^{DIV} \cdot DIV_G \tag{A132}$$

Note: $perc_F^{DIV}$ = % of of total dividends paid by NFCs; $perc_B^{DIV}$ = % paid by financial sector.

VI.7 *Dividends received by financial sector*

$$DIV_B^{RECV} = e_B \cdot DIV_{TOT} \cdot \frac{V_B^{PUR}}{V_{TOT}} \tag{A133}$$

$$DIV_{F,B} = perc_F^{DIV} \cdot DIV_B^{RECV} \tag{A134}$$

$$DIV_{ROW,B} = perc_{ROW}^{DIV} \cdot DIV_B^{RECV} \tag{A135}$$

$$DIV_B^{PAID} = (1 - s_B) \cdot \Pi_B \tag{A136}$$

$$DIV_B = DIV_B^{RECV} + DIV_B^{PAID} \tag{A137}$$

Note: e_B = correction coefficient for dividends received by financial sector.

VI.8 *Dividends received by foreign sector*

$$DIV_{ROW}^{RECV} = e_{ROW} \cdot DIV_{TOT} \cdot \frac{V_{ROW}^{PUR}}{V_T OT} \tag{A138}$$

$$V_{ROW}^{PUR} = V_{ROW} \ for \ V_{ROW} > 0 \tag{A139}$$

$$DIV_{F,ROW} = perc_F^{DIV} \cdot DIV_{ROW}^{RECV} \tag{A140}$$

$$DIV_{B,ROW} = perc_B^{DIV} \cdot DIV_{ROW}^{R} ECV \quad \text{(A141)}$$

$$DIV_{ROW}^{PAID} = DIV_{ROW,H} + DIV_{ROW,G} + DIV_{ROW,B} \quad \text{(A142)}$$

$$DIV_{ROW} = DIV_{ROW}^{PAID} + DIV_{ROW}^{RECV} \quad \text{(A143)}$$

Note: e_{ROW} = correction coefficient for dividends received by foreign sector.

VI.9 *Securities demanded by NFCs*

$$B_F = B_{F,B} + B_{F,H} + B_{F,ROW} \quad \text{(A144)}$$

$$B_{F,B} = q_F \cdot B_B \quad \text{(A145)}$$

$$B_{F,H} = q_F \cdot B_H \quad \text{(A146)}$$

$$B_{F,ROW} = q_F \cdot B_R OW \quad \text{(A147)}$$

Note: q_F = percentage of NFC securities to total securities.

VI.10 *Securities issued by government sector*

$$B_G = B_{G,H} + B_{G,ROW} + B_{G,B} + B_{G,F} \quad \text{(A148)}$$

$$B_{G,H} = B_H \cdot (1 - q_F) \quad \text{(A149)}$$

$$B_{G,ROW} = (1 - q_F) \cdot B_{ROW} \quad \text{(A150)}$$

$$B_{G,B} = (1 - q_F) \cdot B_B \quad \text{(A151)}$$

$$B_{G,F} = q_{GF} \cdot B_G \quad \text{(A152)}$$

Note: q_{FG} = net percentage of T-bonds purchased by NFCs.

VI.11 *Interests paid by NFCs*

$$INT_{F,H} = INT_H \cdot i_F \quad \text{(A153)}$$

$$INT_{F,B} = INT_B \cdot i_F \quad \text{(A154)}$$

$$INT_{F,ROW} = INT_{ROW} \cdot i_F \quad \text{(A155)}$$

Note: i_F = percentage of interest payments made by NFCs to total interests.

VI.12 *Interests paid by government*

$$INT_{G,B} = INT_B - INT_{F,B} \quad \text{(A156)}$$

$$INT_{G,H} = INT_H - INT_{F,H} \quad \text{(A157)}$$

$$INT_{G,ROW} = INT_{ROW} - INT_{F,ROW} \quad \text{(A158)}$$

VII. *Central bank stance and interest rates*

$$r_{ECB} = \bar{r}_{ECB}$$

$$r_Z = \bar{r}_Z$$

$$NER = N\bar{E}R$$

$$r_{L,F} = r_{ECB} + \mu_{L,F} \tag{A159}$$

$$r_{BA} = r_Z \cdot (1 + \mu_{BA}) \tag{A160}$$

$$\mu_{BA} = \frac{SPREAD_A}{r_Z} \tag{A161}$$

Appendix B - The housing market

While data on housing market have become increasingly available after the US financial crisis of 2007-2008, there are still some gaps. Following Burgess et al. (2016), a simple way to proceed is to assume that the supply of new housing grows at an exogenous rate, g_H:

$$NHOUSE_s = NHOUSE_{s,-1} \cdot (1 + g_H) \tag{A162}$$

The quantity (number) of housing transactions is simply modelled as a linear function of the change in housing price:[37]

$$NHOUSE_d = h_0 + h_1 \cdot d(p_H) \tag{A163}$$

where h_0 and h_1 are empirically estimated coefficients.

The housing price index is defined as a function of households' debt to income ratio ($MORT_H/YD_H$), the expected disposable income and the stock of housing:

$$p_H = h_3 \cdot \frac{MORT_H}{YD_H} \cdot \frac{E(YD_H)}{HOUSE_H} \tag{A164}$$

where the percentage h_3 is an empirically estimated coefficient and $HOUSE_H$ is the stock of housing.

Capital gains/losses on housing can be also calculated:

$$CG_H = HOUSE_{H,-1} \cdot d(p_H) \tag{A165}$$

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

$$INV_H = \vartheta_0 + \vartheta_1 \cdot INV_{H,-1} + \vartheta_2 \cdot MORT_{H,-1} + \vartheta_3 \cdot p_{H,-1} \tag{A166}$$

Housing market main variables are displayed by Figure 12.

[37] Data on transactions are borrowed from the ECB Statistical Data Warehouse (available at: *http://sdw.ecb.europa.eu/*).

B Tables and figures

Table 1: Fine-tuned parameters

Description	Parameter values
Weight on past errors in expectations	$\upsilon = 0.000$
% of NPBL 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)	$p_B = 1.000$
Growth rate of new housing supply	$g_H = 0.010$

Figure 1: The full TFM (Italy, 2015, c.p., million euro) - Excel sheet

Entries (Italy, 2015)	Eurostat Code	Non-Financial Corporation S11	Financial Corporations 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 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
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

Figure 2: The simplified TFM (Italy, 2015, c.p., million euro) - Excel sheet

Entries (Italy, 2015)	Eurostat Code	Non-Financial Corporation S11	(capital)	Financial Corporations 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	= -Σ	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	-1206	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

Figure 3: The super-simplified TFM (Italy, 2015, c.p., million euro) - Excel sheet

Entries (Italy, 2015)	Eurostat Code	Non-Financial Corporation S11	(capital)	Financial Corporations S12	Government S13	Households S14_S15	Rest of World S2	Total economy (row total) S1
GDP Redistribution		-909915	= -Σ	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	4271	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

Figure 4: Sectoral balance sheets (Italy, 2015, c.p., million euro) - Excel sheet

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	2,027,611.0	-1,701,602.0	75,877.0	239,722.0	-163,845.0	1,273,045.0	0.0	1,273,045.0
Securities other than shares	F3	57,048.0	145,902.0	-88,854.0	1,675,684.0	540,827.0	1,134,857.0	27,908.0	2,097,250.0	-2,069,342.0	413,008.0	0.0	413,008.0
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	475,698.0	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	862,636.0	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 accounts receivable/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.

Figure 5: Programs' structure

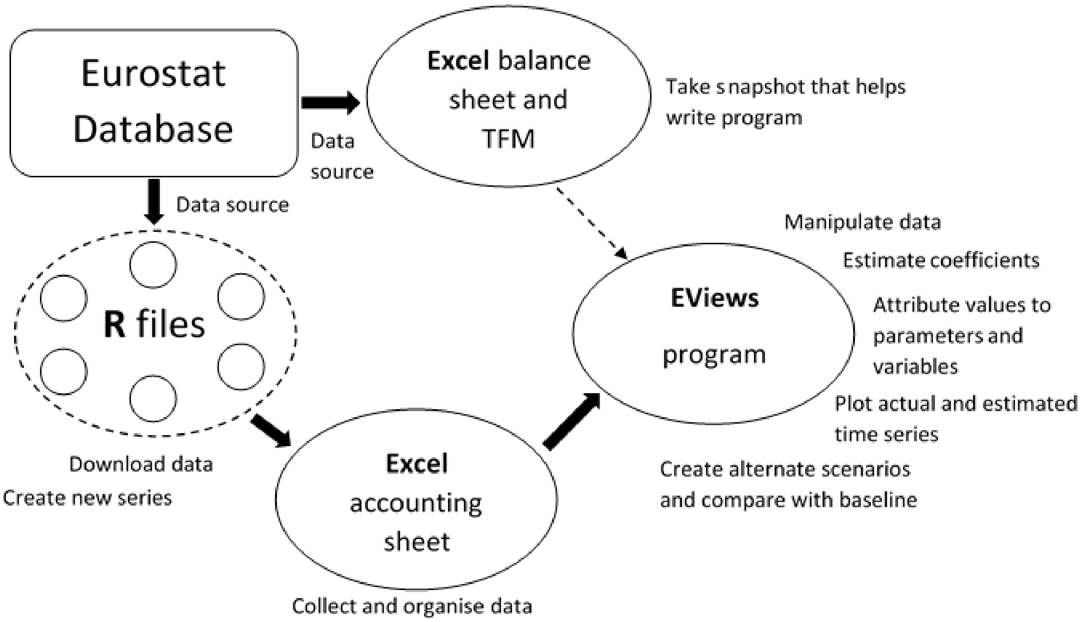

Figure 6: Cross-sector financial balances since 1996 (forecast after 2016)

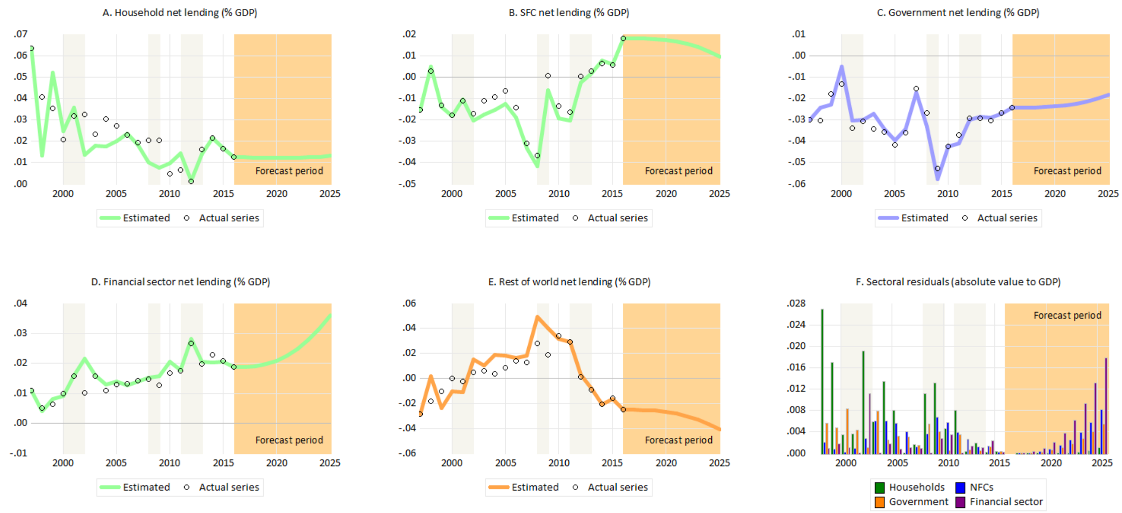

Figure 7: ESSFC model's dependency graph

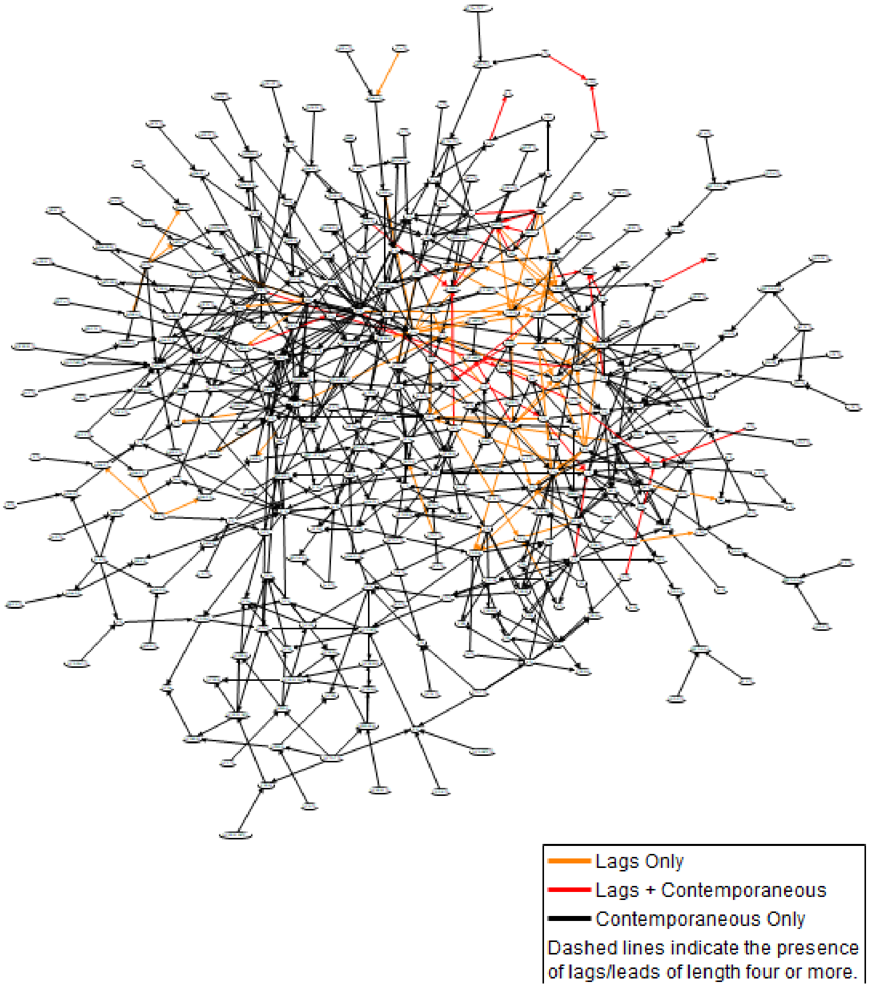

Figure 8: ESSFC reaction following shocks to government spending

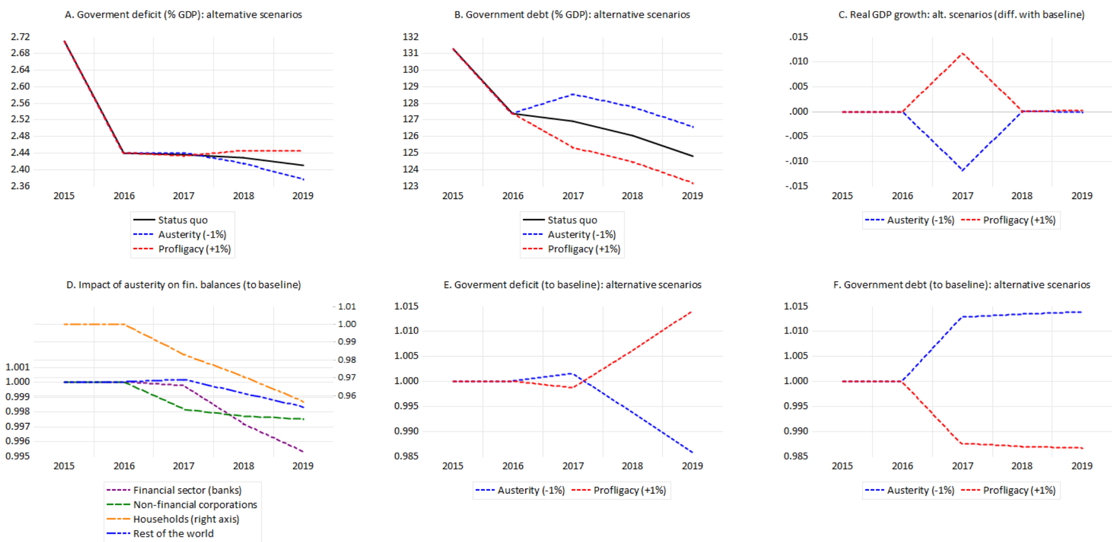

Figure 9: ESSFC reaction following shocks to government spending (cont'd)

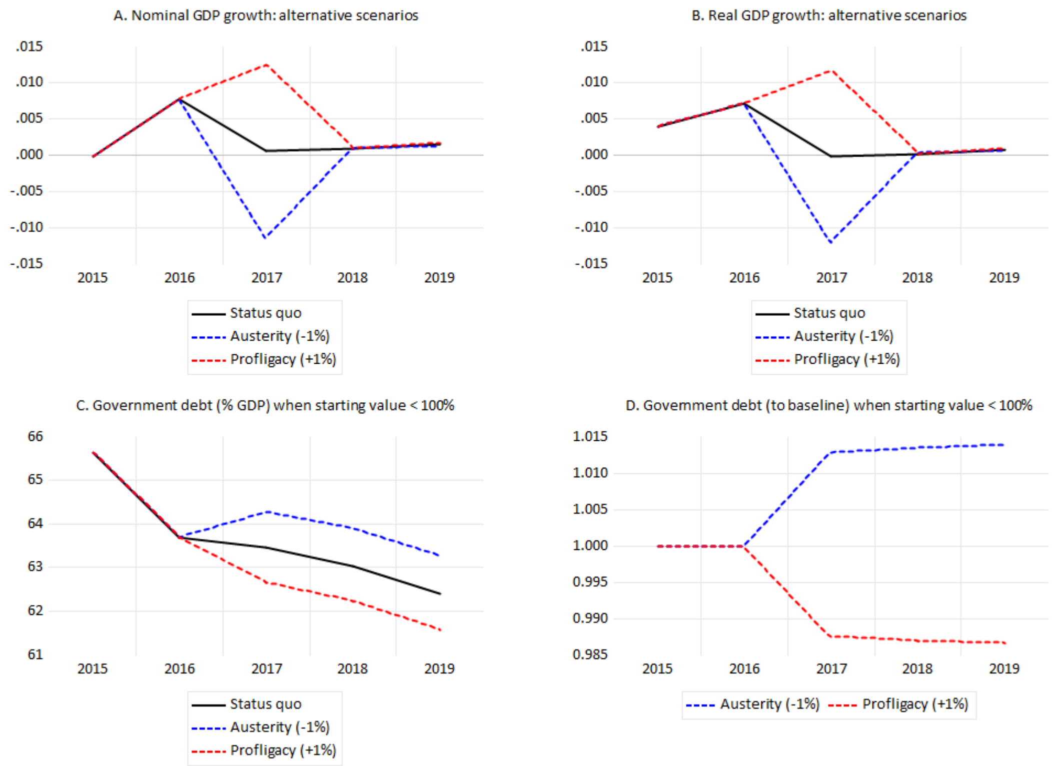

Figure 10: Net lending ratios: stochastic simulations

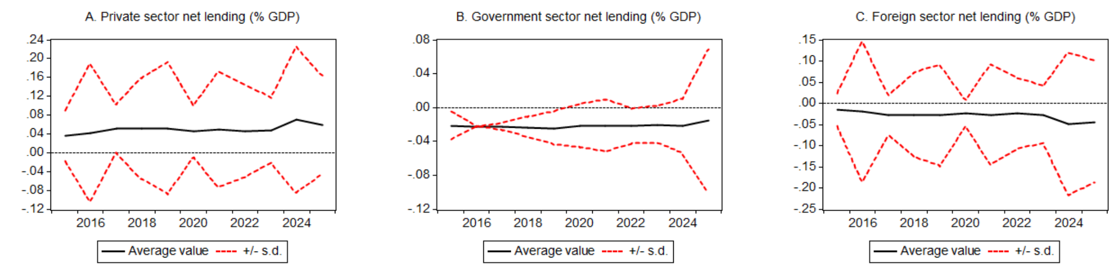

Figure 11: ESSFC position along Pagan's 'best practice' frontier of models

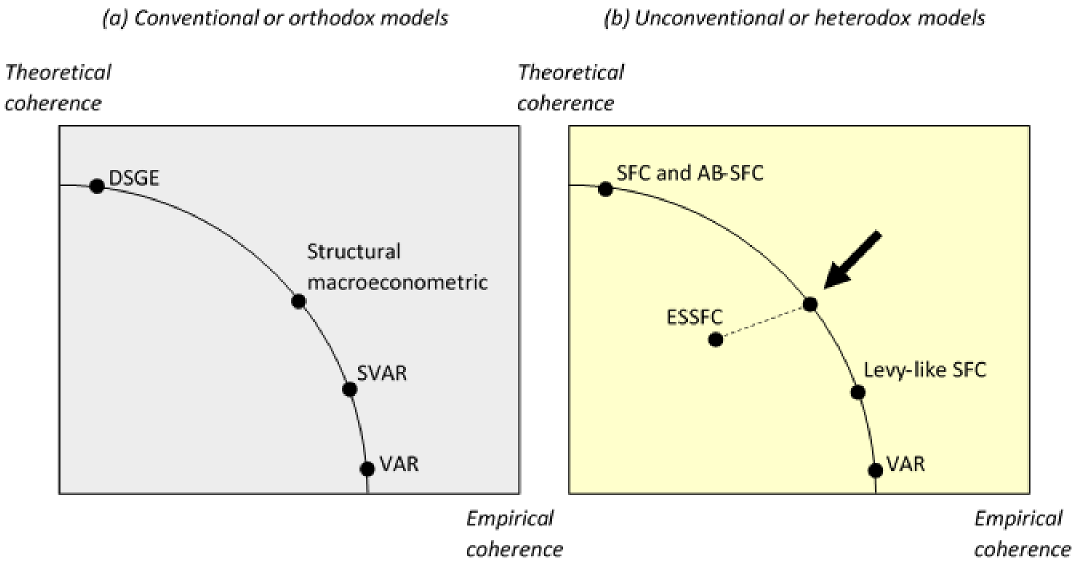

Figure 12: The housing market