Working Paper

Unconventional monetary policy in an econometric SFC model of the French economy: Some lessons for financing the low-carbon transition

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Unconventional monetary policy in an econometric SFC model of the French economy: Some lessons for financing the low-carbon transition

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1. Introduction

The founding works of Godley and Lavoie (Godley, 1999; Lavoie and Godley, 2001; Godley and Lavoie, 2007) were well-adapted to study financialized economies as well as the international imbalances of the 1990s and 2000s. In the 2010s better calibrated or econometrically-based SFC models became more frequent. The Levy model of the US (Godley et al., 2005) was a forerunner. The Cambridge Alphametrics Model (CAM), for the world economy with 10 regions, also appears as a pioneer (for a recent presentation see Cripps, 2014). The econometric SFC model of the Italian economy (Zezza and Zezza, 2020) seems the most complete version. In France the accumulation accounts (*comptes de patrimoine*) from INSEE and the financial accounts by Bank of France provide a detailed statistical framework, well-adapted for an econometric SFC model. It is in this perspective that a first version of an econometric SFC model of the French economy has been presented (Mazier and Reyes, 2022). This paper is based on the same model with a more developed treatment of interest rates and of the central bank. It is organized as follows. A second part presents the overall structure of the model, a third one describes the main equations and displays the simulations in the past. A fourth section is devoted to unconventional monetary policies, helicopter money and a partial cancellation of debt held by the central bank. The last part concludes.[2]

2. The overall structure of the model

The structure of the model is analogous to that of already existing national-level SFC models. The economy is divided into five domestic agents; firms, households, banks, the central bank, the government, all of which interact with the rest of the world. The monetary and financial operations from the European Central Bank are included with the rest of the world (which is in a way quite symbolic) in the statistical conventions adopted.

The model is aggregate with a single product. Production (in volume, at constant prices) is determined by domestic demand (investment and change in inventories by firms, consumption and investment from households, the government and banks) and foreign demand (exports net of imports). A supply constraint is introduced and results, at this stage of the model, in a simple production function that determines potential output and allows for

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[2] The complete working paper of the first version and the technical documentation are available on the website of the *Chaire Energie et Prospérité*.

computation of an output gap. The general price level depends on a mark-up pricing rule, and is a function of unit labor costs with an effect from demand pressures. Value added is calculated from GDP in value after deduction of the VAT and import duties and taxes. This value added is split among the different agents depending on simple structural parameters. Its distribution between wages, profits, social contributions, taxes and other redistribution operations is described in order to arrive at the balance of the agents' accounts, taking into account their expenditures: disposable income, savings and financing capacity/need. Exports and imports are analyzed at the level of all goods and services according to demand (foreign and domestic, respectively) and relative prices.

Financing methods via bank credit, bond and equity issuing, as well as financial investment behavior are then described for each agent. An adjustment item is the statistical discrepancy between the real sector accounts from INSEE and the financial accounts by Bank of France. Changes in assets and liabilities, as well as investments and changes in inventories, combined with the revaluation accounts for capital gains or losses, allow for the transition of the accumulation accounts from one year to the next in an SFC manner. The treatment of Other Changes in Volume (OCV) and of revaluations is important and rather technical. Without delving into the details, it suffices to say that for each item of the balance sheet an OCV or asset price must be added in order to ensure stock-flow consistency (see appendix). Table 1 provides the balance sheet structure of the domestic and foreign sectors and gives the definition of the main variables of the model.

With respect to non-financial assets, a distinction is made between produced capital (productive capital and housing), outstanding stocks and non-produced capital (land), the sharp rise in price of which is one of the characteristics of financialized capitalism and has had a significant macroeconomic impact.

Among the financial assets, a split is made traditionally between monetary gold and SDRs, cash and deposits, securities, loans, equities, insurance and pension funds, financial derivatives and other accounts receivable. For a better understanding of monetary policy, deposits are analyzed in more detail with a subdivision between bills and coins, refinancing between financial institutions, bank reserves, the government account at the central bank, TARGET2 and other deposits. Two items deserve particular attention. On the one hand, the government's account at the central bank is isolated in order to study the effects of helicopter money. On the other hand, TARGET2 corresponds to the balance of the real and financial exchanges between France and the rest of the Eurozone. They are, respectively, on the asset side of Bank of France and on the liability side for the ECB, thus appearing in the column rest of the world in the convention that has been adopted, and are considered exogenous because their determinants lie largely outside of the model. Securities are split between public securities (bonds issued by the government), other domestic securities issued by firms and financial institutions and foreign securities issued by the rest of the world and held by domestic agents. Equities are also split between domestic equities issued by firms and financial institutions and foreign equities issued by the rest of the world and held by domestic agents.

The main closures are the following:

- Firms balance their accounts by issuing the necessary shares.
- Households balance their account by getting into debt with banks.
- Bank reserves balance the banks' accounts.
- The equilibrium between assets and liabilities of the central bank corresponds to the missing equation of the model, deducted from the writing of the other balances.
- Public debt, in the form of bank debt and bonds, balances the government's account.
- Deposits on the liability side, as representative of foreign deposits held by domestic agents, adjust the rest of the world's account.
- Banks absorb all public bonds available and extend credit without restriction.
- Banks balance the market of private domestic bonds and the market of domestic equities, the price of which depends on the price of foreign equity, which has a dominant effect.
- Foreign bonds and equity issued by the rest of the world equal their domestic demand.

Table 1 Symbolic balance sheet structure of economic agents

		Non-Fin. Corporations		Financial institutions				Government		Households + NPISH		Rest of the world	
				Banks		Banque de France							
		Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.
ANF_1	Produced non-financial assets	$p_{K_1}^F K_1^F$		$p_{K_1}^B K_1^B$				$p_{K_1}^G K_1^G$		$p_{K_1}^H K_1^H$			
ANF_{12}	Inventories (12) + valuables (13)	$p_{K_{12}}^F K_{12}^F$						$p_{K_{12}}^F K_{12}^F$		$p_{K_{12}}^F K_{12}^F$ $p_{K_{13}}^F K_{13}^F$			
ANF_2	Non-produced non-financial assets	$p_{K_2}^F K_2^F$		$p_{K_2}^B K_2^B$				$p_{K_2}^G K_2^G$		$p_{K_2}^H K_2^H$			
F_1	Monetary gold and SDRs					$p_G^{CB} G^{CB}$							$p_G^{CB} G^{CB}$
F_2	Bills and coins	H^F		H^B			H			H^H		H^R	
	Refinancing between financial institutions				RF	RF^{CB}							RF^R
	Bank reserves			RES			RES						
	Govt. account at CB						$D_L^{CB_G}$	$D_A^{CB_G}$					
	Target 2					$TRGT2$							$TRGT2$
	Deposits	D_A^F		D_A^B	D_L^B	D_A^{CB}	D_L^{CB}	D_A^G	D_L^G	D_A^H		D_A^R	D_L^R
F_3	Public securities	$p_{B_A}^{F_G} B_A^{F_G}$		$p_{B_A}^{B_G} B_A^{B_G}$		$p_{B_A}^{CB_G} B_A^{CB_G}$			$p_{B_L}^G B_L^G$			$p_{B_A}^{R_G} B_A^{R_G}$	
	Foreign securities	$p_{B_A}^{F_R} B_A^{F_R}$		$p_{B_A}^{B_R} B_A^{B_R}$		$p_{B_A}^{CB_R} B_A^{CB_R}$		$p_{B_A}^{G_R} B_A^{G_R}$		$p_{B_A}^{H_R} B_A^{H_R}$			$p_{B_L}^R B_L^R$
	Other securities		$p_{B_L}^F B_L^F$	$p_{B_A}^B B_A^B$	$p_{B_L}^B B_L^B$	$p_{B_A}^{CB} B_A^{CB}$		$p_{B_A}^G B_A^G$		$p_{B_A}^H B_A^H$		$p_{B_A}^R B_A^R$	
F_4	Loans	L_A^F	L_L^F	L_A^B		L_A^{CB}			L_L^G		L_L^H	L_A^R	L_L^R
F_5	[Domestic] Equity and inv. fund shares	$p_{E_A}^{F_{FR}} E_A^{F_{FR}}$	$p_{E_L}^F E_L^F$	$p_{E_A}^{B_{FR}} E_A^{B_{FR}}$	$p_{E_L}^B E_L^B$	$p_{E_A}^{CB_{FR}} E_A^{CB_{FR}}$	$p_{E_L}^{CB} E_L^{CB}$	$p_{E_A}^{G_{FR}} E_A^{G_{FR}}$		$p_{E_A}^{H_{FR}} E_A^{H_{FR}}$		$p_{E_A}^R E_A^R$	
	[Foreign] Equity and inv. fund shares issued by RoW	$p_{E_A}^{F_R} E_A^{F_R}$		$p_{E_A}^{B_R} E_A^{B_R}$		$p_{E_A}^{CB_R} E_A^{CB_R}$		$p_{E_A}^{G_R} E_A^{G_R}$		$p_{E_A}^{H_R} E_A^{H_R}$			$p_{E_L}^R E_L^R$
F_6	Insurance. pension funds and s.g.s.	A_A^F			A_L^B			A_A^G		A_A^H		A_A^R	
F_7	Fin. derivatives and employee stock options	X_A^F			X_L^B			X_A^G		X_A^H			X_A^R
F_8	Other accounts receivable/payable	Z^F		Z^B		Z^{CB}		Z^G		Z^H		Z^R	
F	**Financial wealth**		$\boldsymbol{FW^F}$		$\boldsymbol{FW^B}$		$\boldsymbol{FW^{CB}}$		$\boldsymbol{FW^G}$		$\boldsymbol{FW^H}$		$\boldsymbol{FW^R}$
B90	**Net worth**		$\boldsymbol{WLTH^F}$		$\boldsymbol{WLTH^B}$		$\boldsymbol{WLTH^{CB}}$		$\boldsymbol{WLTH^G}$		$\boldsymbol{WLTH^H}$		$\boldsymbol{WLTH^R}$

Closes the column (sector) in flow

Closes the row (instrument) in flow

3. The main equations

3.1. Firms

Firms have an accumulation rate of productive capital $\left(\frac{\Delta^* K_1^F}{K_{1-1}^F}\right)$ that depends on four variables, following a Kaleckian logic; the lagged profit rate related to total capital $\left(\frac{\Pi^F{}_{-1}}{p_{K_{1-1}}^F K_{1-2}^F + p_{K_{2-1}}^F K_{2-2}^F}\right)$ including the value of land ($p_{K_2}^F K_2^F$); the real interest rate[3] $(r_L^F - \pi_Y)$ and financial profitability ($r_{E_A}^F - \pi_Y$, where π_Y is the inflation rate), both with a negative sign; the debt structure is represented as the debt-to-own funds ratio $\left(\frac{L_L^F}{p_{E_L}^F E_L^F + WLTH^F}\right)$, also with a negative effect. Financial profitability of equities held is the sum of revaluation and dividends received divided by the stock of equity of the previous period $r_{E_A}^F = \left(\frac{E_{A-1}^F \Delta p_{E_A}^F + Div_r^F}{p_{E_{A-1}}^F E_{A-1}^F}\right)$. It is mainly driven by the growth rate of the price of equities. A version with the output gap (GAP) was tested but is not used in this version of the model. Inventories stock (K_{12}^F) follows a simple accelerator model.

$$\left(\frac{\Delta^* K_1^F}{K_{1-1}^F}\right) = 0.02 + 0.1\left(\frac{\Pi^F{}_{-1}}{p_{K_{1-1}}^F K_{1-2}^F + p_{K_{2-1}}^F K_{2-2}^F}\right) - 0.1(r_L^F - \pi_Y) - 0.02\left(r_{E_A}^F - \pi_Y\right) - 0.03\left(\frac{L_L^F}{p_{E_L}^F E_L^F + WLTH^F}\right)$$

$$\Delta \ln(K_{12}^F) = -0.01 + 0.8\Delta \ln(K_{12-1}^F) + 1.2\Delta \ln(va^F) - 0.6\Delta \ln(va_{-1}^F)$$

In financialized capitalism, firms tend to favor financial accumulation $\left(\frac{\Delta^* E_A^F}{E_{A-1}^F}\right)$ at the expense of productive accumulation. This translates into a financial accumulation rate that is an increasing function of the profit rate $\left(\frac{\Pi^F}{p_{K_1}^F K_{1-1}^F + p_{K_{12}}^F K_{12-1}^F + p_{K_2}^F K_{2-1}^F}\right)$ and of financial profitability of equities held $(r_{E_{A-1}}^F - \pi_{Y-1})$, where indebtedness as a ratio of own-funds $\left(\frac{L_L^F}{p_{E_L}^F E_L^F + WLTH^F}\right)$ plays a supporting role. A split between domestic (E_A^{FFR}) and foreign equity (E_A^{FR}) is also done.

$$\left(\frac{\Delta^* E_A^F}{E_{A-1}^F}\right) = 0.35\left(\frac{\Pi^F}{p_{K_1}^F K_{1-1}^F + p_{K_{12}}^F K_{12-1}^F + p_{K_2}^F K_{2-1}^F}\right) + 0.02\left(r_{E_{A-1}}^F - \pi_{Y-1}\right) + 0.01\left(\frac{L_L^F}{p_{E_L}^F E_L^F + WLTH^F}\right)$$

$$p_{E_A}^{FR} E_A^{FR} = p_{E_A}^F E_A^F - p_{E_A}^{FFR} E_A^{FFR}$$

The change in firms' deposits as % of GDP $\left[\Delta\left(\frac{D_A^F}{p_Y Y}\right)\right]$ and the flow of inter-firm credits[4] as a share of firm's value added $\left(\frac{\Delta^* L_A^F}{VA^F}\right)$, i.e. credit granted by firms to themselves, are the subject of a simplified model in which the real 10-year interest rate (with a negative sign) and the firms' indebtedness (as a liability) intervene respectively.

$$\Delta\left(\frac{D_A^F}{p_Y Y}\right) = 0.004 + 0.6\Delta\left(\frac{D_{A-1}^F}{p_{Y-1} Y_{-1}}\right) - 0.06\left(i_{10yrs} - \pi_Y\right)$$

$$\left(\frac{\Delta^* L_A^F}{VA^F}\right) = 0.49\left(\frac{\Delta^* L_{A-1}^F}{VA^F{}_{-1}}\right) + 0.51\left(\frac{\Delta^* L_L^F}{VA^F}\right) - 0.25\left(\frac{\Delta^* L_{L-1}^F}{VA^F{}_{-1}}\right)$$

[3] r_L^F is the apparent interest rate, calculated as the ratio of interests paid by firms and the stock of indebtedness from the previous period.

[4] Given the presence of the other changes in volume in the flow-stock equations, the flow of an instrument like inter-firm lending is not $\Delta L_A^F = L_A^F - L_{A-1}^F$ but rather $\Delta^* L_A^F = L_A^F - L_{A-1}^F - OCV_{L_A}^F$.

In the medium-term[5] firms' debt structure, as a ratio of total non-financial capital $\left(\frac{p_{BL_L}^F BL_L^F}{p_{K_1}^F K_1^F + p_{K_{12}}^F K_{12}^F + p_{K_2}^F K_2^F}\right)$, depends positively on the profit rate and negatively on the real interest rate[6] $(i_{10years} - \pi_Y)$. More than a debt behavior, it is an indebtedness norm, which reflects a given institutional relation between firms and banks. A split between bank debt (L_L^F) and bonds ($p_{B_L}^F B_L^F$) is also made. Equities issued ($p_E^F \Delta^* E_L^F$) close the firms' account.

$$\left(\frac{p_{BL_L}^F BL_L^F}{p_{K_1}^F K_1^F + p_{K_{12}}^F K_{12}^F + p_{K_2}^F K_2^F}\right) = 7.7\left(\frac{\Pi^F}{p_{K_1}^F K_{1-1}^F + p_{K_{12}}^F K_{12-1}^F + p_{K_2}^F K_{2-1}^F}\right) - 3.2(i_{10years} - \pi_Y)$$

$$\left(\frac{p_{B_L}^F B_L^F}{p_{BL_L}^F BL_L^F}\right) = 0.9\left(\frac{p_{B_{L-1}}^F B_L^F}{p_{BL_{L-1}}^F BL_{L-1}^F}\right) + 0.002\ln(p_{B_L}^F)$$

$$\Delta^* L_L^F = p_{BL_L}^F \Delta^* BL_L^F - p_{B_L}^F \Delta^* B_L^F$$

$$p_E^F \Delta^* E_L^F = p_{I_1}^F I_1^F + p_{I_{12}}^F I_{12}^F + \Delta^* H^F + \Delta^* D_A^F + p_{B_A}^{F_G} \Delta^* B_A^{F_G} + p_{B_A}^{F_R} \Delta^* B_A^{F_R} + \Delta^* L_A^F + p_{E_A}^F \Delta^* E_A^F + \Delta^* A_A^F + \Delta^* X^F + \Delta^* Z^F - p_{B_L}^F \Delta^* B_L^F - \Delta^* L_L^F - S^F + NP^F - Tr_{K_r}^F - Adj^F$$

3.2. Households

Household consumption (C^H) depends on disposable income $\left(\frac{Y_d^H}{p_C{}^H}\right)$ and a wealth effect $\left(\frac{WLTH^H}{p_C{}^H}\right)$, where $p_C{}^H$ stands for the consumer price index. Apart from disposable income, household investment (I_1^H) is a function of the real interest rate $(i_{10years} - \pi_I^H)$ with a negative effect and of the growth rate of the land price ($p_{K_2}^H$), which contributes to enhance the housing boom. The price of land is itself a function of household investment.

$$\ln(C^H) = 0.6 + 0.83\ln\left(\frac{Y_d^H}{p_C{}^H}\right) + 0.06\ln\left(\frac{WLTH^H}{p_C{}^H}\right)$$

$$\ln(I_1^H) = 1.1 + 0.5\ln\left(\frac{Y_d^H}{p_I^H}\right) - 0.9(i_{10years} - \pi_I^H) + 0.2\left(\frac{\Delta p_{K_2}^H}{p_{K_2-1}^H}\right)$$

$$\ln(p_{K_2}^H) = 26 + 5.4\ln(I_1^H)$$

Household deposits (D_A^H) are modeled in a simple way, as percentage of disposable income. Bank deposits depend on the 10-year real interest rate with a negative sign. Equity purchases ($p_{E_A}^H E_A^H$) are a function of the financial rate of return ($r_{E_A}^H - \pi_C^H$) and the 10-year real interest rate with a negative sign. There is a split between foreign ($p_{E_A}^{H_R} E_A^{H_R}$) and domestic ($p_{E_A}^{H_{FR}} E_A^{H_{FR}}$) equities held by households. Insurance purchases (A_A^H) are related to the weight of the eldest (60 or older) in total population $DepRatio_{old}$, supplemented in the short-term by a positive effect of the real 10-year interest rate and financial profitability. Loans (L_L^H) close households' account.

$$\left(\frac{D_A^H}{Y_d^H}\right) = 0.9 - 1.04(i_{10yrs-1} - \pi_{C-1}^H)$$

$$\left(\frac{p_{E_A}^H E_A^H}{Y_d^H}\right) = 0.87 + 2.2(r_{E_A}^H - \pi_C^H) - 3.1(i_{10years} - \pi_C^H)$$

[5] For the equations estimated with an error correction model only the medium-term relationship is shown.
[6] $i_{10years}$ is the interest rate on 10-year government bonds.

$$p_{E_A}^{H_R} E_A^{H_R} = p_{E_A}^{H} E_A^{H} - p_{E_A}^{H_{FR}} E_A^{H_{FR}}$$

$$\left(\frac{A_A^H}{Y_d^H}\right) = -2.7 + 0.13(DepRatio_{old})$$

$$\Delta^* L_L^H = p_{I_1}^H I_1^H + p_{I_{12}}^H I_{12}^H + \Delta^* H^H + \Delta^* D_A^H + p_{B_A}^{H_R} \Delta B_A^{H_R} + p_{B_A}^H \Delta^* B_A^H + p_{E_A}^H \Delta^* E_A^H + \Delta^* A_A^H + \Delta^* Z^H - S^H + NP^H + Tr_{K_p}^H - Adj^H$$

3.3. Banks

Banks are accommodating in the current version of the model. They grant all credit requested ($\Delta^* L_A^B$), buy all public bonds available ($p_{B_A}^{B_G} \Delta^* B_A^{B_G}$) and balance the market of domestic private bonds ($p_{B_L}^B \Delta^* B_L^B$), as well as domestic equities ($p_E^{FR} \Delta^* E_L^B$). The rate of accumulation of foreign securities ($\frac{\Delta^* B_A^{B_R}}{B_{A-1}^{B_R}}$) depends on foreign-domestic long-term interest rates differential ($i^{LTcr} - i^{LT*}$). The demand for private domestic securities ($p_{B_A}^B \Delta^* B_A^B$) depends of the domestic rate of growth and of the domestic-foreign interest rate differential after exchange rate adjustment ($r_A^B - i_{10yr}^* + \frac{\Delta NEER}{NEER_{-1}}$). Bank financial accumulation rate $\left(\frac{\Delta^* E_A^B}{E_{A-1}^B}\right)$ depends on financial profitability lagged one period $\left(r_{E_{A-1}}^B - \pi_{Y-1}\right)$. There is a split between foreign and domestic equities $\left(\frac{p_{E_A}^{B_R} E_A^{B_R}}{p_{E_A}^B E_A^B}\right)$ depending on exchange rate variation. Banks collect the net deposits (D_L^B), insurance policies (A_L^B) and financial derivatives (X_L^B). Last, banks' reserves (RES) close the banks' account.

$$\Delta^* L_A^B = \Delta^* L_L^F + \Delta^* L_L^G + \Delta^* L_L^H + p_{L_L}^R \Delta^* L_L^R - \Delta^* L_A^F - p_{L_A}^R \Delta^* L_A^R - \Delta^* L_A^{CB}$$

$$p_{B_A}^{B_G} \Delta^* B_A^{B_G} = p_{B_L}^G \Delta^* B_L^G - p_{B_A}^{CB_G} \Delta^* B_A^{CB_G} - p_{B_A}^{F_G} \Delta^* B_A^{F_G} - p_{B_A}^{R_G} \Delta^* B_A^{R_G}$$

$$p_{B_L}^B \Delta^* B_L^B = p_{B_A}^B \Delta^* B_A^B + p_{B_A}^{CB} \Delta^* B_A^{CB} + p_{B_A}^G \Delta^* B_A^G + p_{B_A}^H \Delta^* B_A^H + p_{B_A}^R \Delta^* B_A^R - p_{B_L}^F \Delta^* B_L^F$$

$$\Delta^* E_L^B = [(p_{E_A}^{F_{FR}} \Delta^* E_A^{F_{FR}} + p_{E_A}^{B_{FR}} \Delta^* E_A^{B_{FR}} + p_{E_A}^{CB_{FR}} \Delta^* E_A^{CB_{FR}} + p_{E_A}^{G_{FR}} \Delta^* E_A^{G_{FR}} + p_{E_A}^{H_{FR}} \Delta^* E_A^{H_{FR}} + p_{E_A}^R \Delta^* E_A^R)/p_E^{FR}] - \Delta^* E_L^F - \Delta^* E_L^{CB}$$

$$\left(\frac{\Delta^* B_A^{B_R}}{B_{A-1}^{B_R}}\right) = 0.65 \left(\frac{\Delta^* B_{A-1}^{B_R}}{B_{A-2}^{B_R}}\right) - 3.1(i^{LTcr} - i^{LT*})$$

$$\left(\frac{p_{B_A}^B \Delta^* B_A^B}{p_Y Y}\right) = 0.6 \left(\frac{\Delta Y}{Y_{-1}}\right) + 0.6\, r_A^B - 0.6\, \left(i^{LT*} - \frac{\Delta NEER}{NEER_{-1}}\right)$$

$$\left(\frac{\Delta^* E_A^B}{E_{A-1}^B}\right) = 0.03 + 0.4 \left(\frac{\Delta^* E_{A-1}^B}{E_{A-2}^B}\right) + 0.04\left(r_{E_{A-1}}^B - \pi_{Y-1}\right)$$

$$\left(\frac{p_{E_A}^{B_R} E_A^{B_R}}{p_{E_A}^B E_A^B}\right) = 0.03 + 0.86 \left(\frac{p_{E_{A-1}}^{B_R} E_{A-1}^{B_R}}{p_{E_{A-1}}^B E_{A-1}^B}\right) - 0.4 \left(\frac{\Delta NEER}{NEER_{-1}}\right)$$

$$\Delta^* D_L^B = \Delta^* D_A^F + \Delta^* D_A^{CB} + \Delta^* D_A^B + \Delta^* D_A^G + \Delta^* D_A^H + p_{D_A}^R \Delta^* D_A^R - p_{D_L}^R \Delta^* D_L^R - \Delta^* D_L^{CB} - \Delta^* D_L^G$$

$$\Delta^* A_L^B = \Delta^* A_A^F + \Delta^* A_A^G + \Delta^* A_A^H + \Delta^* A_A^R$$

$$\Delta^* X_L^B = \Delta^* X_A^F + \Delta^* X_A^{CB} + \Delta^* X_A^G + \Delta^* X_A^H - \Delta^* X_L^R$$

$$\Delta^* RES = \Delta^* RF + \Delta^* D_L^B + p_{B_L}^B \Delta^* B_L^B + p_{E_L}^B \Delta^* E_L^B + \Delta^* A_L^B - \left(\Delta^* D_A^B + p_{B_A}^{B_G} \Delta^* B_A^{B_G} + p_{B_A}^{B_R} \Delta^* B_A^{B_R} + p_{B_A}^B \Delta^* B_A^B + \Delta^* L_A^B + p_{E_A}^B \Delta^* E_A^B + \Delta^* X_A^B + \Delta^* Z^B + p_{I_1}^B I_1^B - S^B - Tr_{K_r}^B + NP^B + Adj^B\right)$$

3.4. Banque de France

Interests and dividends paid and received are computed according to the corresponding assets. Profits are transferred to the government as tax. Bills and coins (H) are supplied by the central bank. Central bank deposits held by the government ($D_L^{CB_G}$) are isolated as they are used to study the helicopter money. Foreign bonds held ($p_{B_A}^{CB_R} B_A^{CB_R}$), public bonds ($p_{B_A}^{CB_G} \Delta^* B_A^{CB_G}$), other domestic bonds ($p_{B_A}^{CB} \Delta^* B_A^{CB}$) and refinancing ($RF^{CB}$) correspond to different forms of quantitative easing. Equities issued ($p_{E_L}^{CB} E_L^{CB}$) are exogenous. Central bank equilibrium is the unwritten equation.

$$\Delta^* H = \Delta^* H^F + \Delta^* H^B + \Delta^* H^H + \Delta^* H^R$$

$$D_L^{CB_G} = D_A^{G_{CB}}$$

$$p_{B_A}^{CB_R} B_A^{CB_R} = \varphi_{BA}^{CB} p_Y Y$$

$$p_{B_A}^{CB_G} \Delta^* B_A^{CB_G} = \gamma_{B_A}^{CB_G} p_Y Y$$

$$p_{B_A}^{CB} \Delta^* B_A^{CB} = \gamma_{B_A}^{B} p_Y Y$$

$$\Delta^* RF^{CB} = \varphi_{RF}^{CB} p_Y Y$$

$$p_G^{CB} \Delta^* G^{CB} + \Delta TRGT2 + \Delta^* RF^{CB} + \Delta^* D_A^{CB} + p_{B_A}^{CB_G} \Delta^* B_A^{CB_G} + p_{B_A}^{CB_R} \Delta^* B_A^{CB_R} + p_{B_A}^{CB} \Delta^* B_A^{CB} + \Delta^* L_A^{CB} + p_E^{CB} \Delta^* E_A^{CB}$$
$$= \Delta^* H + \Delta^* RES + \Delta^* D_L^{CB} + \Delta^* D_L^{CB_G} + p_{E_L}^{CB} \Delta^* E_L^{CB} + Adj^{CB}$$

3.5. Interest rates and assets' prices

Interest rates are treated exogenously with the ECB key interest rate ($r_€$) and the 10-year rate on public bonds (i_{10yrs}) playing a leading role. Apparent (or implicit) rates are calculated for the various securities and are determined with simple margins with respect to the 10-year bonds rate or the ECB rate. The short-term rate on deposits (r_D) and the long-term rate on credit ($i^{LT_{cr}}$) are determined in the same manner. The price of public bonds ($p_{B_L}^G$) varies inversely with respect to the one paid by the government (r_L^G). It plays a leading role in the determination of other prices of bonds such as bonds issued by firms ($p_{B_L}^F$), public bonds held by firms ($p_{B_A}^{F_G}$), private bonds held by households ($p_{B_A}^H$) or private bonds held by banks ($p_{B_A}^B$). Last, for each security (domestic private bonds, foreign bonds, public bonds), one price ($p_{B_L}^B$, $p_{B_A}^{B_R}$, $p_{B_A}^{R_G}$) must be obtained implicitly to guarantee flow-stock consistency by writing that the sum of the revaluation effects equals to zero.

$$r_D = 1.4 + 0.5 r_€$$

$$i^{LT_{cr}} = 0.93 i_{10yrs}$$

$$r_L^G = 0.9 + 0.85 i_{10yrs}$$

$$\ln(p_{B_L}^G) = -0.39 + 0.1 \ln\left(\frac{1}{r_L^G}\right)$$

$$\ln(p_{B_L}^F) = 0.8 \ln(p_{B_{L-1}}^F) + 0.9 \ln(p_{B_L}^G) - 0.7 \ln(p_{B_{L-1}}^G)$$

$$p_{B_A}^{F_G} = \psi_{pBA}^{F_G} p_{B_L}^G$$

$$p_{B_A}^H = \psi_{pBA}^H p_{B_L}^B$$

$$\Delta\ln\left(p_{B_A}^B\right) = 0.2\Delta\ln\left(p_{B_{A-1}}^B\right) + 0.7\Delta\ln\left(p_{B_L}^G\right)$$

$$\Delta p_{B_L}^B = -\left(\frac{B_{L-1}^F}{B_{L-1}^B}\right)\Delta p_{B_L}^F + \sum_i \left(\frac{B_{A-1}^i}{B_{L-1}^B}\right)\Delta p_{B_A}^i \quad \text{for } i = B, CB, G, H, R$$

$$\Delta p_{B_A}^{B_R} = \left(\frac{B_{B_{L-1}}^R}{B_{B_{A-1}}^{B_R}}\right)\Delta p_{B_L}^R - \sum_i \left(\frac{B_{B_{A-1}}^{i_R}}{B_{B_{A-1}}^{B_R}}\right)\Delta p_{B_A}^{i_R} \quad \text{for } i = F, CB, G, H$$

$$\Delta p_{B_A}^{R_G} = \left(\frac{B_{L-1}^G}{B_{A-1}^{R_G}}\right)\Delta p_{B_L}^G - \sum_i \left(\frac{B_{A-1}^{i_G}}{B_{A-1}^{R_G}}\right)\Delta p_{B_A}^{i_G} \quad \text{for } i = F, B, CB$$

3.6. Government

Government is described in a traditional manner with taxes linked to economic activity and incomes, public expenditures exogenous or dependent on GDP, public value added (VA^G) related to public wages and public employment are exogenous. Total public indebtedness ($p_{BL_L}^G BL_L^G$) closes the account of the government with a split between loans (L_L^G) and public bonds ($p_{B_L}^G B_L^G$).

$$VA^G = \alpha_{VA}^G (W_p^G + LC_p^G)$$

$$p_{BL_L}^G \Delta^* BL_L^G = \Delta^* D_A^{G_{CB}} + \Delta^* D_A^G + p_{B_A}^G \Delta^* B_{B_A}^G + p_{B_A}^{G_R} \Delta^* B_{B_A}^{G_R} + p_{E_A}^G \Delta^* E_A^G + \Delta^* A_A^G + \Delta^* X_A^G + \Delta^* Z^G - \Delta^* D_L^G + p_{I_1}^G I_1^G + p_{I_{12}}^G I_{12}^G - S^G + Tr_{K_p}^G + NP^G - Adj^G$$

$$\Delta^* L_L^G = p_{BL_L}^G \Delta^* BL_L^G - p_{B_L}^G \Delta^* B_L^G$$

3.7. Rest of the world

Exports (X) and imports (IM) depend respectively on foreign (Y^f) and domestic demand (Y) as measured by GDP in volume. Since the analyses are conducted for all goods services, it is more difficult to obtain satisfactory econometric results on price competitiveness. For imports the relative price effects could not be identified and only import prices (p_{IM}) could be isolated. Export and import prices are determined in standard fashion with a price maker/price taker arbitrage.

$$\ln(X) = 1.7 + 0.6\ln(Y^f) - 0.5\ln\left(\frac{p_X}{p_{X*}}\right)$$

$$\ln(IM) = 1.8\ln(Y) - 0.2\ln(p_{IM}) - 8.5 + 0.01t$$

$$\ln(p_X) = 0.03 + 0.5\ln(p_{X*}) + 0.3\ln(p_Y)$$

$$\ln(p_{IM}) = 0.6\ln(p_{MSH})$$

Capital inflows, in the form of bank deposits (D_A^R) and of loans granted by the rest of the world (L_A^R), depend on economic activity and on the short-term interest rate differential after correction of the exchange rate variation. Similarly, public bonds held ($\Delta^* B_A^{R_G}$) and other debt securities held by the rest of the world ($\Delta^* B_A^R$) are related to economic activity and to the long-term interest rate differential. Share purchases, including inward foreign direct investment (E_A^R), depend on economic activity and financial profitability for shares ($r_{E_A}^R$). Since the mid-2000s, purchases of government securities by the rest of the world have been part of quantitative easing policy. Capital outflows, in the form of credit to the rest of the world ($\Delta^* L_L^R$), depend on foreign economic activity. It was not possible to find a significant effect of interest rate differential. Foreign securities issued by the rest of the world, medium term capital outflows ($p_{B_L}^R \Delta^* B_L^R$), are determined by the demand of foreign securities by domestic agents. Likewise foreign equities issued by the rest of the world, including outward foreign direct investments ($p_{E_L}^R \Delta^* E_L^R$), equal the sum of the demand of foreign equities by domestic agents. Lastly, the flow of deposit liabilities of the rest of the world held in France ($\Delta^* D_L^R$) balance the rest of the world's account.

$$\left(\frac{\Delta^* D_A^R}{D_{A-1}^R}\right) = 2.9\left(\frac{\Delta Y}{Y_{-1}}\right) + 2\left(i_{-1}^D - i_{-1}^{D*} + \frac{\Delta NEER_{-1}}{NEER_{-2}}\right)$$

$$\left(\frac{\Delta^* B_A^{R_G}}{B_{A-1}^{R_G}}\right) = 0.04 - 0.14\left(\frac{\Delta^* B_{A-1}^{R_G}}{B_{A-2}^{R_R}}\right) + 2.2\left(\frac{\Delta Y}{Y_{-1}}\right) + 3.9\left(i_{10yr} - i^{LT*} + \frac{\Delta NEER}{NEER_{-1}}\right)$$

$$\left(\frac{\Delta^* B_A^R}{B_{A-1}^R}\right) = 0.34\left(\frac{\Delta^* B_{A-1}^R}{B_{A-2}^R}\right) + 2.2\left(\frac{\Delta Y}{Y_{-1}}\right) + 3\left(i_{10yr} - i^{LT*} + \frac{\Delta NEER}{NEER_{-1}}\right)$$

$$\left(\frac{\Delta^* L_A^R}{L_{A-1}^R}\right) = 0.03 + 1.2\left(\frac{\Delta Y}{Y_{-1}}\right) + 1.3\left(i^{LT_{cr}} - i^{LT*} + \frac{\Delta NEER}{NEER_{-1}}\right)$$

$$\left(\frac{\Delta^* E_A^R}{E_{A-1}^R}\right) = 0.04 + 0.05\left(r_{E_A}^R - \pi_Y\right) + 0.6\left(\frac{\Delta Y_{-1}}{Y_{-2}}\right)$$

$$\left(\frac{\Delta^* L_L^R}{L_{L-1}^R}\right) = 1.9\left(\frac{\Delta Y^*}{Y_{-1}^*}\right)$$

$$p_{B_L}^R \Delta^* B_L^R = p_{B_A}^{CB_R} \Delta^* B_A^{CB_R} + p_{B_A}^{B_R} \Delta^* B_A^{B_R} + p_{B_A}^{G_R} \Delta^* B_A^{G_R} + p_{B_A}^{F} \Delta^* B_A^{F_R} + p_{B_A}^{H_R} \Delta^* B_A^{H_R}$$

$$p_{E_L}^R \Delta^* E_L^R = p_{E_A}^{F_R} \Delta^* E_A^{F_R} + p_{E_A}^{B_R} \Delta^* E_A^{B_R} + p_{E_A}^{CB_R} \Delta^* E_A^{CB_R} + p_{E_A}^{G_R} \Delta^* E_A^{G_R} + p_{E_A}^{H_R} \Delta^* E_A^{H_R}$$

$$\begin{aligned}\Delta^* D_L^R = {} & \Delta^* H^R + \Delta^* D_A^R + p_{B_A}^{R_G} \Delta^* B_A^{R_G} + p_{B_A}^R \Delta^* B_A^R + \Delta^* L_A^R + p_{E_A}^R \Delta^* E_A^R + \Delta^* A_A^R + \Delta^* Z^R - Adj^R - FCN^R \\ & - p_G^{CB} \Delta^* G^{CB} - \Delta^* RF^R - p_{B_L}^R \Delta^* B_L^R - \Delta^* L_L^R - p_{E_L}^R \Delta^* E_L^R - \Delta^* X_L^R\end{aligned}$$

3.8. Prices, wages and employment

The general price level (p_Y) is determined by mark-up pricing from unit labor costs (ULC) with a short-term effect on demand pressure, measured (in the absence of a better indicator) by an output gap (GAP). A short-term effect of import price (p_{IM}) has also been added. Potential output (va^{M^p}) results from a simple production function used as an approximation. Wage per worker in the market sector (w^M) results from a wage-price-unemployment relation with an indexation slightly less than unity and a medium-term labor productivity $\left(\frac{va^M}{N^M}\right)$ effect. This wage per worker in the market sector serves as a reference for the evolution of that of other sectors. Employment in the market sector (N^M) adjusts with respect to medium-term employment resulting from the previous production function. Public employment is exogenous. Active population (AP i.e. labor force) results from flexion of activity rates (AP/TAP) as a function of job creation (N).

$$\Delta \ln(p_Y) = 0.01 + 0.4\Delta \ln(ULC) + 0.3GAP + 0.03\Delta \ln(p_{IM-1}) - 0.4vc_{-1}$$

$$vc = \ln(p_Y) - 0.4 - 0.9\ln(ULC)$$

$$GAP = \left(\frac{va^M - va^{p^M}}{va^{p^M}}\right)$$

$$\ln\left(\frac{va^{M^p}}{N^M}\right) = 0.8 + 0.5\ln\left(\frac{K_1^M}{N^M}\right) + 0.014t - 0.01t_{1992-2019}$$

$$\ln(w^M) = 0.9\Delta\ln(p_C^H) - 0.1\ln(u) + 0.7\Delta\ln\left(\frac{va^M}{N^M}\right)$$

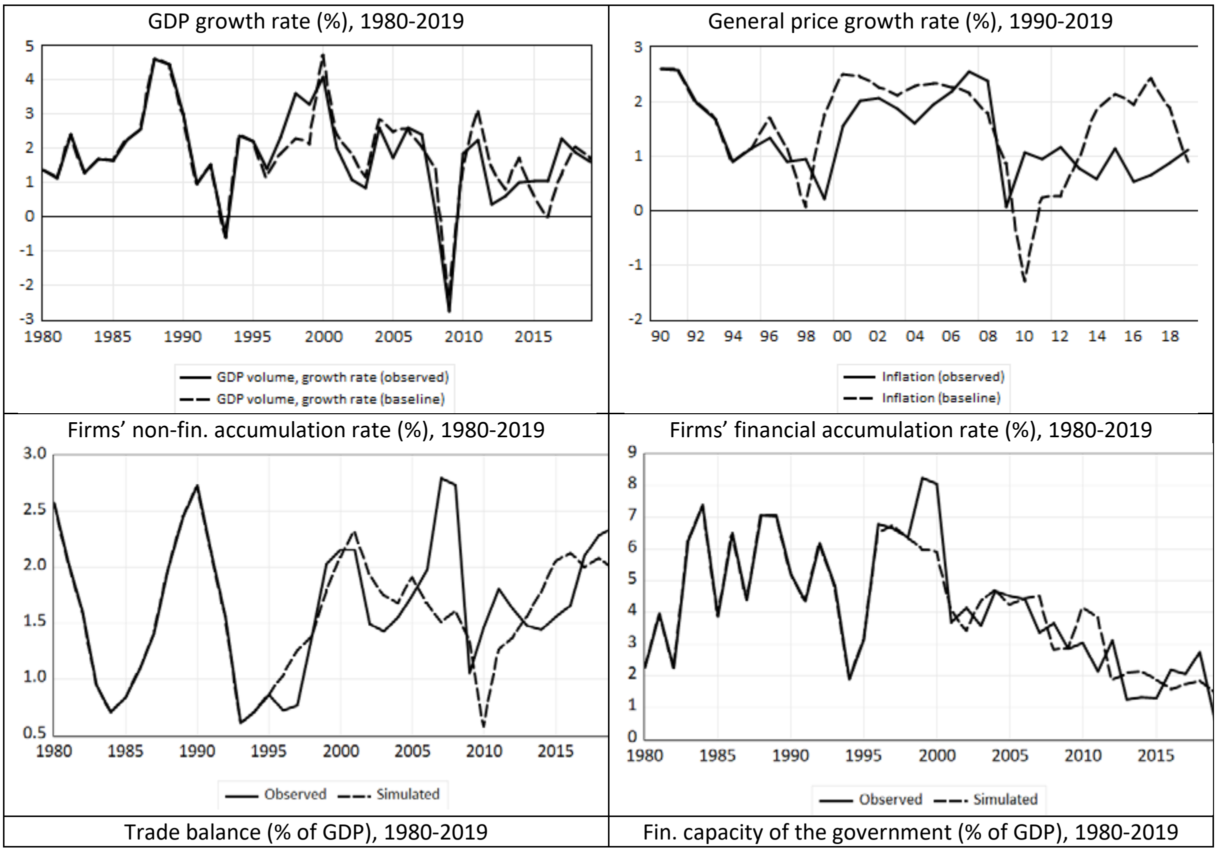
$$\ln(N^M) = 2\ln(va^M) - 1.6 - \ln(K_1^M) - 0.028t + 0.02t_{1992}$$

$$\ln(AP) = 0.37\ln(N) + 0.56\ln(TAP) + 0.002t$$

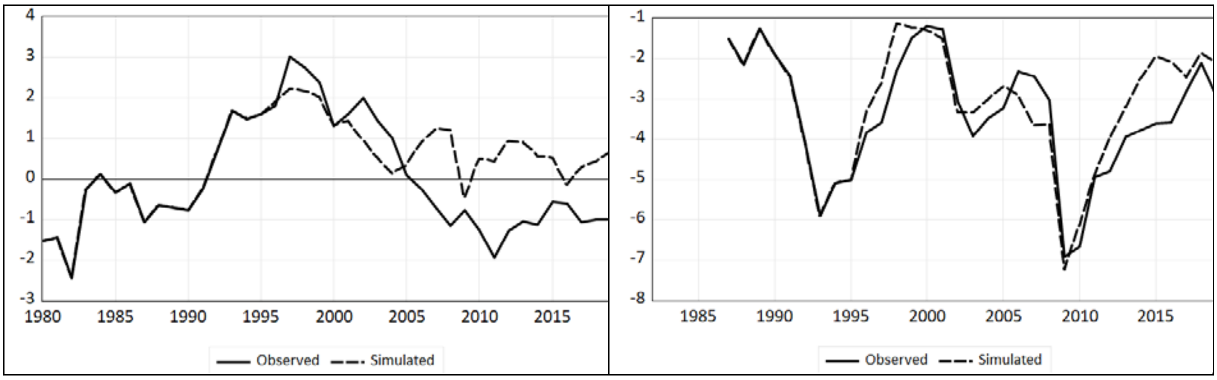
3.9. Simulations on the past

The model is ran in dynamic simulation to reproduce the past starting in 1996, year after which the dataset is homogenous[7]. Results are acceptable (Figure 1). We verify that the sum of financing capacities from the different agents is equal to 0 and that the central bank equilibrium is verified (rounded to the nearest decimal).

Figure 1 Observed series vs simulations since 1996, selected variables



[7] *Banque de France* provides the necessary data for the analysis of the financial accounts in two datasets. The first goes from 1978 to 2009 (discontinued) and the second from 1995 onwards. We kept the second dataset (which follows the SNA 2008 methodology) and adapted the methodology of the first one (SNA 1996) in order to fit before 1995.



4. Unconventional monetary policy and fiscal policy

Two forms of unconventional monetary policy are studied with the model: helicopter money and the cancellation of a part of the public debt held by the central bank. The possibility of the recapitalization of the own funds of the central bank are also examined. Helicopter money can take several forms, either as a distribution of central bank money directly to households or businesses, or as a distribution to the government. If the purpose is to avoid a distribution of banknotes, one way is to assume that all households and firms have an account with the central bank. This is possible and corresponds to the project of development of central bank digital currency. In this section we are only interested in the second form of helicopter money, i.e. via the State and its account with the central bank. Two uses of helicopter money are distinguished, one to finance public investments, the other to finance social transfers. Last, the combination of public indebtedness and repurchase by the central bank are described.

4.1. Helicopter money and public investment

Several steps have to be distinguished to account for helicopter money in the model. The first is pure helicopter money distribution, i.e. the feeding of the State’s account with the central bank for an amount equivalent to 1% of GDP and paid the first year. This distribution alone does not have an impact other than increasing government wealth and diminishing that of the central bank. In a second step, in order to be able to give actual use to this helicopter money the government must transfer it to the accounts of commercial banks. The account with the central bank is debited, and the account with private banks is credited. This transfer also has no impact on the real sector. In each case government wealth increases with respect to the baseline. It even increases slightly more thanks to the interest paid by banks to the government, and public debt decreases accordingly. Conversely, the central bank’s wealth remains reduced by the same amount as before, while bank reserves (i.e. central bank’s debt with private banks) increase.

In a third step the government uses helicopter money to finance additional public investment of the same amount (1% of GDP). Bank deposits are brought back to initial levels. Unsurprisingly, we observe a recovery effect with slight inflationary pressures of an identical size to the effects obtained in the case of public investment financed via public debt. However, financing methods are different. In the current case, the government balance deteriorates by the same amount but public debt does not increase, given that expenditure is financed by the helicopter money transfer. The graphs in level below illustrate this point. The graphs in percentage of GDP may seem paradoxical. Given the GDP increase the public balance as percentage of GDP worsens and simultaneously public debt as % of GDP falls. This recovery via investment without public debt has a counterpart. The wealth of the central bank worsens as much and stays at that level under the effect of the recovery. Symmetrically, government wealth increases given that the stock of capital increases without additional debt. It is worth noting that bank reserves (i.e. central bank indebtedness to banks) initially increase and only slightly fall when the helicopter money is used to finance the public investment (Figure 2).

Helicopter money and public investment in the model (one shot): added variables

First step: helicopter money distribution, without public indebtedness (1%GDP=24.892 or 25 when rounded)

	2021	2022	2023 ...	
D_A^{GCB}	25	25	25	*eq. 299*
$p\Delta BL_L^G$	-25	0	0	*eq. 323*

To account for this distribution of helicopter money in the model, it is necessary to feed the government's account with the CB and add a negative gap-filling variable of the same amount on the accounting identity determining the variation of public debt, in order to translate the fact that the government's account is increased thanks to helicopter money and not by indebtedness.

Second step: transfer to government's bank account

D_A^{GCB}	0	0	0	*eq. 299*
D_A^G	25	25	25	*eq. 303*
D_L^G	$-\psi(25)$	$-\psi(25)$	$-\psi(25)$	*eq. 301*
$p\Delta BL_L^G$	-25	0	0	*eq. 323*

Here again the logic of the model requires the introduction of a gap-filling variable on the government's liability deposits, which are simply modeled as a function of government deposits held. This variable is negative to reflect the fact that these deposits have no reason to increase in the event of a helicopter money transfer.

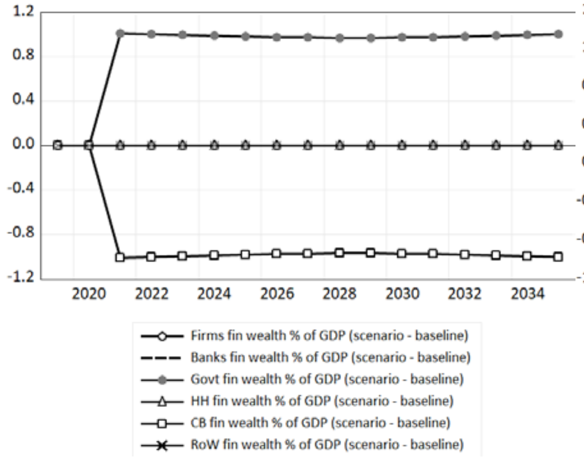
Third step: additional public investment (one year)

I_1^G	$25/p_{I1}$	0	0	*eq. 293*
D_A^G	0	0	0	*eq. 303*
D_L^G	0	0	0	*eq. 301*
$p\Delta BL_L^G$	-25	0	0	*eq. 323*

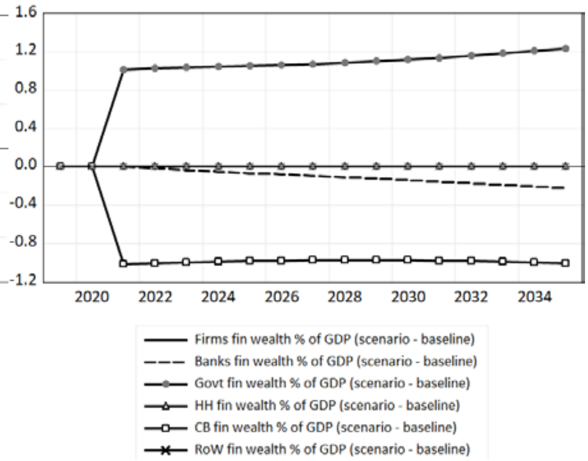
Figure 2 Impact of helicopter money distribution of 1% of GDP, with a one-off increase in public investment in 2021

Absolute deviation from baseline, financial wealth as % of GDP ($Y^{scenario} - Y^{baseline}$)

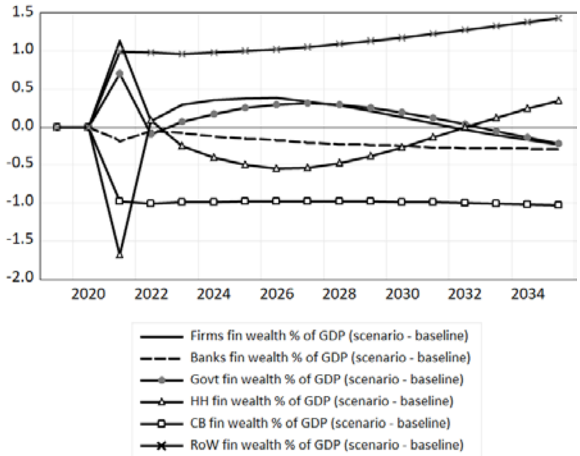
1st step: HM distribution



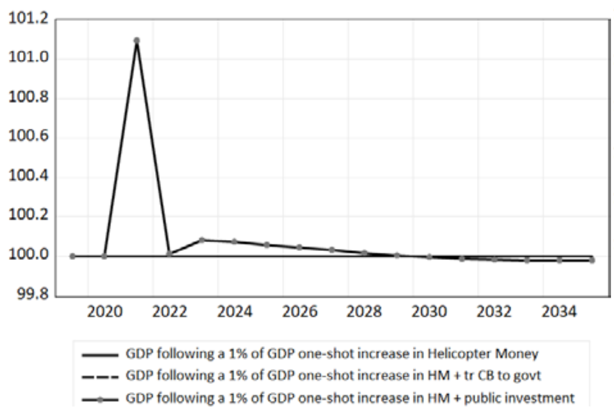
2nd step: transfer to bank account

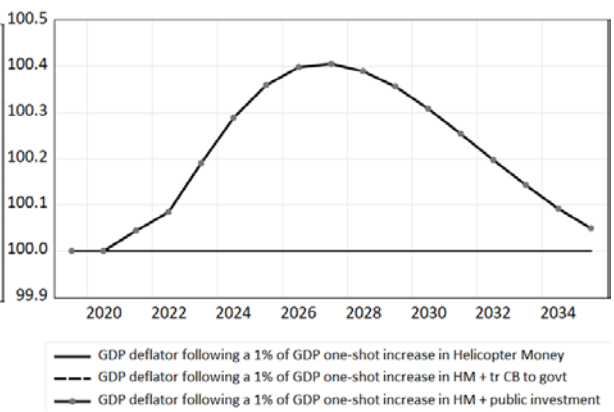


3rd step: increase of public investment

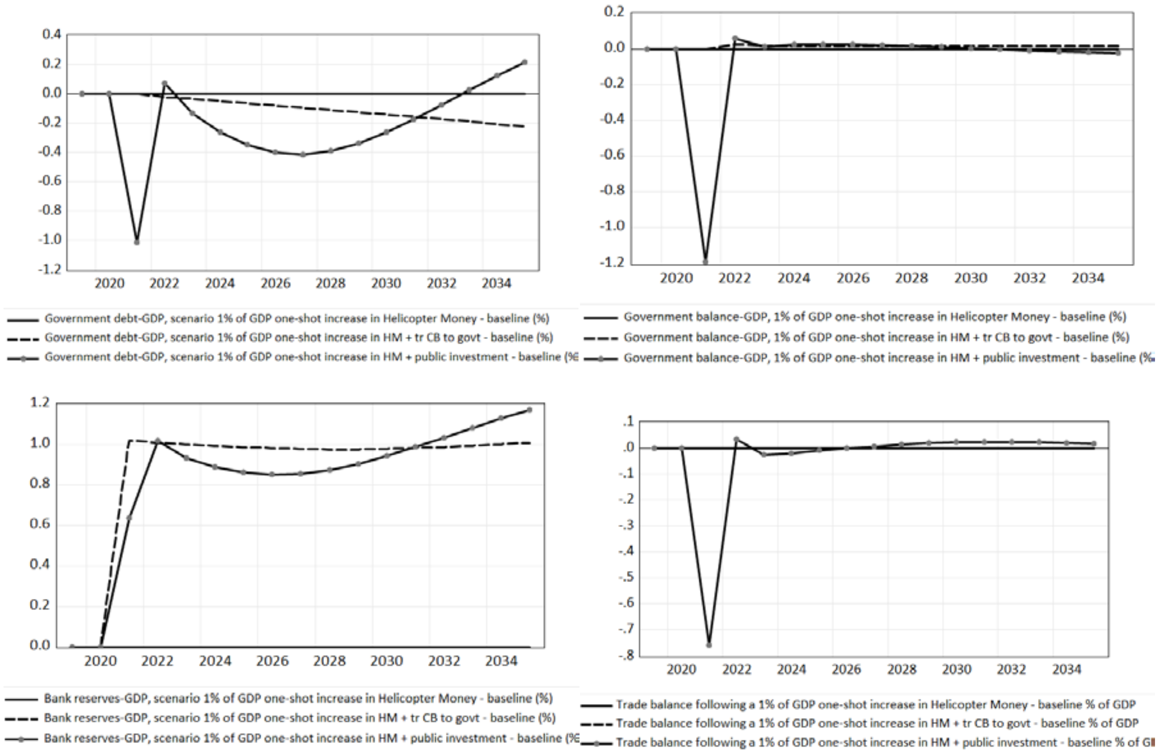


Relative deviation from baseline x 100 ($Y^{scenario}/Y^{baseline}$)





Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)



Helicopter money to finance public investment is presented by its proponents (Couppey-Soubeyran, 2020) as a useful tool in a period of strong public indebtedness. Especially it could be used to finance a part of the huge investment program for the low-carbon transition. The previous simulations can be completed by examining, not only a one-off shock but also a permanent increase in public investment of 1% of GDP. This amount is close to the additional investment (public and private) estimated by the I4CE institute (Berghmans et al., 2021) in order to respect the *Stratégie Nationale Bas Carbone* (1.2% of GDP each year other the period 2022-2028). The same procedure in three steps is followed: first distribution of helicopter money, second transfer to banks' accounts, third new public investment.

The conclusions to be drawn would not be fundamentally different. There is no miracle. The recovery without public debt has as a counterpart a worsening of central bank wealth (Figure 3). The government balance deteriorates of 1.2% of GDP while the public debt decreases by 4% of GDP thanks to the helicopter money distribution and to the recovery. However, the financial wealth of the central bank decreases by 15% of GDP and the bank reserves increase by 13% of GDP. Furthermore, the financial wealth of the rest of the world increases by 17% of GDP which means an equivalent deterioration of the domestic net financial assets, mainly due to a persistent decline of the trade balance (around -0.8%of GDP) induced by the loss of price competitiveness and the volume effect of the recovery.

This would not be a problem according to supporters of this policy. A central bank could continue working with negative own funds. This could be the case if the procedure is punctual and limited, but more problematic in the context of a sustained policy. Financial markets could push up interest rates. The solutions proposed to restore the central bank's own funds are discussed below. The size of bank reserves would facilitate capital outflows or slippages in the securities or real estate markets. In the French case, as in the case of countries in the Eurozone without a central bank properly speaking, such policy would contradict European treaties. It could only be undertaken after a series of time-consuming negotiations whose outcomes would be more than uncertain. Last, this kind of policy can hardly be implemented in a single country at least for two reasons: first, it makes no sense to try to reduce the emission of CO2 in a single country; second, the deterioration of the country's net external position would be difficult to bear. A coordinated policy, at least at the EU level, would reduce these problems but are difficult to implement, as it is illustrated by the long-lasting European negotiations.

Helicopter money and public investment in the model (permanent increase): added variables

First step: helicopter money distribution, without public indebtedness (1%GDP=25)

D_A^{GCB}	25	50	75	eq. 299
$p\Delta BL_L^G$	-25	-25	-25	eq. 323

Second step: transfer to government's bank account

D_A^{GCB}	0	0	0	eq. 299
D_A^G	25	50	75	eq. 303
D_L^G	$-\psi(25)$	$-\psi(50)$	$-\psi(75)$	eq. 301
$p\Delta BL_L^G$	-25	-25	-25	eq. 323

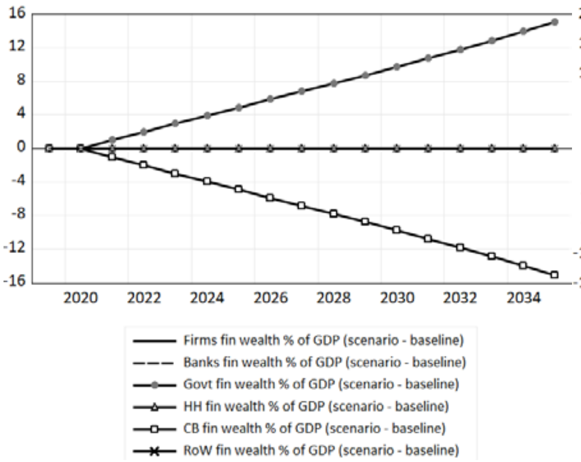
Third step: additional public investment (permanent)

I_1^G	$25/p_{I1}$	$25/p_{I1}$	$25/p_{I1}$	eq. 293
D_A^G	0	0	0	eq. 303
D_L^G	0	0	0	eq. 301
$p\Delta BL_L^G$	-25	-25	-25	eq. 323

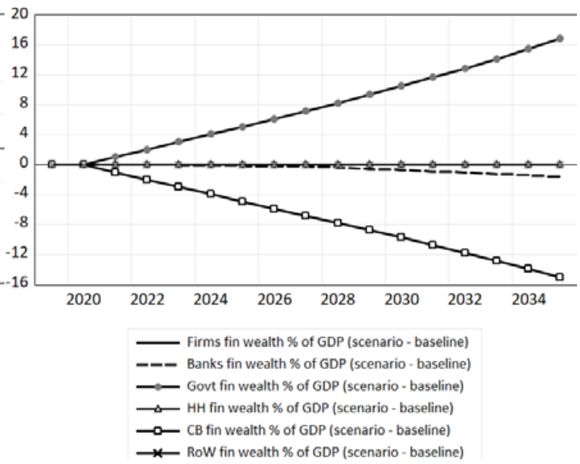
Figure 3 Impact of helicopter money distribution with a permanent increase in public investment of 1% of GDP

Absolute deviation from baseline, financial wealth as % of GDP ($Y^{scenario} - Y^{baseline}$)

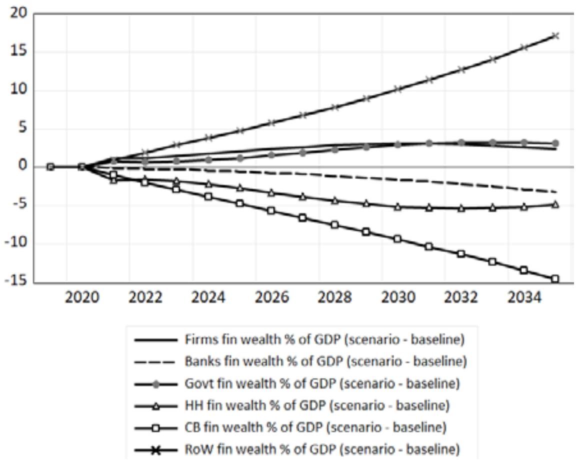
1st step: HM distribution



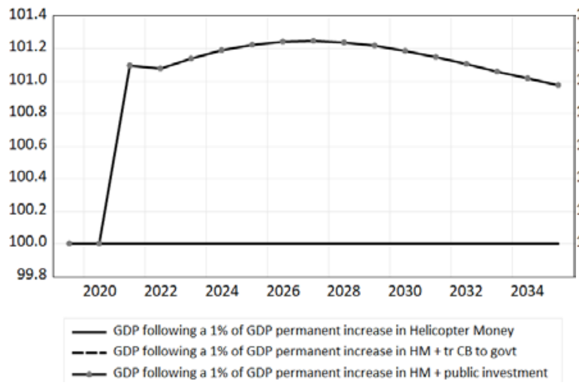
2nd step: transfer to bank account

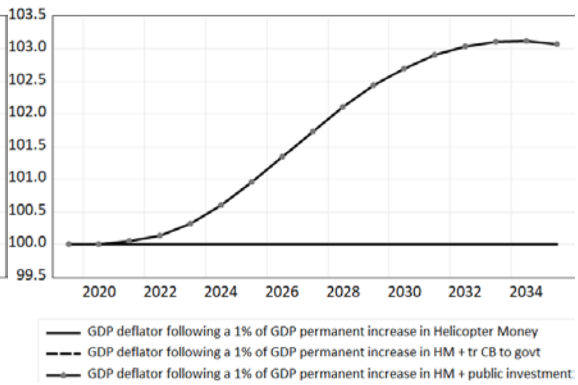


3rd step: increase of public investment

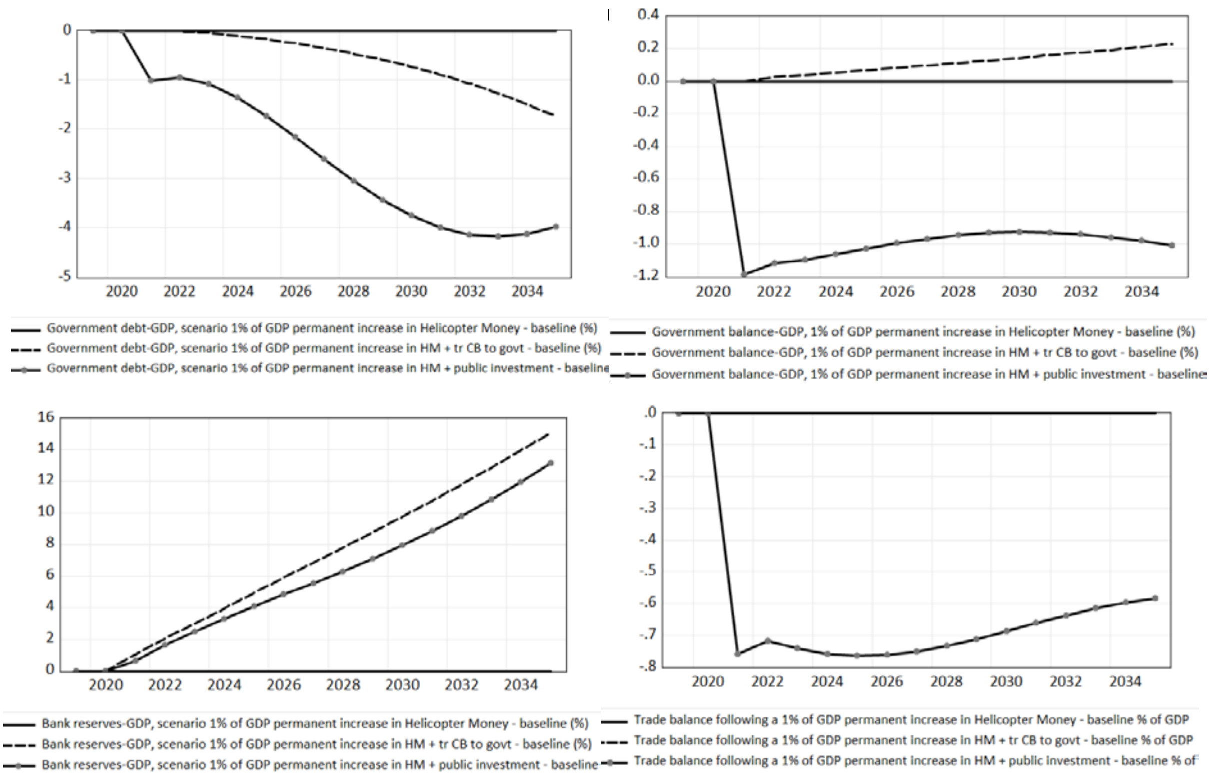


Relative deviation from baseline x 100 ($Y^{scenario}/Y^{baseline}$)





Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)



4.2. Public indebtedness and repurchase by the central bank

We can compare public investment financed by helicopter money with another way of financing, traditional public indebtedness, combined with the case where the central bank repurchases public bonds, which can be seen as an illustration of the Modern Monetary Theory (Kelton, 2020). Repurchasing public bonds by the central bank can be simply described in the model by adding an add-factor in the equation determining the public bonds held by the central bank. The additional public investment can be for one year (1% of GDP) or permanent.

The real effects in terms of growth and inflation are similar in all cases. The deterioration of the financial wealth of the nation is the same (17% of GDP in the long term in case of a permanent shock). Nonetheless, the financial effects are contrasted (Figure 4). Unsurprisingly, government debt decreases in the case of helicopter money whereas it rises when the additional public investment is financed via indebtedness. Financial wealth of the government improves in the first case and deteriorates in the second. In contrast, the financial wealth of the central bank sharply deteriorates and the bank reserves increase in case of helicopter money while they are stable in case of public indebtedness.

To finish the effect of the repurchase of public bonds by the central bank after public debt financing can be examined. The banks hold less public bonds and their reserves increase a lot (13% of GDP in case of a permanent shock). The results appear close to the case where there is no repurchase by the central bank. Compared with the case of helicopter money, an opposition appears at the level of the financial situation of the various sectors. The financial wealth of the government improves in case of HM and decreases in case of repurchase by the central bank. Conversely the financial wealth of the central bank decreases in case of HM while it is stable in case of repurchase by the central bank. However, it can be noticed that the impact of the repurchase of public bonds by the central bank can be underestimated in the current version of the model where the interest rates are exogenous. This will be examined in another version where the interest rate on bonds will be endogenized.

Public indebtedness and repurchase by the central bank in the model: added variables

First step: public investment financed by public indebtedness, one shot (1%GDP=25)

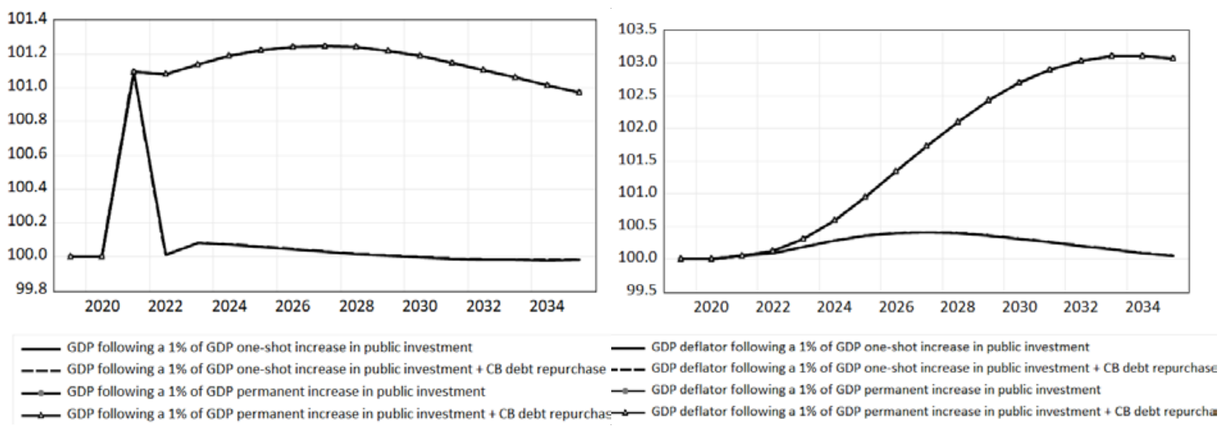
I_1^G	$25/p_{I1}$	0	0

Second step: repurchase by the central bank

I_1^G	$25/p_{I1}$	0	0
$p\Delta B_A^{CBG}$	25	0	0

Figure 4 Impact of an increase in public investment of 1% of GDP (one shot or permanent) with public indebtedness and repurchase by the central bank

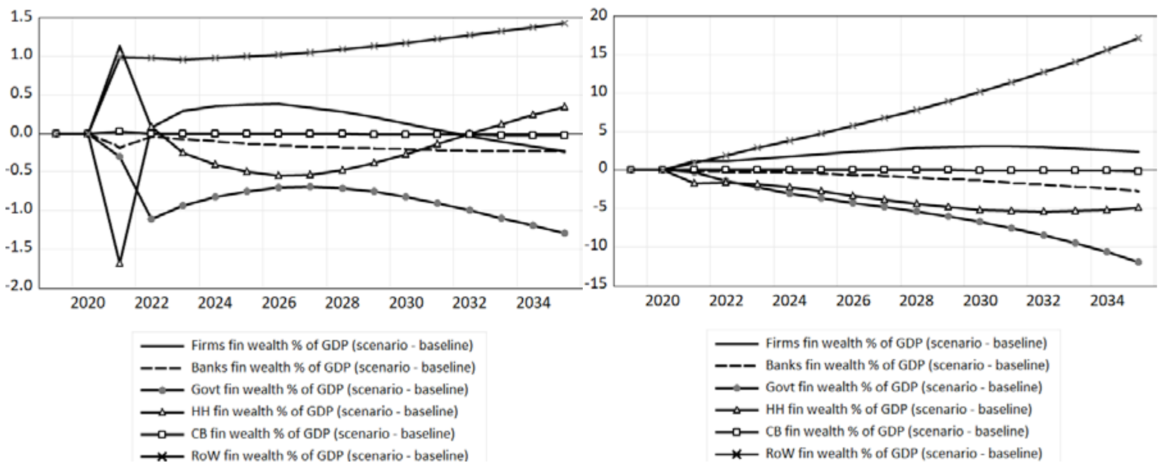
Relative deviation from baseline x 100 ($\frac{Y^{scenario}}{Y^{baseline}}$)

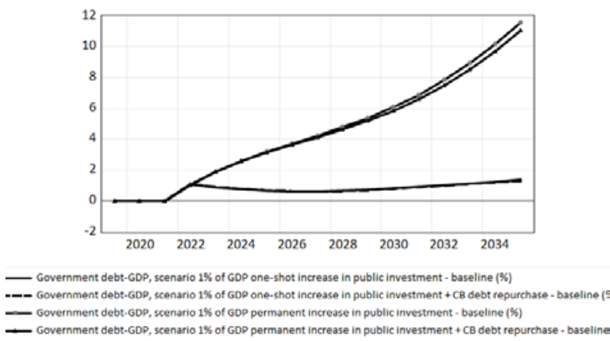


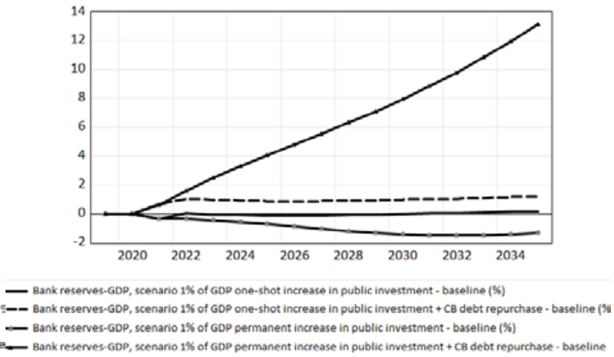
Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)

One shot

Permanent







4.3. Helicopter money and social transfers

Another possible use of helicopter money is to finance increased social transfers to households for a one shot equivalent to 1% of GDP according to the same modalities as in the third step seen previously (the first two steps are identical). The results are similar to the previous ones, a recovery (0.7% the first year) and a moderate price increase (0.3% in the medium run). Government balance deteriorates (-1.1% of GDP) but without rising public debt (in % of GDP) thanks to the helicopter money distribution and to the recovery (Figure 5). The counterpart is a deterioration of the wealth of the central bank and an increase of the bank reserves.

Helicopter money and social transfers in the model (one shot): added variables

First step: helicopter money distribution, without public indebtedness (1%GDP=25)

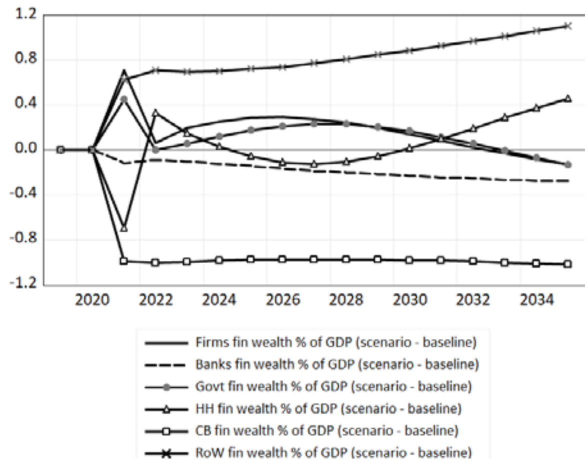
Second step: transfer to government's bank account

Third step: additional social transfers (one year)

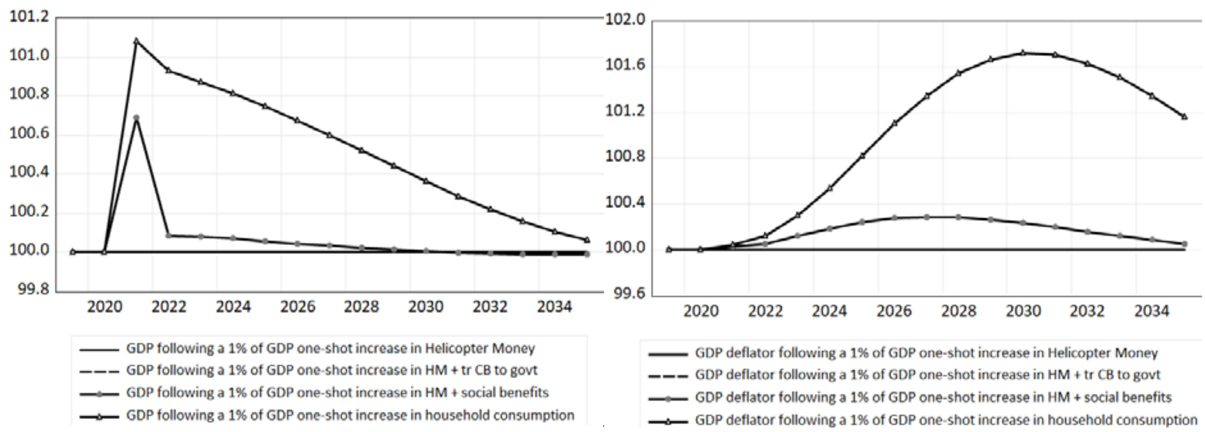
SB_p^G	*25*	*0*	*0*	*eq. 284*
D_A^G	*0*	*0*	*0*	*eq. 303*
D_L^G	*0*	*0*	*0*	*eq. 301*
$p\Delta BL_L^G$	*-25*	*0*	*0*	*eq. 323*

Figure 5 Impact of helicopter money distribution with a one-off increase of 1% of GDP in social transfers in 2021

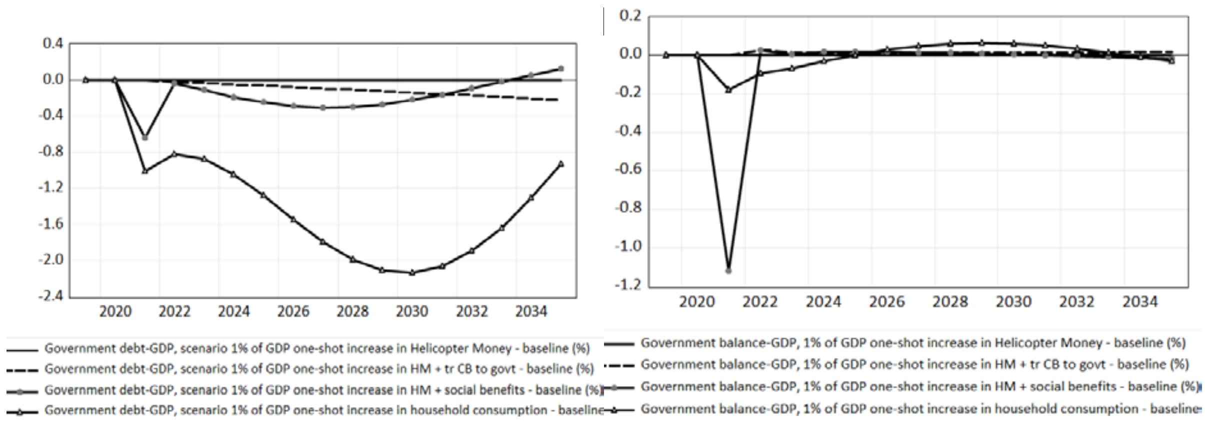
Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)

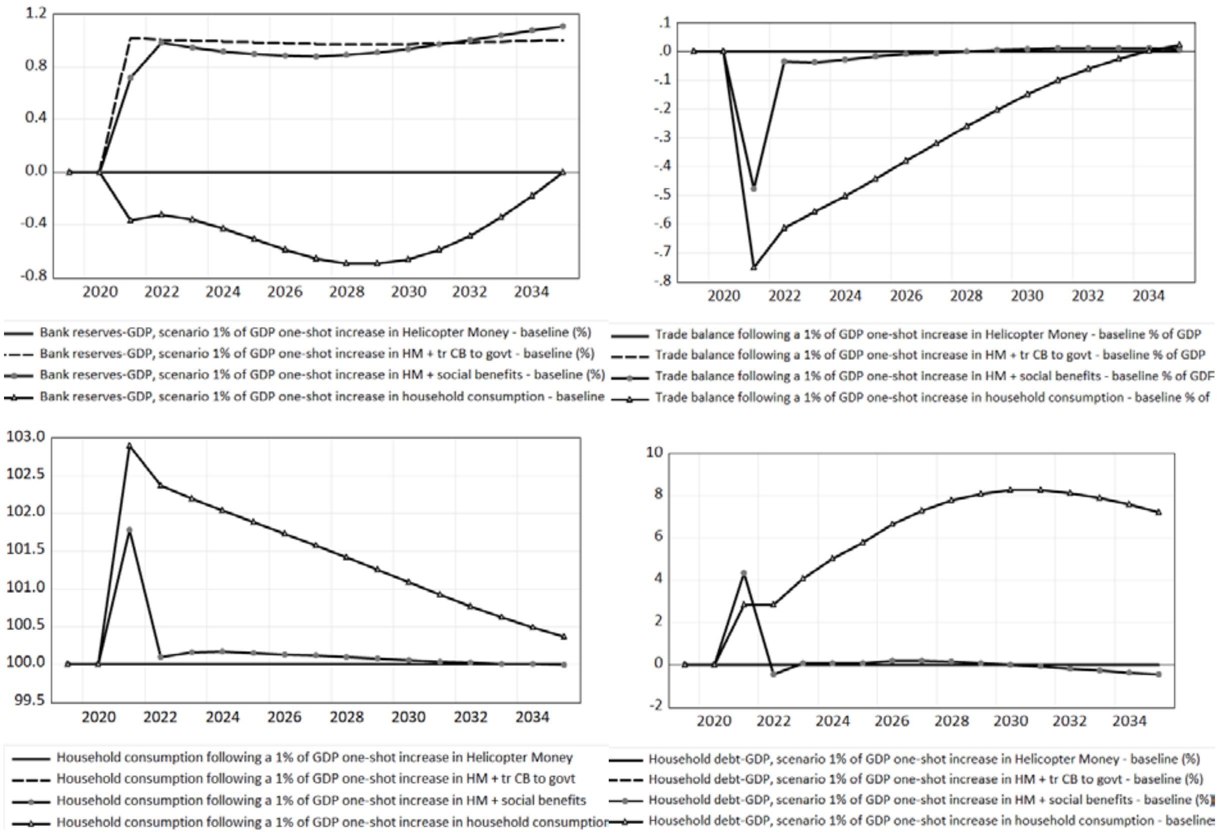


Relative deviation from baseline x 100 ($Y^{scenario}/Y^{baseline}$)



Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)





If the measure is punctual and limited in time this would not be a problem. However, it seems impossible to sustain this measure as a permanent policy as it is illustrated by a permanent distribution of helicopter money to finance social transfers equivalent to 1% of GDP (Figure 6). Production is sustainably higher (0.9% of GDP) with a price drift still rather moderate (2.3% in the long term). Government debt in % of GDP decreases but the central bank wealth falls dramatically (-15% of GDP) and bank reserves rise considerably. Last, the rising financial wealth of the rest of the world (13% of GDP) reflects a sharp decrease of domestic financial wealth.

Helicopter money and social transfers in the model (permanent increase): added variables

First step: helicopter money distribution, without public indebtedness (1%GDP=25)

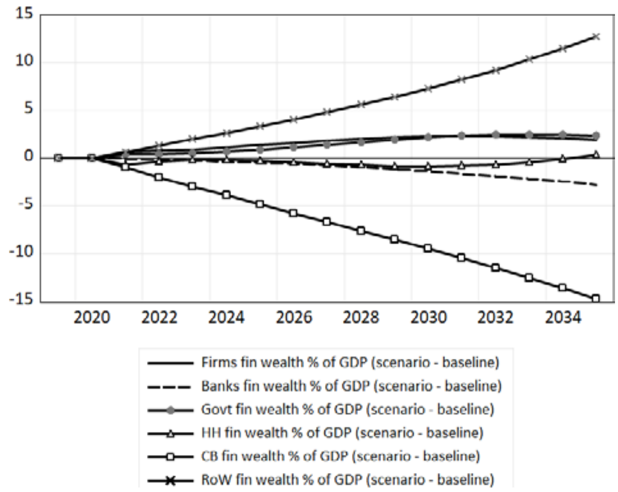
Second step: transfer to government's bank account

Third step: additional social transfers (permanent)

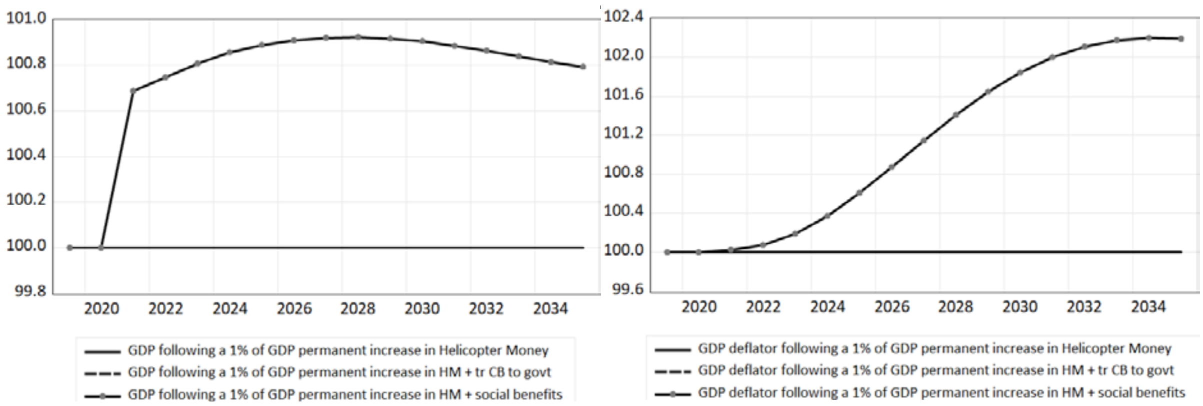
SB_p^G	25	25	25
D_A^G	0	0	0
D_L^G	0	0	0
$p\Delta BL_L^G$	-25	-25	-25

Figure 6 Impact of helicopter money distribution with a permanent increase in social transfers of 1% of GDP

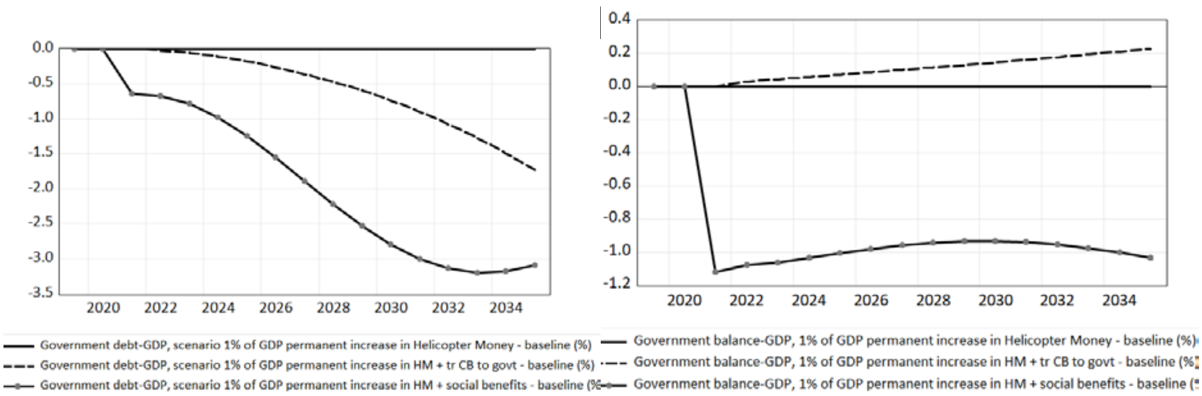
Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)

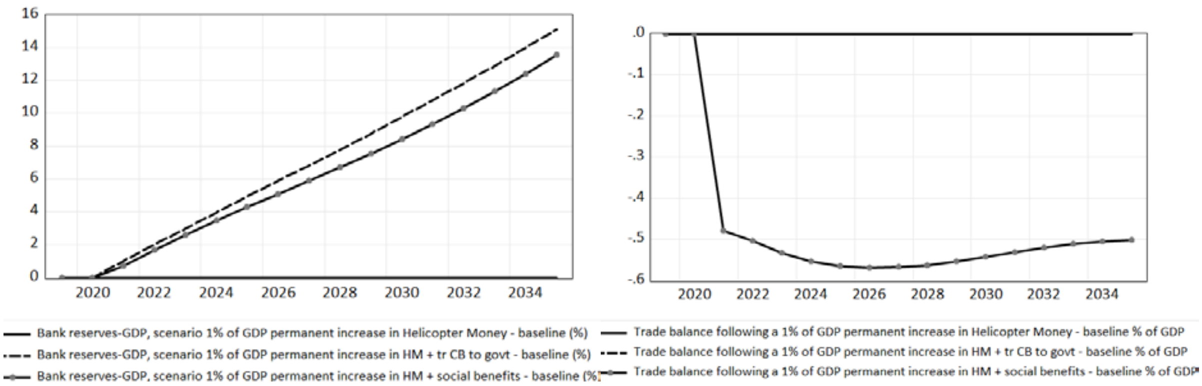


Relative deviation from baseline x 100 ($Y^{scenario}/Y^{baseline}$)



Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)





Last, a comparison can be made with a recovery induced by a decreasing saving rate of households and a surge in consumption. We only consider a one shot increase of the consumption equivalent to 1% of GDP (Figure 6). The recovery is stronger than the one observed with the distribution of helicopter money to finance social transfers, also equivalent to 1% of GDP (1.1% instead of 0.7% for the GDP increase). The price drift is also higher (1.7% in the medium-run instead of 0.3% for the GDP deflator). This is explained by the fact that only a part of the social transfers distributed is consumed. Therefore, the initial impulse is smaller in the case of helicopter money. The main difference between the two shocks is in the funding mechanisms. In the case of helicopter money the recovery is financed by a deterioration of the wealth of the central bank and increasing bank reserves with a stable public debt. In the case of a fall of households' saving rate public debt in % of GDP is reduced (-0.8% in the medium run) but household debt increases significantly (8% of GDP in the medium run).

4.4. Cancellation of public debt held by the central bank

As a result of unconventional monetary policy, central banks hold considerable amounts of government securities, which constitute a significant part of public debt. One proposal put forward by some authors (Scialom and Bridonneau, 2020) is to cancel part of this debt in order to lighten budget constraints, thus providing room for maneuver to better finance the energy/low-carbon transition. This policy (cancellation of public debt equivalent to 15% of GDP) can be studied in the model in a simple way. A first gap-filling variable of -15% of GDP is introduced in the flow-stock equation generating the stock of public debt held by the central bank. The same negative shock is introduced in the flow-stock equation generating the stock of total debt. Lastly, another gap-filling variable equation indicates that the cancellation concerns only public bonds. This partial cancellation of public debt held by the central bank has no effect on the real economy. Public debt falls but central bank wealth falls as much (Figure 7).

For supporters of this policy, the reduction of public debt would loosen the constraints and would open the way to an increase in public investment (1% of GDP on a permanent basis) to finance the energy transition. As the simulations show, the combination of these two measures, partial cancellation of debt and increase in public investment, leads to a sustained recovery with rising inflationary pressures due to demand pressure and wage drift. Thanks to the initial cancellation, public debt remains under control despite the increase in the public deficit. The counterpart of these evolutions is a persistent and marked deterioration of the central bank's wealth (-14% of GDP).

These results raise, in addition, the same reservations as those formulated about helicopter money. Insofar as the amounts of cancellation are high (more than in the previous case), it is difficult to believe that this marked deterioration of the central bank's own funds can remain without consequences. The risk of rising interest rates cannot be ignored. The ways in which the central bank can replenish its capital are not convincing, and accepting such policy within the Eurozone seems rather unlikely.

Partial cancellation of public debt held by the central bank and permanent increase of public investment in the model: added variables

First step: partial cancellation of public debt held by the central bank

$OCVB_A^{CBG}$	$-15\%GDP$	0	0
$OCVBL_L^G$	$-15\%GDP$	0	0
pB_L^G	$-(1-\psi)15\%GDP$	0	0

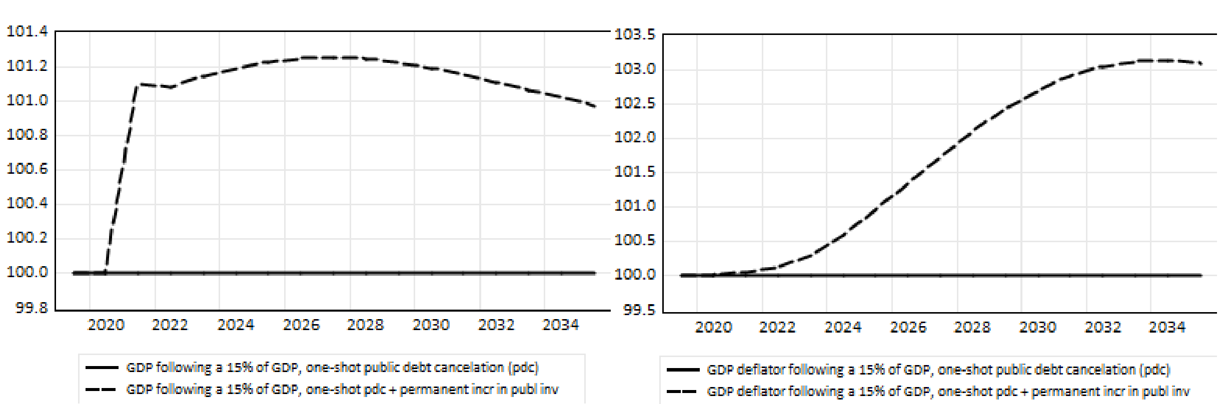
A first gap-filling variable of -15% of GDP is introduced in the flow-stock equation generating the stock of public debt held by the central bank (B_A^{CBG}). The same negative shock is introduced in the flow-stock equation generating the stock of total debt at the liability side of the government (BL_L^G). This is introduced in the term other changes in volume (OCV) that closes the flow-stock equation and integrates, among others, the effects of the cancellation. Lastly, another gap-filling variable indicates that the cancellation concerns only public bonds ($pB_L^G = \psi BL_L^G$).

Second step: additional public investment (permanent)

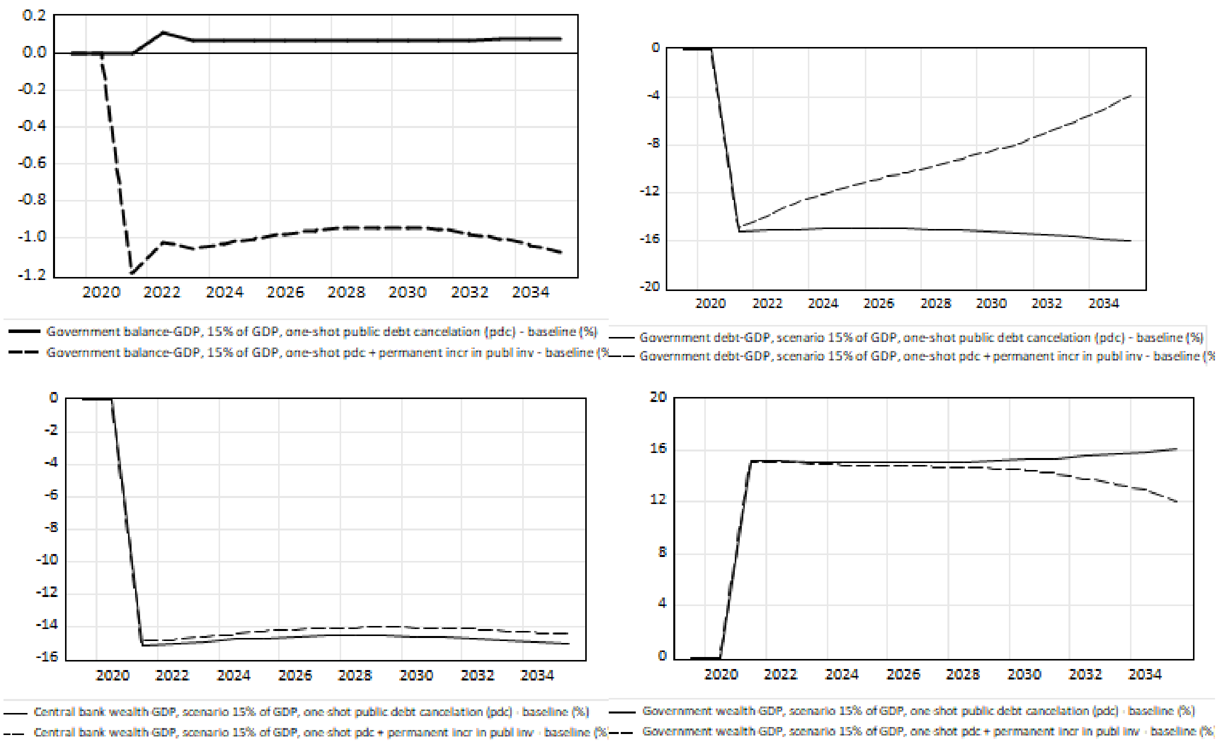
I_1^G	$25/p_{I1}$	$25/p_{I1}$	$25/p_{I1}$
$OCVB_A^{CBG}$	$-15\%GDP$	0	0
$OCVBL_L^G$	$-15\%GDP$	0	0
pB_L^G	$-(1-\psi)15\%GDP$	0	0

Figure 7 Impact of a partial cancellation of public debt held by the central bank and permanent increase of public investment, starting in 2021

Relative deviation from baseline ($Y^{scenario} \cdot 100/Y^{baseline}$)



Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)



4.5. Recapitalization of the own funds of the central bank

Non-conventional monetary policy, whether in the form of helicopter money or of cancellation of public debt held by the central bank, leads to a worsening of central bank wealth. This deterioration could be important in the cases of financing large investment programmes for the low-carbon transition or cancelling the public debt generated by the covid crisis. Supporters of these policies argue that this question of central bank wealth is not essential. A central bank can support negative own funds without difficulty. This is not evident, especially in the case of an important amount. The credibility of the central bank could be questioned and an increase of the interest rates could arise. Another answer is given. As the central bank can create its own currency, its recapitalisation would be easy and without cost.

This point can be examined with the model. Recapitalisation of the central bank can be done in a simple way. The central bank issues new equities which are bought by the government thanks to a distribution of helicopter money to the government. This can be introduced in different steps in the model. First helicopter money is distributed to the government by feeding its account at the central bank for an amount equivalent to 5% of GDP. This amount is taken as a simple illustration as it represents only a part of the cost of the covid crisis for public finance or a part of the public debt which could be cancelled. In a second step the government transfers this amount of helicopter money to its account at commercial banks. Its account at the central bank is debited while its account at the commercial banks is credited (of 5% of GDP). In a third step the central bank issues new equities (for an amount of 5% of GDP) which are bought by the government. Consequently the bank account of the government is debited while the bank deposits of the central bank are increased. In the non-financial sphere (GDP and price) nothing changes. At the monetary and financial level the equities issued by the central bank are increased but the wealth of the central bank is reduced of the same amount (-5% of GDP). All in all, the own funds of the central bank (equities issued plus wealth) remain unchanged (Figure 8).

However, two other evolutions must be noted. Government wealth is increased (of 5% of GDP) since the government holds the new equities issued by the central bank. For the public sector as a whole (government and central bank) this means that its wealth is constant. This yields a more positive estimate of the financial situation of the public sector. But simultaneously the bank reserves, which can be interpreted as a debt of the central bank towards the commercial banks, increase of the same amount (5 % of GDP). As it has already been noticed, these increasing bank reserves could facilitate capital outflows and slippages in the financial markets. Overall, these results show that the recapitalization of the central bank raises problems. It cannot be done as simply as it is often claimed (i.e. with a "simple click").

Recapitalization of the own funds of the central bank in the model: added variables

First step: helicopter money distribution, without public indebtedness (1%GDP=25)

D_A^{GCB}	125	125	125
$p\Delta BL_L^G$	-125	0	0

To account for this distribution of helicopter money in the model, it is necessary to feed the government's account with the central bank and add a negative gap-filling variable of the same amount on the accounting identity determining the variation of public indebtedness, in order to translate the fact that the government's account is increased thanks to helicopter money and not by indebtedness.

Second step: transfer to government's bank account

D_A^{GCB}	0	0	0
D_A^G	125	125	125
D_L^G	$-\psi(125)$	$-\psi(125)$	$-\psi(125)$
$p\Delta BL_L^G$	-125	0	0

Here again the logic of the model requires the introduction of a gap-filling variable on the government's liability deposits, which are simply modeled as a function of government deposits held. This variable is negative to reflect the fact that these deposits have no reason to increase in the event of a helicopter money transfer.

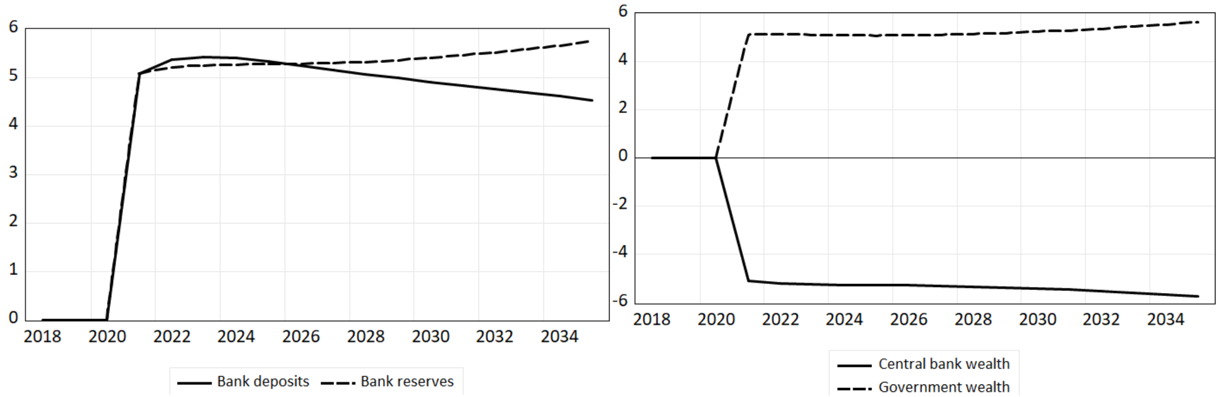
Third step: issue of new equities by the central bank bought by the government

pE_L^{CB}	125	125	125
pE_A^G	125	125	125
pE_A^{GFR}	$(1-\psi_2)125$	$(1-\psi_2)125$	$(1-\psi_2)125$
D_A^G	0	0	0
D_L^G	0	0	0
$p\Delta BL_L^G$	-125	0	0

The central bank equities bought by the government are 100% domestic which implies to put an added variable in the equation determining the domestic equities held by the government ($pE_A^{GFR} = \psi_2 E_A^G$).

Figure 8 Impact of a recapitalization of the own funds of the central bank equivalent to 5% of GDP

Absolute deviation from baseline, series as % of GDP ($Y^{scenario} - Y^{baseline}$)



5. Conclusion

Based on the national accounts and *comptes de patrimoine* by INSEE, as well as the financial accounts by Bank of France, an econometric SFC model of the French economy has been presented. It is an aggregate model with a single product distinguishing five domestic agents (firms, households, banks, central bank, government) and the rest of the world with a complete representation of economic and financial accounts in flows and stocks. The structure of the model is close to that of existing SFC models with demand-led dynamics, an accumulation behavior of a Kaleckian type and an indebtedness norm. The dynamic simulations on the past over the period 1996-2019 provide acceptable results.

The model has been used to study the effects of different forms of unconventional monetary policies. First, a distribution of helicopter money in favor of the government to finance additional public investments or social transfers has a stimulating impact without increasing the public debt. However, as a counterpart the wealth and own funds of the central bank deteriorate by an amount equivalent to the initial shock. If the intervention is not punctual and limited, this evolution could be problematic. It seems difficult to finance large public investment programs for the climate transition by this simple distribution of helicopter money. Second, the combination of public indebtedness and repurchase by the central bank has been described and appeared close to the case where there is no repurchase by the central bank but the effects of the repurchase may be underestimated in a version of the model with exogenous interest rates. Third, partial cancellation of the public debt held by the central bank has been examined. It has, as a counterpart, a degradation of the wealth and own founds of the central bank which are too important to remain without consequences. It does not give new leeway to finance public expenditures. Last, the recapitalization of the own funds of the central bank has been discussed. It raises also problems and cannot be done as a "simple click".

Overall, the use of public debt seems necessary to finance investments linked to the low-carbon transition. There is no miracle to expect from helicopter money or repurchase of public bonds by the central bank or partial cancellation of the public debt held by the central bank.

This version of the model could be improved on several points. The 10-year interest rate could be endogenized by no longer assuming that the market of public bonds is balanced by the demand of the banks. This would allow an examination of the consequences of monetary financing and repurchase of public bonds by the central bank. An explicit treatment of the ECB currently integrated in the rest of the world and a modelling of the rest of the euro zone remain to be done. This would help to analyze the potentiality of a central bank digital currency.

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Appendix

The treatment of Other Changes in Volume (OCV) and of revaluations is important, and rather technical. For each item of the balance sheet an OCV or asset price must be computed in order to ensure stock-flow consistency. Taking domestic equities as an example,

$$p_{E_L}^{i}E_L^{i} = p_{E_{L-1}}^{i}E_{L-1}^{i} + p_{E_L}^{i}(E_L^{i} - E_{L-1}^{i}) + E_{L-1}^{i}(p_{E_L}^{i} - p_{E_{L-1}}^{i})$$

$$p_{E_A}^{j_{FR}}E_A^{j_{FR}} = p_{E_{A-1}}^{j_{FR}}E_{A-1}^{j_{FR}} + p_{E_A}^{j_{FR}}(E_A^{j_{FR}} - E_{A-1}^{j_{FR}}) + E_{A-1}^{j_{FR}}(p_{E_A}^{j_{FR}} - p_{E_{A-1}}^{j_{FR}})$$

with $i = F, B, CB$ and $j = F, B, CB, G, H, R$

In order to have assets = liabilities $\Sigma p_{E_L}^{i}E_L^{i} = \Sigma\, p_{E_A}^{j_{FR}}E_A^{j_{FR}}$ both in $t-1$ and in t, some constraints must be imposed on flows (OCV) and on revaluation effects (prices). The equilibrium of flows between equities issued and held gives

$$\begin{aligned} p_E^{FR}\,(\Delta^* E_L^B + \Delta^* E_L^F + \Delta^* E_L^{CB}) \\ &= p_{E_A}^{F_{FR}}\Delta^* E_A^{F_{FR}} + p_{E_A}^{B_{FR}}\Delta^* E_A^{B_{FR}} + p_{E_A}^{CB_{FR}}\Delta^* E_A^{CB_{FR}} + p_{E_A}^{G_{FR}}\Delta^* E_A^{G_{FR}} + p_{E_A}^{H_{FR}}\Delta^* E_A^{H_{FR}} \\ &\quad + p_{E_A}^{R}\Delta^* E_A^{R} \end{aligned}$$

with the relations $\Delta E_L^B = E_L^B - E_{L-1}^B = \Delta^* E_L^B + OCV_{E_L}^B / p_{E_B}^L$ for each item. A consistency must exist between the OCV

$$\Sigma OCV_{E_L}^{i} = \Sigma OCV_{E_A}^{j_{FR}}$$

$$OCV_{E_L}^{B} = \Sigma OCV_{E_A}^{j_{FR}} - OCV_{E_L}^{F} - OCV_{E_L}^{CB}$$

Regarding the revaluation effects the constraint to be held is

$$\Sigma\, E_{L-1}^{i}\Delta\, p_{E_L}^{i} = \Sigma\, E_{A-1}^{j_{FR}}\Delta p_{E_A}^{j_{FR}}$$

Which gives a determination of $p_{E_A}^{R}$

$$\Delta p_{E_A}^{R} = \sum_i \left(\frac{E_{L-1}^{i}}{E_{A-1}^{R}}\right)\Delta p_{E_L}^{i} - \sum_j \left(\frac{E_{A-1}^{j_{FR}}}{E_{A-1}^{R}}\right)\Delta p_{E_A}^{j_{FR}} \quad \text{for } i = F, B, CB \quad \& \quad j = F, B, CB, G, H$$