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Macroeconomic policy evaluation in an SFC econometric model: the case of the investment programme for climate action in France

Chin Yuan Chong
Kedge Business School and Chaire Finance d'Impact, France

Jacques Mazier
Université Sorbonne Paris Nord and Chaire Energie et Prospérité, France

Luis Reyes*
Kedge Business School and Chaire Finance d'Impact, France and LASTA, University of Rouen Normandy, France

We study the macroeconomic impact of climate action policy that would allow France to reach its net zero objective by 2050. This policy, detailed in a report commissioned by the French Prime Minister, requires significant additional investments to be made by firms, households and the public sector. Contrary to the findings of the report, our simulations show that these investments are likely to generate economic growth and reduce public debt. However, since growth increases import demand, the trade balance and foreign debt worsen significantly, showing that the foreign sector benefits from France undertaking climate finance domestically. Unfortunately, the cost of climate action is borne mainly by firms and households whose financial position worsens considerably. Our tool for the analysis is a medium-scale empirical stock–flow consistent model built for the French economy (SFC FR).

Keywords: *climate transition policy, climate investments, empirical SFC models*

JEL codes: *E12, E62*

1 INTRODUCTION

SFC models in the lines of the founding works of Godley/Lavoie (2008) have proved useful to study the properties of the financial capitalism regime that has settled since the 1980s (Reyes/Mazier 2014; Clévenot et al. 2010). Thanks to a complete description of the balance sheets of the domestic and foreign agents, they are able to provide a comprehensive analysis of the main financial imbalances characterising this growth regime, both at the national and international levels. Until 2010, the majority of models published in academic journals were theoretical and calibrated rather than estimated or using a mix of both, even if Godley and co-authors made empirical contributions well before then (more on this below). To be clear, non-empirical models facilitate drawing clear-cut conclusions about important issues such as financial fluctuations, US imbalances or euro area disequilibria (Mazier 2020), to name a few. A new generation of SFC models appeared in the 2010s, incorporating climate transition and climate policy issues building at the

* *Corresponding author* – Email: luis.reyes@kedgebs.com.

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scale of the world economy. They combined a traditional SFC structure with a block on stock–flow material resources and/or damage functions. They showed the large negative impact that climate change has on financial stability and economic activity (Dafermos et al. 2017). They also illustrated how a green policy-mix could help reduce financial instability and global warming. Like traditional SFC models, they were calibrated, although in a realistic way based on available estimates. Since the 2010s, publications using econometrically based SFC models have become more abundant than in the past.

These models are country-based, while many theoretical SFC models were simulated for the world economy. This can be easily explained to the extent that the building of econometric national and international SFC models requires considerable preliminary statistical work. From this point of view, the CAM Model of the world economy can be regarded as an exception (see, for instance, Cripps 2016). Other works are also underway to develop ecological SFC models on a national basis with the aim of evaluating both the impact of climate change and the efficiency of the decarbonisation policies implemented.

To face global warming and respect the carbon neutrality objective by 2050, a complex set of measures, regulations, taxes, subsidies and investments have been implemented in most of the countries, with important national specificities according to the nature of the institutions of each country and the form of social compromise accepted. In all cases, important investments, both private and public, are necessary to create new carbon-free energy sources, to install more energy-efficient equipment or to change the nature of consumption. It also implies large transfers between agents with contributions from the private and public sectors. As low-income households are predominantly affected by the rising cost of energy, redistribution policies are necessary to make the transition policy more socially acceptable. The net effect of all these adjustments is far from straightforward. *Ex ante* evaluations about the cost for public finance or the burden for households or firms are not sufficient to shed light on the low-carbon strategy to be followed. Macroeconomic modelling is a traditional answer, and in this regard, the SFC approach is particularly well-suited to provide a coherent evaluation of the financial balances of all the agents.

This article fits in this perspective. Thanks to a rather large mobilisation of the economic administration, an assessment of the main economic problems raised in France with respect to climate action has led to the publication of an important report to the Prime Minister (Pisani-Ferry/Mahfouz 2023; PFM henceforth). This detailed document, with 10 thematic reports, highlights the importance of the industrial revolution implied by the climate transition and the specific role played by the public sector. The large investment effort is estimated at a detailed level with the implication of the various actors concerned. The report evaluates the macroeconomic impact and the consequences for public finance. Although it recognises the high degree of uncertainty that prevails, the report emphasises the need for increasing public debt combined with a temporary rise in taxes on the wealthiest. It also mentions the risk of inflationary pressures in the medium term. The methodology used relies mainly on a detailed bottom-up analysis and the use of a rather disaggregated macroeconomic model to evaluate detailed policies such as assistance with thermal insulation work or investment in new electric power stations. However, the macroeconomic synthesis of the impact of all the measures is not fully achieved. The point of view adopted in this article is simple. The starting point is the investment programme of firms, households and the government induced by climate action in France by 2030–2040, given by the PFM report, with the financial contribution of the public sector. These data are introduced in the SFC FR model to evaluate the *ex post* effects of this rather large shock. The model does not describe all the technical relations in PFM but takes into account all the interdependencies at stake in terms of income distribution and financing for all domestic and foreign agents. A synthesis of the impact of the investment

programme is expected; imperfect but including the necessary feedback effects. Some adjustments are made in SFC FR to incorporate the specificities of some shocks linked to the climate transition.

The article is organised as follows. The next section provides an overview of the existing literature in three parts (country SFC models, models for France and climate investment). Section 3 briefly describes the SFC FR model. Section 4 summarises the main lines of the investment programme listed in the PMF report and evaluates their macroeconomic impact with the help of the model. A sensitivity analysis is carried out to take account of the uncertainty regarding the profit behaviour of non-financial firms and the extent of the public support policy. Overall, it seems that more than a public debt problem, as underlined in the PFM report, the financing of climate action in France raises a problem of worsening the firms' and households' financial situation while enhancing the issue of foreign debt. Section 5 concludes.

2 LITERATURE REVIEW

Stock–flow modelling à la Godley–Lavoie is a powerful tool for policy analysis, since it allows the modeller/user to have at her/his disposal a coherent accounting representation of an economy between the real and financial sectors simultaneously in a dynamic way, explicitly integrating horizontal, vertical, flow-to-stock and balance sheet consistency, as well as stock-to-flow feedbacks (Zezza/Zezza 2019). Country models are usually medium-to-large scale, and given the amount of preliminary work they require to be built and for them to be operational, there is currently no standard methodology, although the principles cited above constitute a compulsory basis. An important methodological issue in this type of model is how the parameters of behavioural equations, inspired by Post-Keynesian theory,[1] are defined. In that respect, Passarella (2019) proposes a method to combine the estimated and calibrated parameters, where the latter are used to respect adding-up constraints.

The list of customised country or empirical SFC models published up-to-date includes, in no particular order: Argentina, the Netherlands, Vietnam, the UK, Tunisia, the US, as well as at least two versions for Iceland, Denmark, Italy, France and Greece. Note that this list does not attempt to be comprehensive, and that, as mentioned above, not all adopt the same methodology. While some are fully empirical (to our knowledge, Italy by Zezza and Zezza, the latest version of Denmark, our version of France and Vietnam), others combine estimated and calibrated parameters, while others rely solely on the latter.

Valdecantos (2022) models the exchange rate in Argentina to analyse the impact of the global financial cycle on that economy. Meijers et al. (2015) are interested in how the banking sector finances real estate in the Netherlands, while Muysken/Meijers (2022) focus on housing bubbles and pension fund challenges in the Dutch economy. The PhD thesis by Nguyen (2022) focuses on the impact of climate change in the Vietnamese economy using a stock–flow model for that economy. Following a methodology similar to that described by Passarella, Burgess et al. (2016) build a model for the UK in order to understand financial balances in that economy. Le Heron/Marouane (2021) study the effects of the pandemic in the Tunisian economy. Raza et al. (2019) model capital inflows in Iceland in order to analyse imported business cycles, whereas Malherbe (2022) focuses on the

1. Nikiforos and Zezza (2017: 1211) argue that 'the SFC literature has developed mostly inside the Keynesian school: it is the aggregate demand that sets the tone for the economy…'

macro-fundamental factors that explain the 2008 crisis in that economy. Byrialsen/Raza (2018) study the effect of an increase in the compensation rate of the unemployed on the Danish economy, while Raza et al. (2023) make a quantitative assessment of inflationary shocks in the same economy. Zezza/Zezza (2022), one of the two SFC models for Italy (the other one being that of Passarella), is interested in quantitative easing and unconventional monetary policies in Italy, whereas Mazier/Reyes (2023) focus on the same question in France. Pierros (2021) is interested in studying the internal devaluation mechanism in the real and financial sectors in Greece, partly inspired by its predecessor Papadimitriou et al. (2013). Last, but certainly not least, perhaps the model that started the empirical SFC movement is that of the US, developed by Godley and his co-workers at the Levy Institute. Godley et al. (2007) briefly describe the core accounting principles of the model and cite many of the strategic analyses that complete the model's approach, scope, structure and results, one of which dates back to 2000 (Godley 2000). An interesting preliminary work that goes in the same sense is Godley/Zezza (1992) who built a simplified stock–flow model for Denmark. Some other country models include Moldova (Le Heron/Yol 2019), Mexico (Nalin/Yajima 2020) and Colombia (Escobar 2016).

Currently, there is also a relatively long list of macroeconomic models for the French economy that have been built with specific objectives and/or characteristics. MESANGE (*Modèle Econométrique de Simulation et d'ANalyse Générale de l'Economie*; Dufernez et al. 2017) is a quarterly model developed by the French Treasury and the national statistics bureau INSEE, with about 50 behavioural equations but no description of the financial sector. Opale (Daubaire et al. 2017), also a quarterly model with a simpler structure than and with results comparable to MESANGE, is used for one to two years forecasts that integrate elements that lie outside of the model. In both, behavioural equations take the form of error correction models, which integrate long-term elements in short-term specifications.

Eurogreen, a calibrated model using French data for 2014 that places particular emphasis on input–output matrices, has been used for analysing alternatives to green growth (D'Alessandro et al. 2020), to analyse the environmental impacts of working time reduction (Cieplinski et al. 2021) as well as raw material sustainability (Boutiab 2024).

ThreeME (Callonnec et al. 2016) is a large Neo-Keynesian Computable General Equilibrium model that details the interdependency of 24 sectors of activity (with 12 in energy). In the short term, production is determined by the demand side. In the long term, the model is supply side with production depending on capital, labour, energy, materials and margin, where each can be either domestic or imported. There is a large financial sector with banks, loans, interest rates following the Taylor Rule and equities. However, the financial block is not used in the current version. The objective of the model is to evaluate macroeconomic public policies, including changes in the economy following changes in the oil price, employer contributions, value added taxes, public investment and the carbon tax. Investment and energy are decomposed by the types of goods and/or by the source of energy. Investment depends on its past values, expected output, substitution phenomena (between capital, labour and energy) and the difference between lagged notional capital and observed lagged capital.

The model for France of the Banque de France FR-BDF (Lemoine et al. 2019) is a large-scale semi-structural replacement of an older model; Mascotte (Baghli et al. 2004). It draws inspiration from the FRB/US model. FR-BDF has a large set of interest rates, an endogenous exchange rate and integrates expectations. It is, however, surprising that this is done with neither the financial sector nor the balance sheets of agents explicitly modelled.

An interesting work dealing specifically with climate investment is that of Hainaut/Cochran (2018), who describe a methodology (updated in Hainaut et al. 2023) to calculate

domestic financial flows in favour of climate in France, which is taken up by PFM to estimate the financing needs shown in Table 2. Their main purpose is to support and encourage the debate on the topic. On the basis of the French National Low-Carbon Strategy, they take as the basis of their methodology the items included in gross capital formation, which are included in the national accounts and are compatible with both the use-resource tables and the flow-of-funds that describe wealth. Expenditures that relate to energy efficiency (for instance, to reduce energy use for heating, cooling, motorisation or to reflect the change in the main source of energy) are amongst the most important ones considered. The authors track initial capital needs by sector or activity, which are divided into residential, transport, agriculture, industry and centralised energy production/networks.

Finally, some clarification of what we mean by climate action. According to EUR-Lex, this term refers to 'efforts taken to combat climate change and its impacts'. These include mitigation and adaptation. Mitigation relates to the avoidance and reduction of greenhouse gas emissions, whereas adaptation aims at stimulating change of behaviour in society while taking the unavoidable as given. Climate finance (as defined by the United Nations Framework Convention on Climate Change) refers to local, national or transnational financing that seeks to support one or the other or both in order to address climate change.

3 THE OVERALL STRUCTURE OF THE SFC FR 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 and 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 in the statistical conventions adopted.

The model is aggregated with a single product and is demand-led. 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). The consumption price level depends on a mark-up pricing rule and is a function of unit labour costs (ULC) and import prices with an effect from demand pressures. Value added is calculated from GDP after deduction of the VAT and import duties and taxes. 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 are 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 analysed 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 behaviour are then described for each agent. The 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 written explicitly to ensure stock–flow consistency. Table 1 shows the balance sheet structure of the domestic and foreign sectors.

Table 1 Symbolic balance sheet structure of economic agents

		Non-fin. corporations		Financial institutions: Banks		Financial institutions: Banque de France		Government		Households		Rest of the world	
		Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.
NFA_1	*Produced non-financial assets*	$p^F_{K_1}K^F_1$		$p^B_{K_1}K^B_1$				$p^G_{K_1}K^G_1$		$p^H_{K_1}K^H_1$			
$NFA_{12/13}$	*Inventories (12) + valuables (13)*	$p^F_{K_{12}}K^F_{12}$						$p^G_{K_{12}}K^G_{12}$		$p^H_{K_{12}}K^H_{12}$ $p^F_{K_{13}}K^F_{13}$			
NFA_2	*Non-produced non-financial assets*	$p^F_{K_2}K^F_2$		$p^B_{K_2}K^B_2$				$p^G_{K_2}K^G_2$		$p^H_{K_2}K^H_2$			
F_1	*Monetary gold and SDRs*					$p^{CB}_G G^{CB}$							$p^{CB}_G G^{CB}$
F_2	*Bills and coins*	H^F		H^B			H^{CB}			H^H		H^R	
	Digital currency	EH^F		EH^B			EH	EH^G		EH^H			
	Refinancing between financial institutions				$\boldsymbol{RF^B}$	RF^{CB}							RF^R
	Bank reserves			$\boldsymbol{RES}$			RES						
	Govt. account at CB						$\boldsymbol{D^{CB_G}_L}$	$D^{G_{CB}}_A$					
	Target 2					$TRGT2$							$TRGT2$
	Deposits	D^F_A		D^B_A	$\boldsymbol{D^B_L}$	D^{CB}_A	D^{CB}_L	D^G_A	D^G_L	D^H_A		D^R_A	$\boldsymbol{D^R_L}$
F_3	*Public securities*	$p^{F_G}_{B_A}B^{F_G}_A$		$\boldsymbol{p^{B_G}_{B_A}B^{B_G}_A}$		$p^{CB_G}_{B_A}B^{CB_G}_A$			$\boldsymbol{p^G_{B_L}B^G_L}$			$p^{R_G}_{B_A}B^{R_G}_A$	
	Foreign securities	$p^{F_R}_{B_A}B^{F_R}_A$		$p^{B_R}_{B_A}B^{B_R}_A$		$p^{CB_R}_{B_A}B^{CB_R}_A$		$p^{G_R}_{B_A}B^{G_R}_A$		$p^{H_R}_{B_A}B^{H_R}_A$			$\boldsymbol{p^R_{B_L}B^R_L}$
	Other securities		$p^F_{B_L}B^F_L$	$p^B_{B_A}B^B_A$	$p^B_{B_L}B^B_L$	$\boldsymbol{p^{CB}_{B_A}B^{CB}_A}$		$p^G_{B_A}B^G_A$		$p^H_{B_A}B^H_A$		$p^R_{B_A}B^R_A$	

(continues overleaf)

Table 1 (continued)

		Non-fin. corporations		Financial institutions				Government		Households		Rest of the world	
				Banks		Banque de France							
		Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.	Asset	Liab.
F_4	*Loans*	L_A^F	L_L^F	$\boldsymbol{L_A^B}$		L_A^{CB}			$\boldsymbol{L_L^G}$		$\boldsymbol{L_L^H}$	L_A^R	L_L^R
F_5	*[Domestic] Equity and inv. fund shares*	$p_{E_A}^{F_D} E_A^{F_D}$	$\boldsymbol{p_{E_L}^{F_D} E_L^{F_D}}$	$p_{E_A}^{B_D} E_A^{B_D}$	$\boldsymbol{p_{E_L}^{B_D} E_L^{B_D}}$	$p_{E_A}^{CB_D} E_A^{CB_D}$	$p_{E_L}^{CB_D} E_L^{CB_D}$	$p_{E_A}^{G_D} E_A^{G_D}$		$p_{E_A}^{H_D} E_A^{H_D}$		$p_{E_A}^{R} E_A^{R}$	
	[Foreign] Equity and inv. fund shares issued by RoW	$p_{E_A}^{F_R} E_A^{F_R}$		$p_{E_A}^{B_R} E_A^{B_R}$		$p_{E_A}^{CB_R} E_A^{CB_R}$		$p_{E_A}^{G_R} E_A^{G_R}$		$p_{E_A}^{H_R} E_A^{H_R}$			$\boldsymbol{p_{E_L}^{R} E_L^{R}}$
F_6	*Insurance. pension funds and s.g.s.*	A_A^F			$\boldsymbol{A_L^B}$			A_A^G		A_A^H		A_A^R	
F_7	*Fin. derivatives and employee stock options*	X_A^F			$\boldsymbol{X_L^B}$			X_A^G		X_A^H			X_L^R
F_8	*Other accounts receivable/ payable*	Z_A^F		Z_A^B		Z_A^{CB}		Z_A^G		Z_A^H		$\boldsymbol{Z_A^R}$	
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**					

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 financialised capitalism and has had a significant macroeconomic impact, particularly in the last three decades.

For financial assets, a split is made traditionally between monetary gold and SDRs, cash and deposits, securities, loans, equities, insurance and pension funds, finance derivatives and other accounts receivable. For a better understanding of monetary policy, deposits are analysed 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 to study the effects of helicopter money (Mazier/Reyes 2022). 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 the Bank of France and on the liability side of the ECB, thus appearing in the column for rest of the world in the convention that has been adopted and are considered exogenous (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 closures of the model by main assets are important to explicit. They help understand how the financing needs generated by the climate investment programme are distributed among domestic and foreign agents. They are as follows:

- Firms balance their accounts by issuing the necessary shares.
- Households balance their account by getting indebted 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 provide 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.

4 ASSESSMENT OF THE INVESTMENT PROGRAMME FOR THE LOW-CARBON TRANSITION IN FRANCE

4.1 The Pisani-Ferry–Mahfouz report

The PFM report provides a detailed assessment of the investments needed in France to achieve carbon neutrality by 2050. It assesses the macroeconomic impact of emission reduction policies in two complementary ways.

According to the first approach, the costing of a set of specific measures (ban on combustion-powered vehicles from 2035, ban on the installation of new oil-fired boilers starting 2022, subsidies on the renovation of low-energy housing, etc.) and their macroeconomic impact is first carried out using the ThreeME model (Callonnec/Cance 2022), which is sufficiently disaggregated to assess this type of measure (see description in Section 2). Two alternative assumptions are made regarding labour productivity gains. Labour productivity is assumed to be exogenous in ThreeME. In this case, investment does not directly affect productivity dynamics, and the plan thus expands GDP by 1 per cent (compared to the baseline), consumer prices increase (+6.5 per cent), public balance-to-GDP improves and net exports first deteriorate and then recover, being 0.3 per cent of GDP higher than the baseline by 2040.

Alternatively, it can be assumed that the major investments devoted to the low-carbon transition will have no direct impact on productivity but are in turn carried out at the expense of productive investments. This leads the authors of the report to assume a slowdown in productivity of 0.33 per cent per year. Overall, following this last assumption and taking into account all possible measures, in the corresponding simulations, they obtain a fall in GDP of around 1 per cent by 2040, a price slippage of around 12 per cent, a deterioration in the public balance of –0.5 per cent of GDP and an improvement in the external balance of around 1 per cent of GDP (figure 18 in chapter 8 of PFM report).

A second approach examines the direct impact of the climate transition on public finance. On the public expenditure side, we find direct costs for the public administrations (building and infrastructure renovation and adaptation investments), investment support for households and small businesses and transition-related financial support (decarbonisation subsidies and vocational training). Table 2 summarises these main measures. On the income side, there will be a gradual reduction in taxes and excise duties on fossil fuels (35 billion euros in 2021), partly offset by new receipts (Carbon Border Adjustment Mechanism, emission allowance market; around 10 billion euros in 2030). Added to this are losses of public revenue due to the deterioration in potential production, as investments in the transition are made at the expense of productivity investments. It is assumed, however, that the gains and losses in public receipts will be fully offset. Combined with the increase in public spending presented in Table 2, there is an estimated rise in public debt of 25 per cent of GDP in 2040, of which 13 per cent would be due to cumulative spending net of revenues and 8 per cent to the erosion of potential output. It can be noted

Table 2 Annual cost of climate transition for public finance, 2030

In bn € per year	Additional investment	Share of public funding
Buildings (10) and infrastructure (7)	17	14
Residential renovation	21	14
Renovation of private commercial buildings	17	0
Electrical equipment by firms	4	0
Firms' investment (incl. Energy, 13) + adaptation (3)	16	3
Total	75	31

Source: Pisani-Ferry/Mahfouz (2023).

that this second approach gives a rather more pessimistic view for the future of public finance than the one obtained with the ThreeME model, where the demand effect was more significant.

The PFM report highlights the uncertainties surrounding these macroeconomic references up to 2040, and the various options that may arise for financing the climate transition. To shed light on these issues, we can attempt, on an exploratory basis, to evaluate the programme presented in the PFM report using the SFC FR model.

4.2 Translating the PFM report's investment programme into the logic of the SFC FR model

The SFC FR model is highly aggregated, with no breakdown by sector of activity, but provides a comprehensive description of the financial system, thus a complementary perspective. To this end, the programme content can be broken down into the categories used in the SFC FR model. The additional investment in buildings and infrastructure can be allocated to public authorities for an amount of €14 billion at 2030 prices, corresponding to the amount of public funding planned, with the remainder (€3 billion) going to firms. Households will be responsible for the renovation of their homes, with public funding of €14 billion (to simplify, in the form of transfers). The rest of the investment (renovation of the private tertiary sector, electrical equipment for firms and their investment) is naturally the responsibility of firms (€40 billion), with public funding of €3 billion (in the form of subsidies; again, to simplify). This gives us Table 3, whose elements can be introduced into SFC FR. It should be noted that public sector investment represents only a modest share (18.8 per cent) of the total investment effort. If aid to the private sector in the form of public funding is added, the public sector's contribution to the overall plan is greater (41 per cent). However, the macroeconomic impact of the two forms of public intervention is very different.

Table 3 The PFM programme in an aggregated version

In bn € 2030 per year	Additional investment in value	Public financing
I public (administrations)	14	
I households	21	14 (social transfers)
I firms	40	3 (subsidies)
Total	**75**	**31**

Note: The figures are the equivalent by institutional sector of Table 2.

In bn € 2023 per year	Additional investment in value	Public financing
I public (administrations)	14/1.2 = 11.7	
I households	21/1.2 = 17.5	14/1.2 = 11.7 (social transfers)
I firms	40/1.2 = 33.3	3/1.2 = 2.5 (subsidies)
Total	**75/1.2 = 62.5**	**31/1.2 = 25.8**

Note: Values at 2023 prices (1.2 is the value of the price index in 2030, base 2023).

Source: Proposed by the authors to adapt the PFM programme for analysis in SFC FR.

To this, we must add a special treatment of automobile purchases by households in the PFM report. It is assumed that households will buy more electric cars (with public support estimated at €2 billion a year) but will buy fewer cars overall (due to changes in mobility patterns, etc.). A reduction in household consumption of €8 billion per year is therefore assumed.

In total, the following shocks are introduced into SFC FR starting in 2023 to assess the expected effects of the PFM programme. Public investment in volume increases by 10.7 billion (11.7/ p_I^G, where p_I^G is the public investment deflator), taking into account the transition from current prices to constant prices. Private investment in volume increased by 30.1 billion (33.3/ $p_{I_1}^F$), household housing investment (I^H) in volume by 15.4 billion (17.5/ $p_{I_1}^H$), social benefits by 13.3 billion and subsidies to firms by 2.5 billion. Finally, household consumption expenditure is 6.7 billion below the baseline path from 2023.

4.3 Additional corrections

Some additional corrections need to be made to take into account the specific features of the climate transition programme and the particularities of the model used.

- The first concerns labour productivity of the market sector, which in SFC FR depends on a simple Cobb–Douglas relationship with an elasticity of 0.2 in relation to capital per capita, and a trend of decreasing technical progress over time with breaks.

$$\ln\left(\frac{va^M}{N^M}\right) = 0.2\ln\left(\frac{K_1^M}{N^M}\right) + 0.02t - 0.01t_{1992} - 0.007t_{2008} + 2.1$$

  As mentioned above, major investments to renovate, insulate or develop renewable energies have no impact on labour productivity and may even have a negative impact (compared to a benchmark with no transition policy or business as usual) by leading to the abandonment of productivity-enhancing investments. We simply assume that the additional investments (€61 billion per year, €55 billion in volume) will have no positive impact on productivity. This leads to the introduction of a negative deviation variable on the productivity growth rate of –0.16 per cent per year, equal to the expected effect of the increase in the accumulation rate $\left(0.2\left(\frac{\Delta K_1^M}{K_{1-1}^M}\right) = 0.2 * \frac{55}{6994} = 0.0016\right)$.

- The second component concerns imports, whose determinants need to be modified to take account of the fact that a significant proportion of the new investments linked to the climate transition will have to be imported, as they are not produced in France. Imports are determined in the model by a highly aggregated equation at the level of all goods and services.

$$\ln(IM) = -9 + 1.9\ln(Y) - 0.2\ln(p_{IM}) + 0.01t$$

Compared to the reference path (r):

$$\ln\left(\frac{IM}{IM^r}\right) = 1.9\ln\left(\frac{Y}{Y^r}\right)$$

$$\ln\left(1+\frac{\Delta IM}{IM^r}\right) = 1.9\ln\left(1+\frac{\Delta Y}{Y^r}\right)$$

By linearising the trend supplement to imports ($\Delta IM^{trend} = IM - IM^r = 1.9\left(\frac{IM^r}{Y^r}\right)$ $\Delta Y = 1.9 * 0.386 * \Delta Y = 0.73\Delta Y$), which gives an already large marginal propensity to import. We assume an exogenous shock of 0.5 per cent to the import growth rate, which is equivalent to assuming a marginal propensity to import of 82 per cent.

- Another point concerns the land price $\left(p^H_{K_2}\right)$, which in the model depends on the evolution of housing investment by households $\left(I^H_1\right)$, with a long-term elasticity of 1.3. This effect needs to be corrected, as major renovation expenditures should not fuel a rise in land prices.

$$\ln\left(p^H_{K_2}\right) = -7.8 + 1.3\ln\left(I^H_1\right) + 0.1t_{1998-2021}$$

$$\Delta\ln\left(p^H_{K_2}\right) = 0.03 + 0.6\Delta\ln\left(p^H_{K_2-1}\right) + 0.5\Delta\ln\left(I^H_1\right) - 0.3vc_{-1}$$

Deviation from reference path is expressed as

$$\Delta\ln\left(p^H_{K_2}\right) = 1.3\Delta\ln\left(I^H_1\right)$$

$$\frac{\Delta p^H_{K_2}}{p^H_{K_2}} = 1.3\frac{\Delta I^H_1}{I^H_1}$$

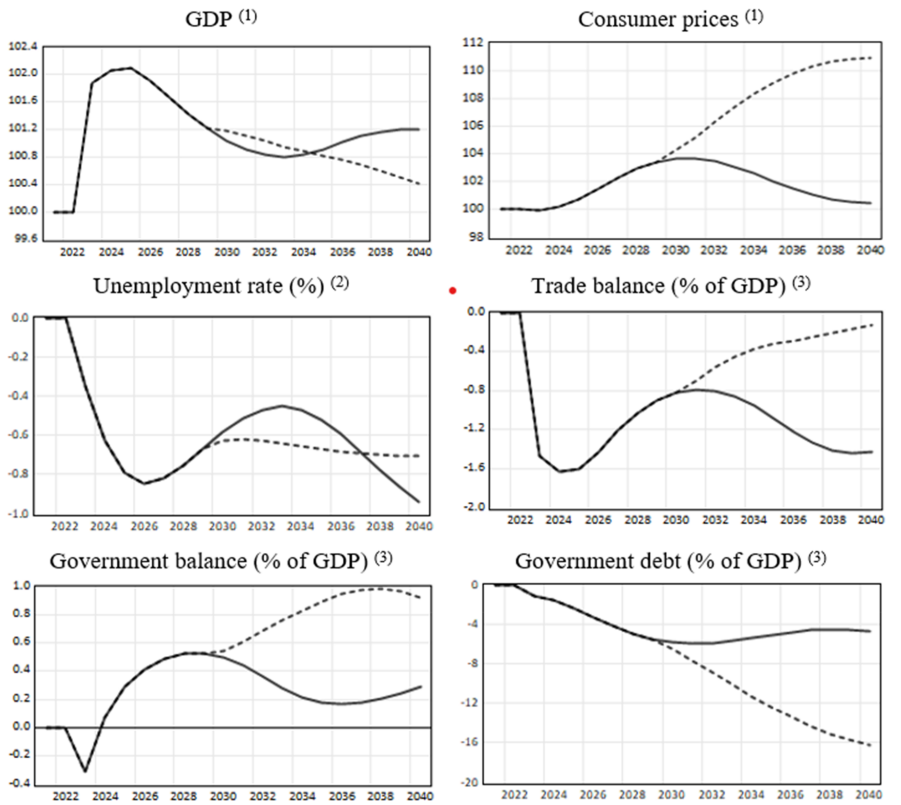
The shock to housing investment $\left(\Delta I^H_1 = 18.5\right)$ results in an increase in land prices of 1.3 (18.5/154) = 15.6 per cent, which needs to be corrected. A deviation variable of –15 per cent is, therefore, introduced for the growth rate of land prices.

- Two final points concern, on the one hand, a slight rise in the rate of accumulation of firms linked to the increase in the share of profits induced by subsidies, and on the other, the rise in housing investment by households linked to the increase in their disposable income also induced by subsidies. In both cases, these effects must be corrected to avoid overestimating the shock, but the offsetting effects are quite small (–0.0003 and –0.49 billion, respectively).

4.4 PFM programme results according to the SFC FR model

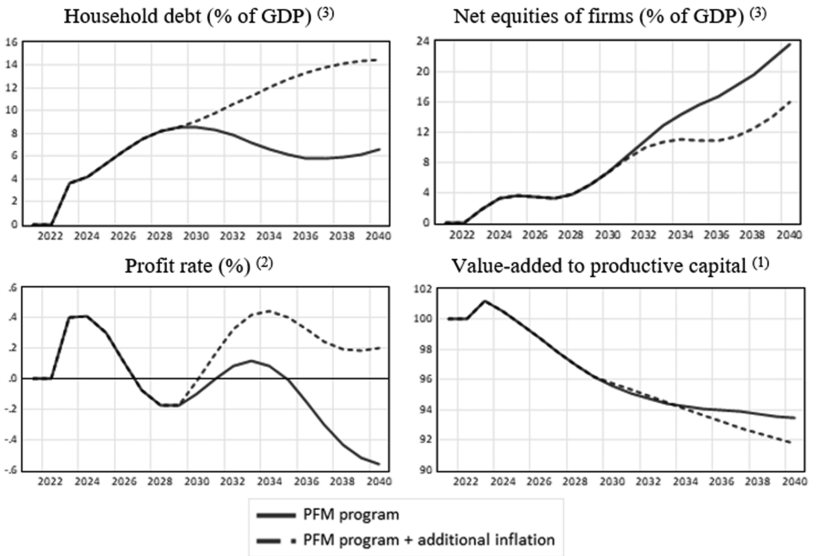
The graphs (Figure 1) show the main results in relation to the baseline path. The low-carbon transition programme results in a sustained recovery in activity (GDP after 3 years

is higher by 2.1 per cent with respect to the baseline), which gradually erodes but persists in the long term (1 per cent). This trend is consistent with the scale of the programme, which affects all agents – public authorities, firms and households. This sustained activity leads to a significant and lasting reduction in the unemployment rate, not to be overestimated (–0.8 per cent to –1 per cent). However, consumer prices rise (3.7 per cent in 2030), but the slippage remains controlled (0.5 per cent annually) and prices gradually return to their reference path over the course of the 2030s, so that 'greenflation' does not last. There is, therefore, no lasting inflationary surge. The public balance improves (0.4 per cent of GDP in the medium term), mainly due to GDP volume and prices rising, and despite rising investment and public spending. Households, however, take on more debt. The financing capacity of non-financial firms worsens steadily (–1.1 per cent of GDP) as does, although to a lesser extent, that of households (–0.5 per cent of GDP). The most worrying counterpart is the deterioration in the current account balance (–1.7 per cent of GDP in the short term), which is only marginally reduced in the longer term. As a result, the financing capacity of the rest of the world improves significantly and permanently (between 1.2 per cent and 1.4 per cent of GDP).



Note: Series under scenario PFM – baseline (per cent).

Figure 1 Effects of the PFM programme according to SFC FR (PFM reference in solid line, with additional inflation from 2030 in dotted line)



(1) Presented as the after-shock series multiplied by 100, divided by the baseline series.
(2) Presented as the after-shock–baseline difference, with the baseline and after-shock series in %.
(3) Presented as the after-shock–baseline difference, with the baseline and after-shock series in % of GDP.

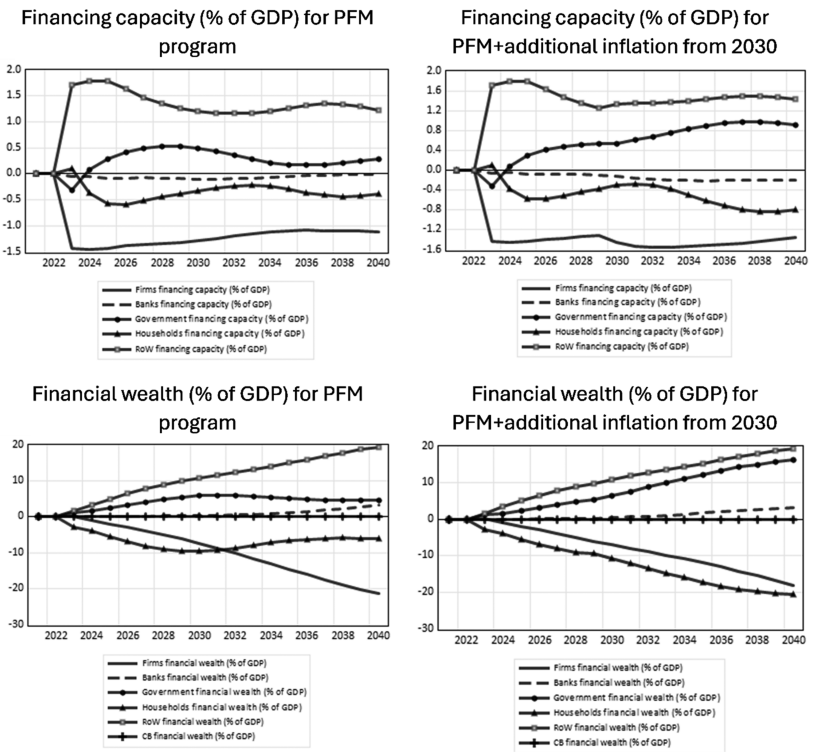


Figure 1 (continued)

The consequences in terms of agents' asset and liability structures are significant. Public debt falls significantly in the medium term (–6 per cent of GDP) due to the improvement in the public balance, contrary to what is expected in the PFM report. Household debt, however, increases significantly (6 per cent of GDP in the medium/long term). On the corporate side, firms' net debt does not increase significantly; it is their net equity issuance that grows at nearly 24 per cent of GDP due to a sharp reduction in financial asset holdings. This decline is explained by the worsening in firms' overall rate of profit and the fall in real financial profitability during the 2020s.

Overall, government financial wealth improves (by around 6 per cent of GDP). However, the financial wealth of companies worsens structurally (–20 per cent of GDP in the long term), as does that of households (–10 per cent of GDP), while the rest of the world increasingly becomes a creditor to France (20 per cent of GDP). The durability of such trends is questionable, both in terms of external debt (how high can it go?) and firms' debt. The financial capacity of the latter seems to deteriorate, even if some highly indebted public companies (such as EDF and SNCF) could benefit from the improvement in public finance.

Price trends can be examined in greater detail. The price slippage clearly appears in the short term but is not durable according to SFC FR. Prices and ULC return to baseline levels in the 2030s, despite the fall in the unemployment rate. A breakdown of the determinants of ULC (Figure 2) shows that the downturn is due to the fall in total labour costs per head (close to wages per head), which is more pronounced than the deterioration in productivity per head (–1 per cent in the medium-to-long term). Wage dynamics and moderation prevail, without triggering an upward wage-price spiral. The trade-offs in terms of income distribution are significant. Real wages per head improve, but only moderately (1 per cent in the medium-to-long term). The ratio of real wages to productivity, that is, the share of wages in value added, rises by only a little more (2 per cent in the medium-to-long term). However, this means that the share of profits falls in the long term. Companies accept a worsening in their profit margins, which explains the price moderation in the 2030s. This is a possible scenario, but not necessarily the most likely one, especially in the context of the sharp worsening in corporate financial positions observed above. This point is discussed in greater detail below.

An analysis of the output-to-capital ratio (at constant prices) sheds further light. This ratio is used to determine prices and it acts as a substitute for a production capacity utilisation rate in the investment function, in both cases positively. A fall in the ratio, reflecting lower capacity utilisation, contributes to lower prices. However, the output-to-capital ratio falls steadily but moderately (–8 per cent over the long term), due to the scale of the investments made, with a smaller effect on production (see Figure 1). Energy transition investments contribute less to increasing production capacity (k_p is lower). The fall in the output-to-capital ratio is a poor reflection of a fall in the capacity utilisation rate. The capacity utilisation rate is undoubtedly higher $\left(TUC = \frac{1}{k_p} \frac{va^M}{K_1^M} \right)$ and this ought to be corrected. However, this correction would be rather minor. The fall in the inflation rate linked to the decrease in $\left(\frac{va^M}{K_1^M} \right)$ as described in the model is in fact only –0.4 per cent over 18 years (see below). Even if this downward effect were corrected, the return of the inflation rate to its reference path value would persist.

ULC = unit labour cost

$\left(\text{market sector} = \text{non} - \text{financial firms} + \text{financial institutions} + \text{households and NPISH} \right)$

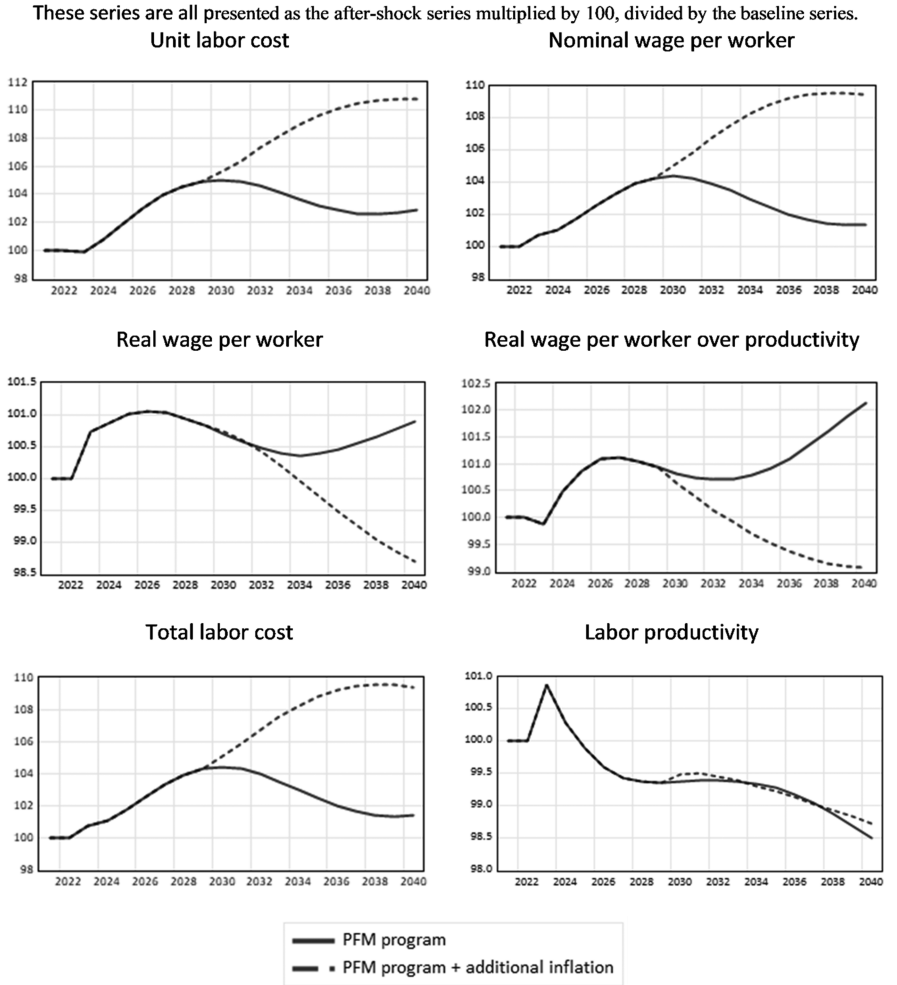


Figure 2 Wage-price dynamics of PFM programme according to SFC FR

$$ULC^{M} = \left(\frac{W^{M} + LC^{M} + LCW_{p}^{H_M} + T_{L_p}^{M}}{va^{M}} \right)$$

$$ULC^{M} = \left(\frac{W^{M}\left(1+\theta_{SC}^{H_M}\right) + LC^{M} + T_{L_p}^{M}}{va^{M}} \right)$$

where $LC^{M} = LC_{p}^{F} + LC_{p}^{B} + LC_{p}^{H} = labor\ contributions$, $T_{L_p}^{M} = T_{L_p}^{F} + T_{L_p}^{B} + T_{L_p}^{H}$ = taxes on payroll and on production and $LCW_{p}^{H_M} = \theta_{SC}^{H_M} W^{M}$.

$$\text{Total labour cost per worker} = \left(\frac{W^M \left(1 + \theta_{SC}^{H_M}\right) + LC^M + T_{L_p}^M}{N^{S_M}} \right)$$

$$va_{pot}^M = k_p K_1^M$$

$TUC = \dfrac{va^M}{va_{pot}^M} = \dfrac{va^M}{k_p K_1^M} =$ Capacity utilisation rate (taux d'utilisation des capacités de production in French).

The consumer price equation is:

$$\ln\left(p_C^H\right) = 0.3 + 0.9\ln\left(ULC^M\right) + 0.1\ln\left(p_{IM}\right)$$

$$\Delta\ln\left(p_C^H\right) = -0.1 + 0.4\Delta\ln\left(p_{C-1}^H\right) + 0.1\Delta\ln\left(ULC^M\right) + 0.2\Delta\ln\left(ULC_{-1}^M\right) + 0.1\Delta\ln\left(p_{IM}\right) + 0.2\left(\frac{va^M}{K_1^M}\right) + 0.3\left(\frac{T_{P-1} - Sub_{-1}}{p_{Y-1}Y_{-1}}\right) - 0.1vc_{-1}$$

The effect of the falls in the output-to-capital ratio is thus:

$$\left(\frac{\Delta p_C^H}{p_{C-1}^H}\right) - \left(\frac{\Delta p_C^H}{p_{C-1}^H}\right)_r = 0.2\left[\left(\frac{va^M}{K_1^M}\right) - \left(\frac{va^M}{K_1^M}\right)_r\right] = 0.2\left[\frac{\left(va^M/K_1^M\right)}{\left(va^M/K_1^M\right)_r} - 1\right]\left(\frac{va^M}{K_1^M}\right)_r$$
$$= 0.2(0.8)(0.25) = 0.004$$

4.5 Preserving firms' profits and increasing public support

According to the simulations presented above, the PFM investment programme would lead to a moderate recovery without any lasting slippage in prices, with a slight reduction in public debt, but at the expense of a deteriorated situation for firms and households, and at the cost of growing external debt. The uncertainties surrounding this type of projection are considerable, not least because of the new nature of the investments envisaged as part of the climate transition. Two variants of sensitivity can be explored to shed light on this issue, taking into account a possible reaction on the part of both companies and the government. The first describes a situation in which companies preserve their profits to a greater extent after 2030, at the cost of a more pronounced inflationary surge (0.5 per cent per year from 2030). In the second scenario, the government uses the fiscal room for manoeuvre at its disposal to further support companies and households through increased subsidies and transfers (twice 10 billion euros more per year starting in 2023). The results of the scenario where firms' profits are preserved are presented in Figure 1, and the scenario of increased government support in Figure 3 (we limit ourselves to the main results).

Sustained higher inflation over the medium-to-long term (+12 per cent, that is, around 0.7 per cent p.a.) reduces real wages and allows a limited rise in the profit share and profit rate. The fall in real incomes weighs on growth, which weakens. The public balance improves thanks to higher tax receipts generated by rising prices, and public debt as a percentage of GDP falls. The trade balance also improves, despite the loss of price

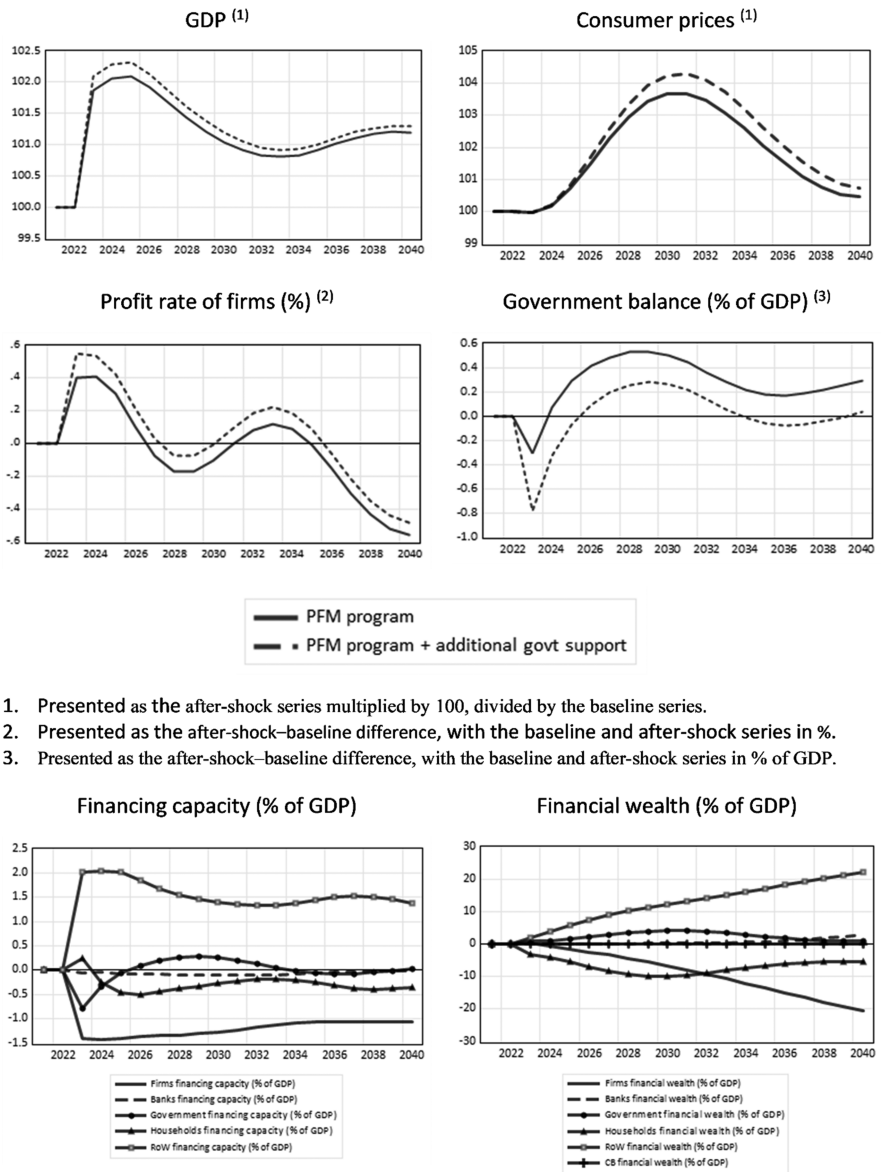


Figure 3 Effects of the PFM programme with increased government support, according to the SFC FR model (baseline in solid line and increased government support in dotted line)

competitiveness, which is more than offset by lower import volumes. Nevertheless, it remains negatively affected, and the financial wealth of the rest of the world (that is, France's net debt) increases as much as in the previous scenario (by around 20 per cent of GDP). Household indebtedness increases as real incomes fall, and household financial wealth further deteriorates. Thanks to a better preservation of profits, the financial balance

of firms worsens less, their profit rate recovers, their liabilities increase less and their financial wealth falls less sharply. However, overall, the restoration of profits thanks to higher inflation does not upset the results of the previous scenario. Firms fare slightly better, with households bearing the brunt of the adjustment.

Increased government support in the form of more transfers to households and subsidies to businesses (20 billion euros per year) has, as Figure 3 shows, only a limited impact compared to the climate action shock: slightly more growth and inflation, a better profit rate, a public balance that is obviously worse off but returns to balance after a few years, but otherwise exhibits similar trends. Despite substantial public support (40 billion euros per year), the broad outlines of the reference scenario remain unchanged. It should be noted, however, that household subsidies designed to support the climate transition are not well-described in the scenario. In fact, the subsidies are paid to all households in a uniform manner, whereas the spirit of recovery policies is that these subsidies should be targeted towards the most disadvantaged households and those most affected by the low-carbon policy. If this point were considered, the effects would undoubtedly be more favourable to households.

Naturally, our work is not without limitations. First, the shocks performed are fixed for the simulations. To illustrate this, public investment in volume is increased by 11.7 billion euros in 2023 and this increase is assumed constant from then on, regardless of changes in the business cycle that may oblige the public authorities to further increase or reduce capital or other forms of expenditure. Second, in this version, we look at the results of the model post-shock compared to our baseline in a single scenario that combines changes in several series simultaneously: prices, subsidies, productivity, public investment and others. In another paper, we observe the results of the shocks one at the time (see, for instance, the part 'basic variants' in Mazier/Reyes 2022). Third, our model is based on our assumptions, which are in turn the result of a combination between theoretical and statistical significance that is often time-consuming to arrive at. This is even more time-consuming when updating the dataset (roughly every three years) and all behavioural equations have to be updated in order to factor in the observations added. A fourth limitation is the high level of aggregation of the model, which prevents it from capturing the structural effects of climate transition policies.

5 CONCLUSION

This paper seeks to assess the effects of climate transition policies and, more specifically, the impact of the vast investment programme envisaged to achieve carbon neutrality in 2050 in France. It drew on the data gathered in the PFM report and integrated them into the SFC FR model built using French data. While the model is highly aggregated and ill-suited to capture the structural effects of climate transition policies, it does have the advantage of describing the distribution and financing mechanisms in a comprehensive way. All the feedback effects are well-described, providing additional insight into the assessments made.

Simulations carried out with SFC FR lead to significantly different results from those in the PFM report. Public indebtedness does not increase; in fact, it falls, and the public finance situation improves because of more sustained activity. A moderate slippage in prices is observed during the first period, but this does not last mainly because companies accept a reduction in their profit margins. The financial situation of firms worsens. Household debt increases. Finally, the trade balance worsens permanently, and indebtedness with respect to the rest of the world increases significantly. More than public indebtedness, external indebtedness is the problem.

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The data that support the findings of this study are available in https://luisreyesortiz.org/resources/.

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