Dipartimento di Scienze Sociali
ed Economiche

Sapienza
Università di Roma

ISSN 2385-2755
Working papers
(Dipartimento di scienze sociali ed economiche)
[online]

WORKING PAPERS SERIES

DIPARTIMENTO DI

SCIENZE SOCIALI ED ECONOMICHE

n. 6/2014

Optimal monetary policy and financial stability in a non-Ricardian economy

Author:

Salvatore Nisticò

Revised version: January 2016

Sapienza – University of Rome
P.le Aldo Moro n.5 – 00185 Roma T (+39) 06 49910563 F (+39) 06 49910231
CF 80209930587 - P.IVA 02133771002

Optimal monetary policy and financial stability in a non-Ricardian economy.*

Salvatore Nisticò
Sapienza University of Rome

January 25, 2016

Abstract

I develop a model with *Discontinuous Asset Market Participation* (DAMP), where all agents are non-Ricardian, and where heterogeneity among market participants implies financial-wealth effects on aggregate consumption. The implied welfare criterion shows that financial stability arises as an additional and independent target, besides inflation and output stability. Evaluation of optimal policy under discretion and commitment reveals that price stability may no longer be optimal, even absent inefficient supply shocks: some fluctuations in output and inflation may be optimal as long as they reduce financial instability. Ignoring the heterogeneity among market participants may lead monetary policy to induce substantially higher welfare losses.

JEL classification: E12, E44, E52.

Keywords: DAMP, Optimal Monetary Policy, Perpetual Youth, Financial Stability, DSGE Model, Asset Prices, LAMP.

*I thank Fabio Canova (editor) and four anonymous referees for their comments on previous versions of the paper. I also wish to thank Pierpaolo Benigno, Nicola Borri, Benjamin Carton, Efrem Castelnuovo, Andrea Colciago, Anastasios Karantounias, Federico Nucera, Giorgio Primiceri, Gianluca Violante, Joseph Zeira, seminar participants at LUISS Guido Carli, Università di Milano "Bicocca", Università "Cattolica" di Milano, the European Central Bank and conference participants at the CEF2011, San Francisco, for helpful comments and discussions. I also wish to thank the Economics Department at NYU for kind hospitality in the spring semester 2009, during which this project was initiated. Any remaining errors are, of course, my sole responsibility. PRIN2008 financial support is gratefully acknowledged. An earlier version of this paper was circulated under the title "Optimal monetary policy and stock-price dynamics in a non-ricardian DSGE model", CASMEF Working Paper n.1107, November 2011.

S. Nisticò: Sapienza Università di Roma, Department of Social and Economic Sciences, piazzale Aldo Moro 5, 00185 Rome, email: salvatore.nistico‘at’uniroma1.it

1 Introduction

The burst of the "dotcom" bubble in 2001 and the recent global financial meltdown highlighted that developments in asset markets can be of great relevance for the business cycle, and revived a theoretical debate about the desirability that central banks be directly concerned with financial stability. To evaluate this concern from a welfare perspective, I develop a tractable dynamic stochastic general equilibrium model of a non-Ricardian economy populated by heterogeneous agents that stochastically cycle between zones of activity and inactivity in asset markets.

In particular, the economy is populated by ex-ante identical infinitely-lived agents that face *discontinuous asset market participation* (DAMP): at the beginning of each period, each agent finds out her current status in asset markets. If inactive, she behaves as a "rule-of-thumber", consuming only her disposable labor income. If active, she trades in asset markets to smooth consumption, but subject to a finite planning horizon, as in each period she faces a constant probability of switching to the inactive type. This economy is therefore non-Ricardian for two reasons: "rule-of-thumbers" are non-Ricardian because they do not smooth consumption in asset markets, "market participants" because they face a finite planning horizon, as in a "perpetual-youth" model.

The model therefore generalizes the *limited asset market participation* (LAMP) framework by introducing an additional layer of agent heterogeneity in the economy – besides "active" versus "inactive" – related to the cross-sectional distribution of financial wealth among market participants.[1] This specific type of heterogeneity gives rise to financial-wealth effects on aggregate consumption of the same kind as those arising in perpetual-youth models, and makes asset-price dynamics non-neutral for the equilibrium allocation.[2] The resulting DAMP framework therefore nests as polar cases two other popular models extensively used to study monetary business cycles: i) the standard "representative-agent" model, where *infinitely-lived* identical agents are active in asset markets at all times, and ii) the discrete-time "perpetual-youth" (PY) model, where all agents are active at all times, but they are *finitely lived* and thus heterogeneous. The latter model, in particular, provides a natural theoretical characterization of the behavior of active agents in a DAMP economy: they face a positive probability of being replaced by previously inactive agents, they discount future util-

[1] For monetary policy analyses within the LAMP framework see, among others, Galí et al (2007) and Bilbiie (2008).

[2] For an analysis of the interplay between monetary policy and asset prices in a perpetual-youth framework see, among others, Nisticò (2012), Airaudo et al (2007), Castelnuovo and Nisticò (2010).

ity to account for both impatience and transition probabilities, they have an incentive to enter an insurance contract *à la* Blanchard (1985) in order to smooth consumption while market participants.

Analyzing welfare-maximizing policy and the implied trade-offs in the DAMP model, thus, requires to deal with a social welfare function that aggregates the utility flows of an infinite set of heterogenous agents, as in PY models.[3] One contribution of this paper is to show how to treat the heterogeneity among market participants to characterize a second-order approximation of social welfare in terms of aggregate variables only: the cross-sectional consumption dispersion among active agents is shown to be proportional to squared aggregate financial wealth. The resulting criterion requires financial stability to be an additional and independent target of a welfare-maximizing policy maker, besides inflation and output stability. The relative weights on the three targets reflect the two layers of heterogeneity of this economy: *between* agent types and *within* the set of market participants. As a consequence, an endogenous trade-off arises between output and price stability on the one hand, and financial stability on the other: price stability may no longer be an optimal monetary policy regime. Even conditionally only on productivity shocks, some fluctuations in inflation and the output gap may be optimal as long as they increase financial stability.

From a methodological perspective, the model developed in this paper builds on two strands of the literature. The first one was initiated by the seminal papers of Yaari (1965) and Blanchard (1985), which introduced and characterized the PY model in a continuous-time framework. Since then, discrete-time baseline versions have been widely used in the literature to study a variety of topics, both in closed and open-economy models,[4] or as building blocks of more elaborate frameworks, to account for demographic factors.[5] In contrast to these studies, all of which use the perpetual-youth structure to characterize the implications of finite lifetimes for economic policy, this paper shows that it captures quite naturally the transient nature of the "active" agent type – while the agent's lifetime itself is infinite – and describe its optimal behavior.

The second strand, initiated by the empirical observation of Campbell and Mankiw (1989) and the theoretical suggestions of Mankiw (2000), features an increasing number of New-Keynesian models formally characterizing *limited asset market participation* as the interplay between two dif-

[3]This complication is one reason why, to my knowledge, no normative analysis in a linear-quadratic framework is available within perpetual-youth models.

[4]See, among others, Ganelli (2005) and Leith et al. (2011).

[5]See, among others, Ferrero (2010).

ferent types of agents in the economy: optimizing (Ricardian) agents smoothing consumption over an infinite horizon through asset-market trading, and hand-to-mouth (non-Ricardian) agents consuming instead their labor income period by period. As also discussed by Bilbiie (2008), these LAMP models essentially build into the dynamic New-Keynesian framework the *exogenous* segmentation in asset markets typical of the literature analyzing the "liquidity effects" of monetary policy, such as Alvarez, Lucas and Weber (2001). Accordingly, in these models such partition of the economy is "static": an agent of a given type stays of that type forever. This paper, in contrast, allows for a stochastic transition between the two *agent types* analogous to that implied by the *endogenously*-segmented market structure discussed in Alvarez, Atkeson and Kehoe (2002).[6]

Indeed, I interpret the transition between agent types – that in the DAMP model is taken as exogenous – as a reduced-form representation of the interaction among (i) a costly decision to participate in asset markets, (ii) some liquidity constraint and (iii) idiosyncratic uncertainty about individual income. This interaction – microfounded by Alvarez, Atkeson and Kehoe (2002) – implies that some agents optimally decide to pay the participation cost and engage in asset-market trading to smooth consumption intertemporally, while the remaining ones decide to be inactive and simply consume their own endowment (previously sold for cash). In every period, idiosyncratic shocks to individual endowments make it optimal, for some agents, to revise their decision and switch between the zones of activity and inactivity, thereby implying stochastic transition between states.

An alternative interpretation might focus on the feature that infinitely-lived agents take intertemporal consumption decisions over a finite planning horizon. A microfounded rationale for such implication is provided by McKay et al. (2015), within a heterogenous-agent model addressing the forward-guidance puzzle. In one specification of their model economy, uninsurable idiosyncratic income risk makes agents randomly switch between employment and unemployment, with the latter further implying a binding liquidity constraint. In this environment, employed agents discount the future more than implied by their time-discount rate, as they also take into account the probability of suddenly becoming unemployed, whereby they would be unable to borrow and forced to consume only their home production. This effectively shortens the agents' planning horizon, despite their infinite lifetime, thus implying a "discounted euler equation" analogous to that arising in PY mod-

[6]A similar Markov-switching mechanism between agent types is used by Curdia and Woodford (2010) and Woodford (2010) to introduce heterogeneity in spending opportunities among *ex-ante* identical households, and provide a related case for a monetary-policy concern for financial stability, mainly related to fluctuations in credit spreads.

els. Under this interpretation, the transition probabilities in the DAMP model would capture the transition in and out of employment, where unemployment also implies inactivity in asset markets.

A third possible interpretation might regard the DAMP model as an approximate description of consumers' behaviour over the life cycle, in an economy where *finitely*-lived agents face (i) borrowing constraints, (ii) hump-shaped expected income profiles and (iii) uninsurable idiosyncratic labor-income risk, as in Gourinchas and Parker (2002).[7] Under this interpretation, the inactive agents are those in the early stage of their life cycle – not smoothing consumption over time because of self-imposed borrowing constraints and only barely saving for precautionary motives – while the active agents are those in the late stage of their life cycle – whose behaviour is instead consistent with the permanent-income hypothesis. Accordingly, under this interpretation, the transition probabilities in the DAMP model would capture the expected duration of the two stages of the life cycle.[8]

As the three interpretations above suggest, therefore, the DAMP model is in principle suitable to address different kinds of issues (with respect to the one analyzed in this paper), in economies where idiosyncratic uncertainty implies occasionally binding liquidity constraints for some agents.[9]

More broadly, this paper is also related to a large literature spurred by the stock-market burst of 2001, evaluating to what extent a central bank is (and should be) concerned with stock-price dynamics. This literature analyzes the implications for monetary policy of fluctuations in asset markets that affect real activity through both a supply-side channel – induced by the financial accelerator, as in Bernanke and Gertler (1999) and Cecchetti et Al. (2000)[10] – as well as a demand-side one – through financial-wealth effects induced by heterogeneity among *finitely-lived* agents, as in Di Giorgio and Nisticò (2007), Nisticò (2012), Airaudo et al (2015). The discontinuous participation to financial markets of this paper introduces an analogous demand-side channel in a more general class of models, where agents are heterogenous both *between* active and inactive types and *within* the active type. The resulting framework is used to complement the positive analysis in Nisticò (2012) and Airaudo et al (2015), and the empirical analysis in Castelnuovo and Nisticò (2010), with a complete welfare analysis of the links between monetary policy and financial stability.

[7]I thank an anonymous referee for pointing out this interpretation of the DAMP model.

[8]Involving low-frequency cycles, however, this interpretation makes the model naturally better suited to address other issues than a monetary policy concern for financial stability, which instead focuses on a business-cycle frequency.

[9]Clearly, different interpretations might imply substantially different calibrations of the relevant transition probabilities. In particular, please refer the online appendix for a discussion of how the main results would change by adopting calibrations more in line with the other two interpretations.

[10]See also Bernanke and Gertler (2001), Gilchrist and Leahy (2002), Carlstrom and Fuerst (2001).

The paper is structured as follows. Section 2 characterizes the DAMP economy, and derives the welfare-based loss function as a second-order approximation of social welfare. Section 3 analyzes the stabilization trade-offs and the optimal monetary policy design. Section 4 concludes.

2 The DAMP Economy

Consider an economy populated by a continuum of infinitely-lived agents in the interval [0, 1]. A mass $(1-\vartheta)$ of these agents is financially inactive, consuming her labor income period by period; I also refer to these agents as "rule-of-thumbers". The remaining mass ϑ of agents trades in asset markets to save/borrow and smooth consumption; I refer to these agents as "market participants", or "active". The LAMP literature (e.g. Galí et al., 2007 and Bilbiie, 2008) typically assumes that a given agent cannot change type: once inactive, always inactive. I generalize this framework by allowing for stochastic transition between these two types of agent. Each agent's type evolves over time as an independent two-state Markov chain: each period, each agent learns whether or not she is going to participate in asset markets, where the relevant probability is only dependent on the agent's current state. In particular, with probability $\xi \in [0,1)$, a market participant becomes inactive, while with probability $1-\xi$ she remains active. Analogously, with probability $\varrho \in [0,1]$, a "rule-of-thumber" becomes active, while with probability $1-\varrho$ she remains inactive.

Define a "cohort" as the set of agents experiencing a transition between types in the same period: given the continuum of agents populating the economy, the size of each individual agent is negligible with respect to her cohort. By the law of large numbers, in each period a mass $\vartheta\xi$ of "market participants" becomes inactive, and a mass $(1-\vartheta)\varrho$ of "rule-of-thumbers" becomes active. Accordingly, the size of each cohort declines deterministically: at time t, the mass of agents that became active at time j and have not yet switched type is $m_{p,t}(j) \equiv \vartheta\xi(1-\xi)^{t-j}$, while the mass of agents that became inactive at time k and have not yet switched type is $m_{r,t}(j) \equiv (1-\vartheta)\varrho(1-\varrho)^{t-k}$, where subscript p denotes market participants and r rule-of-thumbers.

I focus on an economy where the population shares of the two agent types remain constant over time, in which therefore $\varrho(1-\vartheta) = \vartheta\xi$: at each time, the mass of active agents leaving financial markets is equal to the mass of rule-of-thumbers joining them. It follows that, in general, ϑ and ξ

must satisfy the following restriction:

$$\vartheta\xi \leq 1 - \vartheta, \tag{1}$$

requiring the inactive set to be at least large enough to provide a replacement for all active agents switching type, so that all agents are infinitely lived and population is always equal to 1.[11]

Since they face a positive probability of becoming inactive, each cohort of "market participants" has a different stock of accumulated wealth, depending on its longevity in the type. The model therefore introduces an additional layer of agents heterogeneity: agents are not only heterogenous *between* the sets of active and inactive – as in the LAMP framework – but they also are *within* the set of active – as in a PY model. This additional layer of heterogeneity implies, in equilibrium, a financial-wealth effect on aggregate consumption of the same kind as that arising in a PY model. Characterizing the set of active agents, therefore, requires to keep track of the cross-sectional distribution of financial wealth. The rule-of-thumbers, instead, are all identical, as they all consume their entire labor income, regardless of their longevity as inactive. Accordingly, the economy-wide aggregate level of generic variable X is computed as the mass-weighted average

$$X_t \equiv \vartheta X_{p,t} + (1-\vartheta)X_{r,t} = \vartheta \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} X_{p,t}(j) + (1-\vartheta)X_{r,t}, \tag{2}$$

where $X_{p,t} \equiv \sum_{j=-\infty}^{t}(m_{p,t}(j)/\vartheta)X_{p,t}(j) = \sum_{j=-\infty}^{t}\xi(1-\xi)^{t-j}X_{p,t}(j)$ is the average value of X across all "market participants", $j \in (-\infty, t]$ indexes the discrete set of cohorts of the latter at time t, and $X_{r,t}$ is the average level across all "rule-of-thumbers" (which is the same for each of them).

Notice that, although lifetime is *infinite* for each agent, each "market participant" takes intertemporal consumption decisions subject to a planning horizon which is instead *finite*, thereby considering that she will still be active after n periods with probability $(1-\xi)^n$.[12] Thus, the problem of a market participant is isomorphic to that of an agent in a PY model *à la* Blanchard (1985). In

[11]Violating restriction (1) implies that either i) population size is constant but not all agents are infinitely lived, as a mass $\vartheta(1+\xi) - 1$ of agents actually dies each period, or ii) all agents are infinitely lived but population is not constant, as a mass $\vartheta(1+\xi)-1$ of new agents is born, thereby increasing population size to $\vartheta(1+\xi) > 1$ and reducing the relative size of the set of active agents to $\tilde{\vartheta} = 1/(1+\xi)$, satisfying (1) with equality. In both cases, $\varrho = 1$.

[12]Indeed, a market participant anticipates that, upon becoming inactive – *and regardless of the consumption decisions taken while still active* – she will behave as a rule-of-thumber and consume her entire labor income in each period unless she switches back to the active-type. Therefore, the relevant time horizon when taking intertemporal consumption decisions as a market participant is the expected duration of the "active regime": $1/\xi$. Analogously, the expected duration of the "inactive regime" is $1/\varrho$, but the effective planning horizon for consumption decisions is 1 period, since a rule-of-thumber cannot transfer resources over time through financial markets.

particular, market participants also have an incentive to enter an insurance contract which grants them an extra-return on financial assets in exchange for the accumulated wealth at the time in which they are drawn to be replaced. Without such insurance contract active agents would need to consume (pay back) the accumulated wealth (debt) entirely in the period in which they switch type; entering the contract, instead, allows them to insure against the idiosyncratic risk of replacement, and consume (pay back) their wealth (debt) smoothly over time while still active.[13] Therefore, *all agents* in this economy are non-Ricardian: rule-of-thumbers because they do not trade in asset markets, market participants because they face a finite planning horizon.

The resulting DAMP framework nests as polar cases most models extensively used in the monetary policy New-Keynesian literature. If $\vartheta \in (0,1)$ and $\xi = 0$, the model becomes the standard LAMP specification of Galí et al. (2007) and Bilbiie (2008), among others: all agents are infinitely lived and a share of them are inactive in asset markets, but those agents will never become active. If $\vartheta = 1$ and $\xi = 0$ the model instead nests the standard "representative-agent" framework, where all agents are both infinitely lived and continuously active in asset markets. Finally, if $\vartheta = 1$ and $\xi \in (0,1)$ – thus violating (1) – the model collapses to a standard "perpetual-youth" framework, where the transition probability ξ reflects expected lifetime: all agents are active, but they still face a positive probability of exiting the market (dying) and being replaced by newcomers (newborn).

2.1 The Decentralized Allocation

All agents in the economy have Cobb-Douglas preferences over consumption C and leisure $1 - N$:[14]

$$U_{s,t}(h) \equiv \log C_{s,t}(h) + \delta \log(1 - N_{s,t}(h)), \tag{3}$$

for $s = p, r$ and $h = j, k$.[15] Regardless of their specific longevity as rule-of-thumbers, all inactive agents face the same static problem: they seek to maximize their period utility $U_{r,t}$ subject to

[13] An alternative assumption would be to allow inactive agents to passively roll over their assets until they switch back into the active type. This would complicate the analysis considerably (as it would require to keep track of the distribution of wealth within both sets of agents) without affecting the qualitative implication that the transition between agent types induces wealth-effects of financial instability on aggregate spending. See also Section 2.1.

[14] Ascari and Rankin (2007) argue that PY models with endogenous labor supply should feature GHH preferences, to avoid issues related to the negative labor supply of oldest generations. I acknowledge this result – which might affect active agents in the DAMP model as well – but choose to use standard preferences, for the sake of comparability.

[15] This Section describes only the main features of the model. For details, please refer to the online appendix. To save on notation, subscripts p and r are used only for consumption and hours worked, that enter the problems of both types.

the following budget constraint: $C_{r,t} = W_t N_{r,t}$, where W_t denotes the real wage. Solution to this problem yields a labor supply schedule

$$N_{r,t} = 1 - \delta \frac{C_{r,t}}{W_t}, \tag{4}$$

implying that, at equilibrium, inactive agents work a constant amount of hours: $N_{r,t} = 1/(1+\delta)$.

In addition to supplying labor services and demanding consumption goods, "market participants" also demand two types of financial assets: nominal state-contingent bonds $B^*_{t+1} \equiv P_{t+1} B_{t+1}$ and equity shares $Z_{t+1}(i)$ issued by a continuum of monopolistic firms, indexed by $i \in [0,1]$ and selling at real price $Q_t(i)$. At time 0, agents that have been active since period j seek to maximize $E_0 \sum_{t=0}^{\infty} \beta^t (1-\xi)^t U_{p,t}(j)$, where future utility flows are discounted to account for both impatience (β) and the probability of becoming inactive in the next period (ξ). The maximization problem is subject to a sequence of budget constraints (expressed in real terms) of the form:

$$C_{p,t}(j) + E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} B_{t+1}(j) \right\} + \int_0^1 Q_t(i) Z_{t+1}(j,i)\, \mathrm{d}i \\ \leq \frac{1}{1-\xi} \Omega_t(j) + W_t N_{p,t}(j) - T_t(j), \tag{5}$$

where $\mathcal{F}_{t,t+1}$ is the stochastic discount factor for state-contingent assets, $W_t N_{p,t}(j) - T_t(j)$ is real disposable labor income, and the real financial wealth carried over from the previous period is

$$\Omega_t(j) \equiv \int_0^1 \Big(Q_t(i) + D_t(i) \Big) Z_t(j,i)\, \mathrm{d}i + B_t(j), \tag{6}$$

including the pay-off on the equity portfolio and on the contingent claims. As discussed earlier, in order to smooth consumption over the duration of the active regime, "market participants" enter an insurance contract à la Blanchard (1985), which grants them an extra-return ($\frac{\xi}{1-\xi}$) on financial assets in exchange for the accumulated wealth at the time in which they are drawn to be replaced.

It is useful, at this point, to further characterize the partition of agents interacting in asset markets in each period t: call "old traders" those that are active since at least one period (i.e. $j \leq t-1$), and "newcomers" those that became active in the current period (i.e. $j = t$). The latter were previously inactive, and I therefore assume – as in Blanchard (1985) – that they enter with zero holdings of financial assets.[16] The different longevity "market participants" implies a non-degenerate distribution of financial wealth across cohorts, and a related cross-sectional distribution of individual consumption. I assume that the public authority is able to directly affect such distribution only in the steady state, by means of an appropriate redistribution scheme: $T_t(j) = T_t + \phi(j)\mathcal{R}_t$. The first component is common across cohorts, while the second one is a generation-specific transfer, where $\mathcal{R}_t$ is an appropriate scaling factor,[17] and $\phi(j)$ defines whether the transfer is a fee – $\phi(j) > 0$ – or a subsidy – $\phi(j) < 0$.[18]

Using the individual equilibrium conditions to solve equation (5) forward, and aggregating across all market participants, one can derive the equilibrium dynamics of their average consumption:

$$C_{p,t} = \frac{\xi\sigma}{\beta(1-\xi)} E_t \left\{ \mathcal{F}_{t,t+1}(1+\pi_{t+1}) \left(\Omega_{t+1} - \phi^{nc}\right) \right\} + \frac{1}{\beta} E_t \left\{ \mathcal{F}_{t,t+1}(1+\pi_{t+1}) C_{p,t+1} \right\}, \qquad (7)$$

where $\phi^{nc} \equiv -\frac{1}{1-\xi}\phi(t) > 0$ is the transfer received by newcomers upon becoming active, and $\sigma \equiv \frac{1-\beta(1-\xi)}{1+\delta}$. The first term in the equation above captures the financial-wealth effect, and can be traced back to the cross-sectional consumption dispersion, as measured by the wedge between the average consumption of old traders (C_p^{ot}) and that of newcomers (C_p^{nc}):[19]

$$C_{p,t+1}^{ot} - C_{p,t+1}^{nc} = \frac{\sigma}{1-\xi} \left(\Omega_{t+1} - \phi^{nc}\right), \qquad (8)$$

where I defined $C_{p,t+1}^{nc} \equiv C_{p,t+1}(t+1)$, and $C_{p,t+1}^{ot} \equiv \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} C_{p,t+1}(j)$. This mechanism, therefore, implies a direct channel by which financial instability can affect the real economy. An upward revision in financial-wealth expectations at time t implies that all active agents in t increase their current spending, so as to optimally smooth their intertemporal consumption profile; at $t+1$, however, a fraction of these individuals will be replaced by newcomers that were previously inactive, and whose consumption at $t+1$ will therefore not be affected by the current value of financial wealth. Thus, higher asset prices today, signaling an expected increase in future financial wealth, raise current consumption more than it does the expected discounted future level.[20]

[16] I later discuss why this assumption, which considerably simplifies the analysis, is qualitatively inessential.

[17] In particular, $\mathcal{R}_t \equiv (1-\xi)^{-1} - E_t \left\{ \mathcal{F}_{t,t+1} P_{t+1}/P_t \right\}$.

[18] Such "participation fee" serves the only purpose of implementing a *steady-state* cross-sectional distribution of financial wealth that is consistent with the social planner allocation. Please refer to the online appendix for details. This redistribution scheme, clearly, satisfies $\sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j}\phi(j) = 0$.

[19] Please refer to the online appendix for details.

[20] Equation (8) clarifies that, for a financial-wealth effect to arise, the assumption that "newcomers" enter with zero-

Equation (8) shows that the magnitude of the wealth effect depends upon two factors. First, higher rates of replacement ξ, for given fluctuations in financial wealth, imply a larger heterogeneity among active agents. Second, stronger fluctuations in aggregate financial wealth translate a given heterogeneity among active agents into a larger wedge between the average consumption of old traders and that of newcomers. Moreover, it can be shown that this wedge distorts the decentralized equilibrium allocation with respect to the socially optimal one, in which the cross-sectional consumption distribution is egalitarian and, thus, invariant to aggregate shocks.[21] In this respect, equation (8) shows that, even if the economy starts from such social planner allocation, fluctuations in financial wealth induced by aggregate shocks make the decentralized cross-sectional consumption distribution endogenously deviate from the socially optimal one. This is at the heart of the normative implications that will be derived in the next sections. In particular, if either (i) there is no heterogeneity in market participants ($\xi = 0$) or (ii) aggregate financial wealth is stable at ϕ^{nc}, the wedge in average consumption between old traders and newcomers is closed, and the cross-sectional distribution of consumption is egalitarian.

The supply-side of the economy is standard New-Keynesian. A competitive retail sector packs a continuum of intermediate differentiated goods $Y_t(i)$ into a final good Y_t, using a CES technology. A monopolistic wholesale sector produces the former out of labor services, using the linear technology $Y_t(i) = A_t N_t(i)$. Aggregating across firms and using the input demand coming from the retail sector yields $\exp(\Delta_t^p) Y_t = A_t N_t$, in which $N_t \equiv \int_0^1 N_t(i)\,\mathrm{d}i$ is the aggregate level of hours worked and

$$\Delta_t^p \equiv \log \int_0^1 \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} \mathrm{d}i \tag{9}$$

is a (second-order) index of price dispersion over the continuum of intermediate goods-producing firms, where ϵ denotes the price-elasticity of demand for input i and $\mu \equiv \epsilon/(\epsilon - 1)$ the corresponding degree of market power. As in most related literature, I assume that the government subsidizes employment at the constant rate τ, to offset – in the steady state – the monopolistic distortion.

holdings of financial assets is actually inessential. What is essential is that the average asset-holdings of "newcomers" *differ* from that of "old traders". Since "newcomers" were previously inactive, this is generally the case, as they were not able to adjust it over time to smooth consumption, as done instead by "old traders". Accordingly, a level of financial wealth that is passively rolled over while inactive – as for example assumed in Alvarez et al. (2002) – would also imply a financial-wealth effect of the same kind, while making analytical derivations considerably more cumbersome (since one would have to keep track of the distribution of wealth across "rule-of-thumbers" as well).

[21] Please refer to the online appendix for details.

Monopolistic firms are subject to the "Calvo pricing", with $1-\theta$ denoting the probability for a firm of having the chance to re-optimize in a given period. When able to set its price optimally, each firm seeks to maximize the expected discounted stream of future dividends, otherwise they keep the price unchanged. Equilibrium in this side of the economy implies the familiar New-Keynesian Phillips Curve, relating current inflation to future expected inflation and current marginal costs.

Averaging across all agents in the economy yields the aggregate per-capita level of consumption $C_t \equiv \vartheta C_{p,t} + (1-\vartheta)C_{r,t}$ and hours worked $N_t \equiv \vartheta N_{p,t} + (1-\vartheta)N_{r,t} = \vartheta N_{p,t} + (1-\vartheta)/(1+\delta)$. The fiscal authority finances the employment subsidies through lump-sum taxes to active agents: $\vartheta T_t = \tau W_t N_t$. In equilibrium, all output is absorbed by private consumption ($Y_t = C_t$), the net supply of state-contingent assets is nil, and the stock of outstanding equity shares is 1, for each monopolistic firm. As a consequence, aggregate profit income is: $\vartheta D_t = Y_t - (1-\tau)N_t W_t$.

2.2 The optimal steady state and the linear model.

In order to use a linear-quadratic approach to optimal policy analysis, here I define the "optimal steady state" as one that is consistent with the social planner allocation. Notice that the decentralized allocation deviates from the socially optimal one because of three distortions. First, a *static* distortion due to monopolistic competition implies a lower level of supplied output, both in the short and in the long run. As usual, this distortion can be corrected by an appropriate employment subsidy τ such that $(1+\mu)(1-\tau) = 1$. Second, a *dynamic* distortion due to nominal rigidities implies a positively-sloped supply schedule, price dispersion across different firms and ultimately a lower level of short-run equilibrium output (this distortion fades away in a zero-inflation steady state). Third, an analogous *dynamic* distortion is due to the interaction in financial markets of heterogeneous agents, which implies that the cross-sectional consumption distribution across households changes endogenously in response to any aggregate shock affecting aggregate financial wealth. In the social planner allocation, in contrast, the cross-sectional consumption distribution is egalitarian and unaffected by any aggregate shock. This third distortion is specific to the framework with financial-wealth effects and can be corrected in the steady state by an appropriate redistribution scheme $\phi(j)$, for all j. To understand the analogy between the two *dynamic* distortions above, consider an economy starting from a steady state consistent with the social planner allocation, and it is hit by an aggregate shock. In the same way in which the aggregate shock triggers an inefficient response of the relative-price distribution across heterogeneous (in terms of price duration) firms, it also triggers an analogously inefficient response of the cross-sectional consumption distribution across heterogeneous (in terms of asset holdings) consumers: social welfare is reduced by endogenous *consumption* dispersion in an analogous way in which it is by endogenous *price* dispersion.[22]

A socially optimal steady state is implemented by a redistribution scheme $\phi(j)$, such that, for all j, $\phi(j) = \Omega(j) - (1-\xi)\Omega$. As a consequence, the steady-state interest rate satisfies the familiar $\beta(1+r) = 1$, and all agents consume the same level of consumption and supply the same amount of hours worked: $C_p(j) = C_r = C = Y = \frac{A}{1+\delta}$ and $N_p(j) = N_r = N = \frac{1}{1+\delta}$, for all j.

First-order approximation around such "optimal steady state" yields:

$$y_t = E_t y_{t+1} + \frac{\psi}{\Theta} E_t \omega_{t+1} - \frac{1}{\Theta}(r_t - E_t \pi_{t+1} - \rho) + \frac{1-\Theta}{\Theta} E_t \Delta a_{t+1} \tag{10}$$

$$\omega_t = \beta E_t \omega_{t+1} - (1-\beta)\frac{1+\varphi-\mu}{\mu}(y_t - a_t) - \beta(r_t - E_t \pi_{t+1} - \rho) + (1-\beta) a_t \tag{11}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa(y_t - a_t), \tag{12}$$

where $\varphi \equiv N/(1-N) = 1/\delta$ denotes the steady-state labor-leisure ratio, also capturing the elasticity of the real wage with respect to aggregate hours worked; $\kappa \equiv \frac{(1-\theta)(1-\theta\beta)}{\theta}(1+\varphi)$ is the slope of the Phillips Curve, ρ the steady-state real interest rate, and ψ/Θ the elasticity of output with respect to expected future financial wealth, where $\psi \equiv \xi \frac{1-\beta(1-\xi)}{(1-\xi)(1+\delta)} \frac{1}{1-\beta} \frac{\mu}{1+\mu} \geq 0$ and $\Theta \equiv 1 - \varphi(1-\vartheta)/\vartheta$.[23]

The partition of consumption between active and inactive agents is finally determined by

$$c_{p,t} = \Theta y_t + (1-\Theta) a_t \tag{13}$$

$$c_{r,t} = (1+\varphi) y_t - \varphi a_t. \tag{14}$$

2.2.1 The Flexible-Price and Socially Optimal Allocation

The flexible-price equilibrium (FPE) arises in this model when the probability of having to charge last period's price goes to zero ($\theta = 0$). In this case, denoting variables in the FPE with an upper bar, real marginal costs are constant and the optimal employment subsidy implements the efficiency

[22] One notable difference is that the former dispersion only affects the distributional implications of the equilibrium allocation, while the latter affects also aggregate efficiency.

[23] As shown by Bilbiie (2008), Θ relates the average participation rate to financial markets ϑ to the slope of the forward-looking IS curve, with the threshold $\vartheta^* = \varphi/(1+\varphi)$ determining whether the economy behaves according to the *standard* ($\vartheta > \vartheta^*$) or the *inverted* ($\vartheta < \vartheta^*$) *aggregate demand logic.* In the rest of the analysis I will restrict attention to the case ($\vartheta > \vartheta^*$).

condition $\overline{W}_t = A_t$. Accordingly, labor-market clearing implies the equilibrium level of potential output: $\overline{y}_t = a_t$, and the equilibrium allocation can be derived as the solution to the system:

$$\overline{y}_t = a_t \tag{15}$$

$$\overline{\pi}_t = 0 \tag{16}$$

$$\overline{rr}_t = \rho + E_t \Delta a_{t+1} + \psi E_t \overline{\omega}_{t+1} \tag{17}$$

$$\overline{\omega}_t = \beta E_t \overline{\omega}_{t+1} - \beta(\overline{rr}_t - \rho) + (1-\beta) a_t. \tag{18}$$

Thus, the level of financial wealth is proportional to aggregate productivity $a_t \equiv \log(A_t)$:

$$\overline{\omega}_t = \frac{1-\beta\rho_a}{1-\beta\rho_a(1-\psi)} a_t, \tag{19}$$

with ρ_a the persistence of productivity shocks, and the interest rate supporting such allocation is

$$\overline{rr}_t = \rho + E_t \Delta a_{t+1} + \frac{1-\beta\rho_a}{1-\beta\rho_a(1-\psi)} \psi \rho_a a_t. \tag{20}$$

This allocation features *aggregate* efficiency because nominal rigidities are shut down and the static distortion related to monopolistic competition is corrected by the employment subsidy. It does not, however, imply the *socially optimal consumption distribution*: while the heterogeneity *between* the sets of active and inactive agents fades away, as implied by (13)–(15), the heterogeneity *within* the set of market participants does not, and fluctuations in financial wealth still affects the wedge in average consumption, between newcomers and old traders. As a result, the flexible-price allocation is suboptimal with respect to the socially-optimal one. With the benchmark specification of the model (in which $\xi = 0$) the DAMP economy shares the same natural level of output,[24] but the natural levels of real interest rate and financial wealth are generally different. In the benchmark setups, the natural rate of interest fully accommodates the pressures on output coming from productivity shocks ($\overline{rr}_t = \rho + E_t \Delta a_{t+1}$), and financial wealth mirrors the evolution of productivity ($\overline{\omega}_t = a_t$). Equation (20), instead, shows that in the DAMP economy the natural interest rate leans partially against productivity shocks, to absorb the fluctuations in financial wealth that would otherwise distort the dynamics of aggregate consumption.

[24]Since in the flexible-price equilibrium the Phillips Curve is vertical, the equilibrium level of real activity is determined by the supply side of the economy only, for which fluctuations in financial wealth are neutral.

The socially optimal allocation – characterized by both aggregate efficiency and optimal consumption distribution – can be defined as an equilibrium in which not only the output gap and inflation rate are zero, but also financial wealth is stable at the steady-state level ($\omega_t^e = 0$):

$$y_t^e = \overline{y}_t = a_t \tag{21}$$

$$\pi_t^e = 0 \tag{22}$$

$$\omega_t^e = 0. \tag{23}$$

As implied by equation (8), when financial wealth is stable at ϕ^{nc}, the cross-sectional consumption dispersion is zero, and the distributional efficiency of the equilibrium allocation is restored. However, unlike in the FPE, there is no real interest-rate path that supports this equilibrium allocation.

Proposition 1 *In a decentralized DAMP economy with an active stock market, there is no real interest rate dynamics supporting the socially optimal allocation.*

Proof. Impose $y_t = a_t$ and $\pi_t = \omega_t = 0$ on system (10)–(12). Then equation (10) implies $rr_t^e = \rho + E_t \Delta a_{t+1}$, while equation (11) implies $rr_t^e = \rho + [(1-\beta)/\beta]a_t$, which are the same only as long as $a_t = 0$ for all t. ■

2.3 The Welfare-Based Loss Function.

Given Proposition 1, it becomes useful to evaluate the welfare implications of targeting the FPE allocation instead of the socially optimal one. To this aim, I now derive the monetary-policy loss function as a second-order approximation of social welfare around the optimal steady state.[25] Define the period-t social welfare as $\mathcal{U}_t \equiv \vartheta \mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t}$, where $\mathcal{U}_{p,t} \equiv \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} U_{p,t}(j)$, $\mathcal{U}_{r,t} \equiv \sum_{k=-\infty}^{t} \varrho(1-\varrho)^{t-j} U_{r,t}(k) = U_{r,t}$, and $U_{s,t}(h)$ is defined in (3), for $s = p, r$ and $h = j, k$.[26]

Given the efficiency condition $\varphi\delta = 1$ implied by the optimal employment subsidy, and ignoring terms independent of policy and of higher order, a second-order Taylor expansion of the aggregate

[25] This approach satisfies the conditions that deliver a valid second-order approximation of expected welfare when evaluated using private-sector equilibrium conditions that are approximated only to first order. See Woodford (2003).

[26] The definitions of $\mathcal{U}_{p,t}$ and $\mathcal{U}_{r,t}$ are consistent with the assumption that different longevities are treated equally by the social planner. Please refer to the online appendix for details. Analogous definitions of social welfare are adopted by Curdia and Woodford (2010), in a model with Markov-Switching agent-types, and by Bilbiie (2008), among others, in the benchmark LAMP framework.

period$-t$ utility for active agents can be written as

$$\mathcal{U}_{p,t} = c_{p,t} - \frac{1}{2}var_j c_{p,t}(j) - n_{p,t} + \frac{1}{2}var_j n_{p,t}(j) - \frac{1+\varphi}{2}E_j\left(n_{p,t}(j)^2\right)$$
$$= c_{p,t} - n_{p,t} - \frac{1+\varphi}{2}n_{p,t}^2 - \frac{1+\varphi}{2\varphi}var_j c_{p,t}(j), \quad (24)$$

in which the last equality uses $E(z^2) = E(z)^2 + var(z)$ and a first-order approximation of the individual labor supply, to relate the cross-sectional variance of hours worked to that of individual consumption: $\varphi^2 var_j n_{p,t}(j) = var_j c_{p,t}(j)$. Since inactive agents are homogeneous and supply a constant amount of hours worked, a second-order approximation of their period$-t$ utility is simply $\mathcal{U}_{r,t} = c_{r,t}$. Using the resource constraint and a second-order approximation of the aggregate production function, one then obtains the period$-t$ social utility as a function of output gap x_t, price dispersion across firms Δ_t^p and consumption dispersion across active agents $\Delta_{p,t}^c \equiv var_j c_{p,t}(j)$:

$$\vartheta\mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t} = -\frac{(1+\varphi)}{2\vartheta}\left(x_t^2 + \frac{2\vartheta}{1+\varphi}\Delta_t^p + \frac{\vartheta^2}{\varphi}\Delta_{p,t}^c\right). \quad (25)$$

Social welfare thus displays an additional second-order term, compared to the LAMP framework, which is related to the cross-sectional dispersion in consumption $\Delta_{p,t}^c$: were all active agents homogenous, consuming *in every period* the same amount of goods, the cross-sectional variance would be zero, and the LAMP model would arise. To understand the implications of this additional term, it is useful to recall the partition of the set of active agents in "newcomers" and "old traders". Indeed, using the law of total variance on such partition, one can characterize the evolution over time of the cross-sectional consumption dispersion across all active agents in the economy as:[27]

$$\Delta_{p,t}^c = (1-\xi)\Delta_{p,t-1}^c + \psi\frac{\sigma}{1-\beta}\frac{\mu}{1+\mu}\omega_t^2. \quad (26)$$

Moving from an arbitrary initial level $\Delta_{p,-1}^c$, which is independent of policies implemented from $t = 0$ onward, I can therefore write the discounted value over all periods $t > 0$ as

$$\sum_{t=0}^{\infty}\beta^t\Delta_{p,t}^c = \frac{\psi\mu}{(1+\delta)(1-\beta)(1+\mu)}\sum_{t=0}^{\infty}\beta^t\omega_t^2 \quad (27)$$

[27] For details on the derivation, please refer to the online appendix.

Finally, the time-0 conditional expectation of the discounted stream of future period social losses yields the welfare-based loss function, as a share of steady-state aggregate consumption:[28]

$$\mathcal{L}_0 \equiv -E_0 \sum_{t=0}^{\infty} \beta^t [\vartheta \mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t}] = \frac{(1+\varphi)}{2\vartheta} E_0 \sum_{t=0}^{\infty} \beta^t \left(x_t^2 + \alpha_\pi \pi_t^2 + \alpha_\omega \omega_t^2 \right). \tag{28}$$

In the loss function above, $\alpha_\pi \equiv \vartheta \frac{\epsilon}{\kappa}$ denotes the relative weight on inflation stability and $\alpha_\omega \equiv \frac{\vartheta^2 \psi \mu}{(1+\varphi)(1-\beta)(1+\mu)} \geq 0$ the one on *financial stability.* As discussed in Bilbiie (2008), the relative weight on inflation is a fraction ϑ of that arising in the standard Ricardian model – i.e. the ratio between the price-elasticity of demand ϵ and the slope of the Phillips Curve κ – since inflation variability reduces profit income, which is only enjoyed by market participants. The additional weight on financial stability is instead peculiar to the DAMP framework, reflecting the fact that fluctuations in aggregate financial wealth affect the cross-sectional consumption distribution across active agents and make it deviate from the socially optimal one.[29]

3 Stabilization Trade-offs and the Optimal Policy

The loss function (D.62) shows that cross-sectional consumption dispersion is induced by financial instability and is a source of welfare loss, and implies that the flexible-price allocation is therefore not a proper target for welfare-maximizing monetary policy.

Proposition 2 *In a decentralized DAMP economy with an active stock market, a welfare-maximizing policy maker should target the socially optimal allocation. Financial stability ($\omega_t = 0$) becomes an explicit target of welfare-maximizing monetary policy, in addition to output and inflation stabilization ($x_t = \pi_t = 0$). The welfare-relevance of financial stability (α_ω) is higher when financial-wealth effects (ψ) are stronger, the market power of monopolistic firms (μ) is higher and/or the average asset-market participation rate (ϑ) is higher.*

An interesting implication of Propositions 1 and 2 is that a welfare-relevant stabilization tradeoff endogenously arises, even absent inefficient supply shocks: since there is no interest-rate dynamics

[28] Equation (D.62) uses the familiar lemmata $\Delta_t^p \approx \frac{\epsilon}{2} var_i p_t(i)$ and $\sum_{t=0}^{\infty} \beta^t var_i p_t(i) = \frac{\theta}{(1-\theta)(1-\theta\beta)} \sum_{t=0}^{\infty} \beta^t \pi_t^2$.

[29] Notice that an analogous (and even stronger) role for financial stability arises in the welfare criterion of a perpetual-youth economy, which is nested in the DAMP framework under the parameterization $\vartheta = 1$.

supporting the socially optimal allocation, minimization of the loss function (D.62) implies that some fluctuations in inflation and the output gap will be optimal in order to reduce financial instability.

We can see this formally, by evaluating optimal policy in this framework along two dimensions: the optimal response of the DAMP economy to a productivity shock, and the expected welfare loss implied by a specific policy regime, captured by the unconditional mean of the period loss in (D.62):

$$E\{-\mathcal{U}_t\} = \frac{(1+\varphi)}{2\vartheta}\Big(var(x_t) + \alpha_\pi var(\pi_t) + \alpha_\omega var(\omega_t)\Big). \tag{29}$$

The complete system of equilibrium conditions for the private sector, constraining the optimal policy, can be expressed in terms of the relevant gaps from the socially optimal allocation:

$$x_t = E_t x_{t+1} + \frac{\psi}{\Theta} E_t \omega_{t+1} - \frac{1}{\Theta}(r_t - E_t \pi_{t+1} - \widetilde{rr}_t) \tag{30}$$

$$\omega_t = \beta E_t \omega_{t+1} - (1-\beta)\frac{1+\varphi-\mu}{\mu} x_t - \beta(r_t - E_t \pi_{t+1} - \widetilde{rr}_t) + (1-\beta\rho_a)a_t \tag{31}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t, \tag{32}$$

in which $\widetilde{rr}_t \equiv \rho + E_t \Delta a_{t+1}$. As usual in this class of models, I can leave the determination of the optimal path of the nominal interest rate as residual, and derive first the optimal allocation in terms of the other endogenous variables. In this case, the constraints that are relevant for optimal policy can be given the following reduced form:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t, \tag{33}$$

$$\omega_t = \beta(1-\psi)E_t \omega_{t+1} + \eta x_t - \beta\Theta E_t x_{t+1} + (1-\beta\rho_a)a_t \tag{34}$$

in which $\eta \equiv \frac{\mu-(1-\beta)(1+\varphi)}{\mu} - \beta(1-\Theta)$. The IS schedule (30) – or equation (31) – can then be used to back out the equilibrium path of the nominal interest rate consistent with the optimal policy.

Consider a transitory productivity shock ($\rho_a = 0$) and solve equations (33) and (34) forward:

$$\pi_t = \kappa \sum_{k=0}^{\infty} \beta^k E_t x_{t+k}, \tag{35}$$

$$\eta x_t = \omega_t + \left(1 - \frac{\eta(1-\psi)}{\Theta}\right) \sum_{k=1}^{\infty} \left(\frac{\beta\Theta}{\eta}\right)^k E_t \omega_{t+k} - a_t. \tag{36}$$

Equation (35) shows the familiar result that inflation depends on the current as well as expected future output gaps. Absent inefficient supply shocks, this equation clarifies that targeting the flexible-price allocation at all times is consistent with price stability, regardless of productivity shocks: no tradeoff exists between inflation and output-gap. Equation (36), in contrast, implies that a stabilization tradeoff does exist between real and financial stability: conditional on a positive productivity shock, the economy will necessarily experience either a fall in the output gap (and thereby also inflation), or an increase in financial wealth. In the standard Ricardian economy (or the benchmark LAMP model), these tradeoffs are meaningless from a welfare perspective because ω_t does not enter the loss function, and financial stability will not be a concern for the policy maker. In a DAMP economy, instead, ω_t is an explicit argument of the welfare criterion, and these tradeoffs therefore require explicit consideration from welfare-maximizing policy makers. The forward-looking nature of inflation and asset prices, moreover, suggests that such tradeoffs can be improved by credibly committing to a specific state-contingent path for financial wealth and/or the output gap, so that the central bank can reduce the welfare losses associated to any shock.

3.1 Optimal Policy under Discretion and Full Commitment

One way of dealing with the above tradeoffs is for the central bank to chose in every period the optimal level of all target variables, so as to minimize the period welfare loss. The optimal policy under Discretion therefore minimizes the period-loss function

$$\frac{(1+\varphi)}{2\vartheta}\left(x_t^2 + \alpha_\pi \pi_t^2 + \alpha_\omega \omega_t^2\right)$$

such that $\omega_t = \eta x_t + K_{\omega,t}$ and $\pi_t = \kappa x_t + K_{\pi,t}$, where $K_{\pi,t}$ and $K_{\omega,t}$ collect the terms related to expectations about the future and exogenous state variables, that the central bank cannot affect in this policy regime. The solution to this problem requires the following optimal targeting rule:

$$x_t + \alpha_\pi \kappa \pi_t + \alpha_\omega \eta \omega_t = 0. \tag{37}$$

Using the above relation in the reduced system (33)–(34), yields the optimal state-contingent path for the inflation rate, output gap and financial wealth:

$$\pi_t^d = -\Phi_\pi^d a_t \tag{38}$$

$$x_t^d = -\Phi_x^d a_t \tag{39}$$

$$\omega_t^d = \Phi_\omega^d a_t, \tag{40}$$

where

$$\Phi_\pi^d \equiv \frac{\alpha_\omega \kappa \eta (1-\beta\rho_a)}{\mathcal{A} + \alpha_\omega \mathcal{B} + \psi \mathcal{C}}, \qquad \Phi_x^d \equiv \frac{\alpha_\omega \eta (1-\beta\rho_a)^2}{\mathcal{A} + \alpha_\omega \mathcal{B} + \psi \mathcal{C}}, \qquad \Phi_\omega^d \equiv \frac{\mathcal{A}}{\mathcal{A} + \alpha_\omega \mathcal{B} + \psi \mathcal{C}},$$

with $\mathcal{A} \equiv (1-\beta\rho_a)(1+\alpha_\pi\kappa^2-\beta\rho_a)$, $\mathcal{B} \equiv (1-\beta\rho_a)(\eta-\Theta\beta\rho_a)\eta$, $\mathcal{C} \equiv \beta\rho_a(1+\alpha_\pi\kappa^2-\beta\rho_a)$ and $\Phi_\omega \in [0,1]$.

In the case with no real effects of financial instability ($\xi = \psi = \alpha_\omega = 0$) – regardless of the share of active agents ϑ – optimal monetary policy under discretion requires price stability ($\pi_t^d = 0$), output-gap stability ($x_t^d = 0$) and that all volatility be borne by financial wealth ($\omega_t^d = a_t$). This is the familiar case of the optimality of price stability in an economy with no inefficient supply shocks, in which the flexible-price allocation is efficient. The picture changes in a DAMP economy:

Proposition 3 *In a decentralized DAMP economy with an active stock market, price stability is not an optimal policy regime from a welfare perspective.*

Indeed, given convexity of the welfare-based loss function, the optimal discretionary monetary policy requires the volatility implied by productivity shocks to be shared among the three targets. Accordingly, following a positive productivity shock, financial wealth will rise less than under price stability, and both inflation and the output gap will decline.

An alternative way of dealing with the stabilization tradeoff is to commit to a state-contingent path for the target variables. If the commitment is credible, there is room for improving the tradeoff by anchoring expectations, as in the standard framework. In this case, the monetary policy problem at time 0 is to minimize the loss function (D.62) such that the constraints (33)–(34) are satisfied for all t. The optimality conditions for this policy problem under full commitment are:

$$x_t = \eta\lambda_{2,t} - \Theta\lambda_{2,t-1} + \kappa\lambda_{1,t} \tag{41}$$

$$\alpha_\pi \pi_t = \lambda_{1,t-1} - \lambda_{1,t} \tag{42}$$

$$\alpha_\omega \omega_t = (1-\psi)\lambda_{2,t-1} - \lambda_{2,t}, \tag{43}$$

in which $\lambda_{1,t}$ and $\lambda_{2,t}$ are the Lagrange multipliers associated to constraints (33)–(34), respectively, and $\lambda_{1,-1} = \lambda_{2,-1} = 0$. In the benchmark LAMP case with $\xi = \alpha_\omega = 0$, equations (41)–(43) imply $\lambda_{2,t} = 0$ for all t, and therefore price stability is still the optimal policy. In a DAMP economy, instead, $\lambda_{2,t}$ will generally differ from zero, which makes the trade-off discussed earlier relevant for output and inflation, and implies that Proposition 3 applies also under full commitment.

Figure 1 provides a graphical illustration of such proposition, and shows an impulse-response simulation exercise to display the policy implications for the DAMP economy. The figure shows the dynamic response of selected variables – under alternative policy regimes – to a transitory, one-standard-deviation productivity shock, with standard deviation of 0.5%. Table 1 then compares the cyclical and welfare implications of the alternative policy regimes, reporting the equilibrium standard deviations (in percentage points) of selected variables and the implied welfare losses (in basis points of steady-state aggregate consumption).

In the numerical illustration, the key parameters to calibrate are the share of savers ϑ and the turnover rate ξ. As a baseline calibration, I use $\vartheta = 0.8$ and $\xi = 0.17$. The former is the estimated value reported by Bilbiie and Straub (2013) for the Great-Moderation sample (i.e. post 1984); the latter is chosen to imply an elasticity of aggregate consumption to stock-market wealth (ψ/Θ) of about 0.15, as documented by Ludvigson and Steindel (1999) for the Great-Moderation sample, and is consistent with the turnover rate in U.S. financial portfolios reported by Cella et al (2013), which implies an average investment horizon of about 6 quarters.[30]

[30]Please refer to the online appendix for an extensive sensitivity analysis of the main results to the calibration of these key parameters. The baseline calibration $\xi = 0.17$ is also consistent with the replacement rate and the financial-wealth effects documented by Castelnuovo and Nisticò (2010) within an empirical version of the perpetual-youth specification of this model, estimated with post-WWII US data. The rest of the model is calibrated using convention or previous studies: the time discount factor is $\beta = 0.99$, to imply a steady-state annualized real interest rate of 4%, the Calvo parameter $\theta = 0.75$, implying an average price duration of 4 quarters, the average price-markup is $\mu = 20\%$, consistently with Bilbiie and Straub (2013), among others, and the elasticity of real wages to aggregate hours is $\varphi \equiv \frac{N}{1-N} = 0.3$, consistently with Rotemberg and Woodford (1997), Galí et al (2007), and with the average hours worked for the US in the Great-Moderation sample.

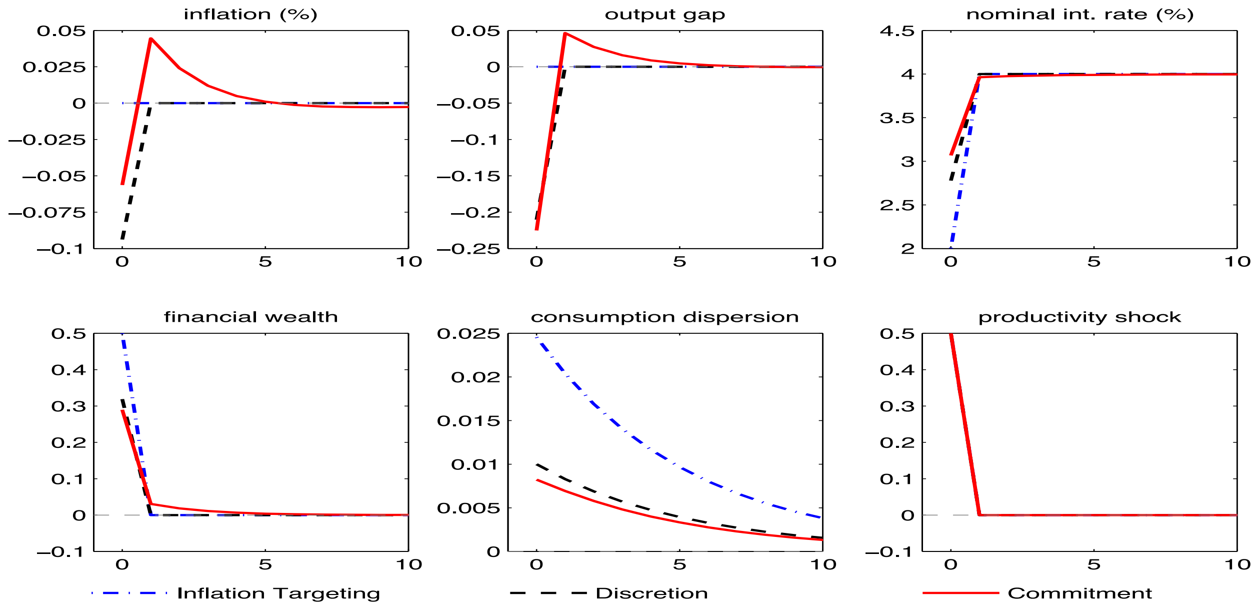

Figure 1: Response of selected variables to a transitory, one-standard-deviation productivity shock. Blue solid line: Inflation Targeting. Black dashed line: optimal policy (Discretion). Red solid line: optimal policy (Full Commitment).

The dashed-dotted line in the Figure 1 displays the case of Inflation Targeting, under which both inflation and the output gap can be fully stabilized – given the absence of inefficient supply shocks – and all the volatility induced by the productivity shock is borne by financial wealth and the interest rate. These dynamics are the same as those that would arise in the standard Ricardian economy – in which $\xi = 0$ and $\vartheta = 1$ – and in the benchmark LAMP framework – in which $\xi = 0$ and $\vartheta \in (0, 1)$.[31] However, in those frameworks fluctuations in financial wealth do not have distributional effects and the welfare loss is therefore zero (see first column of Table 1). In the DAMP economy, instead, fluctuations in financial wealth do affect the cross-sectional consumption dispersion among savers Δ_t^c – evolving according to (D.59) – which in this case is detrimental from a welfare perspective. The baseline calibration, indeed, implies a weight on financial stability of the same order of magnitude as that on the output gap: $\alpha_\omega = 1.18$. As a result, under Inflation Targeting, the welfare loss implied by a productivity shock with standard deviation of 0.5% – evaluated using equation (29) – is about 0.239bp of steady-state aggregate consumption, as reported in the second column of Table 1.

The dashed line in Figure 1 shows instead the dynamic response of the DAMP economy under the optimal discretionary policy. In this case, equations (38)–(40) implies that monetary policy finds it optimal to cut inflation by about 10bp and output gap by about 20bp, in order to reduce by

[31] Indeed, equations (19) and (20) show that, when $\rho_a = 0$, Inflation Targeting implies the same path for interest rates and financial wealth as in the RA setup.

Table 1: Implied volatilities and welfare losses conditional on a productivity shock

	Benchmark	DAMP		
	Inflation Targeting	Inflation Targeting	Discretion	Commitment
Inflation	0.0000	0.0000	0.0235	0.0193
Output Gap	0.0000	0.0000	0.2102	0.2324
Financial Wealth	0.5000	0.5000	0.3189	0.2919
Interest Rate	0.5000	0.5000	0.3055	0.2335
Cons. Dispersion	0.0000	0.0625	0.0254	0.0215
Welfare Loss	**0.0000**	**0.2387**	**0.1522**	**0.1383**

Note: implied volatilities are standard deviations in percentage points; Welfare Losses are bases points of steady-state aggregate consumption. Standard deviation of productivity shock is 0.5%.

about 35% the short-run response of financial wealth to the shock. This requires cutting the nominal interest rate about 75bp *less* than under Inflation Targeting, and allows to reduce the response of cross-sectional consumption dispersion by over a half, throughout the transition. From the cyclical perspective, as reported by the third column of Table 1, the effect is that the volatility implied by the productivity shock is now "shared" among the three welfare-relevant variables: the standard deviation of inflation and the output-gap raises from zero to, respectively, 0.024 and 0.210 percent, while that of financial wealth drops from 0.5% to 0.32%. Given convexity of the welfare criterion, this reduces the welfare loss to about 0.152bp of steady-state aggregate consumption: price stability in this environment is substantially suboptimal, as it implies a welfare loss about 57% larger than under the optimal discretionary policy.

The general implication is reinforced under full commitment, as implied by the solid line in Figure 1 and the fourth column of Table 1. As to the dynamic response of the economy, the commitment takes two forms. On the one hand monetary policy commits to keep financial wealth higher than steady state for some time even after the shock has reverted back to mean, through persistently lower nominal interest rates (which on impact fall more than 1 percentage point less than under Inflation Targeting); this achieves a smaller response of financial wealth on impact and a lower consumption dispersion throughout the transition. On the other hand, it also commits to an output boom after the shock has returned to steady state, in order to dampen the short-run effect of the shock on the inflation rate, which now falls by about 6bp only. Interestingly, note that the short-run response of the output gap in this case is slightly stronger than under discretion: the tradeoff between financial and real variables is such that even full commitment to a specific state-contingent path for the target variables is not enough to dampen the short-run effects of the shock on *all of them*, unlike in the standard analysis of commitment with inefficient supply shocks. From the cyclical perspective, exploiting the effect of the credible commitment on expectations enables the central bank to further reduce the welfare loss to 0.138bp of steady-state aggregate consumption.

Overall, therefore, the optimal response of the DAMP economy – whether under discretion or commitment – requires non-negligible deviations from the corresponding response under the Inflation Targeting regime, that would instead be optimal in an economy with no financial-wealth effects (whether Ricardian or LAMP). In particular, Inflation Targeting implies welfare losses up to 73% higher than under optimal policy, and a variability of consumption dispersion up to three times higher (as implied by the fifth row of Table 1).

3.2 Optimal Policy with Inefficient Supply Shocks

Until now I have considered only productivity shocks to show that a meaningful tradeoff for monetary policy arises in a DAMP economy even when there are no inefficient supply shocks that break the link between inflation and the welfare-relevant output gap. Here I extend the analysis to the case in which such shocks exist, to show – perhaps not surprisingly, at this point – that also in the presence of the familiar inflation-output tradeoff, ignoring the role of financial-wealth effects (whether for welfare or for the propagation mechanism) may have non-trivial implications.

In particular, consider an environment in which the market power of monopolistic firms (μ) is subject to exogenous stochastic disturbances. In this case, the Phillips Curve is subject to a cost-push shock u_t, capturing the stochastic deviations of flexible-price output from potential one:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t. \tag{44}$$

Also in this case, the targeting rules (37) and (41)–(43) characterize the optimal policy under discretion and commitment, respectively. The welfare losses implied by alternative policy regimes, however, now depends on the cyclical features of both shocks.

Consider, as before, purely transitory shocks: a productivity shock a_t with standard deviation of 0.5%, and a cost-push shock u_t with standard deviation of 0.08%.[32] I first evaluate the relevance

[32]The standard deviations of productivity and cost-push shocks are calibrated such that the cyclical implications of the model are consistent with empirical evidence along two dimensions: i) cost-push shocks are about 15% as

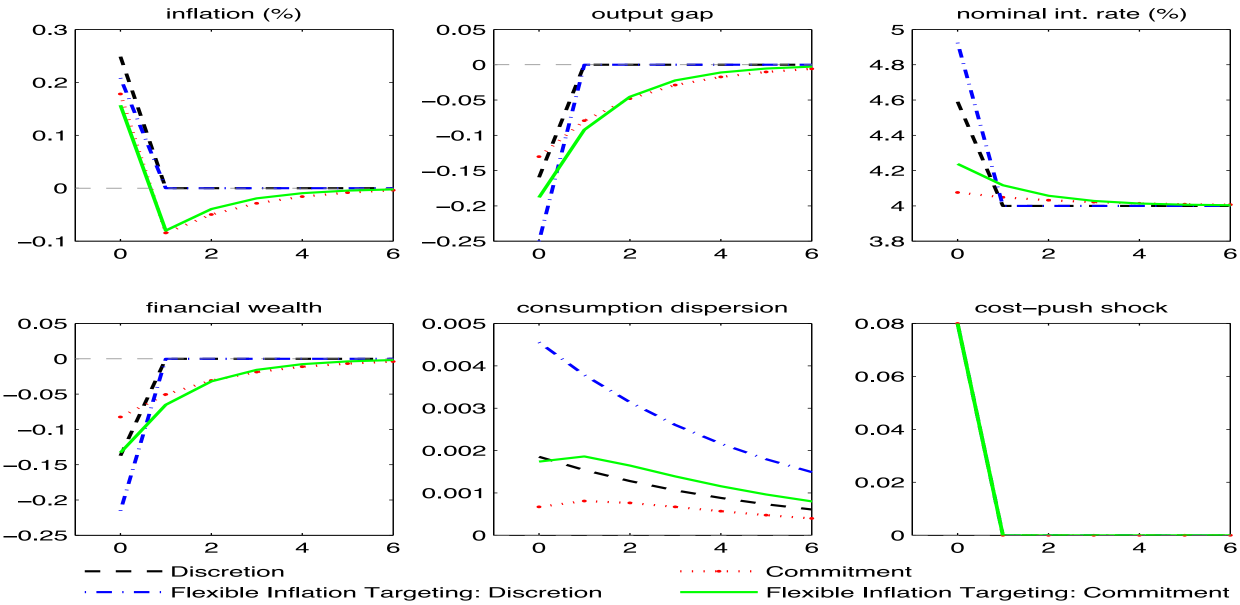

Figure 2: Response of selected variables to a transitory, one-standard-deviation cost-push shock. Black dashed line: optimal policy (Discretion). Red solid line: optimal policy (Full Commitment). Blue dash-dotted line: flexible-inflation targeting (Discretion). Green solid line: flexible-inflation targeting (Full Commitment).

of financial-wealth effects for the monetary-policy loss function, by comparing the dynamic and cyclical implications of four alternative policy regimes. The first two regimes are the optimal policy under discretion and commitment, respectively. The other two regimes consider instead the case in which the central bank disregards the welfare implications of financial-wealth effects and therefore adopts the loss function that would arise in the standard LAMP setup, as in Bilbiie (2008):

$$\mathcal{L}_0 = \frac{(1+\varphi)}{2\vartheta} E_0 \sum_{t=0}^{\infty} \beta^t \left(x_t^2 + \alpha_\pi \pi_t^2 \right), \tag{45}$$

with $\alpha_\pi \equiv \vartheta \frac{\epsilon}{\kappa}$, which is maximized under either discretion or commitment. I will refer to this case as "Flexible Inflation Targeting" regime, consistently with Svensson (1999). Figure 2 displays the optimal response of the economy to a one standard-deviation cost-push shock under the four regimes, and the first four columns of Table 2 report their cyclical and welfare implications.

Ignoring the welfare role of financial instability by minimizing loss (45) instead of (D.62) induces non-negligible differences both in the short-run response of the economy to a cost-push shock and in

important as productivity shocks in explaining the variance of real output, and ii) the standard deviation of the cross-sectional variance of log-consumption is about 0.02 (consistently with Krueger and Perri, 2006). Consistency with the evidence above is evaluated with respect to a policy specification in which the central bank follows a standard Taylor Rule with response coefficients to inflation and output gap equal to 1.5 and 0.5, respectively.

Table 2: Implied volatilities and welfare losses conditional on productivity and cost-push shocks

	DAMP				Benchmark	
			Flexible Inflation Targeting			
	Discretion	Commitment	Discretion	Commitment	Discretion	Commitment
Inflation	0.0665	0.0551	0.0521	0.0454	0.0521	0.0454
Output Gap	0.2639	0.2843	0.2501	0.2159	0.2501	0.2159
Financial W.	0.3472	0.3100	0.5444	0.5228	0.5444	0.5291
Interest Rate	0.3393	0.2349	0.5509	0.5046	0.5509	0.5062
C. Dispersion	0.0295	0.0245	0.0727	0.0679	0.0000	0.0000
Welfare Loss	**0.3262**	**0.2634**	**0.4287**	**0.3710**	**0.1457**	**0.1100**

Note: implied volatilities are standard deviations in percentage points; Welfare Losses are basis points of steady-state aggregate consumption. Standard deviation of productivity shocks is 0.5%; standard deviations of cost-push shocks is 0.08%.

the implied welfare losses. In particular, the monetary policy response is overly restrictive, implying higher nominal interest rates (in the order of 20 to 30bp) and lower output gap (in the order of 7 to 10bp) and inflation (between 3 and 5bp), while consumption dispersion increases by about twice as much, under both discretion and commitment. As a result, the welfare loss implied by ignoring the welfare relevance of financial instability in the DAMP economy is about 31% higher in the case of discretion, and about 41% higher in the case of commitment, as implied by Table 2.

A second dimension along which the relevance of financial-wealth effects can be evaluated is their role in the propagation of structural shocks with respect to the LAMP benchmark. Indeed, comparing the loss under optimal policy in the DAMP model (first two columns of Table 2) with the corresponding loss in the LAMP framework (i.e. $\xi = 0$, last two columns) shows that the welfare costs associated to the additional distortion characterizing the DAMP economy are substantial, as they imply welfare losses more than twice as high, under both discretion and commitment.

Therefore, the *total* welfare costs of ignoring the financial-wealth effects reflect both dimensions analyzed above – their role in the propagation of structural shocks and in the relevant welfare criterion – and can be evaluated by comparing the welfare loss implied by the Flexible Inflation Targeting regime in the DAMP economy (third and fourth columns in Table 2) with the loss under optimal policy in the benchmark LAMP framework (last two columns): a policy maker that believes to be operating in an economy where financial developments are neutral for equilibrium allocation when, in fact, they are not, induces, on average, welfare losses that are about 3 times higher than expected, under both discretion and commitment.

Overall, the quantitative relevance of these welfare implications – though they may seem small in absolute terms – is rather sizeable in relative terms, and suggests potentially important implications of ignoring the financial-wealth channel in the design of monetary policy.[33]

4 Conclusion

This paper builds a dynamic stochastic general equilibrium model of an economy where agents participate to asset markets only discontinuously. The framework implies two layers of agents heterogeneity: *between* types (market participants versus rule-of-thumbers) and *within* the type of market participants (because of different longevities in the type). This latter kind of heterogeneity implies financial-wealth effects on aggregate consumption and makes *all* agents non-Ricardian.

The *discontinuous asset market participation* (DAMP) model nests as special cases most frameworks currently used to study monetary policy: i) the standard representative-agent model, where all agents are infinitely-lived, homogeneous, and with continuous access to asset markets (hence Ricardian); ii) the LAMP model, where all agents are infinitely-lived and heterogeneous only *between* groups, as some have continuous access to asset markets (Ricardian) and some have no access at all (non-Ricardian); iii) the perpetual-youth model, where all agents have continuous access to asset markets but they are finitely-lived, and therefore heterogeneous (and non-Ricardian). With respect to the latter framework, one appealing feature of the DAMP model is that it implies the same kind of wealth-effects on aggregate consumption, but within an infinitely-lived-agent economy: the replacement rate in asset markets is fundamentally disconnected from expected lifetimes. The exogenous transition between agent types captures, in reduced form, the effects of occasionally-binding borrowing (or liquidity) constraints induced by different kinds of idiosyncratic uncertainty: the DAMP model is thus flexible enough to address different issues related to agents' heterogeneity, where the specific structural interpretation is reflected in the calibration of the transition probabilities.

Within a DAMP economy with an active stock market – where the transition between agent types is interpreted as a reduced-form representation of the interaction between a costly decision to participate in asset markets and idiosyncratic uncertainty about individual income – the paper then provides a formal normative analysis of monetary policy, deriving a welfare-based monetary-policy

[33] Also in absolute terms, the reported welfare implications are in the same order of magnitude that characterizes welfare exercises of this kind that have been used in the literature to rank alternative policy regimes. See, among others, Galí and Monacelli (2005). Please refer to the online appendix for a sensitivity analysis of the implications above.

loss function and characterizing the interplay between optimal policy and financial stability.

A second contribution is the derivation of the welfare criterion *per se*: since the demand side of the economy features an infinite number of heterogenous agents, it implies aggregation issues, when deriving a second-order approximation of social welfare. These issues arise also in standard perpetual-youth models, and are behind the lack of optimal policy analyses in a linear-quadratic framework within such models. In this respect, the contribution of the paper is to show how to deal with such heterogeneity and derive a quadratic welfare criterion as a function of aggregate variables only. The same methodology can be used for both perpetual-youth and DAMP models.

The third contribution is heuristic. The paper shows that the discontinuity of asset market participation implies an additional dynamic distortion in the model, which results in an additional term in the welfare criterion: while the social planner allocation implies that the cross-sectional consumption distribution is invariant to aggregate shocks, in the decentralized allocation it endogenously responds to any shock inducing fluctuations in aggregate financial wealth. Hence, financial stability appears in the welfare-based loss function and becomes an explicit additional target for welfare-maximizing policy makers, besides inflation and output stability. Finally, in this economy an endogenous trade-off arises between real and financial stabilization, even in the absence of cost-push or financial shocks. The ultimate implication is that price stability is no longer necessarily optimal: given the quadratic form of the welfare criterion, some fluctuations in output and inflation may be optimal as long as they reduce financial instability.[34] Ignoring the heterogeneity of asset-market participants potentially leads monetary policy to incur substantially higher welfare losses, under both discretion and commitment.

[34]A more elaborate source of agents heterogeneity may affect this result and the implied volatilities of relevant variables, like the cross-sectional consumption dispersion. Indeed, since the meaningful heterogeneity here comes from the perpetual-youth block of the economy, its structure is very stylized and downplays the effects that business cycle risk – and therefore fluctuations in the output gap – may have on the cross-sectional consumption dispersion.

References

Airaudo, M., S. Nisticò and L.F. Zanna (2015). "Learning, Monetary Policy and Asset Prices", *Journal of Money, Credit and Banking*, 47 (7): 1273–1307

Alvarez, F., R.E. Lucas Jr. and W. Weber (2001). "Interest Rates and Inflation", *American Economic Review*, 91 (2): 219–225.

Alvarez, F., A. Atkeson and P. Kehoe (2002). "Money, Interest Rates, and Exchange Rates with Endogenously Segmented Markets", *Journal of Political Economy*, 110 (1): 73–112

Ascari, G. and N. Rankin (2007). "Perpetual Youth and Endogenous Labour Supply: A Problem and a Possible Solution", *Journal of Macroeconomics*, 29: 708–723

Bernanke, B. S. and M. Gertler (1999). "Monetary Policy and Asset Prices Volatility." *Federal Reserve Bank of Kansas City Economic Review*, Fourth Quarter, 84, 17-51

Bernanke, B. S. and M. Gertler (2001). "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review, Papers and Proceedings*, 91, 253-257

Bilbiie, F. (2008). "Limited asset markets participation, monetary policy and (inverted) aggregate demand logic." *Journal of Economic Theory*, 140: 162–196

Bilbiie, F. and R. Straub (2013). "Asset Market Participation, Monetary Policy Rules and the Great Inflation." *The Review of Economics and Statistics*, 95(2): 377–392

Blanchard, O. (1985). "Debt, Deficits, and Finite Horizons." *Journal of Political Economy*, 93(2): 223–247

Burbridge, J. B. (1983). "Government Debt in an Overlapping-Generations Model with Bequests and Gifts," *American Economic Review*, 73, pp. 222–227.

Calvo, G. A. (1983). "Staggered Prices in a Utility Maximizing Framework." *Journal of Monetary Policy*, 12

Calvo, G. A. and M. Obstfeld (1988). "Optimal Time-Consistent Fiscal Policy with Finite Lifetimes", *Econometrica*, 56(2): 411–432

Campbell, Y., and N. Mankiw (1989) "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence," in O. Blanchard and S. Fischer (eds.), *NBER Macroeconomics Annual*

Carlstrom, C.T. and T.S. Fuerst. (2001) "Monetary Policy and Asset Prices with Imperfect Credit Markets." *Federal Reserve Bank of Cleveland Economic Review*, 37, 4

Castelnuovo, E. and S. Nisticò. (2010) “Stock Market Conditions and Monetary Policy in a DSGE Model for the US”, *Journal of Economic Dynamics and Control*, 34(9): 1700–1731

Cecchetti, S.G., Genberg, H., Lipsky, J., and S. Wadhwani (2000). *Asset Prices and Central Bank Policy*, CEPR Geneva Report on the World Economy 2.

Cella, C., A. Ellul and M. Giannetti (2013). “Investors' Horizons and the Amplification of Market Shocks” *The Review of Financial Studies*, 26(7): 1607–1648

Curdia, V. and M. Woodford (2010) “Credit Spreads and Monetary Policy.” *Journal of Money, Credit and Banking*, 42(1): 3–35.

Di Giorgio, G. and S. Nisticò (2007). “Monetary Policy and Stock Prices in an Open Economy.” *Journal of Money Credit and Banking*, 39(8): 1947–1985

Ferrero, A. (2010). “A structural decomposition of the U.S. trade balance: Productivity, demographics and fiscal policy.” *Journal of Monetary Economics*, 57: 478–490

Galí, J., J. López-Salido and J. Valles (2007). “Understanding the Effects of Government Spending on Consumption”, *Journal of the European Economic Association*, 5(1): 227–270

Galí, J. and T. Monacelli (2005). “Monetary Policy and Exchange Rate Volatility in a Small Open Economy”, *The Review of Economic Studies*, 72: 707–734

Ganelli, G. (2005) “The New Open Economy Macroeconomics of Government Debt.” *Journal of International Economics*, 65, pp. 167-184

Gilchrist, S. and J. Leahy (2002). “Monetary Policy and Asset Prices.” *Journal of Monetary Economics.* 49

Gourinchas, P. and J. Parker (2002). “Consumption over the Life Cycle”, *Econometrica*, 70

Hall, R. (2006). “Job Loss, Job Finding and Unemployment in the U.S. Economy over the Past Fifty Years”, in M. Gertler and K. Rogoff (eds.), *NBER Macroeconomics Annual 2005*

Hobijn, B, and A. Sahin (2007). “Job-finding and Separation Rates in the OECD”, Federal Reserve Bank of New York Staff Report No.298

Krueger, D. and F. Perri (2006) “Does Income Inequality Lead to Consumption Inequality? Evidence and Theory”, *Review of Economic Studies*, 73: 163–193

Leith, C., I. Moldovan and S. Wren-Lewis (2011) “Debt Stabilization in a Non-Ricardian Economy”, Economics Series Working Papers 542, University of Oxford, Department of Economics.

Ludvigson, S. and C. Steindel (1999). “How Important is the Stock Market Effect on Consumption?" *Federal Reserve Bank of New York, Economic Policy Review*, 5, 2.

Mankiw, N. G. (2000) "The Savers-Spenders Theory of Fiscal Policy," *American Economic Review*, 90(2), pp. 120–125

McKay, A., E. Nakamura and J. Steinsson (2015) "The Power of Forward Guidance Revisited", mimeo, Boston University and Columbia University

Nisticò, S. (2012). "Monetary Policy and Stock-Price Dynamics in a DSGE Framework", *Journal of Macroeconomics*, 34(1), pp. 126–146

Rotemberg, J. J., and M. Woodford (1997). "An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy", in B. Bernanke and J. Rotemberg (eds.), *NBER Macroeconomics Annual 1997*

Smets, F., and R. Wouters (2002). "Openness, Imperfect Exchange Rate Pass-Through and Monetary Policy." *Journal of Monetary Economics*, 49(5): 947–981

Svensson, Lars E.O. (1999), "Inflation Targeting: Some Extensions", *Scandinavian Journal of Economics*, 101: 337–361.

Woodford, M. (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*, PUP

Woodford, M. (2010). "Inflation Targeting and Financial Stability," a presentation at the conference *"The Future of Monetary Policy,"* EIEF, Rome, September 30, 2010.

Yaari, M. E. (1965). "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer." *Review of Economic Studies*, 32.

Appendix

This appendix starts by discussing – for the nested perpetual-youth case – consistency of the definition of social welfare with Calvo and Obstfeld (1988) and the implied social-planner allocation. Then, it presents details on the derivations of the social-planner and decentralized allocations, as well as of the welfare-based monetary-policy loss function implied by the general DAMP framework. Finally, it reports an extensive sensitivity analysis of the results discussed in the main text to the calibration of key parameters.

A The PY Case: Social Welfare and the Social Planner Allocation.

Consider the discrete-time stochastic version of the "perpetual-youth" (PY) model that is nested in the DAMP framework when the share of active agents is $\vartheta = 1$ and the replacement rate is $\xi \in (0, 1)$, and let $j \in (-\infty, t]$ index the discrete set of cohorts of agents in the economy in period t.

Each household belonging to cohort j has preferences defined over consumption and hours worked, described by the period-utility function $U[C_t(j), N_t(j)]$. The expected lifetime utility for *an individual*, discounted to account for impatience (reflected by the time discount factor β) and uncertain lifetime (reflected by the survival probability $1-\xi$), is therefore

$$E_j \sum_{t=j}^{\infty} \beta^{t-j} (1-\xi)^{t-j} U[C_t(j), N_t(j)].$$

As in Blanchard (1985), the size of each individual agent is negligible with respect to his cohort, and aggregate population is constant and normalized to 1. Two implications follow. First, at the beginning of each period, a constant fraction ξ of traders is replaced by an equivalent mass of newcomers. The cohort of newcomers has therefore size ξ, and expected lifetime utility

$$\mathcal{W}(j) \equiv E_j \sum_{t=j}^{\infty} \xi \beta^{t-j} (1-\xi)^{t-j} U[C_t(j), N_t(j)].$$

Second, the size of each cohort declines deterministically and, at generic time t, the mass of agents belonging to cohort j that are still in the economy is $m_t(j) \equiv \xi(1-\xi)^{t-j}$. As a consequence the aggregate value of the generic variable X is computed as a weighted average of the corresponding generation-specific counterpart, where each cohort's weight is equal to its own mass:

$$X_t \equiv \sum_{j=-\infty}^{t} m_t(j) X_t(j) = \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} X_t(j). \tag{A.1}$$

In a small-scale model – where the only variable factor of production is labor and all output, produced using a linear technology, is absorbed by private consumption – the aggregate resource constraint at time t requires

$$Y_t = C_t \equiv \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} C_t(j) \tag{A.2}$$

and the production function implies

$$Y_t/A_t = N_t \equiv \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} N_t(j), \tag{A.3}$$

where A_t is a stochastic, aggregate productivity index.

I am interested in defining an intertemporal social-welfare criterion that implies optimal time-consistent consumption plans. In a related, continuous-time, perpetual-youth model, Calvo and Obstfeld (1988) show that in order to ensure time consistency, the social planner needs to care about the expected utility of both existing and future cohorts and to treat them symmetrically. This requires the welfare criterion to have two specific features: i) the future period-utilities of both existing and future generations of agents need to be discounted back to their date of birth, rather than to the current period and ii) the lifetime utilities of both existing and future generations need to be weighted using the same social discount factor.[35]

Let $\gamma \in [0,1]$ denote such social discount factor. Accordingly, social welfare at time t_0 consists of two components: the first is the expected discounted stream of lifetime utilities of all current and future newcomers, and the second is the expected stream of utilities of old traders, from period t_0 onward, discounted back to their date of birth:

$$\begin{aligned}\mathcal{W}_{t_0} \equiv E_{t_0}\Bigg\{ & \xi \sum_{j=t_0}^{\infty} \gamma^{j-t_0} \sum_{t=j}^{\infty} \beta^{t-j}(1-\xi)^{t-j} U\left[C_t(j), N_t(j)\right] + \\ & \xi \sum_{j=-\infty}^{t_0-1} \gamma^{j-t_0} \sum_{t=t_0}^{\infty} \beta^{t-j}(1-\xi)^{t-j} U\left[C_t(j), N_t(j)\right] \Bigg\}.\end{aligned} \tag{A.4}$$

Changing the order of summation allows to re-write the above, more compactly, as

$$\mathcal{W}_{t_0} = E_{t_0}\left\{ \sum_{t=t_0}^{\infty} \gamma^{t-t_0} \sum_{j=-\infty}^{t} (\beta/\gamma)^{t-j} \xi(1-\xi)^{t-j} U\left[C_t(j), N_t(j)\right] \right\}. \tag{A.5}$$

As also emphasized by Calvo and Obsftfeld (1988), therefore, social welfare at time t_0 can be characterized as the simple discounted sum, over all future dates, of a weighted sum of period utilities of agents in the market at time t_0 only, where longevity is discounted using the factor β/γ.[36]

This specification of social welfare ensures time consistency of optimal intertemporal consumption plans for any value of the social discount factor γ. Indeed, a benevolent social planner solves a two-stage problem: she first chooses the cross-sectional distribution of consumption and hours worked that maximize the period-t social utility

$$\mathcal{U}_t \equiv \sum_{j=-\infty}^{t} (\beta/\gamma)^{t-j} \xi(1-\xi)^{t-j} U\left[C_t(j), N_t(j)\right] \tag{A.6}$$

for a given level of *aggregate* consumption and hours, defined by the aggregator (A.1), and then chooses the optimal intertemporal path for the latter given (A.2) and (A.3). The socially optimal allocation therefore features both *distributional* efficiency and *aggregate* efficiency.

Since neither the period-utility (A.6) nor the aggregator (A.1) depend on the planning period t_0, the optimal

[35] This implies *reverse discounting* of the lifetime utilities of existing agents. See also Burbridge (1983).

[36] See footnote 11 in Calvo and Obsfteld (1988).

cross-sectional distribution of consumption and hours will be time consistent: by treating all cohorts symmetrically, the social planner does not have any incentive to change the cross-sectional distribution of consumption and hours worked as new agents enter financial markets over time.[37] In particular, the first-order conditions for an optimum imply that the distribution of individual consumption across cohorts under the optimal plan satisfies

$$U_{c,t}(j) = \left(\frac{\beta}{\gamma}\right) U_{c,t}(j-1), \tag{A.7}$$

with $U_{c,t}(j)$ denoting the period$-t$ marginal utility of consumption of an individual trading in financial markets since period $j \leq t$. Therefore, if the social discount factor γ is smaller (bigger) than the time discount factor β, the social planner optimally allocates proportionately more (less) consumption to older traders.

An important implication of (A.7) is that the optimal cross-sectional consumption distribution is unaffected by aggregate shocks, which only affect the intertemporal path of *aggregate* consumption, regardless of the relative magnitude of the social (γ) and subjective (β) discount factors. This is the key dimension in which the decentralized equilibrium allocation – in the PY case as well as in the general DAMP specification of the model – deviates from the social-planner one, and which the normative implications of the paper are rooted in. The special case $\gamma = \beta$ simplifies the analysis considerably, as it implies – as in Calvo and Obstfeld (1988) – that the socially optimal allocation requires an "egalitarian", or "equitable" consumption plan according to which all individuals enjoy the same level of consumption, regardless of their cohort. In this specific case, social welfare at t_0 can be cast in the form of a discounted stream of a mass-weighted average of period utilities of all agents in the economy at t_0:

$$\mathcal{W}_{t_0} = E_{t_0}\left\{\sum_{t=t_0}^{\infty} \beta^{t-t_0}\mathcal{U}_t\right\} = E_{t_0}\left\{\sum_{t=t_0}^{\infty} \beta^{t-t_0} \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} U\left[C_t(j), N_t(j)\right]\right\}, \tag{A.8}$$

The period-welfare function $\mathcal{U}_t$ in equation (A.8) coincides with the average utility of market participants $\mathcal{U}_{p,t}$ in Section 2.3 of the paper. This is the sense in which the latter is consistent with the assumption that different longevities are treated equally by the social planner (as stated in footnote 26 in the paper): the same discount factor is used for both time and longevities ($\beta = \gamma$).

B The Social-Planner Allocation in the general DAMP Model

The DAMP case is a straightforward generalization of the PY case discussed in the previous Section. Each agent has preferences defined over consumption (C) and hours worked (N) described by a utility function $U(C, N)$ with standard properties. Social welfare at time t_0 is the discounted sum, over all future dates, of a mass-weighted average of period utilities across all agents in the economy:[38]

$$\mathcal{W}_{t_0} \equiv E_{t_0}\left\{\sum_{t=t_0}^{\infty} \beta^{t-t_0}\left[\vartheta\mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t}\right]\right\}. \tag{B.9}$$

[37] See Calvo and Obstfeld (1988) for a detailed discussion.

[38] Analogous definitions of social welfare are adopted by Curdia and Woodford (2010), in a model with Markov-Switching agent-types, and by Bilbiie (2008), among others, in a standard LAMP framework.

In equation (B.9) the average period-utility of "market participants" corresponds to equation (A.6) in the case $\beta = \gamma$:

$$\mathcal{U}_{p,t} \equiv \sum_{j=-\infty}^{t} \frac{m_{p,t}(j)}{\vartheta} U\left[C_{p,t}(j), N_{p,t}(j)\right] = \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} U\left[C_{p,t}(j), N_{p,t}(j)\right] \tag{B.10}$$

while that of "rule-of-thumb" agents, analogously, is simply:

$$\mathcal{U}_{r,t} \equiv \sum_{k=-\infty}^{t} \frac{m_{r,t}(k)}{1-\vartheta} U\left[C_{r,t}(k), N_{r,t}(k)\right] = \sum_{k=-\infty}^{t} \varrho(1-\varrho)^{t-k} U\left(C_{r,t}, N_{r,t}\right) = U\left(C_{r,t}, N_{r,t}\right). \tag{B.11}$$

The latter reflects the homogeneity of inactive agents, taking identical decisions regardless of their longevity in the type, while equation (B.10) accounts for the heterogeneity among active agents. Moreover, both equations are consistent with the assumption that different longevities are treated equally by the social planner.[39]

This specification of social welfare implies that a benevolent social planner solves a two-stage problem: she first chooses the cross-sectional distribution of consumption and hours worked that maximize the period-t social utility $\vartheta\mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t}$ for a given level of *aggregate* consumption (C_t) and hours (N_t), defined by the aggregator

$$X_t \equiv \vartheta X_{p,t} + (1-\vartheta) X_{r,t} = \vartheta \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} X_{p,t}(j) + (1-\vartheta) X_{r,t}, \tag{B.12}$$

for $X = C$, N, and then chooses the optimal intertemporal path for the latter given the aggregate resource constraint $Y_t = C_t$ and the production function $Y_t = A_t N_t$, with A_t an aggregate productivity index. Analogously to the PY specification, in this case the cross-sectional distribution of individual consumption across cohorts and types under the optimal social plan satisfies

$$U_{c,p,t}(j) = U_{c,p,t}(j-1) = U_{c,r,t}(k) = U_{c,r,t}(k-1), \tag{B.13}$$

with $U_{c,s,t}(h)$ denoting the period$-t$ marginal utility of consumption of an individual belonging to type s and cohort h, with $s = p, r$ and $h = j, k$: the socially optimal cross-sectional distribution requires an "egalitarian" consumption plan (all individuals enjoy the same level of consumption, regardless of their type and their longevity in that type).

C The Decentralized Allocation in the general DAMP Model

C.1 The problem of inactive agents

Regardless of their specific longevity as rule-of-thumbers, all inactive agents face the same static problem: they seek to maximize their period utility

$$\log C_{r,t} + \delta \log(1 - N_{r,t})$$

[39] Being both the equivalent of equation (A.6) in the case $\beta = \gamma$, they imply that the social planner uses the same discount factor (β) for both time and longevities.

subject to the following budget constraint (expressed in real terms):

$$C_{r,t} = W_t N_{r,t}, \tag{C.14}$$

where W_t denotes the real wage. Solution to this problem yields the following labor supply schedule

$$N_{r,t} = 1 - \delta \frac{C_{r,t}}{W_t}, \tag{C.15}$$

implying that, at equilibrium, inactive agents supply a constant amount of hours worked given by

$$N_{r,t} = \frac{1}{1+\delta}, \tag{C.16}$$

while consumption is simply determined by equation (C.14):

$$C_{r,t} = \frac{W_t}{1+\delta}. \tag{C.17}$$

C.2 The problem of active agents

Active agents take intertemporal decisions over a finite planning horizon, with duration $1/\xi$. Households have Cobb-Douglas preferences over consumption and leisure,[40] and demand consumption goods and two types of financial assets: state-contingent bonds and equity shares issued by monopolistic firms. In equilibrium, this side of the economy implies a dynamic equation for consumption and a pricing equation for the equity shares.

Define a "cohort" as a set of agents that experience a transition between types in the same period. Let $j \in (-\infty, t]$ index the discrete set of cohorts of agents that are active in asset markets in period t, and $i \in [0, 1]$ index the continuum of monopolistic firms in the economy. At time 0, therefore, agents that switched to the active type in period j seek to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t (1-\xi)^t \Big[\log C_{p,t}(j) + \delta \log(1 - N_{p,t}(j)) \Big]$$

subject to a sequence of budget constraints (expressed in real terms) of the form:

$$C_{p,t}(j) + E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} B_{t+1}(j) \right\} + \int_0^1 Q_t(i) Z_{t+1}(j,i)\, \mathrm{d}i \le \frac{1}{1-\xi} \Omega_t(j) + W_t N_{p,t}(j) - T_t(j). \tag{C.18}$$

Consumers belonging to cohort j, therefore, seek to maximize the expected stream of utility flows, discounted to account for impatience (as reflected by the intertemporal discount factor β) and transition probabilities (as reflected by the probability of switching to the inactive type in the next period, ξ). To that aim, they choose a pattern for individual real consumption $C_p(j)$, hours worked $N_p(j)$ and financial-asset holdings. At the end of period t, the latter consist of a set of contingent claims and a portfolio of equity shares. The one-period ahead stochastic nominal payoff of the state-contingent portfolio is $B^*_{t+1}(j) \equiv P_{t+1} B_{t+1}$, for which the relevant stochastic discount factor is $\mathcal{F}_{t,t+1}$. The stock portfolio includes equity shares issued by the monopolistic firms, $Z_{t+1}(j,i)$, whose real price at period t is

[40] The assumption of log-utility in consumption allows to achieve closed-form solutions for individual and aggregate consumption. See Smets and Wouters (2002) for a non-stochastic framework with CRRA utility.

$Q_t(i)$.

At the beginning of each period, then, the sources of funds consist of the real disposable labor income, $W_t N_{p,t}(j) - T_t(j)$, and the real financial wealth carried over from the previous period

$$\Omega_t(j) \equiv \int_0^1 \Big(Q_t(i) + D_t(i)\Big) Z_t(j,i)\, \mathrm{d}i + B_t(j), \tag{C.19}$$

which includes the nominal pay-off on the equity portfolio and on the contingent claims. Moreover, following Blanchard (1985), financial wealth carried over from the previous period also pays off the extra return $(\frac{\xi}{1-\xi})$ from the insurance contract that redistributes among agents that have not been replaced the financial wealth left over from the ones who have.

The first-order conditions for an optimum consist of the budget constraint (C.18) holding with equality, the individual labor supply

$$N_{p,t}(j) = 1 - \delta \frac{C_{p,t}(j)}{W_t}, \tag{C.20}$$

and the inter-temporal conditions with respect to state-contingent assets

$$\mathcal{F}_{t,t+1} = \beta \frac{U_c(C_{p,t+1}(j))}{U_c(C_{p,t}(j))} = \beta \frac{P_t C_{p,t}(j)}{P_{t+1} C_{p,t+1}(j)} \tag{C.21}$$

and equity shares

$$P_t Q_t(i) = E_t \left\{ \mathcal{F}_{t,t+1} P_{t+1} \left[Q_{t+1}(i) + D_{t+1}(i) \right] \right\}. \tag{C.22}$$

Equation (C.22) determines the equilibrium stock-price dynamics, by equating the nominal price of an equity share to its nominal expected payoff one period ahead, discounted by $\mathcal{F}_{t,t+1}$. The latter is the Stochastic Discount Factor (SDF) for one-period ahead nominal payoffs, which in equilibrium is determined by equation (C.21).

An important implication of this relation is that – *at the individual level* – the SDF equals the Intertemporal Marginal Rate of Substitution (IMRS) in consumption. This further implies that the *individual* euler equations in this framework and in the Representative Agent (RA) setup are identical and do not depend on the transition probability ξ. Indeed, taking conditional expectations of equation (C.21), and rearranging, yields:

$$U_c(C_{p,t}(j)) = \beta(1 + r_t) E_t \left\{ U_c(C_{p,t+1}(j)) \right\}, \tag{C.23}$$

where $(1 + r_t)$ is the nominal gross return on a safe, one-period bond paying off one unit of currency in period $t + 1$ with probability 1 (whose price is therefore $E_t \{\mathcal{F}_{t,t+1}\}$), which is defined by the following no-arbitrage condition:

$$(1 + r_t) E_t \{\mathcal{F}_{t,t+1}\} = 1. \tag{C.24}$$

This important result stems from the existence of the competitive insurance contract à la Blanchard (1985), which insures individuals against the risk of being replaced. Although with a finite expected lifetime, therefore, individual agents behave in this framework exactly as they would in the RA setup, smoothing their *individual* consumption over an infinite horizon.

The set of active agents can be partitioned in two relevant subsets: the "old traders" are those agents that are active since at least one period (i.e. $j \leq t-1$), while the "newcomers" are those that switched to the active type in the current period (i.e. $j = t$). As in Blanchard (1985), the latter enter with zero-holdings of financial assets: upon switching to the active type, therefore, they face the following budget constraint

$$C_{p,t}(t) + E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} B_{t+1}(t) \right\} + \int_0^1 Q_t(i) Z_{t+1}(t,i) \, \mathrm{d}i \leq W_t N_{p,t}(t) - T_t(t), \tag{C.25}$$

while in any other period they face constraint (C.18), unless they switch back to the inactive type.

The heterogeneity in the longevity of the several cohorts of agents in the active type implies a non-degenerate distribution of individual financial wealth across market participants, and a consequent distribution of individual consumption. I assume that the public authority is able to affect such distribution in the steady state only, by means of an appropriate redistribution scheme. Public transfers to active agents consist therefore of two components:

$$T_t(j) = T_t + \phi(j) \mathcal{R}_t. \tag{C.26}$$

The first component is common across cohorts and is used to collect resources to finance the employment subsidy to monopolistic firms; the second component, instead, is a "participation fee" (subsidy), proportional to the ex-ante net real return from holding a one-period risk-free bond – inclusive of the extra-return due to the insurance scheme –

$$\mathcal{R}_t \equiv \frac{1}{1-\xi} - E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} \right\} \tag{C.27}$$

where the coefficient of proportionality is generation specific, $\phi(j)$, and defines whether the transfer is a fee ($\phi(j) > 0$) or a subsidy ($\phi(j) < 0$).[41] Such "participation fee" serves the only purpose of redistributing financial wealth across generations, by choosing ϕ so that the steady-state distribution is consistent with an equilibrium allocation around which a quadratic Taylor expansion of expected social welfare is a valid second-order approximation of expected welfare when evaluated using only first-order-approximated equilibrium conditions.[42]

One last requirement for an optimum of the problem above is a transversality condition, ruling out the possibility of Ponzi schemes, i.e. the present value of terminal financial wealth, discounted by the stochastic discount factor and conditional upon staying in the active type, shrinks to zero as time diverges:

$$\lim_{k \to \infty} E_t \left\{ \mathcal{F}_{t,t+k} (1-\xi)^k P_{t+k} \Omega_{t+k}(j) \right\} = 0. \tag{C.28}$$

Using equation (C.22), the equilibrium labor supply (C.20), the equilibrium stochastic discount factor (C.21) and the transversality condition (C.28), I can solve equation (C.18) forward, and derive an equilibrium relation between individual consumption and total wealth:

$$C_{p,t}(j) = \sigma H_t + \frac{\sigma}{1-\xi} \Big[\Omega_t(j) - \phi(j) \Big], \tag{C.29}$$

[41] Hence, for example, for the case of "newcomers" – since they enter with no financial wealth – it will be $\phi(j) < 0$.

[42] Woodford (2003, Ch. 6) derives and discusses the conditions under which such second-order approximation is valid.

where $\sigma \equiv \frac{1-\beta(1-\xi)}{1+\delta}$ denotes the propensity to consume out of total wealth, and

$$H_t \equiv E_t \left\{ \sum_{k=0}^{\infty} (1-\xi)^k \mathcal{F}_{t,t+k} \frac{P_{t+k}}{P_t} \Big(W_{t+k} - T_{t+k} \Big) \right\}, \tag{C.30}$$

denotes the stock of human wealth, defined as the expected discounted after-tax value of the labour endowment while active.[43] Newcomers can instead consume only out of their human wealth, net of the redistributive subsidy that they get upon switching to the active type:

$$C_{p,t}(t) = \sigma \left(H_t + \phi^{nc} \right), \tag{C.31}$$

where $\phi^{nc} \equiv -\frac{1}{1-\xi}\phi(t) > 0$.

The finiteness of the planning horizon of active agents ($\xi > 0$) implies that the propensity to consume out of total wealth is higher than in the RA set up ($\xi = 0$), because a positive ξ reduces the effective rate at which households discount utility (i.e. $\beta(1-\xi)$) and this makes the present even more valuable than the future (σ is increasing in ξ). Moreover, a positive ξ also implies higher returns on current financial wealth through the insurance market.

C.2.1 Aggregation across market participants

The mass of active agents in the economy is ϑ, and the mass of the cohort of agents that are active in t since time j is $m_{p,t}(j) \equiv \vartheta\xi(1-\xi)^{t-j}$. The average value of the generic variable X across market participants is computed as a weighted average of the corresponding cohort-specific counterpart, where each cohort's weight is equal to its own relative mass:

$$X_{p,t} \equiv \sum_{j=-\infty}^{t} \frac{m_{p,t}(j)}{\vartheta} X_{p,t}(j) = \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} X_{p,t}(j). \tag{C.32}$$

Since agents entering the market at time t hold no financial assets, all the financial wealth is held by old traders; accordingly, its aggregate value is defined as the average across old traders only:

$$\Omega_t \equiv \sum_{j=-\infty}^{t-1} \xi(1-\xi)^{t-1-j} \Omega_t(j). \tag{C.33}$$

Thereby, since the aggregator defined in (C.32) computes the average across *all* active agents, it implies

$$\sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} \Omega_t(j) = (1-\xi)\Omega_t, \tag{C.34}$$

capturing the fact that all the financial wealth is held by old traders, whose mass is $(1-\xi)$. Moreover, since the fee/subsidy $\phi(j)$ serves redistributive purposes only, it must be such that its average value across all market participants is zero:

$$\sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} \phi(j) = 0. \tag{C.35}$$

We can now characterize the aggregate equilibrium conditions for the set of active agents by applying the aggregator (C.32) to the individual restrictions derived in the previous Section. Active agents' aggregate consumption is

[43] Notice that this term is common across market participants, regardless of their longevity in the type.

related to total aggregate wealth through the relation

$$C_{p,t} = \sigma\Big(\Omega_t + H_t\Big), \tag{C.36}$$

and their aggregate labor supply schedule reads:

$$N_{p,t} = 1 - \delta \frac{C_{p,t}}{W_t}. \tag{C.37}$$

We need now to derive the dynamic equation for active agents' aggregate consumption, through aggregation of the Euler equation (C.23). Notice that, in the RA setup, the aggregation of the individual euler equations is straightforward because all agents are identical. This implies that, in equilibrium, the *individual* and *average* IMRS in consumption are the same, and equal to the stochastic discount factor. Hence, individual consumption smoothing carries over in aggregate terms and the time$-t$ level of average consumption is related only to the discounted value expected for $t+1$. This case is nested when the transition probability ξ goes to zero. However, when there is replacement in asset markets of agents with some accumulated wealth by others with no financial assets (or a different stock of wealth), the aggregation of the individual Euler equations is no longer straightforward, because agents in the financial market change from one period to the next. In order to see this, first notice that the active agents' aggregate time$-t+1$ consumption can be expressed as the weighted average of two components:

$$C_{p,t+1} = \xi C^{nc}_{p,t+1} + (1-\xi) C^{ot}_{p,t+1}, \tag{C.38}$$

where the first term is the average consumption of newcomers

$$C^{nc}_{p,t+1} \equiv C_{p,t+1}(t+1),$$

the second is the average consumption of old traders

$$C^{ot}_{p,t+1} \equiv \sum_{j=-\infty}^{t} \xi(1-\xi)^{t-j} C_{p,t+1}(j),$$

and the weights are given by the mass of agents in each subset. Second, rearranging equation (C.21) and applying the aggregator (C.32) yields on one side the average time$-t$ consumption across *all active agents*, and on the other side the average consumption of *old traders only*, implying:

$$\mathcal{F}_{t,t+1} = \beta \frac{P_t C_{p,t}}{P_{t+1} C^{ot}_{p,t+1}}. \tag{C.39}$$

In order to relate the equilibrium stochastic discount factor to average consumption growth across all market participants, therefore, we need to account for the wedge between the average level of consumption across "old traders" only and the average across *all* agents that are active at $t+1$. Equations (C.31), (C.36) and (C.38) show that this wedge is proportional to the difference in average consumption between the two subsets, and to the aggregate stock of financial wealth held at $t+1$:

$$C^{ot}_{p,t+1} - C_{p,t+1} = \xi \left(C^{ot}_{p,t+1} - C^{nc}_{p,t+1} \right) = \frac{\xi \sigma}{1-\xi} \left(\Omega_{t+1} - \phi^{nc} \right). \tag{C.40}$$

An increase in financial wealth (even temporary) enlarges this wedge because it makes the difference between the average consumption of old traders and that of newcomers larger, and thus distorts the dynamics of aggregate consumption, for given SDF:

$$\mathcal{F}_{t,t+1} = \beta \frac{P_t C_{p,t}}{P_{t+1} \left[C_{p,t+1} + \frac{\xi\sigma}{1-\xi} \left(\Omega_{t+1} - \phi^{nc} \right) \right]}. \tag{C.41}$$

Equation (C.40) shows that the magnitude of such distortion depends upon two factors. First, higher rates of replacement (ξ), for given swings in stock prices, imply a larger fraction of people entering the market tomorrow and being unaffected by variations in financial wealth. Second, higher levels of aggregate stock-market wealth (Ω), for a given rate of replacement, imply larger effects on current consumption, and therefore a higher difference with the expected future level.

Rearranging equation (C.41) and taking conditional expectations finally yields a dynamic stochastic-difference equation for the average consumption of market participants:

$$C_{p,t} = \frac{\xi \sigma}{\beta(1-\xi)} E_t \left\{ \mathcal{F}_{t,t+1} (1+\pi_{t+1}) \left(\Omega_{t+1} - \phi^{nc} \right) \right\} + \frac{1}{\beta} E_t \left\{ \mathcal{F}_{t,t+1} (1+\pi_{t+1}) C_{p,t+1} \right\}. \tag{C.42}$$

Finally, the evolution of aggregate financial wealth is implied by aggregating budget constraint (C.18) across all active agents:

$$\Omega_t = E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} \Omega_{t+1} \right\} - W_t + T_t + (1+\delta) C_{p,t}, \tag{C.43}$$

where I have used equation (C.37) and the equilibrium dynamics of stock prices:

$$Q_t = E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} \Big(Q_{t+1} + D_{t+1} \Big) \right\}.$$

C.3 The supply side

The supply-side of the economy is standard New-Keynesian. A competitive retail sector packs the continuum of intermediate differentiated goods $Y_t(i)$ – indexed by $i \in [0,1]$ – into a final consumption good Y_t, using

$$Y_t = \left[\int_0^1 Y_t(i)^{1/(1+\mu)} \, di \right]^{(1+\mu)},$$

in which $\mu > 0$ captures the degree of market power in the market for inputs $Y_t(i)$. A monopolistic wholesale sector produces differentiated intermediate goods out of labor services, by means of the linear technology $Y_t(i) = A_t N_t(i)$, in which $A_t \equiv A \exp(a_t)$ is a stochastic, log-stationary, productivity index. Aggregating across firms and using the input demand coming from the retail sector yields

$$\exp(\Delta^p_t) Y_t = A_t N_t, \tag{C.44}$$

in which $N_t \equiv \int_0^1 N_t(i)\,\mathrm{d}i$ is the aggregate level of hours worked and

$$\Delta_t^p \equiv \log \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} \mathrm{d}i \tag{C.45}$$

is a (second-order) index of price dispersion over the continuum of intermediate goods-producing firms, where $\epsilon \equiv \frac{1+\mu}{\mu}$ denotes the price-elasticity of demand for input i. As in most related literature, I assume that the government subsidizes employment at the constant rate τ, to offset – in the steady state – the monopolistic distortion. Given this assumption (and the linear technology used by monopolistic producers), the equilibrium real marginal costs are equalized across firms:

$$MC_t = (1-\tau)\frac{W_t}{A_t}. \tag{C.46}$$

The price-setting mechanism follows Calvo's (1983) staggering assumption, with $1-\theta$ denoting the probability for a firm of having the chance to re-optimize in a given period. When able to set its price optimally, each firm seeks to maximize the expected discounted stream of future dividends, otherwise they keep the price unchanged. Equilibrium in this side of the economy implies the familiar New-Keynesian Phillips Curve, relating current inflation to future expected inflation and current marginal costs.

C.4 Aggregation, the government and general equilibrium.

Aggregation across all agents in the economy yields

$$C_t \equiv \vartheta C_{p,t} + (1-\vartheta)C_{r,t}$$

and

$$N_t \equiv \vartheta N_{p,t} + (1-\vartheta)N_{r,t} = \vartheta N_{p,t} + \frac{1-\vartheta}{1+\delta}.$$

The fiscal authority runs a balanced budget in every period, and finances the employment subsidies through lump-sum taxes to savers:

$$\vartheta T_{p,t} = \tau W_t N_t. \tag{C.47}$$

In equilibrium, all output is absorbed by private consumption ($Y_t = C_t$), the net supply of state-contingent assets is nil, and the aggregate stock of outstanding equity shares is normalized to 1, for each monopolistic firm. As a consequence, the aggregate budget constraint of the economy implies the aggregate profit income:

$$\vartheta D_{p,t} = Y_t - (1-\tau)N_t W_t. \tag{C.48}$$

D The Welfare-Based Loss Function in the general DAMP model.

Social welfare at time t_0 is defined as the discounted sum, over all future dates, of a mass-weighted average of period utilities across all agents in the economy at time t_0:

$$\mathcal{W}_{t_0} \equiv E_{t_0}\left\{\sum_{t=t_0}^{\infty}\beta^{t-t_0}\Big[\vartheta\mathcal{U}_{p,t}+(1-\vartheta)\mathcal{U}_{r,t}\Big]\right\}, \tag{D.49}$$

where $\mathcal{U}_{p,t}$ and $\mathcal{U}_{r,t}$ are defined by equations (B.10) and (B.11), respectively, and

$$U\left[C_{s,t}(h),N_{s,t}(h)\right]=\log C_{s,t}(h)+\delta\log(1-N_{s,t}(h)),$$

for $s=p,r$ and $h=j,k$. In a second-order Taylor expansion, the period utility of market participants, at the cohort level, can be written as

$$U\left[C_{p,t}(j),N_{p,t}(j)\right]=c_{p,t}(j)-\delta\varphi\bigg(n_{p,t}(j)+\frac{1+\varphi}{2}n_{p,t}(j)^2\bigg)+t.i.p.+\mathcal{O}(\|\chi\|^3), \tag{D.50}$$

where $\|\chi\|$ denotes the bound on the magnitude of the vector of disturbances and $t.i.p.$ collects all the terms that are independent of policy. Given the equitability of the optimal steady state, a second-order approximation of the aggregate level of generic variable z across all active agents implies:

$$z_{p,t}=E_j z_{p,t}(j)+\frac{1}{2}var_j z_{p,t}(j),$$

where the cross-sectional mean is defined by (C.32):

$$E_j z_{p,t}(j)=\sum_{j=-\infty}^{t}\xi(1-\xi)^{t-j}z_{p,t}(j).$$

Using the above on (D.50), and given the efficiency condition $\varphi\delta=1$ implied by the optimal employment subsidy, I can write the aggregate period$-t$ utility for market participants as

$$\begin{aligned}\mathcal{U}_{p,t}&=c_{p,t}-\frac{1}{2}var_j c_{p,t}(j)-n_{p,t}+\frac{1}{2}var_j n_{p,t}(j)-\frac{1+\varphi}{2}E_j\left(n_{p,t}(j)^2\right)+t.i.p.+\mathcal{O}(\|\chi\|^3)\\&=c_{p,t}-n_{p,t}-\frac{1+\varphi}{2}n_{p,t}^2-\frac{1+\varphi}{2\varphi}var_j c_{p,t}(j)+t.i.p.+\mathcal{O}(\|\chi\|^3).\end{aligned} \tag{D.51}$$

in which the last equality uses $E(z^2)=E(z)^2+var(z)$ and a first-order approximation of the individual labor supply, to relate the cross-sectional variance of hours worked to that of individual consumption: $\varphi^2 var_j n_{p,t}(j)=var_j c_{p,t}(j)$.

Since inactive agents are homogeneous and supply a constant amount of hours worked, a second-order approximation of their period$-t$ utility is simply

$$\mathcal{U}_{r,t}=c_{r,t}+\mathcal{O}(\|\chi\|^3).$$

Accordingly, using $n_t = \vartheta n_{p,t}$, the aggregate period$-t$ utility across all agents can be written as

$$\vartheta \mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t} = c_t - n_t - \frac{1+\varphi}{2\vartheta} n_t^2 - \vartheta \frac{1+\varphi}{2\varphi} var_j c_{p,t}(j) + t.i.p. + \mathcal{O}(\|\chi\|^3). \tag{D.52}$$

Moreover, using the resource constraint and a second-order approximation of the aggregate production function, one obtains the period$-t$ social utility as a function of squared output gap x_t, price dispersion across firms Δ_t^p and consumption dispersion across all savers $\Delta_{p,t}^c \equiv var_j c_{p,t}(j)$:

$$\vartheta \mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t} = -\frac{(1+\varphi)}{2\vartheta} \left(x_t^2 + \frac{2\vartheta}{1+\varphi} \Delta_t^p + \frac{\vartheta^2}{\varphi} \Delta_{p,t}^c \right) + t.i.p. + \mathcal{O}(\|\chi\|^3). \tag{D.53}$$

The equation above shows that social welfare displays an additional second-order term – with respect to the standard RA or LAMP frameworks – which is related to the cross-sectional dispersion in consumption $var_j c_t(j)$. Indeed, if all active agents were homogenous and consumed *in every period* the same amount of goods, the cross-sectional variance would be zero, and the benchmark LAMP framework would arise.

To understand the implications of this additional term, it is useful to recall the partition of the set of active agents into the two subsets of "newcomers" and "old traders". In particular, in a first-order approximation, individual consumption is

$$c_{p,t}(j) = \begin{cases} \tilde{h}_t & \text{for newcomers } (j = t)\text{, whose relative mass is } \xi \\ \frac{\psi}{\xi} \frac{\Omega(j)}{\Omega} \omega_t(j) + \tilde{h}_t & \text{for old traders } (j \le t-1)\text{, whose relative mass is } (1-\xi), \end{cases} \tag{D.54}$$

in which $\tilde{h}_t$ collects all the terms that are not cohort-specific (related to the average human wealth). Using the law of total variance on such partition, I can express $\Delta_{p,t}^c = var_j(c_{p,t}(j)|j \le t)$ as:

$$\Delta_{p,t}^c = E\Big[var_j\big(c_{p,t}(j)\big|j=t\big),\ var_j\big(c_{p,t}(j)\big|j \le t-1\big)\Big] + var\Big[E_j\big(c_{p,t}(j)\big|j=t\big),\ E_j\big(c_{p,t}(j)\big|j \le t-1\big)\Big]. \tag{D.55}$$

The first term is the relative-mass-weighted average of two cross-sectional variances of individual consumption: the one among old traders and the one among newcomers. Since the newcomers are all identical, they all consume the same amount of goods, and this term is, therefore, proportional to the consumption dispersion among old traders only:

$$E\Big[var_j\big(c_{p,t}(j)\big|j=t\big),\ var_j\big(c_{p,t}(j)\big|j \le t-1\big)\Big] = (1-\xi) var_j(c_{p,t}(j)|j \le t-1). \tag{D.56}$$

In turn, the dispersion of consumption among old traders in period t reflects the composition between newcomers and old traders, characterizing the financial market in $t-1$. Indeed, a first-order approximation of equation (C.21) implies

$$var_j(c_{p,t}(j)|j \le t-1) = var_j(c_{p,t-1}(j) - f_{t-1,t} - \pi_t|j \le t-1) = var_j(c_{p,t-1}(j)|j \le t-1) = \Delta_{p,t-1}^c. \tag{D.57}$$

The second term in (D.55), instead, captures the dispersion in the *average* consumption of market participants, between old traders and newcomers. Since financial wealth is held by old traders only, the average consumption of the latter is proportional to the *aggregate* financial wealth,[44] while that of newcomers is independent of it. As a consequence, the cross-sectional variance of average consumption between the two subsets is proportional to the squared aggregate financial wealth:

$$var\Big[E_j\big(c_{p,t}(j)\big|j=t\big),\ E_j\big(c_{p,t}(j)\big|j\leq t-1\big)\Big] = var\left[\tilde{h}_t,\ \frac{\psi}{\xi}\omega_t + \tilde{h}_t\right]$$
$$= E\left[\tilde{h}_t^2,\ \left(\frac{\psi}{\xi}\omega_t + \tilde{h}_t\right)^2\right] - \left[E\left(\tilde{h}_t,\ \frac{\psi}{\xi}\omega_t + \tilde{h}_t\right)\right]^2 = \psi\frac{\sigma}{1-\beta}\frac{\mu}{1+\mu}\omega_t^2. \quad \text{(D.58)}$$

This component, as argued above, captures the dispersion in average consumption between newcomers and old traders, and is therefore the relevant term driving the wedge that distorts the growth rate of aggregate consumption, as implied by equation (C.40).

Therefore, I can characterize the evolution over time of the cross-sectional consumption dispersion across all active agents in the economy as:

$$\Delta_{p,t}^c = (1-\xi)\Delta_{p,t-1}^c + \psi\frac{\sigma}{1-\beta}\frac{\mu}{1+\mu}\omega_t^2. \quad \text{(D.59)}$$

Moving from an arbitrary initial level $\Delta_{p,-1}^c$, which is independent of policies implemented from $t=0$ onward, I can therefore write the level at time t as

$$\Delta_{p,t}^c = (1-\xi)^{t+1}\Delta_{p,-1}^c + \psi\frac{\sigma}{1-\beta}\frac{\mu}{1+\mu}\sum_{s=0}^{t}(1-\xi)^{t-s}\omega_s^2, \quad \text{(D.60)}$$

and the discounted value over all periods $t>0$ as

$$\sum_{t=0}^{\infty}\beta^t\Delta_{p,t}^c = \frac{\psi\mu}{(1+\delta)(1-\beta)(1+\mu)}\sum_{t=0}^{\infty}\beta^t\omega_t^2 + t.i.p. \quad \text{(D.61)}$$

Finally, taking the time-0 conditional expectation of the discounted stream of future period social losses yields the Welfare-Based Loss Function $\mathcal{L}_0$, expressed as a share of steady-state aggregate consumption. Ignoring the terms independent of policy and those of third or higher order, I can therefore write it as

$$\mathcal{L}_0 \equiv -E_0\sum_{t=0}^{\infty}\beta^t[\vartheta\mathcal{U}_{p,t} + (1-\vartheta)\mathcal{U}_{r,t}] = \frac{(1+\varphi)}{2\vartheta}E_0\sum_{t=0}^{\infty}\beta^t\Big(x_t^2 + \alpha_\pi\pi_t^2 + \alpha_\omega\omega_t^2\Big), \quad \text{(D.62)}$$

which makes use of the familiar lemmata

$$\Delta_t^p \approx \frac{\epsilon}{2}var_i p_t(i)$$

and

$$\sum_{t=0}^{\infty}\beta^t var_i p_t(i) = \frac{\theta}{(1-\theta)(1-\theta\beta)}\sum_{t=0}^{\infty}\beta^t\pi_t^2,$$

[44] Notice that, since the stock of accumulated wealth is not the same across households, the aggregate financial wealth, in a first-order approximation, is properly computed using:

$$\omega_t = \sum_{j=-\infty}^{t-1}\xi(1-\xi)^{t-1-j}\frac{\Omega(j)}{\Omega}\omega_t(j).$$

and where α_π denotes the relative weight on inflation stability and α_ω the relative one on *financial stability*:

$$\alpha_\pi \equiv \vartheta \frac{\epsilon}{\kappa} \qquad\qquad \alpha_\omega \equiv \frac{\vartheta^2 \psi \mu}{(1+\varphi)(1-\beta)(1+\mu)} \geq 0.$$

E Sensitivity analysis

The implications drawn in the paper clearly depend on the calibration of key parameters, like the share of inactive agents in the economy and the transition probabilities. This Appendix reports a sensitivity analysis along two main dimensions. First, I evaluate the sensitivity of the quantitative relevance of the financial-wealth effects implied by the model for both the transmission mechanism of structural shocks and the monetary-policy loss function. Second, I evaluate the sensitivity of the total welfare costs implied by ignoring the financial-wealth effects.

As to the share of rule-of-thumbers in the economy, Galí et al (2007) use a baseline value of 50%, consistently with Campbell and Mankiw (1989) and Mankiw (2000). Bilbiie and Straub (2013) have more recently provided a bayesian estimate of a standard LAMP framework for the US, and showed that the share of rule-of-thumbers actually fell from about 50% in the pre-Volker period to about 20% in the Great-Moderation sample (i.e. post 1984). This evidence is regarded as supportive of the view that the degree of US financial regulation – which might be seen as one of the real frictions behind the limited access to asset markets – decreased in the 1980s and 1990s. As a baseline calibration, I use Bilbiie and Straub's (2013) estimate for the Great Moderation period (i.e. $\vartheta = .8$); here I study sensitivity of the results over the range $\vartheta \in [.5, .9]$ – from a value consistent with the evidence for the pre-Volker period to one arbitrarily larger than the baseline calibration.

As to the turnover rate ξ – which regulates the transition from the active to the inactive type, and affects the elasticity of aggregate consumption with respect to financial wealth – there is not much evidence, to my knowledge, in the macro literature that can discipline its calibration. In this respect, it is important to notice that the financial-wealth channel at work in this economy does not follow from the *individual* feature of non-Ricardian active agents of facing a finite planning horizon in asset markets. Indeed, the risk of being replaced in every period does not affect *individual* intertemporal plans with respect to a framework with $\xi = 0$: this risk is completely insured by the insurance contract *à la* Blanchard (1985), as in the perpetual-youth model. Rather, the financial-wealth effect follows from the transition into the active type of "newcomers" holding a different stock of financial assets.[45] For this reason, to set the baseline calibration I use an indirect strategy, and set ξ and ϱ in order to imply an elasticity of aggregate consumption with respect to stock-market wealth (ψ/Θ) of about .15, consistently with the evidence documented by Ludvigson and Steindel (1999) for the Great-Moderation sample. In the DAMP economy, and considering the baseline calibration $\vartheta = .8$, this requires $\xi = .17$ and $\varrho = .68$. To evaluate the sensitivity of my results to this parameter, I consider a wide range of alternative values, from the limiting case implying no wealth effects to a value arbitrarily larger than the baseline calibration: $\xi \in [0, .3]$.[46]

Figure 1 displays the relevance of the financial-wealth effects from a positive (left panel) and a normative (right

[45]For a discussion of this point, see Section 2.1. in the paper, and Castelnuovo and Nisticò (2010).
[46]The upper bound of the range of alternative values of ξ is adjusted, when required, to satisfy restriction (1) in the paper.

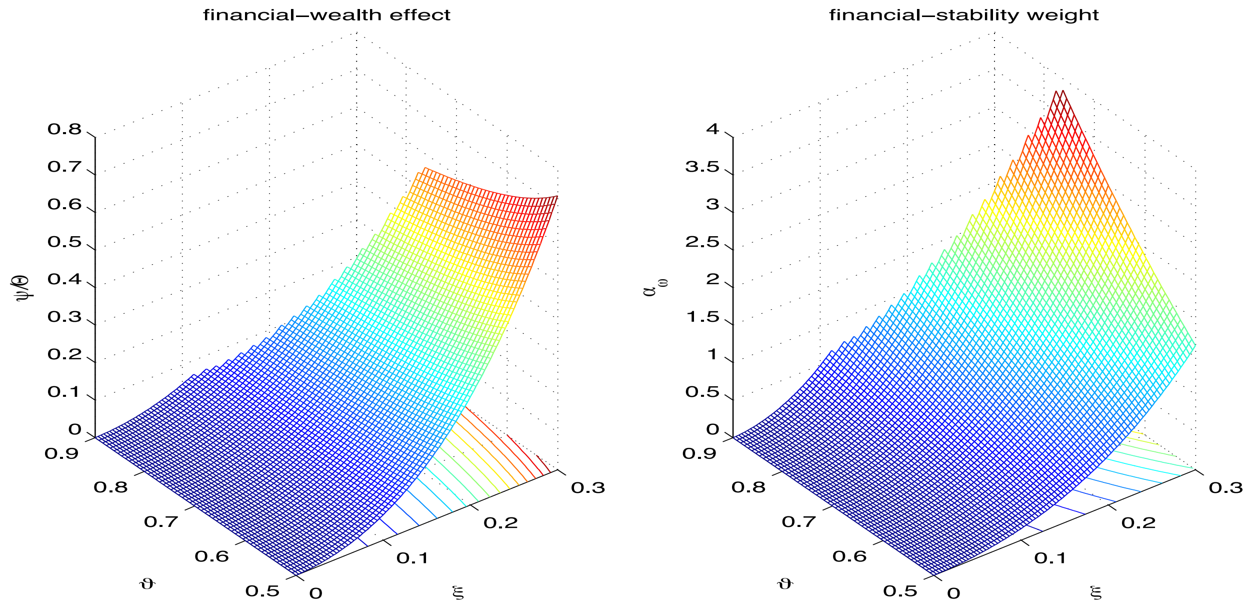

Figure 3: The role of the turnover rate ξ and the share of "market participants" ϑ. Left panel: financial-wealth effects on aggregate consumption (ψ/Θ). Right panel: relative weight on financial stability in welfare criterion (α_ω).

panel) perspective. In particular, the left panel shows the elasticity of output to financial wealth, as measured by the ratio ψ/Θ, and the right panel the relative weight on financial stability in the welfare-based monetary policy loss, as measured by α_ω.

The left panel of Figure 3 reveals that while the financial-wealth effects on output are stronger the higher the replacement rate ξ, their magnitude is instead decreasing in the share of active agents in the economy ϑ. The intuition behind this result is analogous to the one explaining the effect of a change in ϑ on the interest-rate elasticity of aggregate consumption ($1/\Theta$), and relies on the labor-market adjustment.[47] Indeed, a given expected increase in financial wealth expands the current consumption of active agents – through equation (C.42) – thereby reducing their current labor supply for given real wage; price stickiness in turn implies an increase in labor demand, necessary to adjust production to the higher demand for consumption goods. The combined effect is an increase in the real wage. At this stage of the propagation mechanism the share of "rule-of-thumbers" becomes relevant: indeed, the increase in real wage directly increases their consumption and therefore implies an additional upward pressure on aggregate spending and output, the more so the larger the share of inactive agents in the economy. A given expected increase in financial wealth, therefore, has a stronger effect on aggregate consumption and output (higher ψ/Θ) the smaller is ϑ.[48]

From a normative perspective, instead, the right panel of Figure 1 shows that the relative weight on financial stability in the welfare criterion is increasing and convex in both the share of savers in the economy ϑ and the

[47] See Bilbiie (2008) for a detailed discussion of this mechanism with respect to the interest-rate elasticity of output.

[48] As in Bilbiie (2008), also in this framework a large enough share of "rule-of-thumb" agents can trigger an *inverted aggregate demand logic*. Here, moreover, when Θ turns negative not only interest-rate increases become expansionary, but also the financial-wealth effects change sign and become *contractionary*, with potentially interesting implications for economic policy. As underlined in the paper, however, in this work I restrict attention to the case $\Theta > 0$, and leave the scrutiny of such implications to future research.

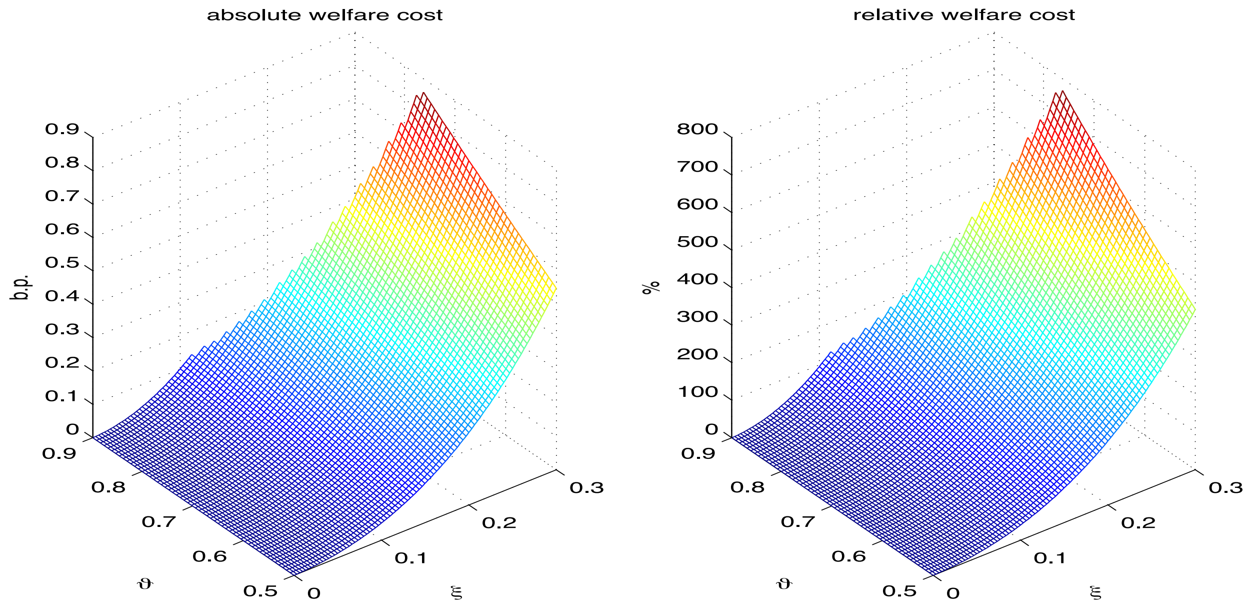

Figure 4: Total welfare costs from ignoring the financial-wealth effects in the design of monetary policy. Left panel: Absolute Welfare Cost (AWC), defined as in (E.63), in basis points of steady-state aggregate consumption. Right Panel: Relative Welfare Cost (RWC), defined as in (E.64), in percentage points. Optimal policy under Full Commitment.

replacement rate ξ, potentially reaching levels substantially higher than those attached to output-gap variability. On the one hand, indeed, as discussed in Appendix D, a higher replacement rate translates a given increase in financial instability into a higher cross-sectional consumption dispersion among active agents, which is detrimental for welfare. On the other hand, a higher share of savers makes such increase in cross-sectional consumption dispersion relatively more relevant for aggregate welfare.

The second dimension along which I conduct a sensitivity analysis is related to the welfare implications of the model with Markov-Switching agent-types. In particular, I am interested in evaluating the total welfare costs of ignoring the financial-wealth effects implied by the discontinuous access to financial markets. Define *Absolute Welfare Cost* as the difference in the average welfare losses (equation (29) in the paper) implied by the *Flexible Inflation Targeting* regime in the DAMP economy and the optimal policy regime in the benchmark LAMP economy:

$$AWC \equiv E\{-\mathcal{U}_t^{FIT}\} - E\{-\mathcal{U}_t^{LAMP}\}, \tag{E.63}$$

and define instead the *Relative Welfare Cost* – in percentage units – as:

$$RWC \equiv \frac{AWC}{E\{-\mathcal{U}_t^{LAMP}\}} \times 100. \tag{E.64}$$

Figure 4 displays these total welfare costs for the case of full commitment, and shows that they are increasing and convex functions of both the share of savers in the economy ϑ and the replacement rate ξ: the more relevant for welfare is financial stability (the higher α_ω) the more it is costly to ignore it, with welfare costs reaching up to 0.9bp of steady-state aggregate consumption, equivalent to about eight times the loss implied under optimal policy

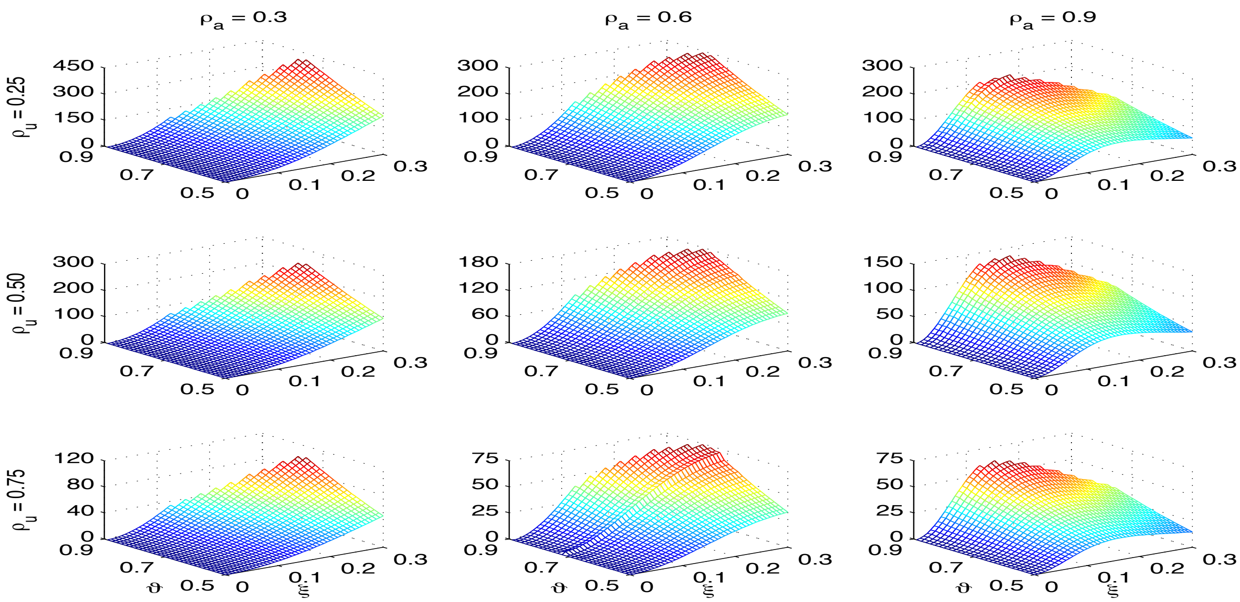

Figure 5: Relative Welfare Cost (RWC), defined as in (E.64), in percentage points, for different degrees of persistency in supply shocks. Optimal policy under Full Commitment.

in the benchmark LAMP economy. The magnitude of these total welfare costs – which seems rather large – also depends on the degree of persistence of supply shocks (on productivity and marginal costs). In particular, Figure 5 reproduces the right panel of Figure 4 for different degrees of persistency in productivity and cost-push shocks, and has two interesting implications. The first is that, in general, more persistent supply shocks induce, *ceteris paribus*, a smaller financial instability in the benchmark LAMP economy,[49] and therefore implies a smaller total welfare costs of ignoring the financial-wealth effects in the design of monetary policy – although they still remain substantial (around 60% higher welfare loss when $\rho_a = 0.9$ and $\rho_u = 0.75$, under the baseline calibration for ϑ and ξ). The second implication is that, while increasing the persistency of cost-push shock does not affect the shape of the surface, more persistent productivity shocks turn it from convex to concave, along the dimension related to the turnover rate ξ: more persistent productivity shocks make lower transition probabilities marginally more relevant compared to the benchmark LAMP economy.

Finally, note that the indirect strategy to calibrate the transition probabilities, consistently with the structural interpretation given to the underlying transition between agent types, is in line with the one adopted by Alvarez et al. (2002), who – in absence of direct evidence on the degree of endogenous segmentation in asset markets – parameterize a numerical example of their framework so that the liquidity effects of money injections on the consumption of active agents is consistent with the empirical evidence. Alternative calibration strategies should be used if the structural interpretation of the underlying transition between agent types were different, as discussed in Section 1 in the paper. For instance, in a model where such transition is related to the employment status, as in McKay et al. (2015), calibrating the probability to switch into the active type (ϱ) should rely on empirical evidence about the

[49] In the case with no inefficient supply shocks, for example, equation (19) in the paper shows that the flexible-price equilibrium level of financial wealth fluctuates less, for given productivity shocks, the more persistent are the latter.

flows in the labor market. In this respect, Hall (2006) and Hobijn and Sahin (2007) provide evidence that the monthly transition rate from unemployment to employment in the U.S. labor market is about 28%, which corresponds to $\varrho = 0.627$ in quarterly terms, and implies $\xi = 0.157$. In this case the implications of the model are robust to this interpretation, as they would not differ substantially from those discussed in the paper. On the contrary, a life-cycle interpretation of the transition underlying the DAMP model would imply a substantially different calibration for the key probabilities, at quarterly frequency. Gourinchas and Parker (2002) provide evidence that consumers self-impose a borrowing constraint until the age of about 40 years, while they behave consistently with the permanent-income hypothesis thereafter. Calibrating the DAMP model to match the duration of these two stages in the life cycle would require $\varrho = 0.017$ and $\xi = 0.004$, thus making – not surprisingly – both the implied financial-wealth effect on aggregate consumption and the relevance of financial stability for monetary policy effectively negligible.