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Disinflation costs in China and monetary policy regimes☆

Maria Ferrara *, Antonio Garofalo, Massimiliano Agovino

Department of Economic and Legal Studies, University of Naples Parthenope, Italy

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ABSTRACT

This paper investigates the real effects of a disinflationary policy in China, in which we conduct a disinflation experiment in a medium-scale New Keynesian model. We highlight two key features of China's economy: the relevance of money to monetary policy rules and household inequality. For the former, we consider two monetary policy regimes: an expanded Taylor rule with money and a money supply rule. For the latter, we take into account a share of the population that is limited in its ability to participate in assets markets. Our analysis suggests that a disinflation policy is more costly when the central bank controls the money supply than the case in which the nominal interest rate is the policy instrument. Our results are driven by the different impacts of disinflation on nominal and real interest rates under the two regimes.

1. Introduction

The Chinese economy has been characterized by a boom-bust inflation cycle (Brandt and Zhu, 2000) until the late 1970s, when China started the transition process from a centrally planned economy to a market-oriented one. Since then, several disinflation periods have occurred,[1] triggering growing interest in the real effects of disinflation in the literature on China's economy (see Narayan et al., 2009; Guerineau and Guillamont Jeanneney, 2005; Zhang and Clovis, 2010).

The empirical literature on disinflation consistently argues that it entails output losses. One of the most widely used indicators to measure disinflation costs is the sacrifice ratio (SR hereafter), defined as the cumulative percentage output loss the economy must sacrifice to obtain a 1% reduction in the inflation rate. Estimates of SRs fall within a large range of values according to the historical periods, estimation techniques, and countries considered (Ascari and Ropele, 2013). For the US economy, Gordon and King (1982) find that SR values range from 0 to 8, while Mankiw (1999) estimates a SR of 2.8 during the Volcker disinflation period. Relying on an analysis of single disinflation episodes, Ball (1994) estimates SRs between 1.8 and 3.3 for 19 moderate-inflation OECD countries during the period 1960–1991. Andersen and Wascher (1999) report SRs for 19 industrialized countries ranging from 1.5 to 2.5. For a large group of "inflation-targeting" countries, Corbo et al. (2001) estimate a SR of 0.6. Cuñado and Gracia (2003) estimate SRs between 0.6 and 2 for European countries during the period 1960–2001. Zhang (2005) reports a number of measures of SRs with long-lived effects in G-7 countries over the period 1960–1999.

While there is a large literature on disinflation costs relative to the US and other advanced economies, this is not the case for transitional countries and, in particular, China. Neither empirical evidence nor theoretical models are available for the real costs of disinflation in China.[2] This is a crucial shortage, given that China is the second largest economy in the world. We aim to fill this gap in the literature.

Over recent decades, a flourishing literature on the Chinese economy has developed New Keynesian dynamic stochastic general equilibrium (DSGE) models, which are widely used in the study of advanced economies, to conduct monetary policy analyses (Li and Liu, 2017). Chow (2002) and Scheibe and Vines (2005) argue that studying the Chinese economy using a DSGE framework is particularly appropriate, given that China's economy has become notably marketised since the

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* Corresponding author.
E-mail addresses: ferraramaria11@gmail.com (M. Ferrara), maria.ferrara1@uniparthenope.it (M. Ferrara), antonio.garofalo@uniparthenope.it (A. Garofalo), agovino.massimo@uniparthenope.it (M. Agovino).

[1] World Bank Data:https://data.worldbank.org; last access May 11, 2020.

[2] As far as we know, only Shu and Huang (2006), using the methodology introduced by Ball (1994), estimate an average SR for China equal to 2.

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late 1970s. Within a DSGE setup, monetary policy behavior is usually represented by a Taylor-type interest rate rule (or price rule) or by a money supply rule (or quantity rule). In terms of theoretical models, there is no consensus regarding which kind of policy rule seems to be more suitable to characterize Chinese monetary policy. Several authors argue that the price rule is preferable, since the money supply seems to be more difficult to target in China (Zhang, 2009; Xu and Chen, 2009; Xi and He, 2010), while others use the quantity rule (Li and Meng, 2006). Another strand of the literature considers a hybrid policy rule that incorporates both policy instruments (Liu, 2008; Liu and Zhang, 2010).[3] In this debate, Li and Liu (2017) contribute fine-tuned Bayesian techniques to estimate three types of monetary policy rules: a conventional interest rate rule, a money supply rule, and an expanded Taylor rule with money. They show that money plays a crucial role in Chinese monetary policy. In particular, while a conventional Taylor-type rule is not suitable for characterizing monetary policy behavior, an expanded Taylor rule with money has been shown to yield the best empirical fit of the DSGE model to the data.

Based on the above, this paper investigates the real effects of a disinflationary policy by computing a model-consistent SR for the Chinese economy. In this setup, we compare the disinflation costs produced according to the two rules that, following Li and Liu (2017), are more suitable to denote monetary authority behavior in China: a money supply rule and an expanded Taylor rule with money. For this purpose, we design a disinflation experiment for China's economy in a medium-scale New Keynesian DSGE model.

Our paper is akin to the work of Ascari and Ropele (2012, 2013), who investigate the costs of disinflation for the US economy in a standard DSGE model and compare different monetary policy rules. We depart from these studies not only because we consider the largest transition economy in the world, but also, and importantly, because we add limited asset market participation (LAMP hereafter) to the model. Accordingly, there are two distinct household types that differ in their ability to participate in asset markets (Coenen et al., 2008b, 2008a), with consequent consumption and income inequalities.[4] This assumption turns out to be an important feature of the Chinese economy: Only about 60% of Chinese individuals have an account in a formal financial institution, while most of the remaining population does not because of a lack of cash (Fungáčová and Weill, 2015). In addition, in the aftermath of the economic boom of the Chinese economy over the last two decades, the ensuing economic gains have not been equally spread across all people. As a consequence, income and consumption inequality have grown (Yao et al., 2004; Du et al., 2005; Qu and Zhao, 2008; Li and Yao, 2013; Li and Zhao, 2015; Han et al., 2016; Zhao et al., 2017). Therefore, households' heterogeneity represents a crucial feature that cannot be ignored in studying the real effects of monetary policy shocks. This was first emphasized by Ferrara and Tirelli (2020), who investigate the redistributive and welfare effects of disinflation in the US. To the best of our knowledge, the few DSGE models that have been set up for China incorporate the representative agent assumption, according to which all consumers participate in asset markets, save, and invest. However, this assumption seems to be at odds with the documented inequality issue in China. In addition, after a disinflationary shock, the hypothesis of differences in participation in asset markets is important. This is because constrained consumers are forced to bear most disinflation costs, since they are limited to smoothing consumption via money holdings alone. Overall, aggregate demand dynamics are not neutral to such mechanisms.

[3] This debate is critical, since institutional factors, such as the monetary policy framework, considerably impact the real effects of a disinflationary policy (Ascari and Ropele, 2013).

[4] Within the DSGE framework, this setup expands the *rule of thumb* framework, as in Galí et al. (2007) and Bilbiie (2008), who assume that constrained households cannot even hold money, but simply consume labour income each period.

In a nutshell, we aim to identify how different monetary policy regimes impact disinflation costs in China by employing a New Keynesian DSGE model (Christiano et al., 2005; Smets and Wouters, 2007) augmented by frictions in asset markets. Our study contributes, therefore, to the literature by more thoroughly examining Chinese monetary policy transmission channels.

Our results can be summarised as follows. Disinflation entails recessionary effects under both the money supply rule and the expanded Taylor rule with money. However, although under the former rule the recession is deeper and more prolonged - and therefore associated with a higher SR - under the latter disinflation costs are lower and output returns faster to the pre-shock level. Therefore, from a disinflationary policy cost perspective, the expanded Taylor rule with money is the preferable rule.

The rest of the paper is organized as follows. Section 2 describes the model, with a particular focus on monetary policy. Section 3 explains the design of our disinflation experiment. Section 4 presents the results. A robustness analysis is conducted in Section 5, and Section 6 concludes.

2. The model

We employ an extended version of the medium-scale New Keynesian DSGE model developed in Christiano et al. (2005) and Schmitt–Grohé and Uribe (2005), (henceforth CEE and SGU, respectively). It features both nominal price and wage rigidities and real frictions such as internal habits in consumption, monopolistic competition in goods and labour markets, adjustment costs in investment decisions and variable capacity utilization. In examining Chinese economy where only 66% of population have an account in a formal financial institutions (Fungáčová and Weill, 2015), we abandon the representative household assumption and assume a limited participation to asset markets (LAMP) (Coenen et al., 2008b, 2008a). Therefore, the model includes two types of households: optimizing (Ricardian) households (o), who have access to financial markets and accumulate physical capital, smoothing their consumption over time; and non ricardian constrained (c) households that do not have access to asset markets, they cannot save nor invest and are allowed to make consumption smoothing only holding money. Importantly, in this model money enters twice: households directly derive utility from money holdings (money in the utility function assumption MIU)[5] and firms demand money to pay wage bill before production (working capital assumption).[6] In this section we provide an overview of the model with a particular focus on households behavior and monetary policy[7]

2.1. Households

There is a continuum of households indexed by i, $i \in [0,1]$. Non ricardian (c) and Ricardian or optimizing (o) households are respectively defined over the intervals $[0,\Omega]$ and $[\Omega,1]$. All households share the same utility function:

$$U_t^i = E_t \sum_{t=0}^{\infty} \beta^t \left\{ \ln\left(c_t^i - bc_{t-1}^i\right) - \frac{\phi_1}{(1+\phi)} \left(h_t^{s,i}\right)^{(1+\phi)} + \log(m_t^{h,i}) \right\} \quad (1)$$

where E_t is the expectation operator, β^t is the subjective discount factor, and b denotes the internal habits parameter. Households utility is defined over per capita consumption c_t^i, labor h_t^i and money holdings $m^{h,i}$.

[5] Sidrauski (1967) introduced MIU assumption into the neoclassical growth model.

[6] Christiano et al. (2005).

[7] Details about model solution and steady state computations are available upon request.

2.2. Ricardian households

Optimizing forward-looking households participate in financial markets where purchase nominal state-contingent assets x_{t+1} in period $t+1$ at the cost $E_t r_{t,t+1} x_{t+1}$, accumulate physical capital K_t^o and rent it out to firms at the real interest rate r_t^k and hold money for transaction purposes. In addition, they control for the intensity of capital utilization u_t.[8]

Therefore, in their optimal choices process, Ricardian households face the following period-by-period real budget constraint:

$$E_t r_{t,t+1} x_{t+1} + c_t^o + i_t^o + m_t^{h,o} == \frac{x_t}{\pi_t} + \left[r_t^k u_t - a\left(u_t\right)\right] K_t^o + h_t^d \int_0^1 w_t^j \left(\frac{w_t^j}{w_t}\right)^{-\eta_w} dj + d_t^o + d_t^{WH} + m_{t-1}^{h,o} \tag{2}$$

Real purchases investment goods at time t are denoted by i_t^o. Ricardian households also receive firms dividends, d_t^o, and returns from financing the working capital of firms, d_t^{WH}. The gross rate of inflation is $\pi_t \equiv \frac{P_t}{P_{t-1}}$.

The capital stock evolves according to the following law of motion:

$$K_{t+1}^o = (1-\delta) K_t^o + i_t^o \left[1 - S\left(\frac{i_t^o}{i_{t-1}^o}\right)\right] \tag{3}$$

where δ is the deprecion rate of capital. The function S introduces the adjustment costs on investment and satisfies the following properties: $S(1) = S'(1) = 0$, $S''(1) > 0$.

The Ricardian household's first order conditions with respect to c_t^o, x_{t+1}, K_t^o, i_t^o, $m_t^{h,o}$ and u_t are, in order:

$$\frac{1}{c_t^o - b c_{t-1}^o} - \frac{b\beta}{c_{t+1}^o - b c_t^o} = \lambda_t^o \tag{4}$$

$$\lambda_t^o = \beta R_{t,t+1} \frac{\lambda_{t+1}^o}{\pi_{t+1}} \tag{5}$$

$$q_t = \beta E_t \frac{\lambda_{t+1}^o}{\lambda_t^o} \left[r_{t+1}^k u_{t+1} - a\left(u_{t+1}\right) + q_{t+1}(1-\delta)\right] \tag{6}$$

$$\lambda_t^o = q_t \lambda_t^o \left[1 - S\left(\frac{i_t^o}{i_{t-1}^o}\right) - \left[S_i\left(\frac{i_t^o}{i_{t-1}^o}\right)\right] i_t^o\right] +$$

$$-\beta q_{t+1} \lambda_{t+1}^o S_i\left(\frac{i_{t+1}^o}{i_t^o}\right) i_{t+1}^o \tag{7}$$

$$\lambda_t^o = \beta \frac{\lambda_{t+1}^o}{\pi_{t+1}} + m_t^{h,o(-1)} \tag{8}$$

$$a_u\left(u_t\right) = r_t^k \tag{9}$$

2.3. Constrained households

As emphasized above, constrained households cannot access to financial markets, and can intertemporally smooth consumption only by their money holdings. Therefore they face the following real budget constraint:

$$c_t^c + m_t^{h,c} = w_t h_t^d + m_{t-1}^{h,c} \tag{10}$$

The first order conditions for non Ricardian households are the following:

$$\frac{1}{c_t^c - b c_{t-1}^c} - \frac{b\beta}{c_{t+1}^c - b c_t^c} = \lambda_t^c \tag{11}$$

$$\lambda_t^c = \beta \frac{\lambda_{t+1}^c}{\pi_{t+1}} + m_t^{h,c(-1)} \tag{12}$$

[8] The cost of capital depends upon the degree of utilization $a(u_t)$ defined as $a(u_t) = \gamma_1(u_t - 1) + \frac{\gamma_2}{2}(u_t - 1)^2$. Following CEE, the function satisfies $a(1) = 0$ and $a'(1), a''(1) > 0$

2.4. Wage setting

Nominal rigidities for wages are modeled following Calvo (1983). In each period a representative union faces a constant probability $(1-\alpha_w)$ of being able to reoptimize wages, where α_w denotes the wage stickiness parameter. Non reoptimizing unions index the wage to a geometric average of past inflation and steady-state inflation according to the following rule:

$$W_t^j = W_{t-1}^j \left(\frac{P_{t-1}}{P_{t-2}}\right)^{\chi_w} \pi^{(1-\chi_w)} = W_{t-1}^j \pi_{t-1}^{\chi_w} \pi^{(1-\chi_w)} \tag{13}$$

where the parameter $\chi_w \in [0,1]$ is the indexation parameter.

While choose optimal wage w_t^*,unions must take into account that they might not be able to do the same after s periods. In that case, real wage at the generic period $t+s$ reads as:

$$w_{t+s} = w_t^* \prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}} \tag{14}$$

2.5. Intermediate firms

Intermediate firms compete monopolistically by producing good z according to the following standard technology:

$$y_t(z) = A_t (K_{t-1}(z))^{\vartheta} (h_t(z))^{(1-\vartheta)} \tag{15}$$

where A_t denotes the standard Total Factor Productivity (TFP) shock and its growth rate evolves according to the following law:

$$g_t = \left(1 - \rho_g\right)\gamma + \rho_g g_{t-1} + \varepsilon_t^g$$

where γ represents the growth rate of A_t along the balanced growth path; $\rho_g \in (0,1)$ is the persistence parameter and $\varepsilon_t^g \backsim i.i.d.N(0, \sigma_g^2)$

As it is standard in the literature, we normalize the steady state value of technology $A = 1$. $K_t(z)$ is the physical capital stock that firms rent by Ricardian households and $h_t(z)$ is the labor input used by each firm z. In particular it is defined as:

$$h_t(z) = \left(\int_0^1 \left(h_t^j(z)\right)^{\frac{\eta_w - 1}{\eta_w}} dj\right)^{\frac{\eta_w}{\eta_w - 1}} \tag{16}$$

Firms must pay the wage bill in advance of the production. In other words they are subject to a cash in advance constraint (CIA, hereafter) of the form:

$$m_{zt}^f \geq \nu w_t h_{zt} \tag{17}$$

where m_{zt}^f denotes money demand by firm z and ν is the fraction of wage bill that must be returned by means of monetary assets. This is the money demand by firms that represents a crucial channel in determining both the interest rate and the quantity of money in equilibrium. The wage is lent by Ricardian households which at the end of the period receive back money at the gross nominal interest rate R_t. Therefore the marginal costs the firms have to face reads as:

$$mc_t = \left(\frac{r_t^k}{\vartheta}\right)^{\vartheta} w_t \left[1 + \nu\left(1 - \frac{1}{R_t}\right)\right] \tag{18}$$

2.6. Price setting

As for wages, we set prices according to the Calvo (1983) framework. In particular, in each period a firm faces a constant probability $(1-\alpha)$ of being able to re-optimize prices. Following Smets and Wouters (2007) non re-optimizing firms index their price to a geometric average of past inflation and steady-state inflation:

$$P_t(z) = P_{t-1}(z)\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\chi}\pi^{(1-\chi)} = P_{t-1}(z)\,\pi_{t-1}^{\chi}\pi^{(1-\chi)}. \quad (19)$$

The optimal price is chosen in order to maximize the discounted value of expected future profits. Moreover, notice that only Ricardian households own firms.

2.7. Aggregation and markets clearing

Aggregating in the goods market, we obtain the aggregate production function:

$$y_t^s = A_t K_t^{\vartheta} h_t^{d(1-\vartheta)}$$

where it is assumed that per capita capital and labor demands are aggregated linearly, i.e. $\int_0^1 K_t(z)\,dz = K_t$ and $\int_0^1 h_t^d(z)\,dz = h_t^d$,

and the aggregate absorption:

$$y_t^d = (c_t + i_i)\,s_t \quad (20)$$

where the following respectively denote aggregate consumption, aggregate capital and aggregate investment

$$c_t = \Omega c_t^c + (1-\Omega)\,c_t^o \quad (21)$$

$$K_t = (1-\Omega)\,K_t^o \quad (22)$$

$$i_t = (1-\Omega)\,i_t^o \quad (23)$$

Aggregate supply of hours and money holdings by households are denoted by

$$h_t^s = \Omega h_t^{s,c} + (1-\Omega)\,h_t^{s,o} \quad (24)$$

and

$$m_t^h = \Omega m_t^{h,c} + (1-\Omega)\,m_t^{h,o} \quad (25)$$

Equilibrium conditions in goods and labor markets read as:

$$y_t^s = s_t y_t^d \quad (26)$$

and

$$h_t^s = \widetilde{s}_t h_t^d \quad (27)$$

where s_t and $\widetilde{s}_t$ respectively denote the price and wage dispersions in the Calvo (1983) mechanism.

Equilibrium in money market reads as:

$$m_t = m_t^h + m_t^f$$

determining the growth rate of nominal money as follows:

$$\omega_t = \frac{m_t}{m_{t-1}}$$

2.8. Monetary policy

In this section we assume two alternative frameworks according to which the PBC implements the monetary policy: an expanded interest rate rule (EIRR, hereafter) and a money supply rule (MSR, henceforth).

2.8.1. Expanded interest rate rule (EIRR)

The Expanded Interest Rate Rule (EIRR) reads as follows:

$$\frac{R_t}{\overline{R}} = \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_\rho}\left[\left(\frac{\pi_t}{\overline{\pi}}\right)^{\phi_\pi}\left(\frac{y_t/y_{t-1}}{e^{\gamma}}\right)^{\phi_y}\left(\frac{\omega_t}{\overline{\omega}}\right)^{\phi_\omega}\right]^{(1-\rho_\rho)} \quad (28)$$

It says that the nominal interest rate reacts to its past value, inflation, output growth rate gap and money growth gap. $\overline{R}$, $\overline{\pi}$ and $\overline{\omega}$ respectively denote the steady state value of nominal interest rate, inflation and money growth rate; while the parameters ϕ_π, ϕ_y and ϕ_ω capture the monetary policy behavior, namely how much the central bank is concerned with each of the targets; ρ_ρ represents the inertia of the interest rate. e^{γ} is the trend growth rate of output and it is equal to the steady state detrended output growth times A_t (Li and Liu, 2017). With respect to the classical Taylor rule, the expanded Taylor rule allows the central bank to target both interest rate and money. In other terms, they are determined at the same time by money demand and monetary policy. This is a "combination policy rule" of the two targets, as it is stressed in Poole (1970).

We follow Li and Liu (2017) and consider the output growth rate in the policy rule. In fact, the output growth rate has denoted one of the most important concerns of the Chinese economy in the last decades. Moreover, it might be difficult to refer to the potential output in a transition economy. However, as we show in the next section, our results qualitatevely hold even when the interest rate responds to the output gap.

In analyzing the Chinese monetary authority we have also to consider that, differently from the advanced economies where the central banks primarily target the goal of lowering inflation, the PBC tries to realize further various ultimate objectives. They are price stability, employment, economic growth and equilibrium in the balance of payments.

2.8.2. Money supply rule (MSR)

Following Sargent and Surico (2011) the central bank controls the growth rate of nominal money supply according to the following rule:

$$\frac{\omega_t}{\overline{\omega}} = \left(\frac{\omega_{t-1}}{\overline{\omega}}\right)^{\rho_\omega}\left[\left(\frac{\pi_t}{\overline{\pi}}\right)^{\phi_\pi}\left(\frac{y_t/y_{t-1}}{e^{\gamma}}\right)^{\phi_y}\right]^{(1-\rho_\omega)} \quad (29)$$

The growth rate of money reacts to its past value, to inflation and to output growth rate gap. ρ_ω is the smoothing parameter of money growth, while ϕ_π and ϕ_y denote the elasticities of the monetary policy target with respect to inflation and output growth rate, respectively.

2.9. Fiscal policy

In this paper we develop a pure monetary macro model, since we are exclusively interested in investigating the effects of a disinflation policy. Therefore, we assume an exogenous fiscal sector. Only relatively to the MSR we assume that seignorage revenues are distributed to households through lump-sum transfers.

3. Calibration

The baseline calibration of structural parameters follows Li and Liu (2017) who estimate a DSGE model for Chinese economy. As stated above, by means of Bayesian techniques, they identify the two monetary policy rules as more suitable to explain the main features of China's economy, namely the expanded Taylor rule with money and the money rule. Accordingly, Table 1 reports the parameters values.

Parameters pertaining to the share of RT consumers deserve, in this context, particular attention. Available estimates for advanced economies range between 0 and 50% of total population. In particular, Iacoviello and Pavan (2013) show that 40% of US households hold no wealth and no debt. Cowell et al. (2013) obtain similar results for

Table 1
Parameters values.

Parameter	Value		Description
	MP rule	MQ rule	
Households			
β	0.99	0.99	Subjective discount factor
b	0.3604	0.5284	Degree of habit persistence
ϕ	0.4242	0.8111	Inverse of intertemporal substitution of labor
ϕ_1	6.06	10.42	Disutility of work[a]
η_w	10	10	Wage elasticity of labor demand
Ω	0.4	0.4	Share of Rule of Thumb consumers[b]
α_w	0.6	0.6	Calvo wage
χ_w	0.6	0.6	Wage indexation
Firms			
ϑ	0.4	0.4	Share of capital in value added
δ	0.035	0.035	Depreciation rate of capital
η	10	10	Price elasticity of good demand
α	0.9165	0.9659	Calvo price
χ	0.6143	0.6143	Price indexation
ν	0.15	0.15	Cash in advance (CIA)
Monetary Policy			
ϕ_π	1.9320	−0.0063	Inflation response
ϕ_y	3.5595	−0.0237	Output growth rate gap response
ϕ_ω	6.3942	–	Money growth rate gap response
ρ_R	0.4429	0.1765	Interest rate/Money persistence

[a] The disutility of work parameter is computed to satisfy steady state hours equal to 0.25.
[b] Campbell and Mankiw (1989).

the Euro area. Overall, a conservative parametrization in the literature ranges between 30% and 40% of total population. As for Chinese economy, World Bank Data report that the poverty headcount ratio at $ 5.50 a day in the last ten years is on average 40%.[9] Moreover, Fungáčová and Weill (2015), using the World Bank's Global Findex Database investigate the financial inclusion in China and find that the 66% of Chinese individuals have an account in a formal financial institutions, while most of the remaining population explains that has not a formal account because of lack of cash. We take into account of that to calibrate the share of liquidity constrained consumers at 40% of total population. Next, in the robustness section we carry out a robustness analysis on different shares of constrained households within the range provided by the literature (0.3–0.5). As well, a crucial parameter is the CIA parameter in the money demand by firms (eq. (17)). For the baseline calibration we follow Rabanal (2007) but we also do some robustness checks with full CIA.

4. The disinflation costs in China

In this section we show the short-run effects of disinflation in New Keynesian DSGE model with liquidity constrained households for the Chinese economy. We first focus on technical considerations and then we report the results.

4.1. Technical considerations

The disinflation policy shock we are dealing with is an unanticipated permanent decrease in the inflation rate. A permanent shock entails a transition from one steady state to another. In this context, we simulate the perfect foresight transition paths of the endogenous variables numerically solving the non linear model (see Ascari; Ropele, 2012)[10] in Dynare.[11]

The permanent shock in the inflation rate occurres as follows. Before the implementation of the disinflation policy, the economy is at a steady state characterized by a positive trend inflation, denoted by $\pi_1^* > 0$. At time 0, we assume that the PBC aims to disinflate the economy, unexpectedly and instantaneously, from π_1^* to π_2^*, and no other policy change is expected. As concerns the first steady state, we consider the highest value of the annual inflation rate in China over the sample period 1996–2015 in Li and Liu (2017), namely 8%; while the second steady state denotes on average the inflation level in the last five years,[12] namely 2%. The theoretical SR reads as:

$$SR_y = -\frac{1}{\pi_1^* - \pi_2^*} \sum_{t=0}^{T} \left(\frac{y_t - y_1}{y_1} \right) \tag{30}$$

where π_1^* and π_2^* respectively denote the initial and final steady state inflation, y_1 is the level of output associated with the initial steady state inflation and y_t represents the current output. Equation (30) defines the SR, namely the cumulative output loss in deviation from the initial steady state inflation. T denotes the number of quarters in which the output is below its initial steady state level. Therefore, the SR is computed over the period the economy takes to recover.

4.2. Aggregate output costs

In this section we investigate how much costly is disinflation for Chinese economy. Table 2 reports SRs and output bottom values. For each percentage point of permanent reduction in inflation, the Chinese economy has to sacrifice 2.08 percentage points of output under the EIRR regime and 3.25 percentage points of output under the MSR regime.

In order to figure out such different SRs under the two policy regimes, Fig. 1 displays the transition paths of inflation, output and aggregate consumption. Under both policy rules, disinflation is sizably costly in terms of aggregate consumption and output. In fact, as soon

[9] World Bank Data:https://data.worldbank.org; last access March 1, 2019.
[10] Moreover, Ascari and Merkl (2009) show that the use of standard log-linear approximation to study disinflation may imply misleading results.
[11] For further details see the webpage http://www.dynare.org/.
[12] World Bank Data; https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?locations = CN; last access on January,16th.

Table 2
SRs and output bottom values.[a]

EIRR (T = 29)		MSR (T = 54)	
SR	Output Bottom	*SR*	Output Bottom
2.08	−0.99	3.25	−0.93

[a] Values are expressed in percentage deviation from the initial steady state.

as the disinflationary policy is implemented, only a fraction $(1-\alpha)$ of firms is able to lower price, once they are aware that the inflation rate is dropping and that output necessarily has to fall down to curb inflation. The remaining α firms mechanically adjust the price to both past and trend inflation. Between the two effects, the former prevails on the latter and the aggregate price index reduces. In the light of the new inflation target, the ex-ante real interest rate increases entailing a drop in consumption and investment spending. Overall, the output drops.

Albeit the transmission channels of disinflation under EIRR and MSR results to be quite similar, under the MSR, the timing that output takes to recover the initial steady state level features a greater inertia with respect to EIRR. As a matter of fact during a disinflation of six percentage points, under the EIRR output recovers in 29 quarters while under the MSR it takes 54 quarters to come back to the initial steady state. The intuition for this lies in the fact that under the two regimes the PBC uses two different policy instruments, namely the nominal interest rate under EIRR and the money growth rate under MSR. Therefore, disinflation differently impacts on nominal and real interest rates under the two regimes (Figs. 1 and 2), with unavoidable consequences on real economy. Under EIRR, the PBC immediately cuts the nominal interest rate that even undershoots its target (Fig. 1). Inflation rapidly falls down achieving the new steady state. The result is a boost in the ex-ante real interest rate (Fig. 2) that, after two quarters from the policy implementation, peaks and immediately next achieves the target. This produces a sizable impact on aggregate demand and output that achieves the bottom (−0.99) in 5 quarters before starting to recover. Under MSR, the PBC stops printing money driving gradually down inflation and nominal interest rate. As a consequence, after three quarters from the policy implementation, real interest rate peaks half as large compared to the EIRR regime and then reverts to the new steady state. This gradual impact of the disinflationary policy produces a milder but much prolonged contraction of aggregate demand. Overall, by achieving the bottom (−0.93) in 6 quarters from the policy implementation, output takes twice as more to recover the initial steady state, compared the EIRR regime. In addition, the different impact of the two regimes on nominal interest rate works also via the CIA channel. In fact, the decline of nominal interest rate reduces firms'marginal costs (eq. (18)). Under EIRR, the policy rate immediately falls down. This translates into a quick reduction of marginal costs and faster recovery phase. Under MSR, marginal costs only gradually drop entailing therefore a slower recovery phase.

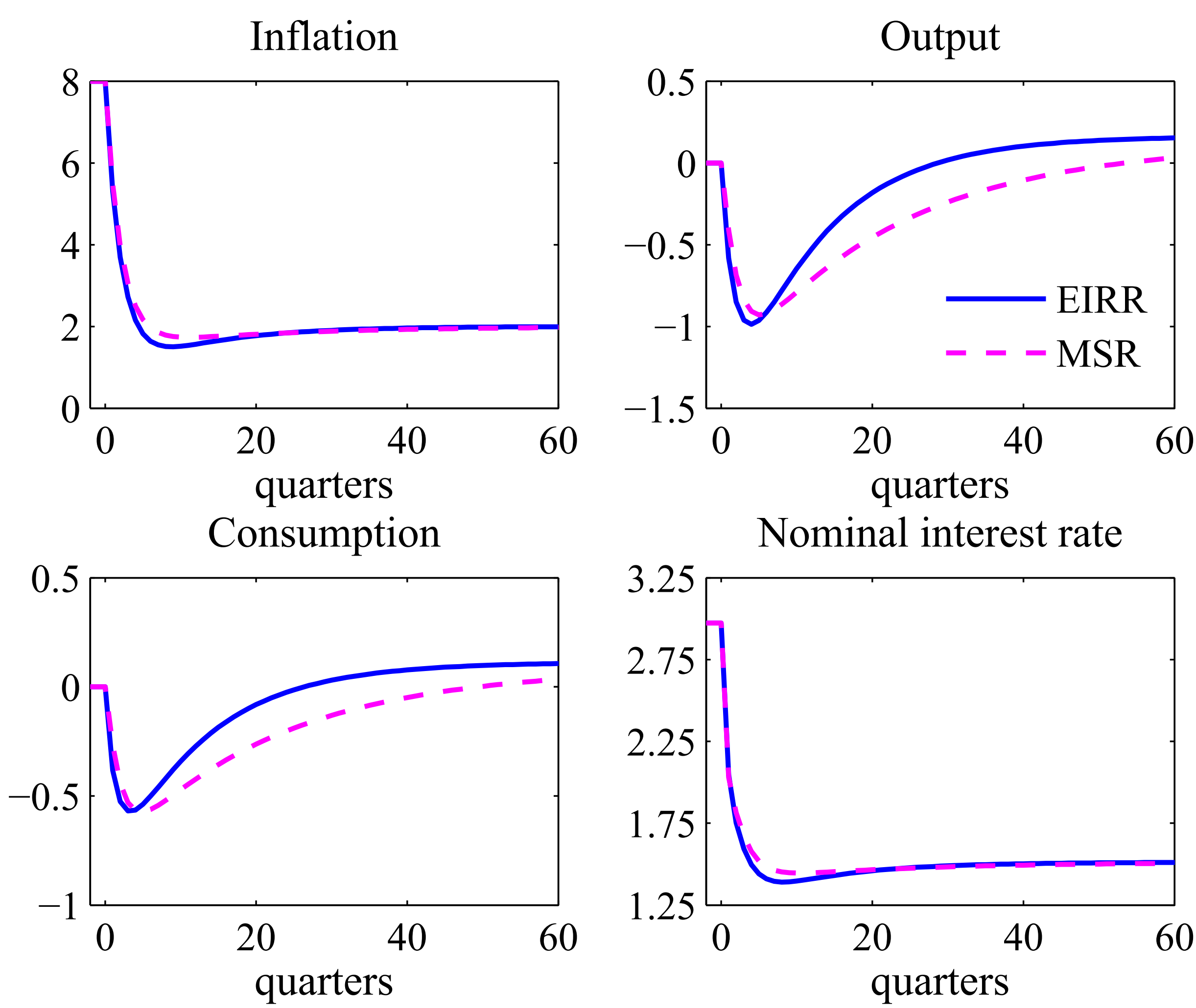

Fig. 1. Disinflation costs in China.

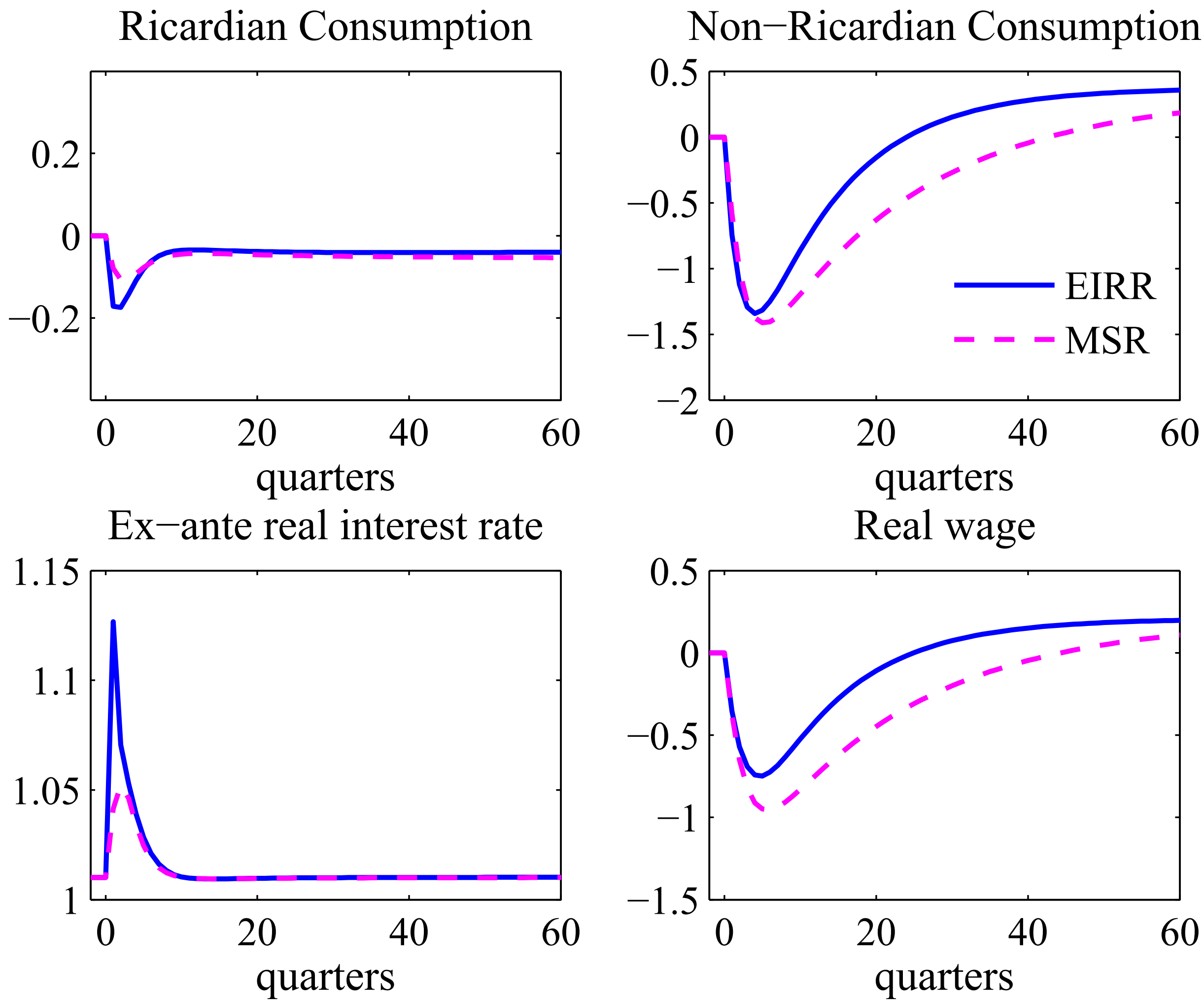

Fig. 2. Transmission channels of disinflation.

4.3. Individual consumption costs by household type

As previous section shows, disinflation entails a cost also in aggregate consumption. However, in an economy characterized by a documented households heterogeneity, as the Chinese economy actually is, we investigate the disinflationary effects on consumption of the two groups of households we consider in this economy.

Fig. 2 shows that a disinflationary process produces a drop in the consumption of both Ricardian and non Ricardian households, however the size of such a cost is notably different. Regardless of the monetary policy rule, disinflation produces an increase in the real interest rate that affects ricardian consumption via Euler equation (eq. (6)) and a reduction of real wages that pushes down the consumption of non Ricardian households via their budget constraint (eq. (10)). However Ricardian households are able to smooth their consumption thanks to their intertemporal saving/investments decisions, therefore the recessive effect on their consumption is limited. On the other hand, liquidity constrained households suffer the short-run fall of the real wage and totally bear the cost of the disinflationary policy, as they consume their entire labor income in each period. Overall, as Fig. 1 shows, aggregate consumption falls impacting aggregate demand.

Fig. 2 also shows that the transmission channels described above are importantly affected by the two monetary policy regimes under consideration. In fact, ricardian consumption falls down more under the EIRR reflecting the greater increase of the ex-ante real interest rate. Differently, consumption of liquidity constrained agents follows the wage dynamics that is more inertial under the MSR. Therefore, the different duration of the recessionary effect of the disinflation policy under the two regimes importantly impacts on the transmission mechanism of disinflation, as well.

5. Robustness

In this section we assess the robustness of our results along three distinct dimensions. First, we let the cash in advance parameter in firms' money demand to vary. Second, we consider the implications of different shares of constrained households in the economy within the range of values found in the literature. Third, we assume that in the expanded Taylor rule the PBC targets the output gap, as the widespread practice in the macroeconomic literature is.

5.1. The cash in advance parameter

As stated above, intermediate firms must pay by cash a fraction of wage at the beginning of the period. This is the case of our baseline calibration following Rabanal (2007) that estimates for the CIA parameter a posterior mean of 15%. Differently, Christiano et al. (2005) assume that wage bill is entirely paid in advance of the production. Therefore, we simulate the model considering the full CIA assumption.

Table 3 shows that our results qualitatevely hold when full CIA works. In fact, it still holds that under the MSR regime disinflating the economy is more expensive with respect to the EIRR regime because

Table 3
SRs and output bottom values.[a]

EIRR (T = 15)		MSR (T = 28)	
SR	Output Bottom	*SR*	Output Bottom
1.46	−1.13	2.71	−1.12

[a] Values are expressed in percentage deviation from the initial steady state.

Table 4
SRs and output bottom values.[a]

EIRR (T = 29)		MSR (T = 54)	
Ω = 0.3			
SR	Output Bottom	*SR*	Output Bottom
2.25	−1.03	3.42	−0.96
Ω = 0.4			
SR	Output Bottom	*SR*	Output Bottom
2.08	−0.99	3.25	−0.93
Ω = 0.5			
SR	Output Bottom	*SR*	Output Bottom
1.93	−0.95	3.09	−0.89

[a] Values are expressed in percentage deviation from the initial steady state.

output needs more time to come back to the pre-shock level. It is worth-noting that, compared to the baseline, if firms must pay by cash the entire wage bill in advance of the production, the marginal cost reduction fully reflects the decline of nominal interest rate (eq. (18)). This translates into a much faster recovery phase and into a lower SR under both regimes. Nevertheless, the recession turns out to be slighter deep since the faster reduction of inflation entails a higher increase of the real interest rate that pushes down aggregate demand.

5.2. Non ricardian households

In our analysis, we assume that a fraction of population, i.e. non ricardian households only holds money as opposed to Ricardian households who are able to smooth consumption accumulating physical capital and participating to financial markets. In our baseline calibration we assume that 40% of households do not save neither invest. In this section we simulate our model assuming a lower (30%) and higher (50%) of percentage of population that is financially constrained. Table 4 reports the SRs and the output bottom values according to three shares of non ricardian households: (30%, 40%-baseline-, 50%).

Results show that even considering lower and higher shares of financially constrained households still the disinflationary policy turns out to be more costly under the MSR regime. Importantly, we notice that under both policy rules as the quota Ω of constrained households increases the recessive effect dampens and the SR reduces. This apparently counterintuitive result is due to the aggregate consumption and investment behavior that change according to different shares of non ricardian households. In fact, the more constrained households populate the economy the more aggregate consumption falls down. This outcome, in turn, is driven by the consumption of constrained households that reduces because these households suffer the drop in real wages and in their disposable income. Differently, the higher is the quota Ω of non ricardian households, or equivalently, the lower is the quota $(1-\Omega)$ of ricardian households that solely invest in the economy, the less aggregate investment reduce. Between the two effects, namely a larger fall of consumption and a smaller reduction of investments, the latter prevails and entails a softer recessive effect and a smaller SR. In other terms, as the quota of non ricardian households increases, a reallocation from consumption to investment operates in the economy.

Table 5
SRs and output bottom values.[a]

EIRR (T = 10)		MSR (T = 46)	
SR_y	Output Bottom	SR_y	Output Bottom
0.56	−0.69	2.79	−0.91

[a] Values are expressed in percentage deviation from the initial steady state.

5.3. PBC's response to the output gap

In this subsection we assume that under both monetary policy rules under consideration the PBC targets the output gap in place of the output growth gap, following the widespread practice in the macroeconomic literature.

In this case, the EIRR monetary policy rule reads as:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_\rho} \left[\left(\frac{\pi_t}{\overline{\pi}}\right)^{\phi_\pi} \left(\frac{y_t}{y}\right)^{\phi_y} \left(\frac{\omega_t}{\overline{\omega}}\right)^{\phi_\omega}\right]^{(1-\rho_\rho)} \tag{31}$$

and the MSR rule is:

$$\frac{\omega_t}{\overline{\omega}} = \left(\frac{\omega_{t-1}}{\overline{\omega}}\right)^{\rho_\omega} \left[\left(\frac{\pi_t}{\overline{\pi}}\right)^{\phi_\pi} \left(\frac{y_t}{y}\right)^{\phi_y}\right]^{(1-\rho_\omega)} \tag{32}$$

We re-simulate the model and find out that our results are qualitatevely confirmed (Table 5). In fact, even when the PBC responds to the output gap the MSR implies a bigger SR with respect to EIRR. This outcome reaffirms the key role of money in the China monetary policy rule and that the expanded Taylor rule is to be preferred.

6. Conclusions

In this paper we investigate the costs of disinflation for Chinese economy comparing two different monetary policy rules: an expanded interest rate rule and a money supply rule. Within theoretical models, there is no consensus about which kind of policy rule seems to be more suitable to characterize the Chinese monetary policy. We contribute to such a debate computing a model consistent SR in order to provide a measure of disinflation costs in China, according to the two policy regimes examined. To this purpose, we simulate a permanent disinflation experiment in an otherwise standard DSGE model augmented with LAMP. Our calibrated model suggests that from a policy cost perspective, the expanded Taylor rule with money is the most favoured rule, being associated to a lower SR. In fact, under the money supply rule the economy takes 54 quarters (relative to 29 quarters for the expanded interest rate rule) to come back to the initial steady state after a disinflation of 6 percentage points. Therefore, the monetary policy regime significantly impacts the SR and the dynamics of the model during the transition phase from the old to the new inflation target.

Given the deterministic nature of our experiment, where it is assumed full information, perfect foresights and no uncertainty around the shock, in this model we do not take into account that the Chinese monetary policy is asymmetric (Chen, 2018). We acknowledge this shortcoming with the intention of introduce in future research this important feature of Chinese monetary policy considering a standard stochastic monetary policy shock.

In addition, our model takes into account the documented households inequality in China. In this regard, our results emphasize the effects of how, during a disinflationary policy, households differ in terms of their ability to smooth consumption over time. Beyond the LAMP assumption, other financial frictions should be exploited for Chinese economy, since they cause an 8.3% of aggregate TFP loss (Wu, 2018). We leave this for future research, as well.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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