Whither monetary policy when decentralized finance prevails?

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Abstract

The emergence of a decentralized peer-to-peer platform that matches lending and borrowing without collateral requirement has called the bank lending and balance-sheet channels for monetary transmission into question. “Is monetary policy still relevant when decentralized platform finance prevails?” is precisely the main question this paper addresses via a standard New Keynesian macroeconomic model that incorporates two-sided P2P platform and group identity. We find three repeatedly rhymed choruses irrespective of the sources of disturbance, and regardless whether monetary policy is actively pursued or passively reacts: monetary policy largely keeps its ability to control inflation and the real economy, macro and financial stability are disrupted as they become more volatile, and decentralized platform finance is a mirror image of the conventional bank finance.

Keywords: P2P lending; Two-sided platform; Monetary transmission

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1. Introduction

Although today's payment system is already by and large electronic, it is still centralized and bank-based. Private non-financial sector can only gain access to the liquidity by holding claims against or by the financial institutions. Against this backdrop, the recent financial technology development seems capable to unprecedentedly reshape our conventional understanding about money. With the use of a ledger distributed across agents with no central entity, for instance, a decentralized digital currency can be created to facilitate transactions. By being so, it defies the role of monetary authority in monetary control. This explains why the profession has paid nearly all the attention to the question if decentralized digital currency compromises the ability of central bank to control money supply and hence the economy (see, for instance, Bordo and Levin, 2017; Heller, 2017; Camera, 2017; Raskin and Yermack, 2016; Fernandez-Villarverde and Sanches, 2016;). Proposal that central bank should seriously contemplate to issue its own digital currency even starts to gain momentum (Barrdear and Kumhof, 2016; Fung and Halaburda, 2016).

Nonetheless, financial technology disrupts not only the payment system and currency issuance but also access to credits. Private non-financial companies already participate in internet finance based on data gleaned from electronic transaction platform or a user's social network history (see, for instance, Atz and Bholat, 2016). Peer-to-peer (P2P) lending platforms are exactly decentralized markets for debt finance through which lenders and borrowers match and trade directly. Borrowers submit loan request attached with information about their current financial situation. Based on this information on top of credit scores and peer reviews, lenders can offer a loan with an interest rate. In this sense, every successful platform transaction generates a pair of loan and deposit.

What makes P2P finance fascinating is the absence of intermediation and collateral guarantees. Without a bank-based intermediation, bank lending channel as according to Bernanke and Blinder (1988) becomes obsolete. As an individual lender has no claims against central bank, policy rate would have no leverage on interest rate the individual is willing to offer via the platform. Hence, monetary policy won’t be able to influence deposit rate and hence aggregate supply of loans. Likewise, without collateral requirement, the agency cost of lending is decoupled from monetary policy. Net worth of borrowers becomes an irrelevant factor in loan formation. Balance sheet channel of monetary policy in the fashion of Bernanke, Gertler, and Gilchrist (1996) turns trivial. Of main concern is if financial frictions magnify the effects of monetary policy, does it follow that frictionless financial transaction implies the impotence of monetary policy?

The focus of our paper is precisely the assessment of the impact on monetary policy effectiveness and transmission when P2P finance becomes common. We form our arguments via a standard New Keynesian model by incorporating a two-sided P2P platform a-la Amstrong (2006), and Rochet and

Tirole (2003) that matches lenders and borrowers, and identity in utility function in the spirit of Benjamin, Choi, and Strickland (2010) and Akerlof and Kranton (2000) to bring in the role of trust on peers reviews in the formation of P2P loans. Built on Eng and Wong (2016), and also Wong and Eng (2015), in this paper we require households to secure loans in advance of the investment undertaking either from bank or P2P loans. What makes the later different from the former is that access to bank loans is subject to borrowers' creditworthiness fed into bank lending-deposit rates spread.

A main result is that monetary policy is still effective in shaping inflation, bank rates, and aggregate demand even when P2P loans become equally important as bank loans to investment financing. Note that this is despite our modeling feature that monetary policy has no direct control in the platform interest rate determination and loans-deposits formation, but only indirectly through its association with the real economy. However, magnitude of monetary spillovers has been amplified. Value and size of business investment, and hence demand for bank loans, for instance, exhibit larger variation.

Beside this, we find that monetary policy affects P2P finance via its impact on conventional bank activities. An uptick in policy rate that raises bank loans rate and tightens up creditworthiness, for instance, places the drop in loan demand mostly on bank's shoulder. Investment financing requirement has then been channeled to P2P loans, creating greater formation of P2P deposit. If the density of platform participation is inelastic to fees charged, rising P2P loans and deposits density actually implies higher per-agent fees incurred, prompting P2P loan and deposit rates to fall.

This is an interesting observation in consistent with Bertsch et al.'s (2016) empirical finding, though for different reasons, that a liftoff in federal funds rate has driven average loan interest rates in P2P lending market downward. Our finding, though with different modeling approach, is also consistent with Faia and Paiella (2017), where an increase in the risk of bank run in the traditional banking sector increases P2P platform participation and reduces their rates. That monetary policy can influence only indirectly the dynamics of platform finance via its association with the real economy and conventional banking sector interestingly corroborates the internet finance development in China that hosts the fastest growing decentralized finance in the world (Guo,Kong, and Wang, 2016).

We also examine whether P2P finance has altered the way the economy responds to a variety of disturbances, given the identical monetary policy reaction. We find the same chorus as when monetary policy is actively pursued: transmissions of shocks are largely alike when conventional bank loan is the only option and when P2P loans are proportionally important, but both macroeconomic and financial conditions become more volatile, and sometimes with opposite instantaneous responses especially if the disturbance originates in value of investment.

There is a growing literature on this kind of decentralized platform finance with particular attention paid to the role of signals and the extent of asymmetric information in P2P loans formation (see, for instance, Freedman and Jin, 2011, 2017; Bertsch et al., 2016; Iyer et al., 2016; Duarte et al., 2012). Closer to us Faia and Paiella (2017) that work out a general equilibrium dynamic model with borrowers and lenders who can turn either to the conventional or P2P finance to understand the link between information and platform interest rates. In this respect, our paper has been among the first that explores the macroeconomic impact of decentralized digital finance via a standard general equilibrium dynamic model enriched with bells and whistles loaned from industrial economics and identity economics. By doing so, our paper not only contributes to broaden the literature on decentralized digital finance, but is related also to the literature examining two-sided markets (see, for instance, Rochet and Tirole, 2006) and the application of identity economics (Epstein and Heizler, 2015; Georgiadis and Manning, 2013; Akerlof and Kranton, 2010).

The remaining discussion is organized in the following layout. We detail our model construction in Section 2 with more ink poured on how interest rates and loans are formed via the two-sided P2P platform. The model is then parameterized in Section 3. “Whiter monetary policy?” becomes the main theme of result discussion in Section 4. Last section concludes.

2. When two-sided platform meets collateral constraint in A NK model

To address the question whether the presence of decentralized P2P lending and borrowing meaningfully compromises the ability of central bank to keep hold of the economy hit by exogenous shocks, and reshapes the monetary spillovers, we make use of a canonical new Keynesian model as expounded for instance in Gali (2015). We expand the model to incorporate a dynamic investment function with Tobin's q, which takes into account the need to acquire loans prior to carrying out investment project, $I_t \leq L_{t-1}/P_t$. There are two external financing options available: conventional bank or P2P loans, $L_t \equiv L_t^B + L_t^{P2P}$.

Two characteristics in the model distinguish the latter from the former. Unlike conventional bank loans that require collateral to mitigate asymmetric information, no collateral is required in the P2P platform. The asymmetric information problem is moderated via credit scoring and publicly available reviews on the past records. A larger pool of transactions with more reviews makes borrowers' creditworthiness more visibly transparent. Without collateral, borrowers' borrowing capacity is eased. At the same time, the worry of pecuniary externalities, in which individual borrower's failure to take into account the adverse externality of individual borrowing on aggregate borrowings can lead to overborrowing (see, for instance, Korinek and Mendoza, 2014), disappears as overall creditworthiness is no longer directly linked to debt-to-collateral ratio. On the flipside, this implies the irrelevance of debt-to-collateral ratio as alarming device.

Which brings us to the second characteristics: the platform lending and deposit rates are disconnected to policy rate. In a canonical monetary model with banks, policy rate sets the tune for bank deposit rate, which in turn transmits to bank lending rate subject to overall borrowers' creditworthiness and bank leverage ratio that shapes the investment and hence the economy. However, the platform lending and deposit rates are determined by cost and benefit of participating in the platform, and its market thickness.

2.1 P2P lending and borrowing: A two-sided platform perspective

Here is how we think about the decentralized decision via the platform. It is a platform operated by a fintech company through which anyone can lend and get a loan. Whether an individual will spend time searching potential borrowers online via the platform depends on the thickness of the availability of borrowers $\mathbb{m}_{l,t}$. Deeper is the pool of borrowers, more benefits a depositor can extract from the interactions with borrowers, higher it will be the utility of joining the platform. By the same token, willingness of potential borrowers to identify financing opportunity via the platform depends on the density of depositors available $\mathbb{m}_{d,t}$. Borrowers' utility of joining the platform is stronger when interaction with a more dense pool of depositors yields larger benefits.

Put it formally, we start with a monopoly platform in the spirit of Armstrong (2006). There is a $\mathbb{m}_d$ continuum of depositors that join the platform in search of yield $r_{d,t}^{DEC}$. Unlike conventional banking system where banks bear the risk of loan default, in the platform depositors are solely responsible for the risk. Net yield on the platform deposits after taking into account the probability of run with 100 percent loss is $r_{d,t}^{P2P}(1-\Psi)$. At the same time, there is a $\mathbb{m}_{l,t}$ continuum of investors who search credit opportunities via the platform that offer to pay $r_{l,t}^{P2P}$. Individuals who participate as depositors are required to pay processing fee f_d whereas borrowers are subject to credit scoring fee f_l. An individual's utility of joining the platform as depositor and borrower, respectively, can be written as

$$u_{d,t} = \alpha_d \mathbb{m}_{l,t} - f_d; \quad u_{l,t} = \alpha_l \mathbb{m}_d - f_l \tag{1}$$

where α_d and α_l, respectively, refer to the benefits enjoyed when depositors (borrowers) interact with borrowers (depositors). We let the thickness of the platform be determined by the willingness of each individual to participate, which depends on the utility of participation. Greater utility prompts an individual to join, contributing to market thickness that enhances the benefits of interaction and hence utility to join for the other side. In this sense, $\mathbb{m}_{l,t} = \phi(u_{l,t})$ and $\mathbb{m}_{d,t} = \phi(u_{d,t})$, where $\phi' > 0$.

The platform operator's profit is given by

$$\pi = f_d \mathbb{m}_d + f_l \mathbb{m}_l + \eta \left(r_{l,t}^{P2P} - r_{d,t}^{P2P}(1-\Psi) \right) \mathbb{m}_d \mathbb{m}_l \tag{2}$$

where η is transaction fee charged on a pair of deposit and loan successfully created based on the interest rate differential. Suppose the platform operator concerns about utility the participants obtain rather than the processing and credit scoring fee charged, Eq. (1) can be rearranged to get $f_d = \alpha_d \mathbb{m}_{l,t} - u_{d,t}$

and $f_l = \alpha_l \mathbb{m}_d - u_{l,t}$, respectively, which, in turn, enable Eq. (2) to be reformulated as

$$\pi = \phi(u_{d,t})\left(\alpha_d \phi(u_{l,t}) - u_{d,t}\right) + \phi(u_{l,t})\left(\alpha_l \phi(u_{d,t}) - u_{l,t}\right)$$
$$+ \eta\left(r_{l,t}^{P2P} - r_{d,t}^{P2P}(1-\Psi)\right)\phi(u_{d,t})\phi(u_{l,t})$$

Differentiate the profit function against $u_{d,t}$ and $u_{l,t}$, and rearrange the first-order conditions, we can obtain $r_{d,t}^{P2P}$ and $r_{l,t}^{P2P}$.

$$\boldsymbol{r_{d,t}^{P2P} = \frac{1}{1-\Psi}\left\{r_{l,t}^{P2P} + \frac{\alpha_l}{\eta} + \frac{f_d}{\eta \mathbb{m}_{l,t}}\left(1 - \frac{1}{\varepsilon_{d,t}}\right)\right\}}$$
$$\boldsymbol{r_{l,t}^{P2P} = r_{d,t}^{P2P}(1-\Psi) - \frac{\alpha_d}{\eta} - \frac{f_l}{\eta \mathbb{m}_{d,t}}\left(1 - \frac{1}{\varepsilon_{l,t}}\right)} \tag{3}$$

where $\varepsilon_{d,t} \equiv \phi'(u_{d,t}) f_d / \phi(u_{d,t})$ and $\varepsilon_{l,t} \equiv \phi'(u_{l,t}) f_l / \phi(u_{l,t})$, respectively, refer to fee elasticity of depositors' and borrowers' participation.

Several points are noteworthy on platform interest rate determination. First, when depositors exert a large positive benefit on lenders (higher α_l), then depositors group will be targeted aggressively by the platform. In our context, deposit rate offered will be higher. Likewise, if lenders bring about a large positive benefit on depositors (higher α_d), cost of borrowing will be lower. The role of "cross-group externalities", however, is weakened by the imposition of per-transaction charges η.

Second, higher fixed processing fee will cause deposit rate to go up, whereas higher fee paid on credit scoring is compensated by lower borrowing rate. The link is stronger when platform participants are less elastic to fixed fee charged. Last but not least, the link is also shaped by the density of other side. When there is large pool of borrowers, which implies more options and greater odds for successful transaction, depositors are more tolerant of higher fixed fee. Similarly, when there is a large pool of depositors, borrowers would have greater access to credits and therefore can go along with credit scoring fee without being compensated by lower borrowing rate.

2.2 Endogenous creditworthiness and conventional banking system

For every loan the bank advances, there is a probability of default. Once being defaulted, the bank can only recover a fraction of the expected value of pledged real assets $\varphi P_{t+1} Q_{t+1} I_{t+1}$, where QI stands for value of investment project. Otherwise, the bank will be able to receive full repayment in terms of principal L_t^B and interest payments $r_{l,t}^B L_t^B$. In this respect, expected return on a bank loan can be written as

$$\mathbb{E}_t\left(1 + r_{l,t}^B\right) L_t^B = \omega_t\left(1 + r_{l,t}^B\right) L_t^B + (1 - \omega_t) \varphi P_{t+1} Q_{t+1} I_{t+1}$$

where ω_t refers to the probability of full repayment. We let the probability be endogenously determined by the borrowers' creditworthiness measured by debt-to-collateral ratio

$$\boldsymbol{\omega_t = \exp\left(-\frac{\left(1 + r_{l,t}^B\right) L_t^B}{\varpi P_t Q_t I_t}\right)} \tag{4}$$

where ϖ can be defined as pledgeability parameter. When creditworthiness is strong (low debt-to-collateral ratio), ω_t approximates one. In other words, a deteriorating creditworthiness will witness an increasing probability of default and hence a falling expected return on bank loan as $\left(1+r_{l,t}^{B}\right)L_{t}^{B} > \varphi Q_{t+1}I_{t+1}$.

Suppose ρ denotes the share of investment project financed by bank loans, $L_{t}^{B}=\rho P_{t+1}I_{t+1}$ so that $L_{t}\equiv L_{t}^{B}+L_{t}^{DEC}=\rho P_{t+1}I_{t+1}+(1-\rho)P_{t+1}I_{t+1}=P_{t+1}I_{t+1}$. Expected return on bank loan is rewritten as

$$\mathbb{E}_{t}\left(1+r_{l,t}^{B}\right)L_{t}^{B}=\left(\omega_{t}\left(1+r_{l,t}^{B}\right)+(1-\omega_{t})\varphi Q_{t+1}\rho^{-1}\right)L_{t}^{B} \tag{5}$$

Meanwhile, bank's balance sheet can be presented as

$$L_{t}^{B}=D_{t}^{B}\left(1+d_{t}^{-1}\right) \tag{6}$$

where D_{t}^{B} refers to bank deposits, and d_{t} is bank's debt-to-equity ratio (bank leverage henceforth). The bank is assumed to maximize expected return on loans subject to cost of funding as what follows:

$$\max_{L_{t}^{B}}\mathbb{E}_{t}\left(1+r_{l,t}^{B}\right)L_{t}^{B}-\left(1+r_{d,t}^{B}\right)D_{t}^{B}$$

Together with Eqs. (5) and (6), first-order condition gives us the determination for bank lending rate

$$\boldsymbol{1+r_{l,t}^{B}=\frac{1}{\omega_{t}}\left(1+r_{d,t}^{B}\right)\left(1+d_{t}^{-1}\right)^{-1}-\left(\frac{1}{\omega_{t}}-1\right)\left(\frac{\varphi Q_{t+1}}{\rho}\right)} \tag{7}$$

When borrowers' creditworthiness is strong, Eq. (7) boils down to

$$\frac{1+r_{l,t}^{B}}{1+r_{d,t}^{B}}=\frac{d_{t}}{1+d_{t}}$$

Lending-deposit rate differential is completely driven by bank leverage. The spread widens if bank has greater debt leverage. In other words, a better capitalized bank will result in a smaller interest rate spread. This is in line with the existing literature that found a rising cost of funding and a modest rise in bank loan rates, which reduces spreads, when banks are better capitalized (see, for instance, Wallen, 2017; Miles, Yang, and Marcheggiano, 2012; Kashyap, Stein, and Hanson, 2010). Once creditworthiness deteriorates ($\omega < 1$), interest rate spread escalates, which, however, can be moderated if expected value of investment is high enough and can be recovered. The linkage between spread and creditworthiness is also loosened if fraction of bank loans in project financing gets smaller. Last but not least, Eq. (7) also demonstrates a sensible argument that during time of financial distress with fire sales of assets that crash the value of investment projects, lending rate skyrockets.

2.3 Household I: A dynamic investment relation and Tobin's q

Household is another important economic agent in the model as she borrows to accumulate investment goods; she therefore can join the platform as borrower if not depositor; her creditworthiness will determine her ability and willingness to get access to bank loans (Wong an Eng, 2015; Eng and Wong, 2016). This goes without saying the role of her decision on consumption and leisure. Formally speaking, a household optimally chooses a sequence of consumption goods C, hours worked N, one-period bonds B, investment goods I, bank loans and deposits, platform credits, and a level of capital stock K at date t to maximize her utility. Subject to flow budget constraint, credit-in-advance constraints, and motion of capital accumulation, household's utility maximization problem can be written as

$$\max u = \mathbb{E}_t \left\{ \sum_{k=0}^{\infty} \beta^k \exp(H_{t+k}) \left(\frac{C_{t+k}^{1-\sigma}}{1-\sigma} - \phi \frac{N_{t+k}^{1+\chi}}{1+\chi} - \vartheta_d \left(\frac{D_{t+k}^{P2P}}{P_{t+k}} - \psi_l \frac{\tilde{L}_{t-1+k}^{P2P}}{P_{t+k}} \right)^2 \right) \right\}$$

s.t

$$\lambda_t \left\{ r_{K,t} K_{t-1} + w_t N_t + \frac{L_t^B - \left(1 + r_{l,t-1}^B\right) L_{t-1}^B}{P_t} + \frac{L_t^{P2P} - \left(1 + r_{l,t-1}^{P2P}\right) L_{t-1}^{P2P}}{P_t} \right.$$

$$- \frac{B_t - (1 + r_{t-1}) B_{t-1}}{P_t} - C_t - I_t - \Phi_{I,t} K_{t-1}$$

$$\left. - \frac{D_t^B - \left(1 + r_{d,t-1}^B\right) D_{t-1}^B}{P_t} - \frac{D_t^{P2P} - \left(1 + r_{d,t-1}^{P2P}\right) D_{t-1}^{P2P}}{P_t} \right\}$$

$$\Lambda_t^B \left\{ \frac{L_{t-1}^B}{P_t} - \rho I_t \right\}$$

$$\Lambda_t^{P2P} \left\{ \frac{L_{t-1}^{P2P}}{P_t} - (1-\rho) I_t \right\}$$

$$\Omega_t \{ (1-\delta) K_{t-1} + \exp(\zeta_t)\, I_t - K_t \}$$

where λ_t , Λ_t^B , Λ_t^{P2P} , and Ω_t denote the Lagrangian multipliers for the corresponding constraints. β is the subjective discount factor, and $\mathbb{E}_t$ is the expectation operator. The parameters σ, χ, ϕ, and δ, respectively, indicate the degree of risk aversion, the (inversed) wage elasticity of labor supply, disutility of work in household's utility, and rate of depreciation on past capital stock. We leave the discussion on the third item in the utility function to next section. H_t and ζ_t can be viewed as preference and investment-specific technology (IST) shock, respectively, in first-order autoregressive dynamics

$$H_t = \rho_H H_{t-1} + \sigma_H \varepsilon_{H.t}$$

$$\zeta_t = \rho_\zeta \zeta_{t-1} + \sigma_\zeta \varepsilon_{\zeta,t}$$

where $\varepsilon_{H.t}$ and $\varepsilon_{\zeta,t}$ denote i.i.d preference and IST shock, respectively, with constant volatility. In particular, IST shock resembles “capital quality shock” as in Gertler, Kiyotaki, and Queralto (2012) as a simple way to introduce an exogenous source of variation in the value of capital. Last but not least, $\Phi_{I,t}$ refers to a convex capital adjustment cost that takes the following specific form

$$\Phi_{I,t} = \frac{1}{2}\Phi\left(\frac{I_t}{K_{t-1}} - \delta\right)^2$$

for $\Phi_I = \Phi_I' = 0$ and $\Phi_I'' > 0$ in steady state.

By rearranging the first-order conditions, we can get marginal rate of substitution between consumption and hours worked, Euler consumption function, marginal price of bank and P2P loans, and marginal benefit of investment and possessing capital stock, respectively.

$$C_t^\sigma N_t^\chi = w_t \tag{8}$$

$$C_t = \left(\frac{P_{t+1}}{P_t} \times \frac{1}{\beta(1+r_t)} \times \frac{\exp(H_t)}{\exp(H_{t+1})}\right)^{1/\sigma} C_{t+1} \tag{9}$$

$$\frac{\Lambda_{t+1}^B}{\lambda_{t+1}} = r_{l,t}^B - r_t \tag{10}$$

$$\frac{\Lambda_{t+1}^{P2P}}{\lambda_{t+1}} = r_{l,t}^{DEC} - r_t \tag{11}$$

$$-\lambda_t\left(1+\Phi\left(\frac{I_t}{K_{t-1}}-\delta\right)\right)-\Lambda_t^{B}\rho-\Lambda_t^{P2P}(1-\rho)+\Omega_t\exp(\zeta_t)=0 \tag{12}$$

$$\lambda_{t+1}\left(r_{K,t+1}-\Phi_{I,t}-\Phi\left(\frac{I_{t+1}}{K_t}-\delta\right)\right)-\Omega_t-\Omega_{t+1}(1-\delta) \tag{13}$$

Because one-period bonds and bank deposits are perfectly substitutable, bank deposit rate is anchored to bond rate, which happens to be the policy rate too.

$$r_{d,t}^{B}=r_t \tag{14}$$

By defining $\mathcal{Q}_t \equiv \Omega_t/\lambda_t$ as Tobin's marginal q, Eq. (13) can be rearranged for

$$\boldsymbol{\mathcal{Q}_t=\left(\frac{P_{t+1}}{P_t}\right)\left(\frac{1}{1+r_t}\right)\left((1-\delta)\mathcal{Q}_{t+1}+r_{K,t+1}-\Phi_{I,t}-\Phi\left(\frac{I_{t+1}}{K_t}-\delta\right)\right)} \tag{15}$$

The corresponding investment dynamics can be derived by combining Eqs. (10)-(12).

$$\boldsymbol{\frac{I_t}{K_{t-1}}=\frac{1}{\Phi}\left(\mathcal{Q}_t\exp(\zeta_t)-\rho\left(r_{l,t}^{B}-r_t\right)-(1-\rho)\left(r_{l,t}^{P2P}-r_t\right)-1\right)+\delta} \tag{16}$$

Investment dynamics as in Eq. (16) comprises the one that replenishes the depreciated capital and that contributes to capital stock. The latter is driven by Tobin's *q*, IST shock, and cost of financing from bank and the platform. The q ratio, in turn, depends on opportunity cost of holding capital stock net of adjustment cost, and expected value of future *q* ratio.

Decision whether to resort to bank loan or raise fund via the platform depends the level of investment and the relative prices. It is thus a cost minimization problem subject to the loans portfolio in CES fashion. Optimal demand for bank and P2P loans, respectively, as well as the weighted average cost of funding, can be derived as

$$\boldsymbol{L_t^B = \rho P_{t+1} I_{t+1} \left(\frac{r_{l,t}^B}{\tilde{r}_{l,t}}\right)^{-\kappa}} \tag{17}$$

$$\boldsymbol{L_t^{P2P} = (1-\rho) P_{t+1} I_{t+1} \left(\frac{r_{l,t}^{P2P}}{\tilde{r}_{l,t}}\right)^{-\kappa}} \tag{18}$$

$$\tilde{r}_{l,t} = \left(\rho {r_{l,t}^B}^{1-\kappa} + (1-\rho) {r_{l,t}^{P2P}}^{1-\kappa}\right)^{1/(1-\kappa)}, \kappa > 0 \tag{19}$$

2.4 Household II: Modelling trust on public information

If collateral is requested in processing conventional bank loan to alleviate the problem of asymmetric information, it has not been the way the problem is moderated in the platform. Two screening features are considered in our model: first is the credit scoring that costs f_l. We assume that higher is the fee, more thorough will be the assessment. Second is the public review implicitly reflected by the formation of past loans through the platform

$$\tilde{L}_{t-1}^{P2P} = \int_0^{\mathbb{m}_{l,t-1}} L_{t-1}^{P2P} \mathrm{d}\mathbb{m}_l = \mathbb{m}_{l,t-1} L_{t-1}^{P2P}$$

The intuition is straightforward: if more loans were successfully transacted in the past, it is an indicator of trustworthiness. This eases the depositors' worries, prompting depositors to lend via the platform. As larger size of the pool of past borrowers also means more varieties of lending opportunities with tested track record, depending on the degree of trust the depositors have on the platform ψ_l, utility-maximizing depositors would tend not to behave too differently from the general reviews to avoid adverse selection. The parameter ϑ_d thus measures the penalty for deviating too far from the consensus. The empirical importance of availability of peers and public reviews in trust formation on P2P lending has been accumulating (see, for instance, Iyer, Khwaja, Luttmer, and Shue, 2016; Duarte, Siegel, and Young, 2012; Freedman and Jin, 2011)

The way we formalize trust and the tendency not to behave too differently from the general reviews (i.e., one is less likely to make a deal with a potential borrower if he was given bad feedbacks in the past transactions) is rooted on Akerlof and Kranton's (2000) and Benjamin et al.'s (2010) formalization of the role of identity in shaping human behavior. Put in our context, differentiating utility function against the platform deposits given the flow budget constraint gives us the following optimal demand for

$$\boldsymbol{\frac{D_t^{P2P}}{P_t} = 0.5\left(\frac{N_t^{\chi}}{w_t}\right)\left(\frac{r_{d,t}^{P2P} - r_t}{\vartheta_d}\right) + \psi_l\left(\frac{\mathbb{m}_{l,t-1} L_{t-1}^{P2P}}{P_t}\right)} \tag{20}$$

Eq. (20) puts forward an important perspective: P2P lending-borrowing dynamics, at least in our context, is driven by borrowing side. Greater loan transactions and density of borrowers in the past incentivize the formation of today's platform deposits and hence loans, especially when trust for the reviews on the past deals is stronger. This is coherent with Freedman and Jin's (2017) finding that social networking feature in Prosper (one of the biggest lending platforms worldwide), through which members can identify each other as friends and impose social pressure for their members to repay their loans, enables borrowers to have their loans funded.

2.5 Production technology

Production technology takes the typical Cobb-Douglas form where capital stock installed one-period earlier K_{t-1} and hours of worked hired N_t are processed at date t to produce real output

$$Y_t^P = e^{A_t} K_{t-1}^{\alpha} N_t^{1-\alpha},\ 0 < \alpha < 1 \tag{21}$$

where α denotes capital share in production. A_t is the first-order autoregressive total factor productivity (TFP) with i.i.d shock $\varepsilon_{A,t}$ at constant volatility σ_A

$$A_t = \rho_A A_{t-1} + \sigma_A \varepsilon_{A,t}$$

Marginal product of labor and capital, respectively, can be written as

$$w_t N_t = (1-\alpha) Y_t \tag{22}$$

$$r_{K,t} K_{t-1} = \alpha Y_t \tag{23}$$

By solving a cost minimization problem, we can obtain the real marginal cost function

$$\mathcal{R}_t = \exp(-A_t)\, \alpha^{-\alpha} (1-\alpha)^{-(1-\alpha)} r_{K,t}^{\alpha} w_t^{1-\alpha} \tag{24}$$

Aggregate output is then divided between household consumption, investment expenditure, and convex adjustment cost incurred by the households in the accumulation of capital stock $\Phi_{I,t} K_{t-1}$.

$$Y_t \equiv C_t + I_t + \Phi_{I,t} K_{t-1} \tag{25}$$

2.6 Pricing decision

Firm j chooses a price $\mathbb{P}_t(j)$ that maximizes the profit over nominal marginal cost $\mathcal{R}_t^N$ given the market demand for her products.

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k (\mathbb{P}_{t+k}(j) - \mathcal{R}_t^N) \left(\frac{\mathbb{P}_{t+k}(j)}{P_t}\right)^{-\epsilon} Y_t$$

The parameter $\varepsilon > 0$ denotes price elasticity of demand for the varieties. Optimal frictionless price symmetrically applied to all firm setters is thus given by

$$\mathbb{P}_t = \left(\frac{\epsilon}{\epsilon - 1}\right) \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \mathcal{R}_t^N$$

Like in the standard New Keynesian monetary model, not all firms are able to reset price optimally. The fraction of those who could θ will reset the price to approximate the optimal frictionless price. Another fraction $1 - \theta$ will stick to last-period price. Aggregate price level in a New Keynesian economy is thus a weighted average of last-period aggregate price level and the newly reset price

$$\frac{P_t}{P_{t-1}} = \left(\frac{P_{t+1}}{P_t}\right)^{\beta} \left(\frac{\mathcal{M}_t}{1 - \beta} \times \mathcal{R}_t\right)^{(1-\theta\beta)(1-\theta)/\theta} \tag{26}$$

where $\mathcal{M}_t \big(= \epsilon \exp\big(\varepsilon_{p,t}\big)/(\epsilon - 1)\big)$ refers price markup shock with i.i.d shock $\varepsilon_{p,t}$.

2.7 Monetary transmission in a borrower-driven platform

The central bank conducts the policy by utilizing a reaction function that stabilizes inflation and output gap (defined as the difference between market-clearing output as in Eq. (25) and potential output as in Eq. (21).

$$1 + r_t = (1 + r_{t-1})^{\rho_r} \left(\frac{1}{\beta} \times \left(\frac{P_t}{P_{t-1}} \right)^{\nu_\pi} \times \left(\frac{Y_t}{Y_t^P} \right)^{\nu_Y} \right)^{1-\rho_r} \exp(\varepsilon_{r,t}) \tag{27}$$

where ρ_r denotes the degree of interest rate persistence, ν_π and ν_Y, respectively, refer to weight given to inflation and output gap stabilization, and $\varepsilon_{r,t}$ is i.i.d monetary policy shock.

Viewing Eqs. (15), (16), (18), (20), and (3) together, we can make a sense on what the central bank can and cannot do with respect to decentralized finance. Take an expansionary monetary stance for example. A reduction in policy rate is expected to raise the value of investment, and directly reduces bank deposit rate. In result, bank lending rate falls, stimulating business investment. It is then the financing needs for greater investment that feeds into the demand for platform loans and the corresponding deposits alongside conventional bank loans. Whether to opt for bank or platform loans hence depends on the borrowing rates.

Unlike the case of conventional credit channel in which lower policy rate is transmitted into a lower deposit and lending rate with a reduction in interest rate spread (see Eq. (7)) , monetary policy has no role at all in P2P lending and deposit rates, and the spread. Lower bank rates vis-à-vis platform rates direct the financing demand toward bank loans, nullifying the need for P2P loans that results in shrinking density of platform participants. It is then the density that shapes P2P lending and borrowing rates.

In this sense, central bank can only indirectly shape the platform transactions via the real economy, not vice versa. Monetary policy on its own cannot steer the economy by leveraging the platform transactions. In fact, monetary policy can only influence the platform transactions as a mirror-image result of its impact on conventional credit channel.

3. Parameterization

There are generally two categories of parameters to be calibrated, as reported in Table 1. First group comprises conventional parameters with respect to the real economy and the banking sector, which we largely allow the value to be consistent with the literature on New Keynesian model. For instance, subjective discount rate is set to 0.99, which gives a policy rate and hence bank deposit rate of 1.01 percent per quarter, coefficient for constant risk aversion takes the value of 2, while (inverse) wage elasticity of labor supply is one. Capital depreciates by 2.5 percent per quarter, and accounts for 60 percent as input of total production. Prices once set last for four quarters $\theta = 0.75$.

Meanwhile, parameter for labor disutility $\phi = 6.4147$ is calibrated so that wage equalizes marginal product of labor and marginal rate of substitution between consumption and hours worked at the given unitary Frisch elasticity on the intensive margin, which is in line with New Keynesian literature (see, for instance, Gali, 2015) and not too far away from the proposed 0.5 by Chetty et al. (2011). Likewise, rate of recovery during fire sale of assets is calibrated so that bank lending rate equals 6.01 percent, given bank deposit rate of 1.01 percent in steady state, to yield an interest rate spread of 5 percent, coherent with East Asia & Pacific average (4.8 percent) and the world average (5.7 percent) in year 2016. Bank's debt to equity ratio is set to yield bank's equity-to-asset ratio that is consistent to Basel III's minimum requirement of capital (4.5 percent) and conservation buffer (2.5 percent)

[Insert Table 1]

Second group of parameters are about the platform lending and borrowing. Due to the lack of relevant empirical evidence and model, parameters that govern P2P interest rates and deposits formation are calibrated to yield an interest rate spread of only 2 percent with platform deposit rate of 3 percent. We assume a very low elasticity of substitution between bank and P2P loans, where $\kappa = 0.2$. We assume the following specific function for platform participation

$$\mathbb{m}_{l,t} = \exp\big(\mu(\alpha_l \mathbb{m}_d - f_l)\big)$$

$$\mathbb{m}_{d,t} = \exp\Big(\mu\big(\alpha_d \mathbb{m}_{l,t} - f_d\big)\Big)$$

The scale parameter is preset at $\mu = 0.1$. In steady state with no entry, benefit of platform participation shall be identical to the fee incurred, $\alpha_l \mathbb{m}_d = f_l$ and $\alpha_d \mathbb{m}_{l,t} = f_d$. By normalizing the density of borrowers and depositors to one, we have $\alpha_l = f_l$ and $\alpha_d = f_d$, which we set at 0.02. Lastly, we make transaction fee to be unit proportional to interest rate spread, which gives us $\eta = 1$.

4. Whither monetary policy?

Has monetary policy spillovers been reshaped once P2P finance prevails? To address this question, we consider three financing conditions, which include a "Baseline" case where only bank loans are available $\rho = 1$, "Rise of P2P" when 5 percent of financing needs are met by P2P lending $\rho = 0.95$, and "Pervasive P2P" with 50 percent of financing needs satisfied via P2P lending $\rho = 0.5$. Figure 1 illustrates the dynamic responses of the real economy and financial sectors to a one-percent increase in ε_r. The policy shock is assumed to be purely transitory.

[Insert Figure 1 here]

What we can observe are two distinct responses. On the one hand, irrespective of the source of investment financing, monetary tightening still causes bank deposit rate to go up, and consumption, investment, inflation, and bank loan demand to fall. On the other hand, a significant presence of P2P finance does alter monetary spillovers to the real economy and the conventional financial sector. In particular, value of investment, business investment, and demand for bank loans exhibit larger drop, although bank lending rate hardly goes up on impact. The later implies a declining bank lending-deposit rate spread amid a rise in policy interest rate, and the creditworthiness actually improves as a result.

Turning to the platform market itself, a higher policy rate brings about a fall in P2P lending and deposit rates, placing the drop in loan demand mostly on bank's shoulder. It is evidenced by a rise in platform borrowings. This is an interesting observation in consistent with Bertsch et al.'s (2016) empirical finding, though for different reasons, that a liftoff in federal funds rate has driven average loan interest rates in P2P lending market downward.

Applying the argument in Sections 2.1 and 2.4 , it is easy to see why policy rate and P2P rates are adversely related. Greater demand for P2P loans creates greater formation of P2P deposit. That means a more intensive density of borrowers and depositors. Given the inelastic responses of density to fees charged, rising density actually implies a more than proportional increase in processing and credit scoring fees. According to Eq. (3), P2P loan rates fall in compensation for higher per-agent fees incurred, which then causes P2P deposit rates to fall as well.

Figures 2 to 4 depict the responses of the model economy to one-percent increase in shocks hitting total factor productivity (TFP), investment-specific technology (IST), and price markup under the three different financing conditions. While the first two are persistent efficiency shocks, the inefficient price markup shock is transitory. Of question is given the identical monetary policy response, where policy rate leans against the positive efficient demand and price shocks but toward the favorable efficient supply shock, can central bank still maintain her control on the economy?

[Insert Figures 2 to 4]

Generally yes. Monetary easing that accommodates favorable TFP shock would still bring about the usual suspects even when P2P finance is prevalent: bank rates and inflation falls while consumption is stimulated. Likewise, when facing unfavorable price shock, monetary tightening would still be transmitted to rising bank rates that slow down consumption and investment.

That said, macro and financial stability are going to be disrupted. It is especially impactful when shock hits investment-specific technology, resulting in either greater volatility – inflation rate goes to higher ground, policy and bank rates react stronger, and consumption dives deeper – or with opposite instantaneous responses. While favorable IST shock expands business investment directly as in Eq. (16), increasing aggregate demand that prompts a rise in policy rate makes Tobin’s *q* as in Eq. (15) goes South, taking a toll on business investment. The unfavorable later apparently overwhelms the favorable former when P2P loans become prevalent. Business investment thus falls on impact. This is in sharp contrast to the scenario when bank loans are dominant. However, P2P borrowings keep expanding, providing the necessary liquidity to investment expansion later on when the *q* ratio recovers.

5. Concluding remark: Monetary policy is here to stay, but…

Decentralized platform finance has been growing impressively since the last decade, and is expected to take off once it has a stronger footing enabled by better developed financial technology and more established regulatory framework are ready. Sooner or later, perhaps sooner than we expect, decentralized finance will pose real challenges to traditional banking sector as well as monetary policymakers when its direct influence on bank rates determination and loans formation has been compromised.

Through a general-equilibrium dynamic macroeconomic model equipped with simple devices to capture interest rate determination in platform finance and role of trust and tendency not to deviate from group assessments in platform transactions, we obtain some findings of which two implications are worthy for reiteration.

i. Typical bank lending and balance-sheet channels, in which central bank steers the economy via bank lending and borrowing, are absent in platform finance. In turn, decentralized finance is largely a reflection of the real economy and traditional banking sector. Platform interest rates go in opposite to the direction of policy rate.

ii. Although monetary policy is still able to keep inflation and the real economy as intended, it comes at the expense of macro and financial stability.

In view of these findings, our paper calls for further investigations on how monetary policy can innovatively regain direct control on interest rate determination in the platform transactions, and on the new form of regulatory framework on platform finance that complements the conduct of monetary policy to preserve macro and financial stability.

References

Akerlof, G.A., Kranton, R.E. (2000). Economics and identity. *Quarterly Journal of Economics* 115(3), 715-753.

Akerlof, G.A., Kranton, R.E. (2010). *Identity Economics: How Our Identities Shape Our Work, Wages and Wellbeing*. Princeton University Press.

Amstrong, M. (2006). Competition in two-sided markets. *RAND Journal of Economics* 37(3), 668-691.

Atz, U., Bholat, D. (2016). Peer-to-peer lending and financial innovation in the United Kingdom. *Staff Working Paper* No. 598, Bank of England.

Barrdear, J., Kumhof, M. (2016). The macroeconomics of central bank issued digital currencies. *Staff Working Paper* No. 605, Bank of England.

Benjamin, D. J., Choi, J. J., Strickland, A.J. (2010). Social identity and preferences. *American Economic Review* 100(4), 1913-1928.

Bernanke, B., Blinder, A. (1988). Credit, money, and aggregate demand. *American Economic Review* 78, 435-439.

Bernanke, B., Gertler, M., Gilchrist, S. (1996). The financial accelerator and the flight to quality. *Review of Economics and Statistics* 78, 1-15.

Bertsch, C., Hull, I., Zhang, X. (2016). Fed liftoff and subprime loan interest rates: Evidence from the peer-to-peer lending market. *Sveriges Riksbank Working Paper Series* No. 319.

Bordo, M.D., Levin, A.T. (2017). Central bank digital currency and the future of monetary policy. *NBER Working Paper* No. 23711, NBER.

Camera, G. (2017). A perspective on electronic alternatives to traditional currencies. *Sveriges Riksbank Economic Review* 2017:1, 126-148.

Chetty, R., Guren, A., Manoli, D., Weber, A. (2011). Are micro and macro labor supply elasticities consistent? A review of evidence on the intensive and extensive margins. *American Economic Review* 101(3), 471-475.

Duarte, J., Siegel, S., Young, L. (2012). Trust and credit: The role of appearance in peer-to-peer lending. *Review of Financial Studies* 25(8), 2455-2483.

Eng, Y.-K., Wong, C.-Y. (2016). Asymmetric growth effect of capital flows: Evidence and quantitative theory. *Economic systems* 40, 64-81.

Epstein, G.S., Heizler, O. (2015). Ethnic identity: a theoretical framework. IZA Journal of Migration 4(9), 1-11.

Faia, E., Paiella, M. (2017). P2P lending: Information externalities, social networks and loans'substitution.

Fernandez-Villarverde, J., Sanches, D. (2016). Can currency competition work? *NBER Working Paper* No. 22157. NBER.

Freedman, S.M., Jin, G.Z. (2011). Learning by doing with asymmetric information: Evidence from Prosper.com. *NBER Working Paper* No. 16855, NBER.

Freedman, S.M., Jin, G.Z. (2017). The information value of online social networks: Lessons from peer-to-peer lending. *International Journal of Industrial Organization* 51, 185-222.

Fung, B.S.C., Halaburda, H. (2016). Central bank digital currencies: A framework for assessing why and how. *Staff Discussion Paper* 2016-22, Bank of Canada.

Gali, J. (2015). *Monetary Policy, Inflation, and the Business Cycle*. Princeton University Press.

Georgiadis, A., Manning, A. (2013). One nation under a groove? Understanding national identity. Journal of Economic Behavior & Organization 93, 166-185.

Gertler, M., Kiyotaki, N., Queralto, A. (2012). Financial crises, bank risk exposure and government financial policy. *Journal of Monetary Economics* 59, S17-S34.

Guo, F., Kong S.T., Wang, J. (2016). General patterns and regional disparity of internet finance development in China: Evidence from the Peking University Internet Finance Development Index. China Economic Journal 9(3), 253-271.

Heller, D. (2017). Do digital currencies pose a threat to sovereign currencies and central banks? *PIIE Policy Brief* 17-13, Peterson Institute for International Economics.

Iyer, R., Khwaja, A.I., Luttmer, E.F.P., Shue, K. (2016). Screening peers softly: Inferring the quality of small borrowers. *Management Science* 62(6), 1554-1577.

Kashyap, A., Stein, J.C., Hanson, S.G., 2010. An analysis of the impact of “substantially heightened”capital requirements on large financial institutions. Mimeo, Harvard Business School, Harvard University.

Korinek, A., Mendoza, E.G. (2014). From sudden stops to Fisherian deflation: Quantitative theory and evidence. *Annual Review of Economics* 6, 299-232.

Miles, D., Yang, J., Marcheggiano, G., 2012. Optimal bank capital. *Economic Journal* 123(567), 1-37.

Rochet, J.-C., Tirole, J. (2003). Platform competition in two-sided markets. *Journal of the European Economic Association* 1, 990-1029.

Rochet, J.-C., Tirole, J. (2006). Two-sided markets: a progress report. *RAND Journal of Economics* 37(3), 645-667.

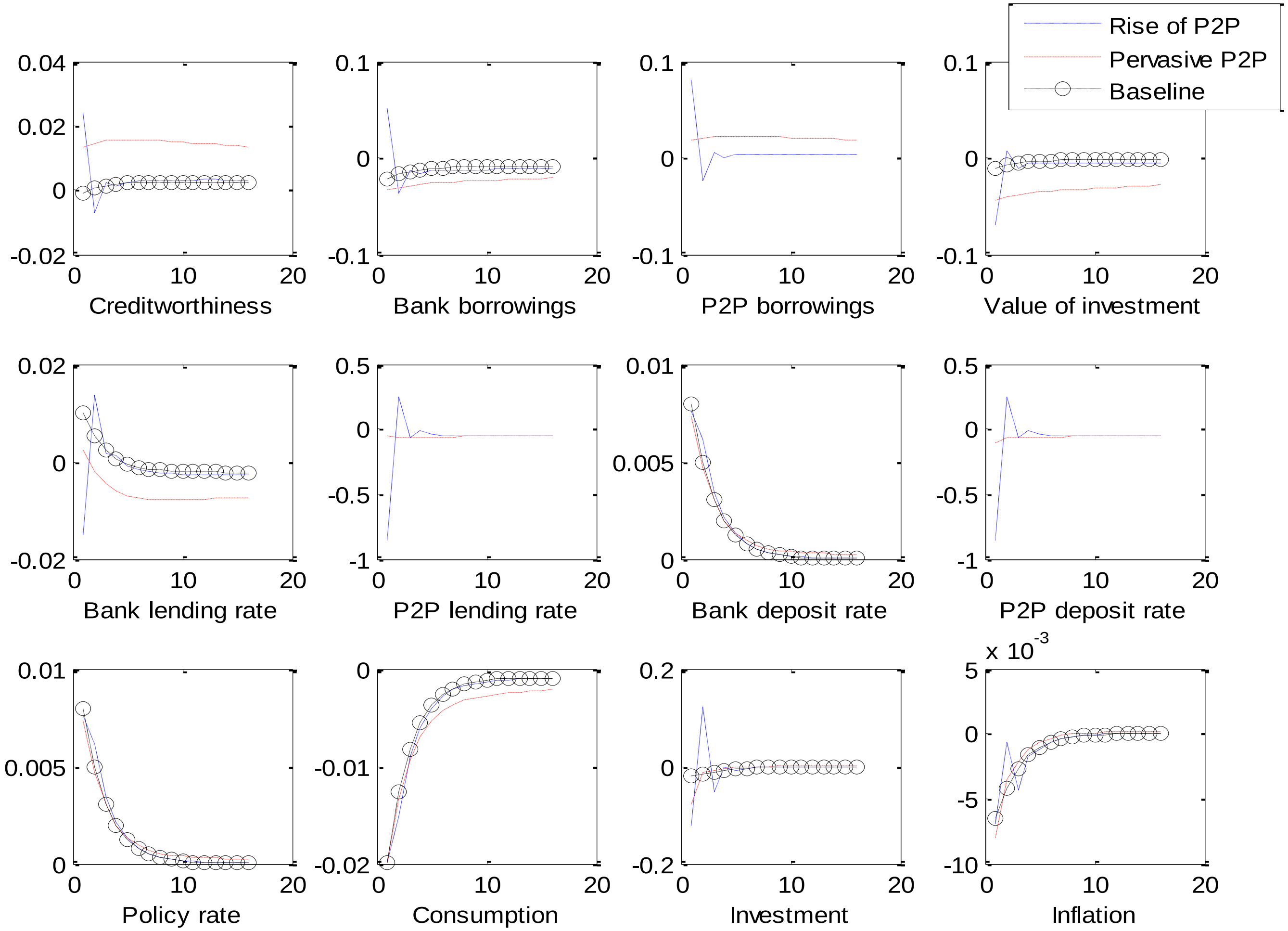
Raskin, M., Yermack, D. (2016). Digital currencies, decentralized ledgers, and the future of central banking. *NBER Working Paper* No. 22238, NBER.

Wallen, J., 2017. The effect of bank capital requirements on bank loans rates. Mimeo, Graduate School of Business, University of Chicago.

Wong, C.-Y., Eng, Y.-K. (2015). Surviving asymmetry in capital flows and the business cycles: The role of prudential capital controls. *Review of Development Economics* 19(3), 545-563.

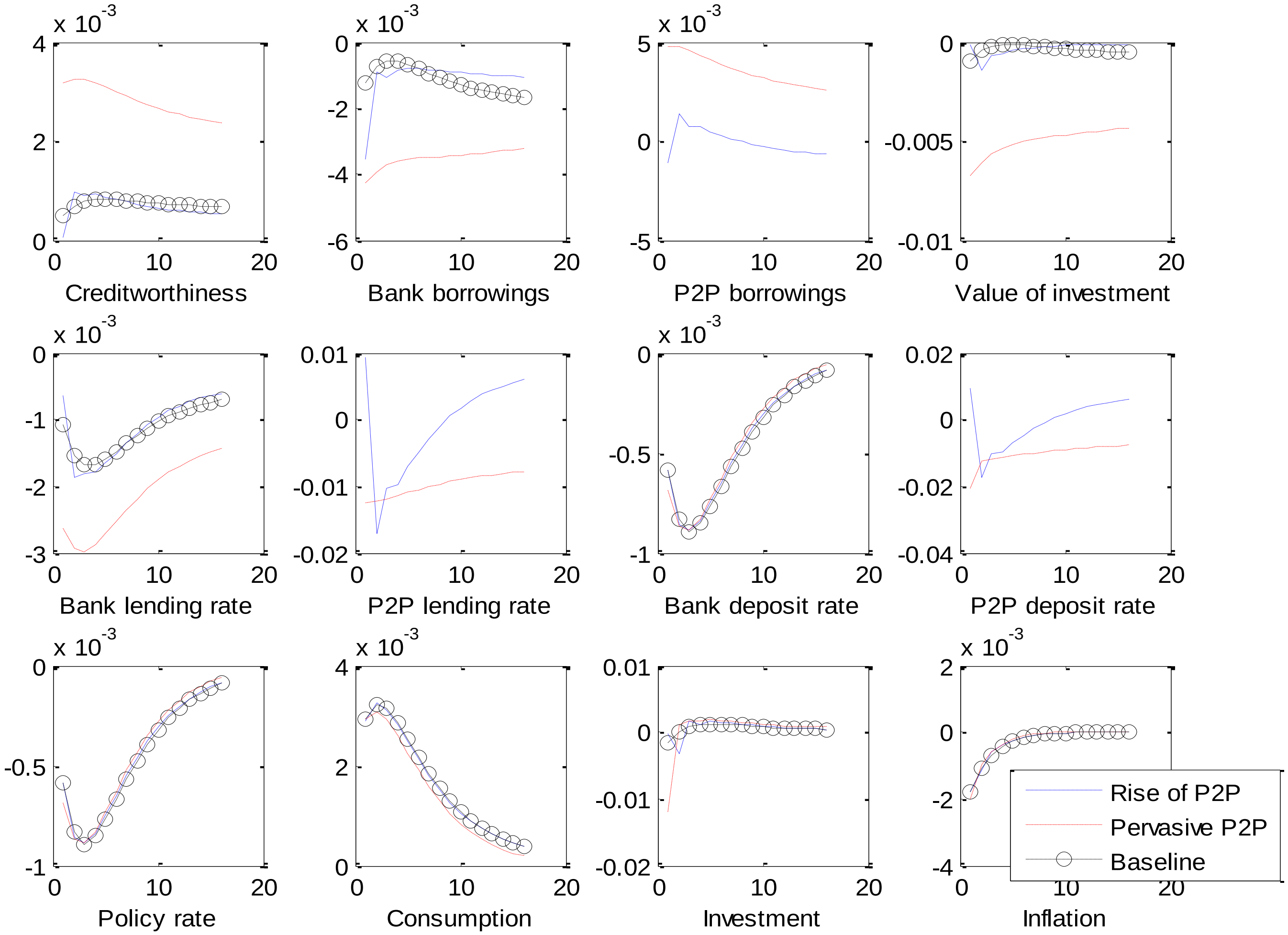
Table 1 Parameter and steady state values

β	0.99	Subjective discount rate
δ	0.025	Capital depreciation rate
α	0.4	Capital share in production
σ	2	Risk aversion
χ	1	Wage elasticity of labor supply
θ	0.75	Calvo price stickiness
ϵ	5	Elasticity of substitution between varieties
ν_π	1.5	Policy weight on inflation stabilization
ν_y	0.125/4	Policy weight on output gap stabilization
d	13.2857	Bank debt-equity ratio in line with Basel III's bank equity-asset ratio of 7%
ϕ	6.4147	Labor disutility in utility function
φ	0.2638	Rate of recovery during fire sale of asset
ϖ	6.0315	Scale parameter for asset pledgeability
P2P platform		
κ	0.2	Elasticity of substitution between bank and P2P loans
f_d	0.02	Processing fee
f_l	0.02	Credit scoring fee
η	1	Scale parameter for P2P transaction fee (1-4%)
ϑ_d	0.5262	Disutility for not self-sorting into public reviews
ψ_l	0.4	Degree of trust on public reviews on past P2P loan transactions
μ	0.01	Scale parameter for utility of joining the platform
α_d	0.02	Benefit of interaction with borrowers for depositors
α_l	0.02	Benefit of interaction with depositors for borrowers
ε_l	0.3333	Fee elasticity of participation by borrowers
ε_d	0.3333	fee elasticity of participation by depositors
Ψ	0	Default risk facing platform depositors
Selected steady state value		
N	0.33	Hours worked
r, r_d^B	0.0101	Interest rates
ω	0.85433	Creditworthiness/Probability of full payment
ρ	1	Share of bank loans
$r_l^B - r_d^B$	0.05	Bank lending-deposit rate spread
$r_l^{P2P} - r_d^{P2P}$	0.02	By assumption
r_l^{P2P}	0.05	Platform loan rate
r_d^{P2P}	0.03	Platform deposit rate



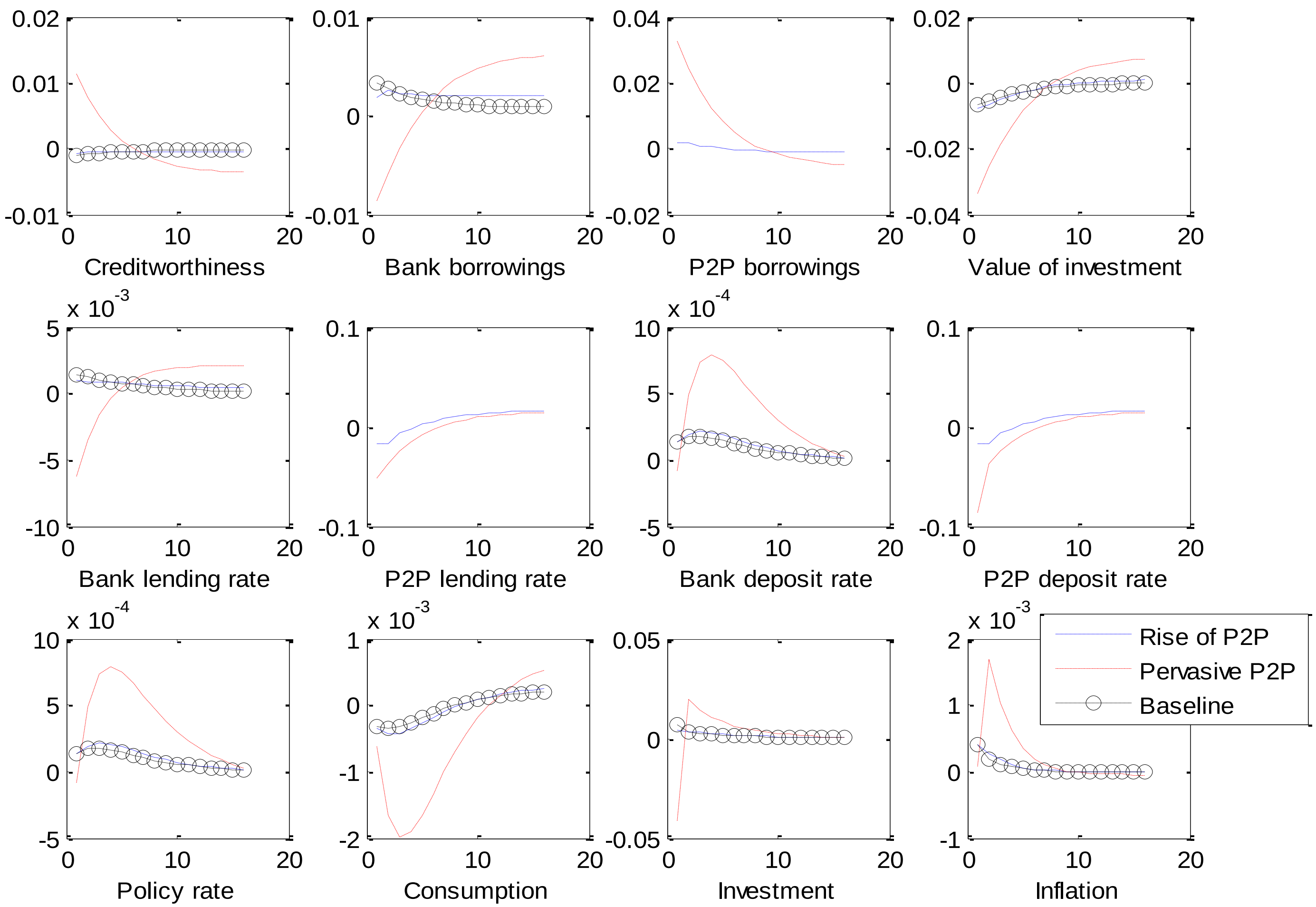
Note: Y-axis: % deviation from steady state; X-axis: quarters ahead. Rise of P2P: $\rho = 0.95$; Pervasive P2P: $\rho = 0.5$; Baseline: $\rho = 1$

Fig.1 Responses of the model economy to one-percent increase in monetary policy shock



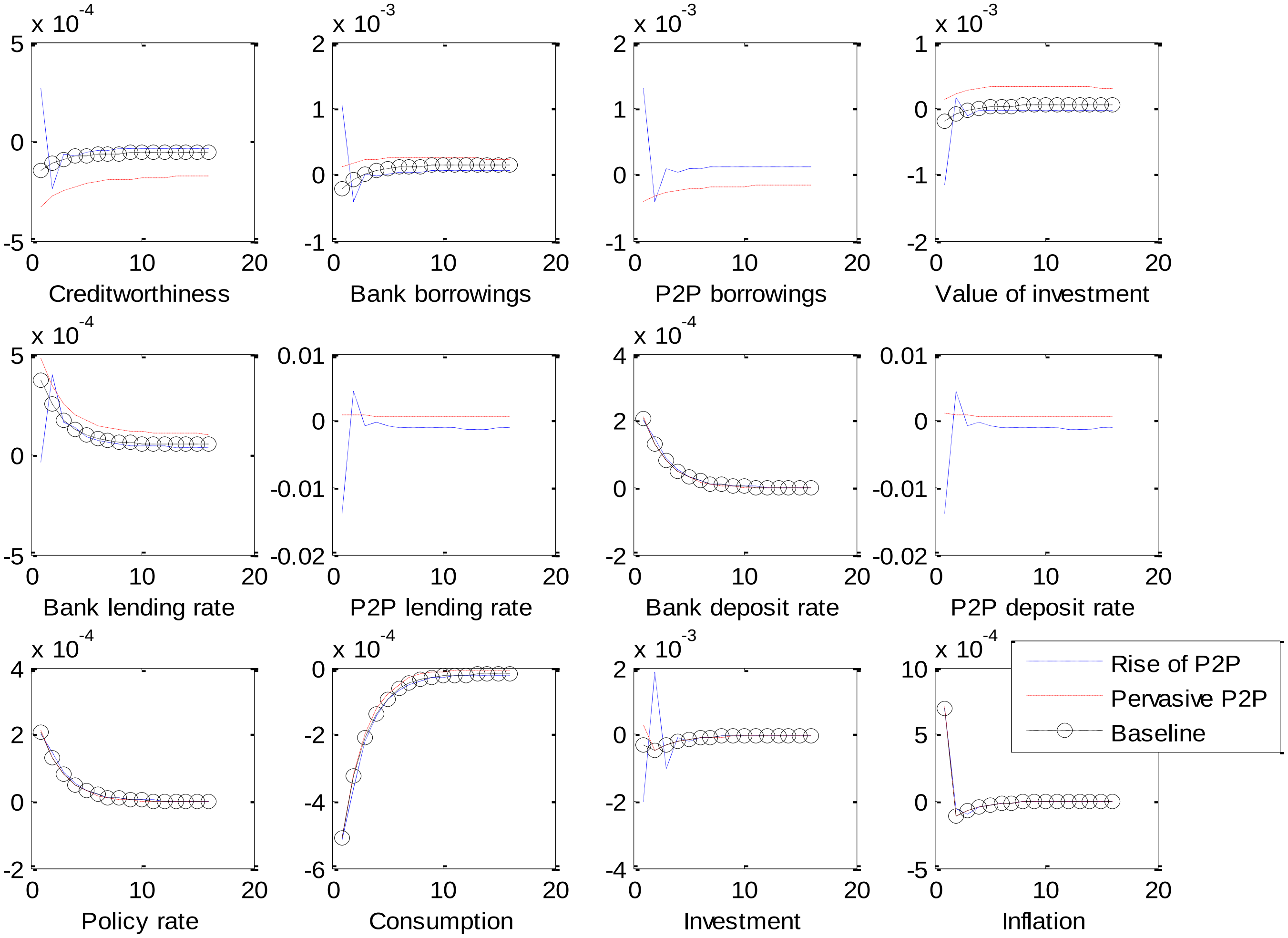
Note: Y-axis: % deviation from steady state; X-axis: quarters ahead. Rise of P2P: $\rho = 0.95$; Pervasive P2P: $\rho = 0.5$; Baseline: $\rho = 1$

Fig.2 Response of the model economy when shock hits total factor productivity by one percent



Note: Y-axis: % deviation from steady state; X-axis: quarters ahead. Rise of P2P: $\rho = 0.95$; Pervasive P2P: $\rho = 0.5$; Baseline: $\rho = 1$

Fig.3 Response of the model economy to one-percent shock hitting investment-specific technology



Note: Y-axis: % deviation from steady state; X-axis: quarters ahead. Rise of P2P: $\rho = 0.95$; Pervasive P2P: $\rho = 0.5$; Baseline: $\rho = 1$

Fig.4 Responses of the model economy to one-percent shock hitting price markup