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Deposit Flight and Capital Controls: A Tale from Greece

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Deposit Flight and Capital Controls: A Tale from Greece*

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Abstract

This paper presents an analytical narration of the later stages of the Greek crisis, focusing on two key events that unfolded during 2014-2015 and set Greece apart from other episodes of sovereign debt crises: the risk of Grexit and the imposition of capital controls on the banking sector. To account for them both, we extend the standard small open economy environment along three dimensions. First, we allow for an informal sector. Second, we allow for a richer menu of assets that include cash, which is needed for informal consumption and is costly to hold. Third, we introduce a banking sector that turns households' deposits into capital. We show that a risk of Grexit leads households to run down their deposits to the detriment of bank balance sheets, increase their demand for cash, and increase their consumption whilst reallocating it towards formal goods. As evidenced by the data capital controls mitigate the deposit flight and reinforce the switch of consumption to formality.

Keywords: Capital controls, small open economy, exit from a currency union, cash, informal economy, financial intermediaries, Greece

JEL Classification: E2, E4, F41, G11, G28

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1 Introduction

Amidst growing fears of Grexit that were threatening Greek banks with a deposit dry up and an extraordinary political turmoil, on June 28, 2015 the Greek authorities mandated a series of measures to avoid an uncontrolled bank run, mitigate the risk of Grexit, and stabilize the economy. To prevent euros from flowing out of Greek banks and into overseas financial institutions, foreign currencies, or simply under the mattresses, households were faced with strict limits on daily cash withdrawals, €60 a day per cash card, and businesses were left with a shortage of liquidity to finance purchases of imported intermediate and final goods.

This series of measures have been labelled by the parties involved and the news headlines as *capital controls*, a term which the international finance literature typically attaches to just a subset of the policy tools implemented in Greece. In particular, the literature considers the "defining feature of capital controls as the exclusive application of restrictions to financial transactions between residents and non-residents of an economy, i.e. a discrimination based on the residency of the parties involved in a financial transaction" (p.S27, Korinek and Sandri (2016)). The Greek manifestation (as well as the Cypriot one) of capital controls, however, has extended well beyond the usual "capital inflow-outflow" dimension. With Greek households and firms alike being heavily reliant upon cash, a new, "*domestic*," dimension has gained importance and been reflected upon the cash shortages that domestic agents have suffered. It is precisely this dimension that we deem novel and distinctive, and which we therefore discuss here.

Motivated by these developments that set Greece apart from other episodes of sovereign debt crises, we provide here an analytical narration of the effects of the risk of Grexit and the imposition of capital controls on the domestic banking sector. We approach this task by building a stylized model with detailed macro-financial linkages. Our model is tailored to explain the theoretical channels through which a risk of Grexit and a restriction on cash withdrawals have spilled over to the aggregate economy, whilst at the same time replicate the major features of the Greek data over the period 2014-2015. Two forces seem to have been at play: in the face of a potential exit from the Eurozone ("Grexit") and/or under the threat of outright deposit haircuts, households started running down their deposits and spending

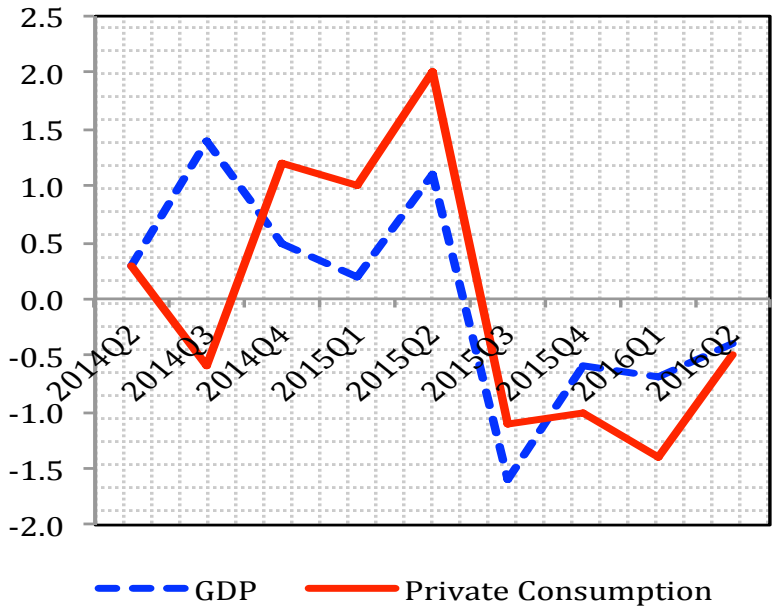
part of them, while the imposed limits on cash withdrawals together with the absence of restrictions on card payments and bank transfers facilitated the reallocation of consumption from the informal to the formal economy.[1]

To this end, we extend the standard small open economy environment along three dimensions. First, we allow for two sectors, a formal one and an informal one. Second, we allow for three assets: capital, deposits and cash. Cash is costly to hold and it is exclusively used for the consumption of goods produced in the informal sector of the economy, and we motivate its use via a cash-in-advance (CIA) constraint. Third, we assign a role to financial intermediaries, which receive deposits from households and turn them into capital in a more efficient way than households.

Fluctuations in the model are driven by two sources of uncertainty: Grexit risk and an exogenous policy of capital controls. We interpret "Grexit risk" as concerns that households may have regarding a potential redenomination, or an outright haircut of their deposits. We model this process as a sequence of negative shocks that uniquely affect the expected return to deposits, but not the realized return, so as to be in line with the data. As a result, a "Grexit shock" only affects the households' consumption and savings decisions, but not their budget constraint. We show that a fear of Grexit leads households to run down their assets, increase their consumption and reallocate it towards formal goods as well as to substitute their savings away from deposits and towards cash and capital. These, in turn, not only cause a switch of capital from the financial intermediaries to households, but also lead to a drop in both the value and the aggregate stock of capital, inflicting thereby financial intermediaries' dividends and lowering aggregate output. In turn, we model capital controls as an increase in the households' cost of holding cash and capital. We show that capital controls bring down cash holdings, inducing thereby a further switch to formality, as well as stabilize the banking sector by preventing deposits from falling further and mitigating the reallocation of capital from financial intermediaries to households. All these results are in line with the stylized facts that have emerged during the post-2014 stages of the still-unfolding Greek sovereign debt crisis.

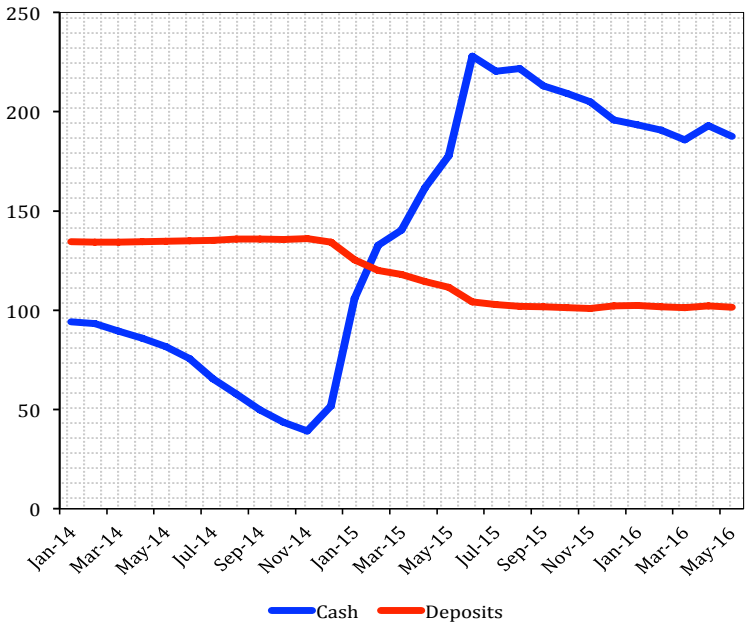
[1]Notably, we abstract from commenting on factors like tourism and low energy prices that may have contributed to amplifying certain mechanisms we propose, such as the resilience of private consumption.

Figure 1: Real GDP and private consumption: Annual percent changes



Notes: The figure presents gross domestic product and household and NPISH final consumption expenditure for Greece, at quarterly frequency, non-seasonally adjusted with 2010 as the base year. Annual percent changes. Source: Eurostat.

Figure 2: Extra cash holdings and deposits in Greece



Notes: The figure presents extra cash holdings (net liabilities related to the allocation of euro banknotes within the Eurosystem, EUR hundreds of millions), and monthly deposits of households and non-profit institutions (EUR billions). Source: Bank of Greece.

We argue that the resilience of the Greek economy in 2015 can in part be attributed to these novel dimensions. In particular, Greek real GDP contracted by just 0.3% in 2015, falling significantly less than forecast after capital controls had been imposed,[2] and its surprising endurance seems to have drawn at least in (good) part upon that of private consumption (see also Figure 1). In particular, private consumption rose by 0.3% in 2015, having performed particularly well in in the first two quarters (Q1: +1.3%, Q2: +2.4%) and been strongly resilient in the final two (Q3: -1.3%, Q4: -1.2%), which followed the imposition of capital controls. This came at a time when households withdrew about 25% of their deposits and the amount of cash in circulation rose to ca 28% of GDP, whereas the Eurozone average is ca 10% (see also Figure 2).[3] Moreover, from November 2014 to June 2015, "extra cash" increased by nearly 5 times, from an amount of 0 in February 2010.[4]

At the same time, there is a large amount of evidence on the effects of capital controls on the informal economy. In particular, based on data from the Bank of Greece, in H2:2015, i.e. right after the enforcement of capital controls, the number of new (debit) cards issued rose by 11.26% (12.9%) vis-a-vis H1:2015, the number of transactions increased by 59% (71%), the value of transactions increased by 12% (14%), while the number of transactions per card increased by 33.3% (41.7%). In addition, in the entire 2015 the number of card transactions increased by 33% and their value by 12% vis-a-vis 2014 (see also Figure 3 as well as Mylonas et al. (2016) for an extensive analysis). Since it is typical of the literature on the informal economy (see, e.g., Schneider et al. (2010), Schneider and Buehn (2012), Rogoff (2016)) to assume that informal activities are facilitated by the use of cash, it follows that the surge in the use of cards must have facilitated a shift from the informal to the formal economy, which is in line with our model's predictions.[5] Finally, the surge in VAT revenues (Figure 4) lends

[2] In July 2015, IOBE, a Greek non-profit research organization, forecast GDP in 2015 to contract by 2-2.5%, the IMF in October 2015 (World Economic Outlook) forecast GDP to contract by 2.3%, and the European Commission in November 2015 (ECFIN (2015)) forecast GDP to contract by 1.4%.

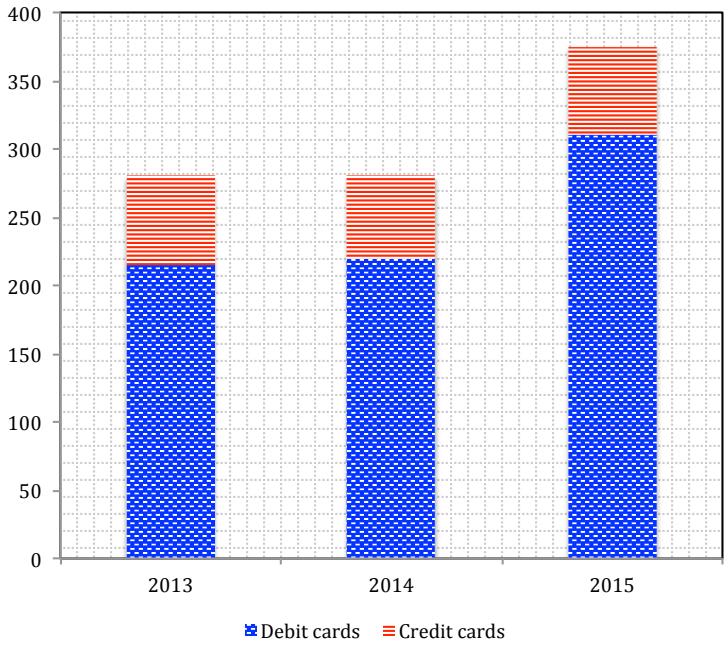
[3] See also Monokroussos et al. (2015) for more details.

[4] "Extra cash" refers to the entry "net liabilities related to the allocation of euro banknotes within the Eurosystem" in the monthly financial statements of the Bank of Greece, which we interpret as the amount of cash needed in excess of the amount allocated normally.

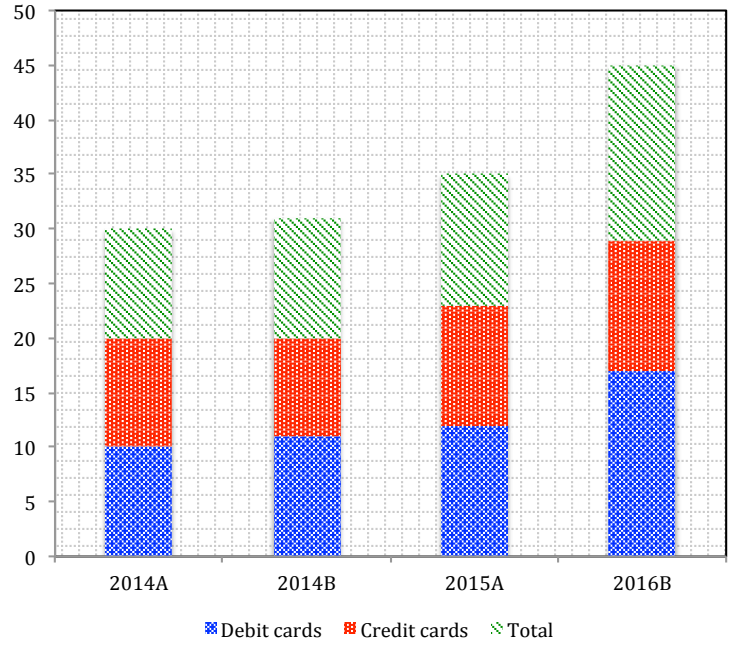
[5] The informal economy as percent of GDP in Greece has been of the highest among OECD countries according to, e.g., Schneider et al. (2010). Likewise, cashless transactions accounted for less than 5% of GDP until 2014 versus an average of 15.5% in the Eurozone (see also Mylonas et al. (2016)). This suggests that there is ample space for a shift from the informal to the formal economy.

Figure 3: Transaction using debit and credit cards

(a) Volume of transactions per card type (millions)



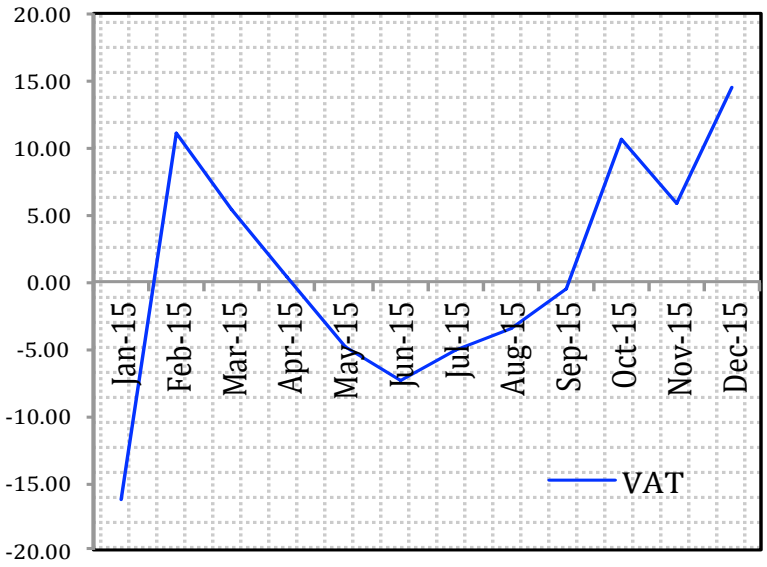
(b) Average number of transactions per card type



Source: Bank of Greece.

further support to the sectoral reallocation the Greek economy underwent (see also Mylonas et al. (2016)).

Figure 4: Revenues from VAT



Source: Greek Ministry of Finance.

This paper comes to complement the recent study by Gourinchas et al. (2016), who estimate a DSGE model in an attempt to account for the causes of the Greek crisis as it developed until 2014. We instead opt to focus on the aftermath of the crisis, that is the period 2014-15, with the renewed fears of Grexit looming and capital controls dominating the headlines.

Our modelling strategy draws on the literature on sudden stops that was pioneered by Mendoza (2001) and developed further by Mendoza (2010), Bianchi (2011), Korinek (2011), Benigno et al. (2012), and Korinek and Sandri (2016) among others (see Korinek and Mendoza (2014) for an overview). The specification of the financial intermediaries' sector in our model builds on insights offered by Gertler and Kiyotaki (2015). Finally, works related to ours that also require a financial asset to facilitate transactions are those of Jaccard (2013) and Grilli and Roubini (1996).

The remainder of this paper is structured as follows. Section 2 presents the model. Section 3 characterizes the equilibrium. Section 4 performs a quantitative analysis and presents the

paper's results. Section 5 concludes.

2 Model

We consider a small open economy populated by a continuum of households, a continuum of financial intermediaries, and a continuum of firms each producing "formal" and "informal" goods; all agents are of unit measure.

2.1 Households

Households supply labor to firms in both sectors, consume formal and informal goods, and can save in three real assets: cash, deposits, and capital.[6]

The households' preferences are given by

$$E_{-1} \sum_{t=0}^{\infty} \beta^t \left[u\left(c_{f,t}, c_{i,t}\right) - v(n_{f,t}) - v(n_{i,t}) \right] \tag{1}$$

where $c_{f,t}$ and $c_{i,t}$ denote consumption of formal and informal goods, and $n_{f,t}$ and $n_{i,t}$ denote labor in the formal and the informal sector. We require $u\left(c_{f,t}, c_{i,t}\right)$ to be increasing in both arguments, quasi-concave, satisfy the Inada conditions, and exhibit constant-relative-risk-aversion (CRRA), $v(\cdot)$ to be increasing and quasi-convex, and both functions must be twice-continuously differentiable.

The period budget constraint is expressed in units of the formal good and is given by

$$c_{f,t} + p_t\, c_{i,t} + m_{t+1} + f(m_{t+1}) + d_{t+1} + k^h_{t+1} + f(k^h_{t+1}) = \sum_{j=\{f,i\}} \left(w_{j,t}\, n_{j,t} + \Pi_{j,t}\right) + m_t + R_t\, d_t + \left(Q_t + 1 - \delta\right) k^h_t \tag{2}$$

Period expenditure is on the LHS of (2). We can see that part of period income is spent on formal and informal goods, where p denotes the relative price of informal goods, and part of period income is saved in cash, deposits, and capital, which we denote by m, d, and k^h, respectively. Saving in deposits, which one can think of as one-period bonds, is costless,

[6] Inflation (of all items less food and energy) has not played a noteworthy role throughout the Greek crisis, hence we opt to express everything in real terms and keep the analysis tractable.

however saving in cash and capital is costly and their respective costs, given by $f(m)$ and $f(k^h)$, could be thought of as reflecting a storage cost in the case of cash and a management cost in the case of capital. We assume that the costs to holding cash $f(m)$ and capital $f(k^h)$ are stochastic and we specify their stochastic processes below. An increase in the values of $f(m)$ and $f(k^h)$ functions as a policy shock, hindering households from saving in cash and capital and, in our setting, is a proxy for the exogenous imposition of capital controls. Period income in turn is on the RHS of (2), and it consists of labor income, firms' profits, and the gross returns to the assets carried over from the period before: the gross return to cash is one, the gross return to deposits is R, and the gross return to capital is $Q + 1 - \delta$, where Q denotes the price of capital and $\delta \in (0, 1)$ its depreciation rate.

Importantly, we assume that households need to hold cash for their purchases of informal goods. As such, we let their informal consumption be subject to a real cash-in-advance constraint:

$$p_t \, c_{i,t} \; \leq \; m_t \tag{3}$$

2.2 Financial intermediaries

Financial intermediaries obtain funds from households in the form of deposits as well as from other sources and lenders, including potentially foreign lenders. They transform them into next-period capital in a one-to-one fashion. Holding (managing) capital is costly to financial intermediaries too, but less costly compared to households, an assumption in line with Gertler and Kiyotaki (2015). Financial intermediaries are risk-neutral and maximize the discounted sum of their expected lifetime dividends:

$$E^f_{-1} \sum_{t=0}^{\infty} \beta^t \, D_t \tag{4}$$

Period dividends are in turn given by

$$D_t \; + \; R_t \, (d_t \; + \; d^o_t) \; + \; f(k^b_{t+1}) \; = \; (Q_t \; + \; 1 \; - \; \delta) \, k^b_t \tag{5}$$

where d^o denotes net borrowing via means other than deposits and $f(k^b)$ denotes the financial

intermediaries' cost to holding capital. The marked-to-market financial intermediaries' assets are on the RHS of (5), while their liabilities are on the LHS of (5).

To simplify matters, we assume that financial intermediaries consume their period dividends entirely, i.e. they do not reinvest them, which lets their problem yield a simple, period-by-period solution. This implies that financial intermediaries start building capital afresh each period, which they finance entirely by borrowing from households and other sources, i.e.

$$k^b_{t+1} \;=\; d_{t+1} \;+\; d^o_{t+1} \tag{6}$$

2.3 Firms

Finally, there are two types of competitive firms in operation, one for the production of the formal good and one for the production of the informal one. The formal-sector firms use capital and labor as inputs, while following Busato and Chiarini (2004) and Pappa et al. (2015) we assume that the informal-sector firms only use labor:

$$y_{f,t} \;=\; \phi(k_t, n_{f,t}) \tag{7}$$

$$y_{i,t} \;=\; g(n_{i,t}) \tag{8}$$

where $k_t \;=\; k^h_t + k^b_t$. We require both $\phi(\cdot)$ and $g(\cdot)$ to be increasing in their arguments, concave and satisfy the Inada conditions.

The firms' profits are then given by

$$\Pi_{f,t} \;=\; \phi(k_t, n_{f,t}) \;-\; Q_t\, k_t \;-\; w_{f,t}\, n_{f,t} \tag{9}$$

$$\Pi_{i,t} \;=\; p_t\, g(n_{i,t}) \;-\; w_{i,t}\, n_{i,t} \tag{10}$$

3 Equilibrium

In equilibrium, (i) households choose their consumption $\{c_{f,t}, c_{i,t}\}$, labor $\{n_{f,t}, n_{i,t}\}$, and asset holdings $\{m_{t+1}, d_{t+1}, k^h_{t+1}\}$, to maximize their expected lifetime utility (1) subject to their budget constraint (2) and the real cash-in-advance constraint given by (3); (ii) financial intermediaries choose capital, deposits, and net borrowing from other sources $\{k^b_{t+1}, d_{t+1}, d^o_{t+1}\}$, to maximize their lifetime dividends given by (4) and (5) subject to their balance-sheet constraint (6); (iii) formal- and informal-sector firms choose the amount of inputs k_t and $n_{f,t}$ and $n_{i,t}$, respectively, to maximize their profits given by (9) and (10); (iv) all markets clear; (v) agents optimize and markets clear at a deposit-elastic interest rate, which we specify below.

The first-order conditions are:

$$u'(c_{f,t}) = \lambda_t \tag{11}$$

$$u'(c_{i,t}) = p_t\,(\lambda_t + \nu_t) \tag{12}$$

$$\nu_t \geq 0 \text{ and } p_t\,c_{i,t} \leq m_t \quad \text{w.c.s.} \tag{13}$$

$$v'(n_{j,t}) = \lambda_t\,w_{j,t}\,,\ j = \{f, i\} \tag{14}$$

$$\lambda_t\,[1 + f'(m_{t+1})] = \beta\,E_t\,(\lambda_{t+1} + \nu_{t+1}) \tag{15}$$

$$\lambda_t = \beta\,E_t\,R_{t+1}\,\lambda_{t+1} \tag{16}$$

$$\lambda_t\,[1 + f'(k^h_{t+1})] = \beta\,E_t\,[\lambda_{t+1}\,(Q_{t+1} + 1 - \delta)] \tag{17}$$

$$f'(k^b_{t+1}) = \beta\,E^f_t\,[Q_{t+1} + 1 - \delta - R_{t+1}] \tag{18}$$

$$Q_t = \phi'_k(k_t, n_{f,t}) \tag{19}$$

$$w_{f,t} = \phi'_{n_f}(k_t, n_{f,t}) \tag{20}$$

$$w_{i,t} = g'(n_{i,t}), \tag{21}$$

where λ and ν are the Lagrange multipliers associated with the budget constraint (2) and the real cash-in-advance constraint (3).

Eqs. (11)-(17) follow from the households' optimization problem. Eqs. (11) and (12) are the households' FOCs with respect to formal and informal consumption. Eq. (13) follows from the real cash-in-advance constraint (3) and it will be binding for all the parametrizations we consider here, which suggests that households are forced to save in cash, i.e. they hold cash only in order to finance their consumption of informal goods.[7] Eq. (14) is the households' FOC with respect to labor, while (15)-(17) are the households' FOCs with respect to their holdings of cash, deposits, and capital. Regarding the latter set of conditions, (16) specifies how much of the formal good households save and, together with (13) and (15), it helps pin down the households' cash holdings, while together with (17) for a given price of capital Q, it helps pin down the amount of capital households hold. Eq. (18) follows from the financial intermediaries' problem and, at given prices, it pins down their capital stock holdings. Finally, eqs. (19)-(21) are the firms' FOCs with respect to their inputs.

Turning to market clearing, the market-clearing conditions of the informal- and the formal-good markets are given by

$$c_{i,t} = y_{i,t} \tag{22}$$

[7] To see this, use eqs. (15) and (17) and note that, for the real cash-in-advance constraint to be binding in the steady state, it has to be that $\beta\left(Q_{ss} + 1 - \delta\right) - f'(k^h_{ss}) > \beta - f'(m_{ss})$, where the LHS is the net marginal benefit of investing in an extra unit of capital in the steady state and the RHS is the net marginal benefit of investing in an extra unit of cash. That is, for the real cash-in-advance constraint to be binding, households must prefer to save in capital than cash. Along these lines, the real cash-in-advance constraint is binding (in expectation) when the expected return to capital exceeds that to cash, which will always be true for the parameters we choose here.

$$D_t + R_t\, d_t^o + c_{f,t} + m_{t+1} + f(m_{t+1}) + d_{t+1} + k_{t+1}^h + f(k_{t+1}^h) + f(k_{t+1}^b) = y_{f,t} + m_t + (1-\delta)\, k_t \tag{23}$$

The market-clearing condition of the formal-good market (23) follows from the households' budget constraint (2) after taking into account the financial intermediaries' dividends given by (5), the profit functions (9) and (10), and the market-clearing condition of the informal sector (22). Of the remaining market-clearing conditions, we need the financial intermediaries' balance-sheet constraint (6) to pin down net borrowing from sources other than deposits.

Finally, following Schmitt-Grohe and Uribe (2003) we let a deposit-elastic interest rate close the model (and induce stationarity). The deposit-elastic interest rate is given by

$$R_{t+1} = \overline{R} + \psi * (e^{\overline{d} - d_{t+1}} - 1) + \xi_t \tag{24}$$

where $\overline{R} = 1/\beta$ is the steady-state value of the interest rate which follows from (16), $\overline{d}$ denotes the steady-state level of deposits, and ψ parametrizes the elasticity of the interest rate with respect to deviations of deposits from their steady-state level. It follows from (24) that when the level of deposits falls below its steady-state value, financial intermediaries become less solvent and households demand a real interest-rate premium in return, which increases in the value of ψ.[8]

Importantly, we also introduce a stochastic term ξ_t which follows an AR(1) process. Negative realizations of ξ push the interest rate below its steady-state level, and we will interpret them as (part of) a Grexit shock. We become more precise about this in the following section.

4 Quantitative Analysis

In this section we undertake a quantitative analysis of the model in order to illustrate its key mechanisms. We do so by exploring the response of the economy to exogenous shocks that replicate the effects of an anticipation of Grexit and the imposition of capital controls in the

[8] This is in line with Schmitt-Grohe and Uribe (2003). In our case, households assume the role of foreign lenders and deposits should be thought of as bonds (minus debt in theirs).

Greek economy as outlined in the Introduction.

4.1 Functional forms and calibration

We let the functions $u\left(c_{f,t}, c_{i,t}\right)$ and $v(n_{j,t})$ in the period utility (1) assume the following forms:

$$u\left(c_{f,t}, c_{i,t}\right) = \frac{\left\{\left[\omega\, c_{f,t}^{\frac{\eta-1}{\eta}} + (1-\omega)\, c_{i,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}\right\}^{1-\gamma}}{1-\gamma} \text{ and } v(n_j) = \frac{n_{j,t}^{1+\zeta}}{1+\zeta} \text{ with } \mathrm{j} = \{\mathrm{f}, \mathrm{i}\},$$

where $\omega \in (0,1)$ denotes the weight of formal goods in the households' consumption basket, $\eta > 0$ denotes the elasticity of substitution between formal and informal goods, and $\zeta > 0$ denotes the inverse Frisch labor elasticity.

In addition, we fix $\phi(k_t, n_{f,t}) = k_t^{\alpha}\, n_{f,t}^{1-\alpha}$ and $g(n_{i,t}) = n_{i,t}^{\theta}$, where $\theta \in (0,1]$ and we let the cost to holding cash and capital be given by $f_s(s) = a_s \frac{s^2}{2}$, where $a_s > 0$ and $s = \{m, kh, kb\}$. We assume that α_m follows an AR(1) process, with drift equal to $\overline{\alpha}_m$ and persistence given by ρ_m. Shocks to this process are policy shocks and we will use positive values of them, which increase the cost to holding cash, to replicate the effects of capital controls.

The calibrated parameters for our quarterly model can be seen in Table 1. Following standard parameterizations in the literature (see, e.g., Mendoza (1991)), we set the coefficient of relative risk aversion to 2, the Frisch elasticity of labor supply to 0.5, the discount factor to 0.99, the depreciation rate of capital to 0.025, and the capital share in the formal sector to 0.36. The share of formal goods in consumption ω is set to 0.7, which is broadly in line with the 28% size of the Greek shadow economy (as a % GDP) found in Bitzenis et al. (2016). Regarding the values reflecting the cost to households of holding cash $\overline{\alpha}_m$ and capital $\overline{\alpha}_{kh}$, we choose them to target a share of cash-to-household assets of 1% and deposits-to-household assets of 98%. Regarding the value reflecting the cost to financial intermediaries of holding capital α_{kb}, it is such that the capital stock in the steady state is nearly entirely (in particular, 99.5%) held by financial intermediaries rather than households, which is in line with Gertler and Kiyotaki (2015). Finally, the deposit-elastic interest rate parameters $\{\overline{d}, \psi\}$ are set to

Table 1: Parameter values

Symbol	Value	Description
β	0.99	Discount factor
ζ	0.5	Inverse Frisch elasticity of labor supply
γ	2	Coefficient of relative risk aversion
ω	0.7	Share of formal goods in consumption basket
η	2	Elasticity of substitution between formal and informal goods
δ	0.025	Depreciation rate of capital
α	0.36	Capital share in formal sector
θ	0.7	Labor share in informal sector
α_{kb}	0.00025	Cost to financial intermediaries of holding capital
$\overline{\alpha}_{kh}$	0.05	Cost to households of holding capital in steady state
$\overline{\alpha}_{m}$	0.05	Cost to households of holding money in steady state
$\{\overline{d}, \psi\}$	{20, 0.001}	Deposit-elastic interest rate

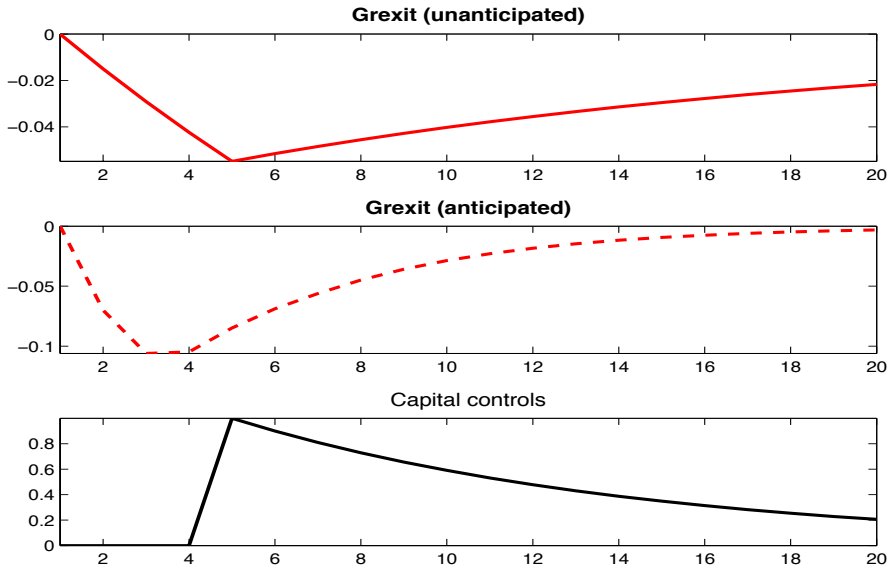
obtain a response of deposits following an anticipated "Grexit" shock that is in line with the evidence laid out in the Introduction, namely a decline by roughly 20% in real terms after 3 quarters (average monthly inflation in 2015 was -1.7%). It follows that the lower the value of ψ, the more deposits respond.

4.2 Simulation experiment

We first explore the response of the economy to a sequence of negative ξ shocks to the interest rate (24), which we interpret as a "Grexit shock." Crucially, we assume that the Grexit shock is a sequence of shocks that affect negatively only the real interest rate that households expect, not the realized one. By doing so, we let a Grexit shock affect the households' savings and consumption decision (Euler equation (16)) but not their budget constraint (2), which is in line with the evidence. Further to this, we assume that a negative interest-rate shock does not affect the financial intermediaries' decision, captured by (18), either. This is so because we implicitly assume that after a potential Grexit both the assets (capital) and the liabilities (deposits, other borrowing) of the financial intermediaries would be denominated in a new currency, turning Grexit into a mere accounting issue for the financial intemediaries and thus leaving their decision unaffected. Finally, we model the risk of Grexit as an independent, exogenous process since it is widely perceived to have been

caused by factors that remain exogenous to our model, e.g., Greece's debt sustainability, political stability etc. We experiment with two different specifications for the Grexit shock, taking the forms shown in Figure 5: in the top panel we consider a series of stochastic shocks that hit the economy for four consecutive periods, with persistence $\rho_\xi = 0.93$. In the middle panel, we consider an anticipated version[9], whereby households have perfect foresight over the path of the shock. It is designed to hit the economy for six periods and has persistence $\rho_\xi = 0.8$.

Figure 5: Calibration of shock processes



Notes: One period corresponds to one quarter. % deviations from the steady state.

Next, we perform a different set of experiments, this time exploring the response of the economy, first, to a one-off unanticipated positive shock to the cost of holding cash α_m and, second, to both a one-off unanticipated positive shock to the cost of holding cash α_m and to the cost of holding capital α_{kh}. Via these experiments we wish to model the difficulty with which households turn their deposits into cash in the former case, and both cash and capital in the latter one. These shocks reflect the key and distinctive domestic dimension of the Greek episode of capital controls, and we therefore label them "capital controls shocks." They have a size equal to 0.3 and persistence $\rho_m = 0.8$ and are shown in the bottom panel

[9] An anticipated Grexit shock is effectively a news shock as in Beaudry and Portier (2004) and the pertinent literature.

of Figure 5. We have calibrated their size and persistence to obtain a fall in cash holdings of roughly 25% in the same period, which is consistent with the data.

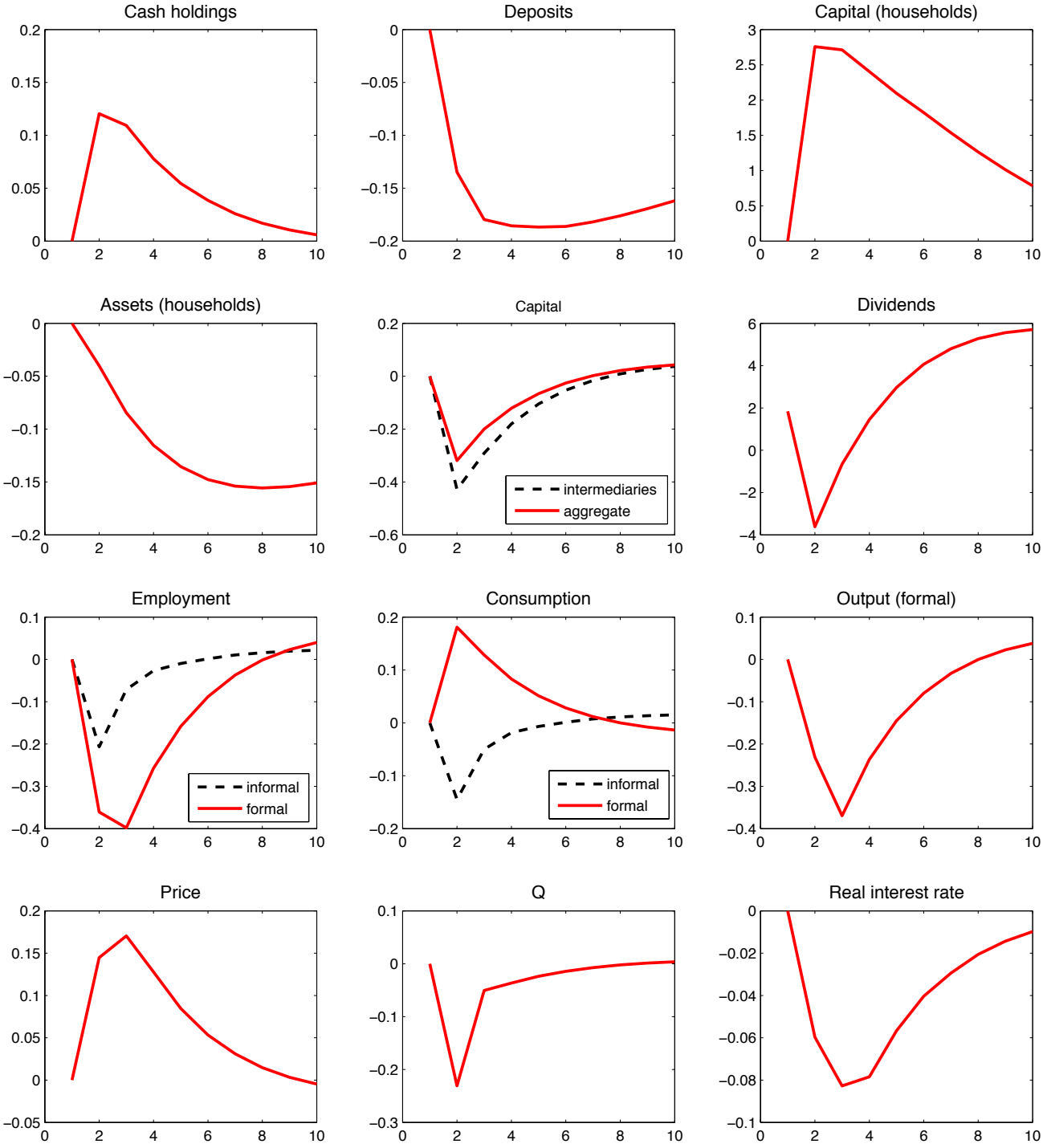
4.3 Results

Figures 6 and 7 plot the response of the economy's key variables to a Grexit shock. As expected, in response to a Grexit shock, households run down their deposits and reallocate their savings towards cash and capital, whose holdings they increase substantially. Households' total asset holdings (i.e. the sum of deposits, cash and capital), however, fall because of the lower expected return to saving and, instead, households increase their consumption and reallocate it towards that of formal goods, which also appears in market-clearing condition (23). This is important as it is formal consumption that GDP accounts for. Informal consumption, on the other hand, falls despite the households' increased cash holdings and this is because a higher amount of cash results in a less tight cash-in-advance constraint which, as we can also see from eqs. (11) and (12), causes the relative price of informal goods to increase. Employment, formal and informal alike, falls and so does the price of capital, which leads financial intermediaries to lower their capital holdings and suffer lower dividends. Since capital is mainly held by financial intermediaries, its aggregate level falls too, causing formal output to fall further.

Figure 8 plots the responses following a capital control shock targeting only the cost of holding cash. We see that as soon as it hits, households lower their cash holdings and reallocate their savings towards capital. This results in a less tight cash-in-advance constraint, reflected in a lower relative price of informal goods, whose consumption falls—and, consequently, so does informal employment. The financial intermediaries' dividends increase whereas, importantly, all the other variables remain fairly stable, except for formal consumption which increases slightly.

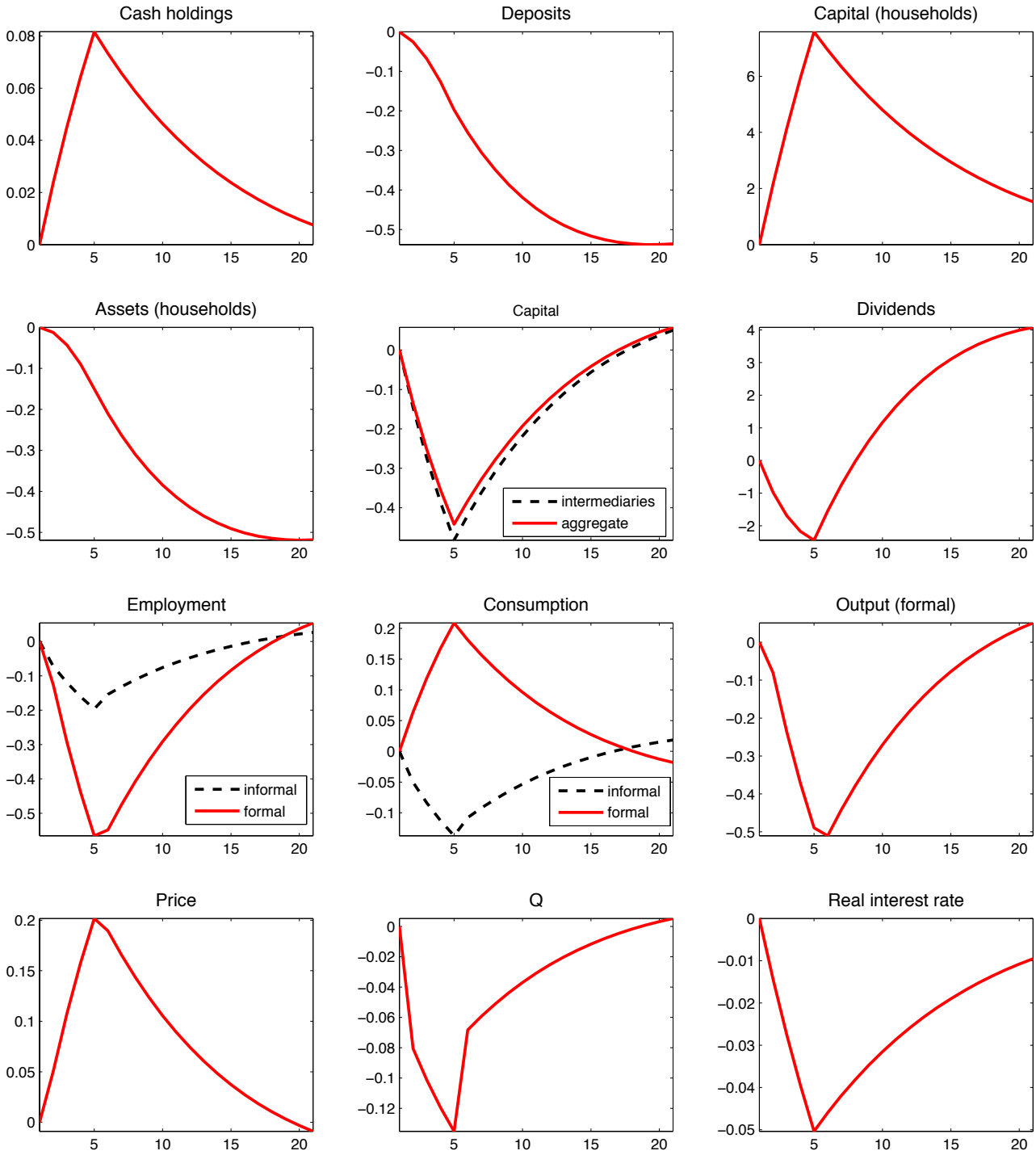
Figure 9 plots the responses following a capital control shock targeting both the cost of holding cash and the cost of holding capital, i.e. effectively targeting the difficulty with which households can convert their deposits into cash and capital. Consequently, as soon as the capital controls shock hits, households lower both their cash and capital holdings substantially, and reallocate their savings towards deposits.

Figure 6: Simulation following an anticipated GREXIT shock



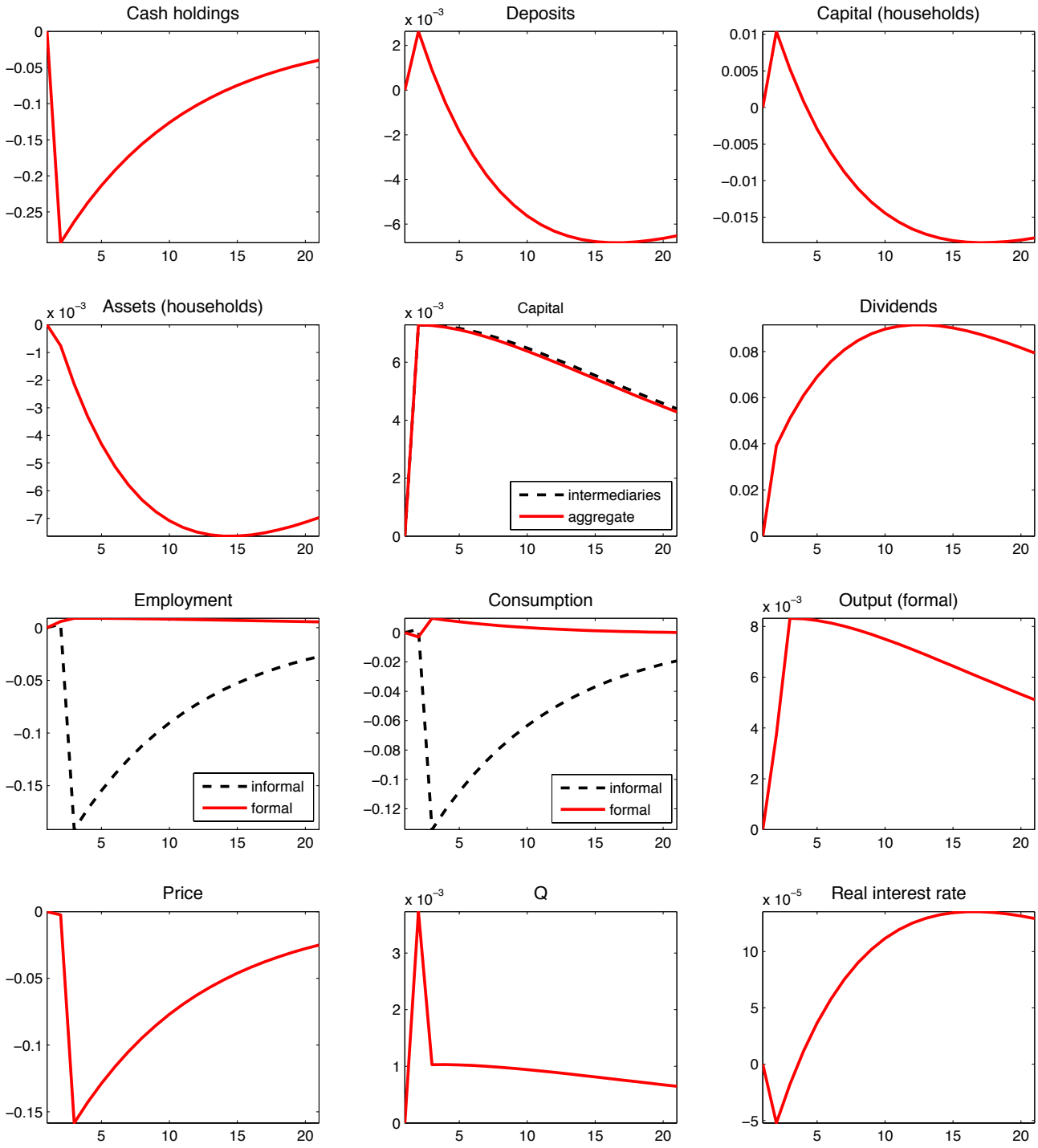
Notes: One period is a quarter. All variables are reported in % deviations from their steady state.

Figure 7: Simulation following an unanticipated GREXIT shock



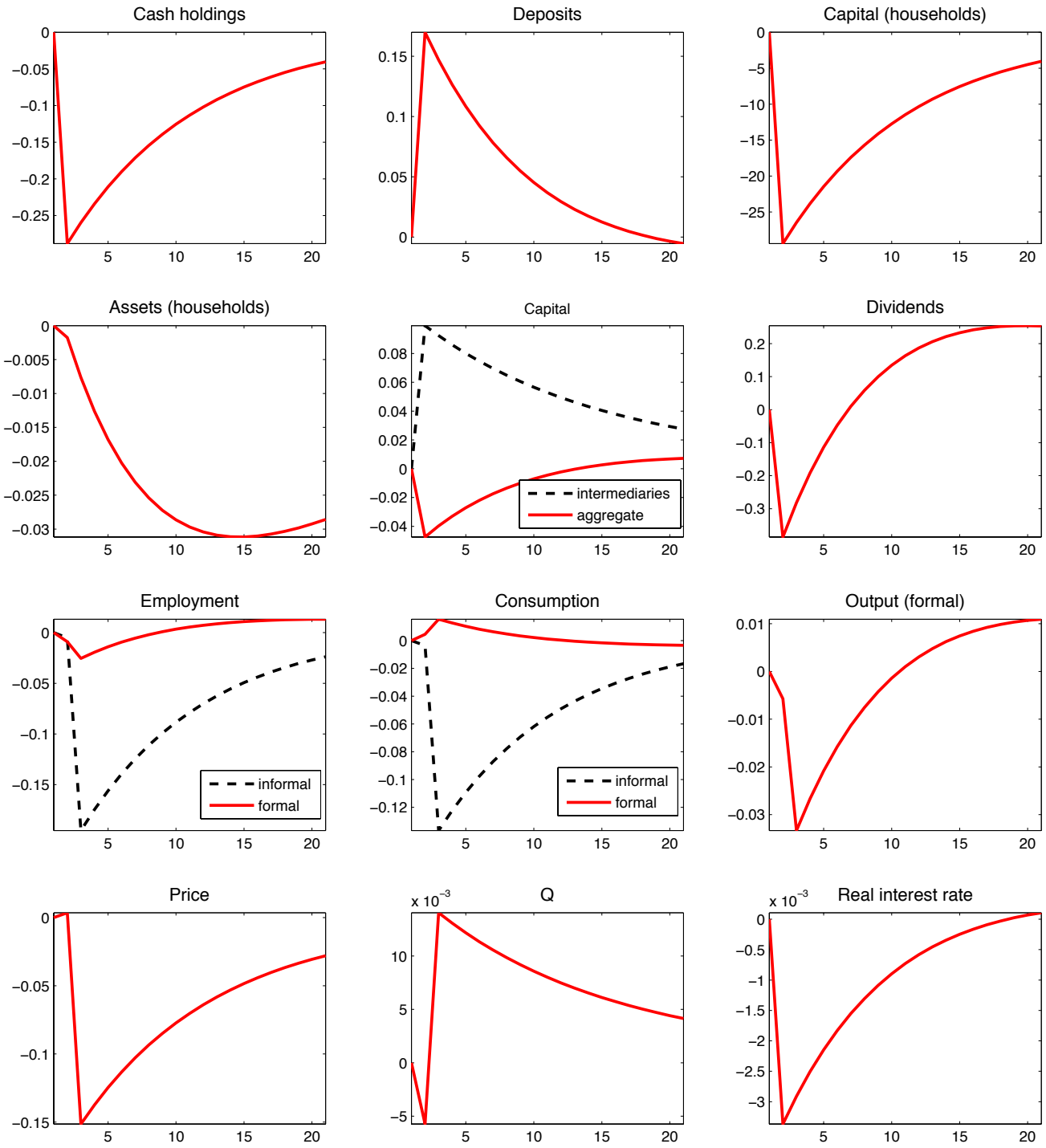
Notes: One period is a quarter. All variables are reported in % deviations from their steady state.

Figure 8: Simulation following a Capital Controls shock - cost of holding cash



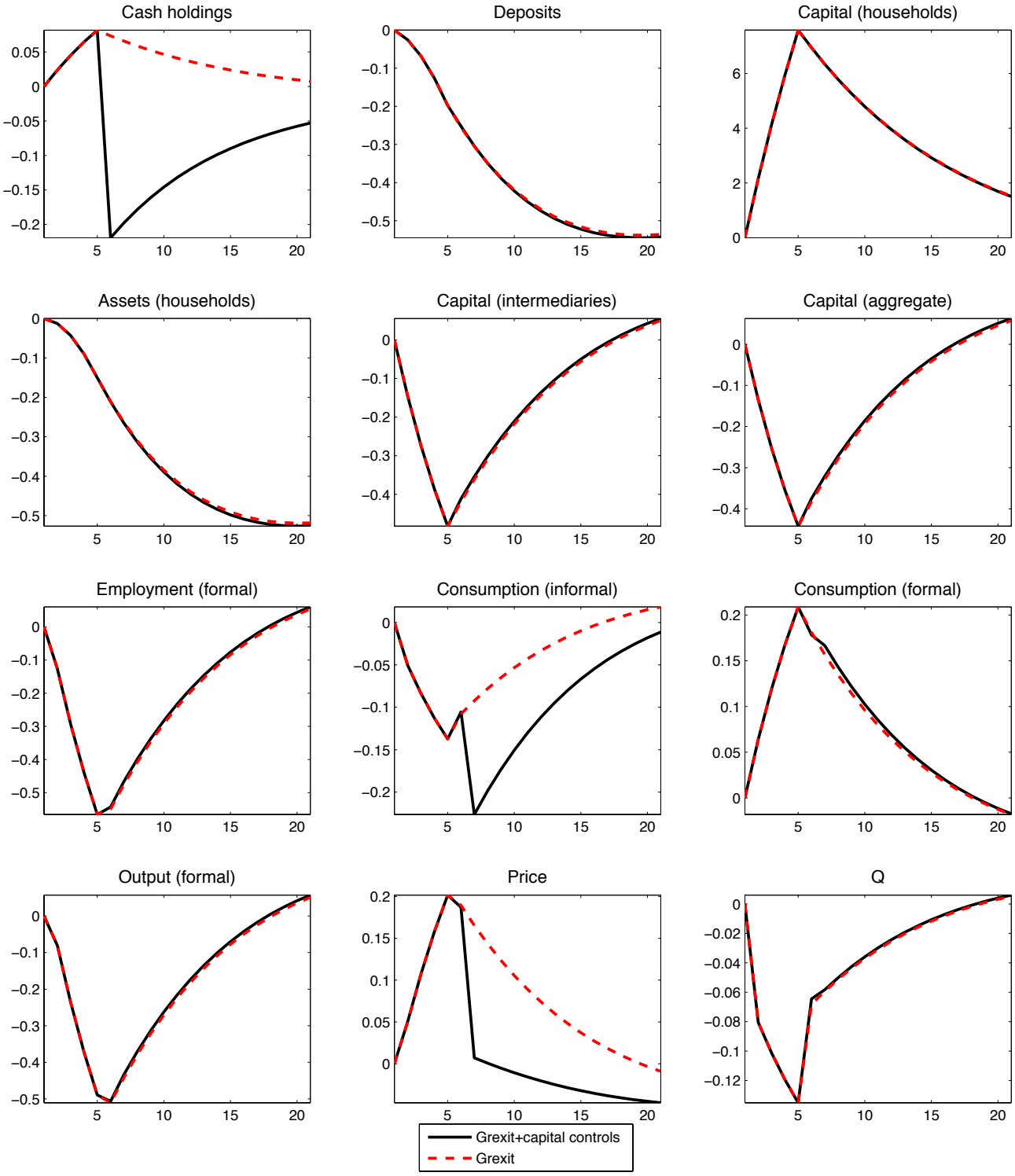
Notes: One period is a quarter. All variables are reported in % deviations from their steady state.

Figure 9: Simulation following a Capital Controls shock - cost of holding cash and capital



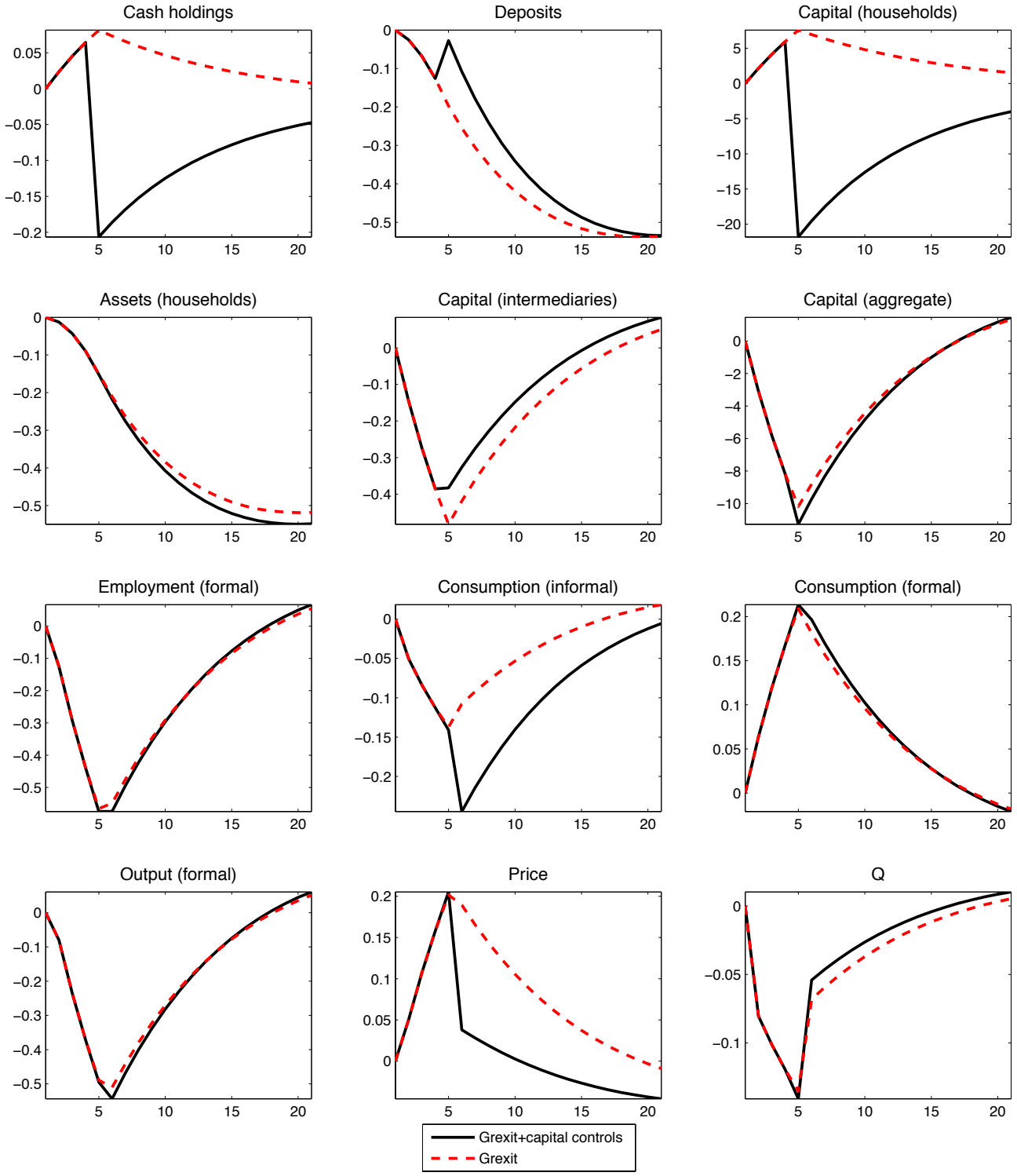
Notes: One period is a quarter. All variables are reported in % deviations from their steady state.

Figure 10: Simulation following both a GREXIT and a Capital Controls shock - cost of holding cash



Notes: One period is a quarter. All variables are reported in % deviations from their steady state.

Figure 11: Simulation following both a GREXIT and a Capital Controls shock - cost of holding cash and capital



Notes: One period is a quarter. All variables are reported in % deviations from their steady state.

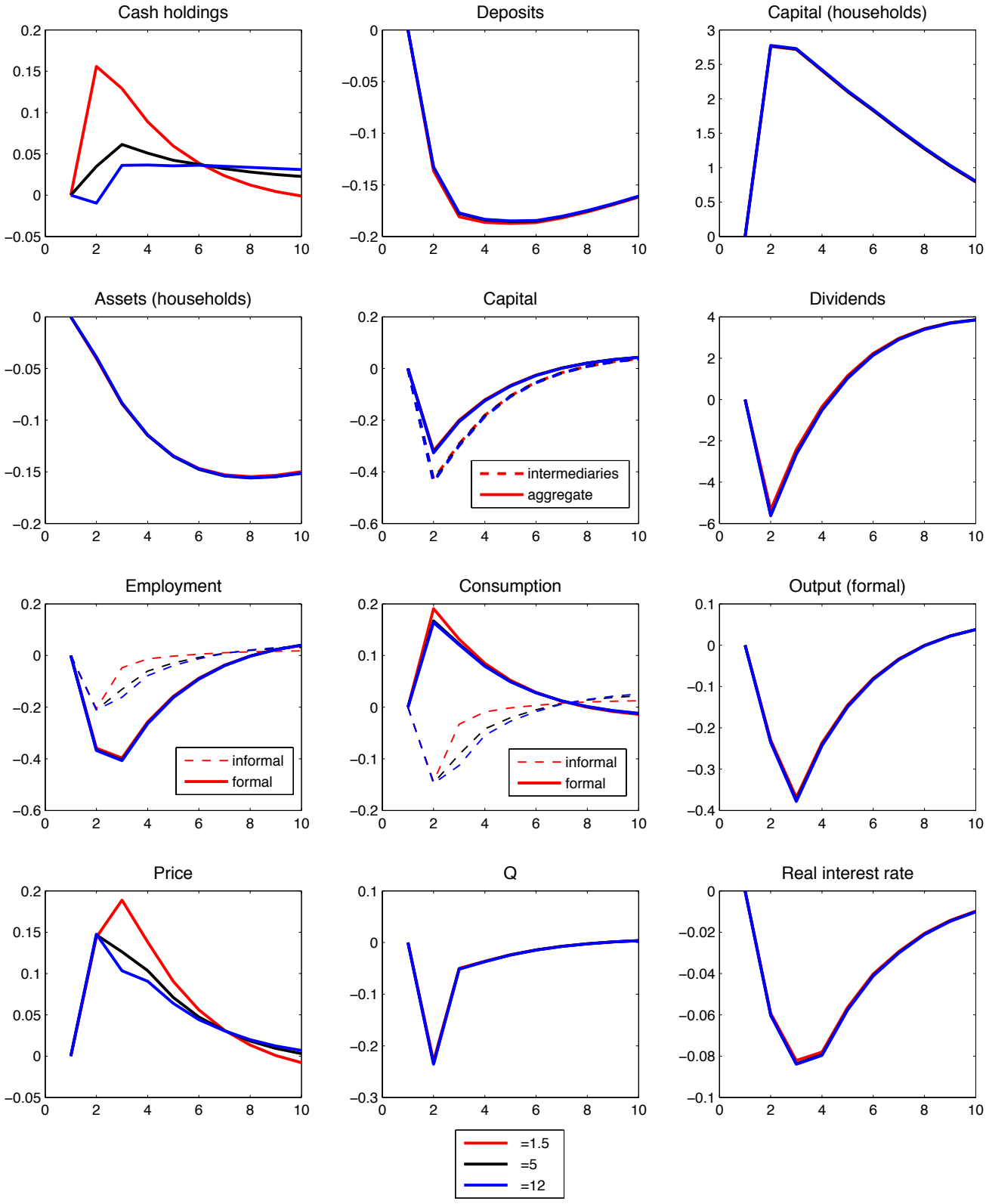
For the reasons outlined above, the relative price of informal consumption falls and so does informal consumption, while formal consumption increases moderately. Despite the increased amount of capital held by financial intermediaries, aggregate capital falls, causing output to also fall. All the other variables remain fairly stable, except for the financial intermediaries' dividends which fall because the substantial increase in deposits does not match that of the value of their capital stock.

Figures 10 and 11 bring the previous experiments together. We allow then for both a Grexit shock and a capital controls shock in order to mimic the economic environment in Greece in 2015 when, amid growing fears of Grexit, capital controls were imposed in order to prevent an uncontrolled bank run. In particular, we consider an unanticipated Grexit shock that hits in period 1 and a capital controls shock that hits in period 5 (see Figure 5 for the shock paths), with capital controls only referring to the cost of holding cash in the experiment shown in Figure 10 and both cash and capital in that shown in Figure 11. As can be seen from Figure 10, relative to a baseline of Grexit, the primary effect of the exogenous policy of capital controls when it only targets the cost of holding cash is to mitigate the surge in cash and lower the consumption of informal goods. More interestingly though, Figure 11 shows that, when capital controls affect the costs of holding both cash and capital, i.e. the cost of converting deposits into cash and capital, the financial sector of the economy gets stabilized as intended, again relative to a baseline of Grexit: the surge in cash is mitigated, the reallocation of capital from financial intermediaries to households is hindered, and the decline in deposits is dampened. In addition, a further switch to formality is incentivized, while all the remaining variables remain fairly stable.

4.4 Sensitivity

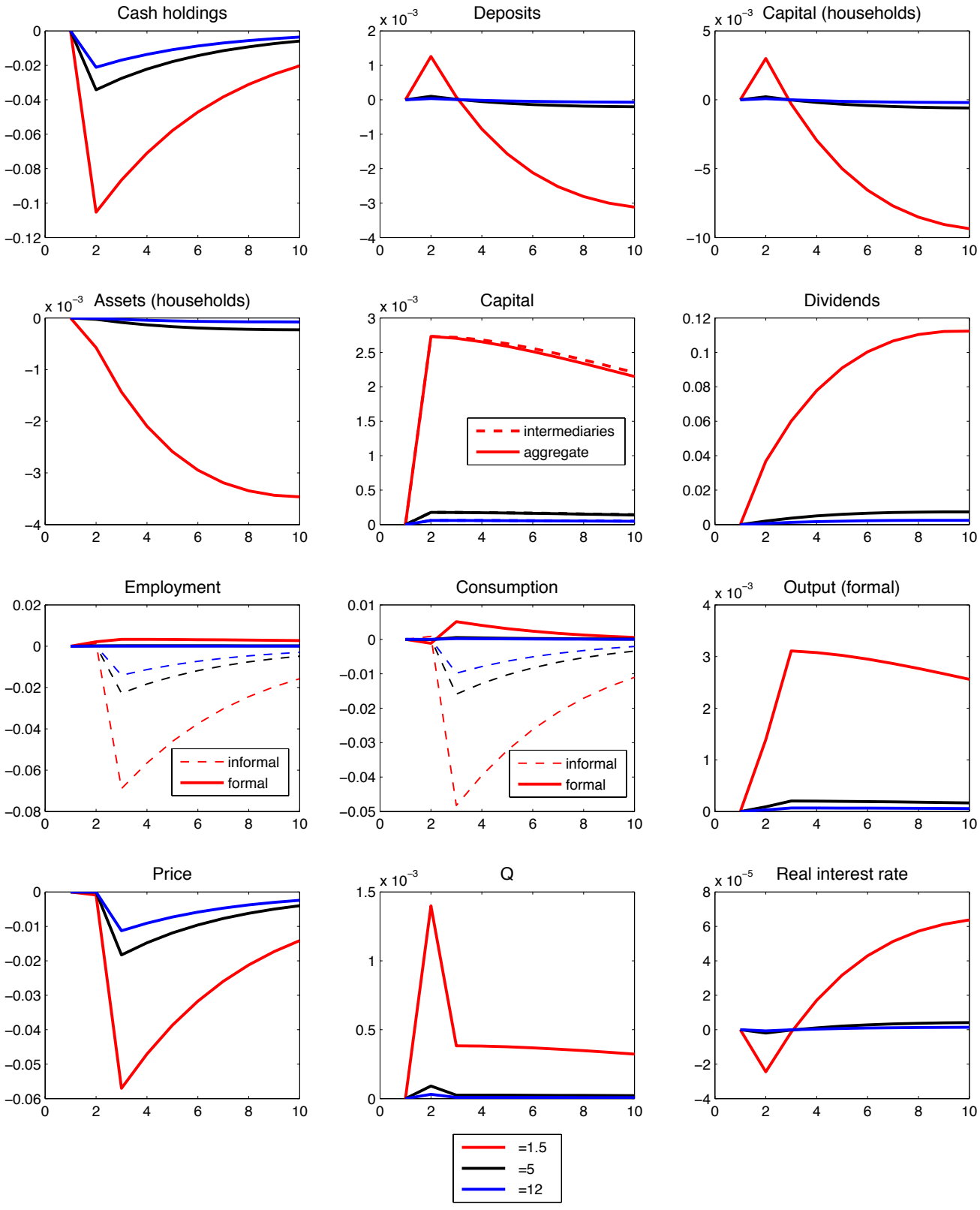
We repeat our experiments in Section 4.2 for different values of η, which measures the elasticity of substitution between formal and informal goods. This elasticity affects the dynamics of formal and informal consumption and its value is key in replicating the stylized facts on private consumption reported in the Introduction. With no loss of generality, in this exercise we restrict attention to an anticipated Grexit shock and a capital controls shock that only affects the cost to holding cash.

Figure 12: Impulse responses following a GREXIT shock for different values of η



Notes: One period is a quarter. All variables are reported in % deviations from their steady state with the exception of dividends, which are reported as absolute deviations from their steady state.

Figure 13: Impulse responses following a Capital Controls shock (cost of holding cash) for different values of η



Notes: One period is a quarter. All variables are reported in % deviations from their steady state with the exception of dividends, which are reported as absolute deviations from their steady state.

In the case of a Grexit shock (Figure 12), as η increases, cash holdings increase by less (or can even fall) as households can rely less on informal goods, whose relative price increases by less and consumption falls more. Formal consumption in turn increases by less—even though it remains fairly stable—reflecting in part households' lower labor income. Deposits and all the remaining variables are insensitive to changes in η.

Under a capital controls shock (Figure 13), a higher η implies that cash holdings need to drop less again because households rely less on informal goods, whose consumption and relative price also fall less. Interestingly, the lower η is, the more dividends increase, which implies that capital controls are needed the most when households find it hard to substitute their consumption away from informal goods and are therefore more cash-reliant. All the remaining variables are insensitive to changes in η.

5 Conclusion

This paper formalizes the later part of the Greek crisis, which was characterized by the heightened fears of an exit from the Eurozone and culminated in the imposition of capital controls. We are able to reproduce and account for a number of stylized facts: the deposit dry up and the surge in cash holdings, the increase in consumption and its reallocation from the informal to the formal sector which, at least in part, underscored the resilience of the Greek economy in 2015, the reallocation of capital from financial intermediaries to households as well as the subsequent fall in the price and the aggregate stock of capital and the squeeze of the financial intermediaries' dividends. We are able to do so by extending the standard small open economy model to allow for both a formal and an informal sector, a richer set of assets including cash, and financial intermediation.

A full-blown empirical assessment of the later parts of the Greek crisis and the optimal design of capital controls in a currency-union member country can be interesting follow-ups.

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