Endogenous Liquidity Constraints and Domestic Capital Controls in a Small Open Economy *

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Abstract

Inspired by the recent imposition of domestic capital controls on the Greek economy, this paper studies the effects of endogenously binding liquidity constraints in an economy with real money holdings. Building on a standard small open economy environment with two sectors (tradables and nontradables) and one real asset serving as a medium of exchange, we incorporate a liquidity constraint that binds following a shock that characterizes a *domestic* capital control regime. Such a shock causes agents to raise their money holdings and reduce their consumption of tradable goods in view of scarce liquidity in the future. Our model captures several stylized facts of the Greek economy in 2015:Q3, in particular the appreciation in the real effective exchange rate as well as the increase in net exports. The model also introduces a novel pecuniary externality, which arises due to the agents' inability to internalize the effects of their real money holdings on the movement of the real exchange rate.

Keywords: Endogenous liquidity constraints, capital controls, financial markets, Greece, open economy macroeconomics.

JEL Classification: E21, E23, E32, E44 , F32, F38, F41

*The views expressed are those of the authors and do not necessarily reflect those of the European Commission. All errors are our own.

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1 Introduction

Following a long period of financial instability, on June 28, 2015 the Greek government mandated a series of measures as a prudential policy tool to prevent euros from flowing out of Greek banks and into overseas financial institutions, foreign currencies, even from being stashed under the mattress. For the duration of this regime households were faced with strict limits on daily cash withdrawals, €60 a day, and businesses were left with a shortage of liquidity to finance purchases of imported intermediate inputs and final goods.

This series of measures have been characterized in the press and in the public debate as *capital controls*, a term which in the international finance literature alludes to only a subset of the policy tools implemented in the Greek economy. In particular, the academic 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.2,Korinek and Sandri [2014]). Other studies, which interpret capital controls along the same lines are Aizenman and Binici [2016] among others. For a review of recent practices see Eichengreen and Rose [2014].

However, the Greek manifestation (as well as that of Cyprus) of these policies has concentrated on the *domestic* side, with a significant focus on preserving the stability of domestic financial institutions. This was attained through the imposition of strict limits on withdrawals from the Greek banking system suggesting that the differentiation based on residence is still valid. However an additional dimension has now gained importance: the benefits of financial stability have come at the cost of liquidity shortages for domestic agents —households and firms alike.

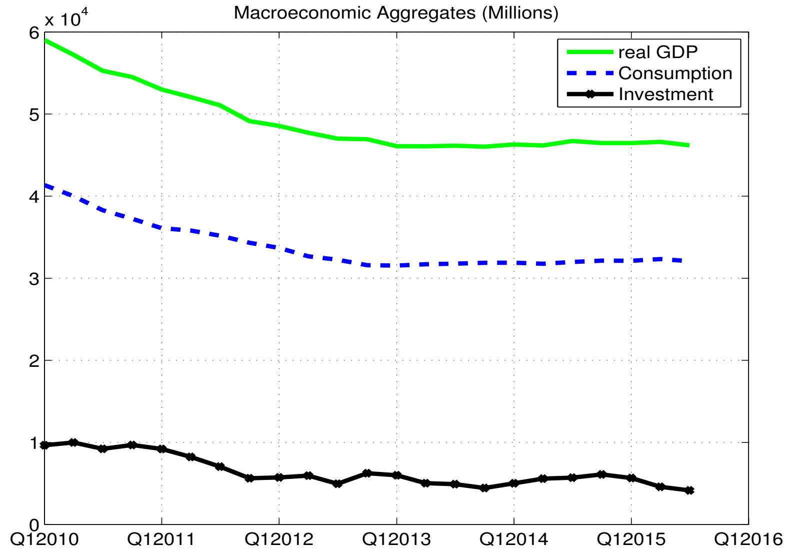
In light of these disturbances in the market for liquidity that the Greek episode of capital controls induced, this paper attempts to explain the behavior of the economy at a time when liquidity becomes scarce. Its focus is on the domestic significance of 'capital controls', and in order to keep a terminological consistency with the literature, we propose the term *domestic capital controls* to characterize the regime of a reduction in liquidity.

We approach this question by building on a standard small open economy environment with two sectors (tradables and nontradables) and one real asset which, in our case, serves as a medium of exchange. This medium of exchange, interpreted as money holdings, faces an exogenous depreciation rate, akin to inflation, and is subject to an endogenous and occasionally binding constraint on the totality of consumption goods. The liquidity constraint requires the agents' consumption expenditure in period t not to exceed a stochastic proportion of their money in period $t+1$. A shock which causes the liquidity constraint to bind is interpreted in the model as the imposition of a 'domestic capital control regime' and causes agents to raise their money holdings and reduce their consumption of goods in view of scarce liquidity in the future. A similar framework to ours with regards to the assumption that a financial asset is needed to facilitate transactions can be found in Jaccard [2013] as well as in Grilli and Roubini [1993].

Our model is inspired by the literature on sudden stops and occasionally binding borrowing constraints pioneered by Mendoza [2002] and developed further by Mendoza [2010], Bianchi [2011], Korinek [2011], Benigno et al. [2012], Korinek and Mendoza [2013], Korinek and Sandri [2014] among others. Our key departure from this literature is the substitution of real money holdings in the place of debt. As such, the only intertemporal decision agents in our framework make is to choose state-contingent paths for their medium of exchange. Accordingly, we also redefine the endogenous collateral constraint present in such models by specifying an endogenous liquidity constraint. The latter comprises a pecuniary externality, which arises due to the agents' inability to internalize the effects of their real money holdings on the movement of the real exchange rate.

On the policy front, our framework is able to capture several stylized facts that have emerged since the onset of the sovereign debt crisis in Greece during the period 2010-2012 as well as the more recent times since the imposition of domestic capital controls in the final two quarters of 2015. The latest sectoral data available suggest that domestic capital controls are producing supply shortages in the manufacturing sector, particularly in industries such as wearing apparel, leather and related products, repair and installation services of machinery and equipment, as well as in the mining and electricity sectors (see Figure 8 in Appendix). These sectoral value-added inputs in Greece are imported components of real GDP, and we can capture such a decline in imported goods by specifying a liquidity constraint that is

Figure 1: GDP, Private Consumption, and Investment



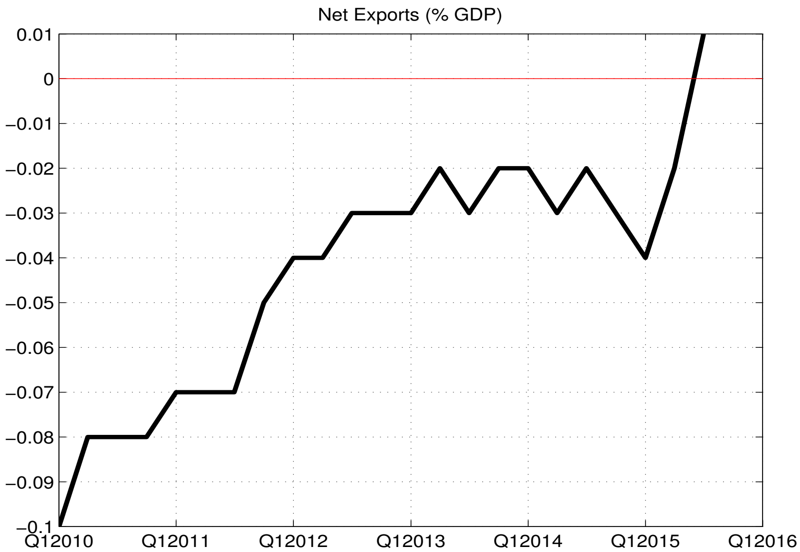
present on both tradable and nontradable goods and its tightening endogenously affected by the movement in the real exchange rate.

Furthermore, we can also replicate a number of more general data patterns pertaining to the recent growth slowdown in Greece as well as the movement of key price indicators. Figures 1 - 4 refer to the Greek economy from 2010:Q1 until 2015:Q3 and comprise data around the period of the first bailout package that was agreed in 2010:Q2, the second bailout package that was agreed in 2012:Q2, and the third bailout package that was agreed in 2015:Q2. Capital controls were implemented in June 2015.[1] We can see from Figure 1 that the Greek GDP, private consumption, and investment fell over the course of the crisis, while the implementation of capital controls seems to have only affected investment significantly with a reduction of approximately 10% in 2015.

Figure 2 shows that the net exports/GDP ratio has increased over the course of the crisis, and it responded particularly strongly to the implementation of capital controls, with an increase in approximately 0.06 percentage points in the last two quarters of 2015. This pattern is interestingly similar to the one observed in emerging markets during sudden stop

[1] For further stylized facts on the Eurozone related to government debt see Grauwe and Ji [2013], whereas for further empirical evidence on the effect of the Greek bailout on domestic banks see Mink and de Haan [2013].

Figure 2: Net Exports/GDP



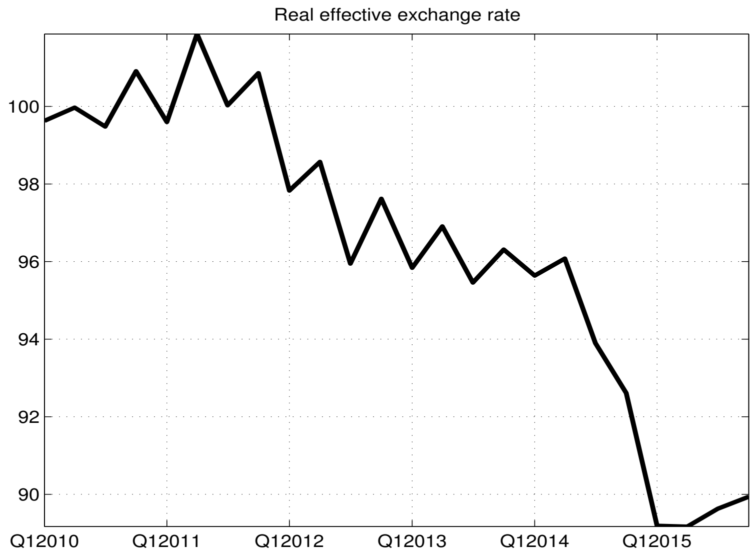
Notes: The data in Figures 1 and 2 are collected from the Hellenic Statistical Authority, they are Greek quarterly, seasonally adjusted, and span the period 2010:Q1-2015:Q3 with 2010 as the base year. The data can be accessed here: http://www.statistics.gr/statistics/-/publication/SEL84/2015-Q3.

episodes (see, for instance, Korinek and Mendoza [2013] and Benigno et al. [2015]).

What we find noteworthy is the response of the Greek real exchange rate, which is captured by Figure 3. We can see that, even though the real exchange rate index depreciated considerably over the course of the crisis, it has appreciated since the implementation of capital controls from around 88 to 90, a pattern closer to the one observed in advanced economies during sudden stop episodes (see again Korinek and Mendoza [2013]).

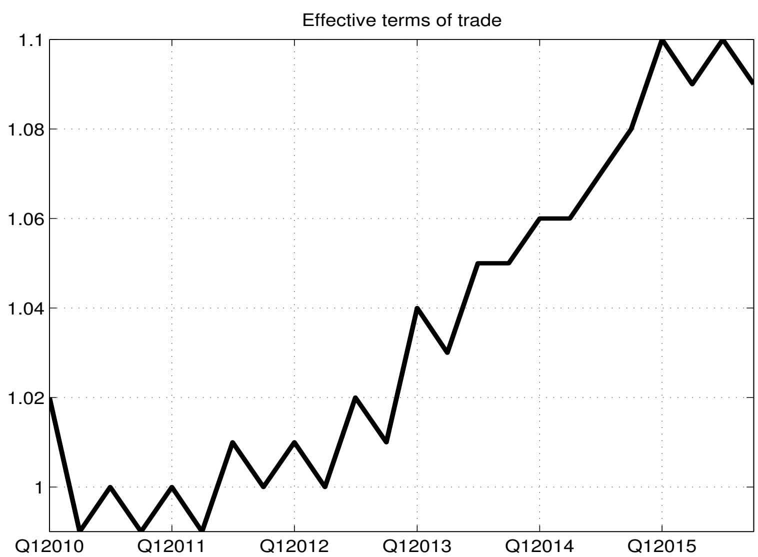
Finally, Figure 4, which plots the evolution of the Greek terms of trade over the course of the Greek crisis, provides further support for our story: it manifests that capital controls have not had a negative effect on the Greek terms of trade, which have even moderately improved over the course of 2015.

Figure 3: Real Effective Exchange Rate



Data collected from the Bank for International Settlements (BIS). The row data are Greek monthly and span the period 2010:Jan-2015:Nov with 2010 as the base year. The plot indicates quarterly averages, and for 2015:Q4 the quarterly average reflects the 2015:Oct and 2015:Nov monthly ones. An increase indicates an appreciation. The data can be accessed here: http://www.bis.org/statistics/eer.htm.

Figure 4: Effective Terms of Trade



Data collected from the Bank for International Settlements. The row data are Greek monthly and span the period 2010:Jan-2015:Nov with 2010 as the base year. The plots indicate quarterly averages, and for 2015:Q4 the quarterly average reflects the 2015:Oct and 2015:Nov monthly ones. The effective terms of trade is defined as the ratio of the BIS (nominal) effective exchange rate to the BIS real effective exchange rate. An increase indicates an appreciation. The data can be accessed here: http://www.bis.org/statistics/eer.htm.

The remainder of this paper is structured as follows. Section 2 describes the theoretical environment and constructs a model for capturing the effects of domestic capital controls through endogenous liquidity constraints. Section 3 characterizes the equilibrium conditions, whilst section 4 performs a quantitative analysis of the models and presents results following a shock to the tightness of the liquidity constraint and the tradable endowment. Finally, section 5 concludes.

2 Model

Consider a small open economy environment populated by a continuum of identical, infinitely-lived agents of unit measure, and two sectors: a tradables goods sector and a nontradable goods sector. Agents receive a stochastic endowment of tradables and they produce nontradables. They use their period income to consume and invest, and they invest in a storable real asset that pays no return and depreciates over time. Crucially, agents' consumption depends on their holdings of the real asset, which thus serves as a real medium of exchange, and the way it does so is dictated by an endogenous liquidity constraint.

The agents' preferences are given by

$$E_{-1} \sum_{t=0}^{\infty} \beta^t \left[\frac{(u\,(c_{T,t}, c_{N,t}))^{1-\gamma}}{1-\gamma} - v(n_t) \right] , \tag{1}$$

where we let

$$u\,(c_{T,t}, c_{N,t}) \;=\; \left[\omega\, c_{T,t}^{\frac{\eta-1}{\eta}} \;+\; (1-\omega)\, c_{N,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \quad \text{and } v(n_t) \;=\; \frac{n_t^{1+\zeta}}{1+\zeta} \,.$$

$c_{T,t}$ and $c_{N,t}$ denote consumption of tradables and nontradables, n_t denotes labor supply, ω reflects the weight of tradables in the consumption basket, η is the elasticity of substitution between tradables and nontradables and ζ is the inverse Frisch labor elasticity. We let $\omega \in (0,1)\,, \eta > 0$ and $\zeta > 0\,.$

The period budget constraint is denominated in units of the tradable good and is given by

$$c_{T,t} \;+\; p_t\, c_{N,t} \;+\; m_{t+1} \;=\; y_{T,t} \;+\; d_t \;+\; w_t\, n_t \;+\; (1 - r_m)\, m_t \,, \tag{2}$$

where we have normalized the price of tradables and let p_t denote the relative price of nontradables. m_t denotes the holdings of the real asset and $r_{m,t}$ is its exogenously given depreciation rate. In this context, where the real asset serves as a medium of exchange, we can interpret m_{t+1} as real money holdings and $r_{m,t}$ as inflation. $y_{T,t}$ denotes the agents' endowment of tradables, $w_t\, n_t$ denotes the agents' labor income, and d_t denotes the profits that accrue to the agents from the production of nontradables.

The agents' decisions are subject to an endogenous liquidity constraint of the following form:

$$\theta_t \left[\xi\, c_{T,t} \,+\, (1-\xi)\, p_t\, c_{N,t}\right] \,\leq\, m_{t+1}\,. \tag{3}$$

Controlling for ξ, the liquidity constraint requires the agents' consumption expenditure in period t not to exceed a proportion $1/\theta_t$ of their "money" in period $t+1$, m_{t+1}, where $\theta_t \,\geq\, 0$. The greater θ is, the higher the amount of money agents need to put aside in order to consume, and for $\theta \,=\, 0$ the liquidity constraint ceases to matter. Parameter ξ in turn parametrizes the weight of tradables' consumption expenditure relative to the nontradables' one within the liquidity constraint, and we let $\xi \,\in\, (0,1)$. The greater the value of ξ is, the more money, m_{t+1}, agents will need to hold to fund a certain consumption level of tradables relative to nontradables, and for $\xi \,=\, 1/2$, the liquidity constraint affects the consumption of tradables and nontradables in the same way. Since capital controls affect the consumption of tradables more than that of nontradables, we consider the case in which $\xi \,>\, 1/2$ more relevant from an empirical standpoint. Crucially, all else equal, the higher the relative price of nontradables, p_t, is, the tighter the liquidity constraint will be, and we elaborate on this point below.

Finally, agents operate a competitive firm which produces the nontradable good. The firm operates a decreasing-returns-to-scale technology using the agents' labor as its only input:

$$y_{N,t} \,=\, n_t^{\alpha}\,,$$

where $\alpha \,\in\, (0,1)$. Its profits are given by

$$d_t \,=\, p_t\, y_{N,t} \,-\, w_t\, n_t\,. \tag{4}$$

3 Equilibrium

In equilibrium, agents maximize their utility subject to their budget and liquidity constraints, the firm maximizes its profits given its technology, and all markets clear.

Starting with the firm's profit maximization problem, it yields

$$n_{d,t} \;=\; \left(\alpha\,\frac{p_t}{w_t}\right)^{\frac{1}{1-\alpha}} \tag{5}$$

$$y_{N,t} \;=\; \left(\alpha\,\frac{p_t}{w_t}\right)^{\frac{\alpha}{1-\alpha}} \quad . \tag{6}$$

Turning to the agents' problems, let λ_t denote the Lagrange multiplier associated with the budget constraint in period t, and ν_t the Lagrange multiplier associated with the liquidity constraint in period t. The agents' first order conditions with respect to their consumption of tradables and nontradables, their labor supply, and their money holdings are:

$$p_t \;=\; \left(\frac{1-\omega}{\omega}\right)\,\left(\frac{c_{T,t}}{c_{N,t}}\right)^{\frac{1}{\eta}}\;\frac{\lambda_t \,+\, \xi\,\theta_t\,\nu_t}{\lambda_t \,+\, (1-\xi)\,\theta_t\,\nu_t} \tag{7}$$

$$n_{s,t}^{\zeta} \;=\; \lambda_t\,w_t \tag{8}$$

$$\lambda_t = \nu_t \,+\, \beta\,(1-r_m)\,E_t\,\lambda_{t+1}\,. \tag{9}$$

The market clearing conditions of the labor market, the nontradable goods market, and the tradable goods market are:

$$n_{d,t} \;=\; n_{s,t} \tag{10}$$

$$c_{N,t} \;=\; y_{N,t} \tag{11}$$

$$c_{T,t} \,+\, m_{t+1} \;=\; y_{T,t} \,+\, (1 \,-\, r_m)\,m_t\,. \tag{12}$$

It follows from (5), (8), and (10) that

$$n_t = (\alpha\, \lambda_t\, p_t)^{\frac{1}{1-\alpha+\zeta}} \tag{13}$$

$$w_t = \frac{n_t^{\zeta}}{\lambda_t}\,. \tag{14}$$

Equilibrium is then pinned down by the following conditions:

$$p_t = \left(\frac{1-\omega}{\omega}\right) \left(\frac{c_{T,t}}{y_{N,t}}\right)^{\frac{1}{\eta}} \frac{\lambda_t + \xi\, \theta_t\, \nu_t}{\lambda_t + (1-\xi)\, \theta_t\, \nu_t} \tag{15}$$

$$y_{N,t} = (\alpha\, \lambda_t\, p_t)^{\frac{\alpha}{1-\alpha+\zeta}} \tag{16}$$

$$\lambda_t = \nu_t + \beta\, (1-r_m)\, E_t\, \lambda_{t+1} \tag{17}$$

$$c_{T,t} + m_{t+1} = y_{T,t} + (1 - r_m)\, m_t\,. \tag{18}$$

Eq. (15) is this paper's central equation. We can see that when $\xi = 1/2$, i.e. when the liquidity constraint affects the tradables and the nontradables' consumption in the same way, it assumes the following familiar form:

$$p_t = \left(\frac{1-\omega}{\omega}\right) \left(\frac{c_{T,t}}{y_{N,t}}\right)^{\frac{1}{\eta}}\,. \tag{19}$$

When this is the case, a relative shift towards nontradables in response, for instance, to a positive shock to θ or a negative shock to the agents' endowment of tradables, will lower the price, p_t, and, all else equal, ease the liquidity constraint (3). Further, in this special case, shocks to θ will have no direct effect on prices.

Nevertheless, the relative price of nontradables, p_t, may respond differently when $\xi > 1/2$, i.e. when the liquidity constraint affects the consumption of tradables more than that of nontradables. We elaborate on this point in the next section.

4 Quantitative Analysis

This section undertakes a quantitative analysis of the model in order to illustrate the basic mechanisms. It does so by studying the response of the economy to exogenous shocks that mimic the effects of a financial crisis and the imposition of capital controls in the Greek economy.

We proceed by simulating two scenarios. The first scenario consists of a negative shock to the tradable endowment y_t^T. This case can be interpreted as a collapse in the domestic production of tradable goods, or a shock to the terms of trade, resulting from external sources. In related environments with foreign debt and endogenous constraints on borrowing this shock triggers a financial amplification mechanism similar to the debt-deflation mechanism of Fisher [1933]. We illustrate its effects here to contrast our setting with that of such environments (see e.g. Jermann and Quadrini [2012], Korinek and Sandri [2014]).

The second scenario, and most pertinent to this paper consists of a positive shock to θ. Recall that θ reflects the fraction of money holdings agents need to put aside for consumption. An increase in this share hence mimics the imposition of domestic controls on capital in the form of a shortage in liquidity through a tightening in liquidity constraints for households.

4.1 Parametrization and Numerical Solution

The parameters for the quantitative analysis can be seen in Table 1. Since no estimation has been performed at this stage, they have been illustratively set to standard values in the literature (e.g.Mendoza [1991] or Schmitt-Grohe and Uribe [2013] calibrate a similar environment to Argentina). Following this conventional parameterization we set the coefficient of relative risk aversion to 1, the share of tradables in total consumption to 0.3, the intratemporal elasticity between tradables and nontradables to 3, the Frisch elasticity of labor supply to 0.5, the labor share in the nontradable sector to 0.3, the discount factor to 0.945, a relatively low value for our quarterly model. The depreciation rate of money holdings is calibrated ex-post and set to 0.95 in order to capture an increase in the real exchange rate following the positive shock to liquidity constraints. This is in line with the empirical evidence presented in Figure 3. Lastly, we experiment with several values for ξ, the parameter governing the share of tradables in the liquidity constraint, and report simulations for several parameterizations in the range [0,1].

Regarding the exogenous processes for the tradable endowment, and θ (the severity of 'domestic capital controls'), we set the autoregressive coefficient to 0.7, which implies a relatively low level of persistence for each shock. We argue that the 'domestic capital control' experience was internalized rather quickly by the Greek economy, and hence would be in line with such a value for the decay of the 'capital control shocks'. However, in order to retain some interesting dynamics in the responses of our endogenous variables we construct a 5-period path for both shocks, which cumulatively builds up by a standard deviation of 30%. The shock paths can be seen in the top right panels of Figures 5, 7, and 6.

Table 1: Parameter Values

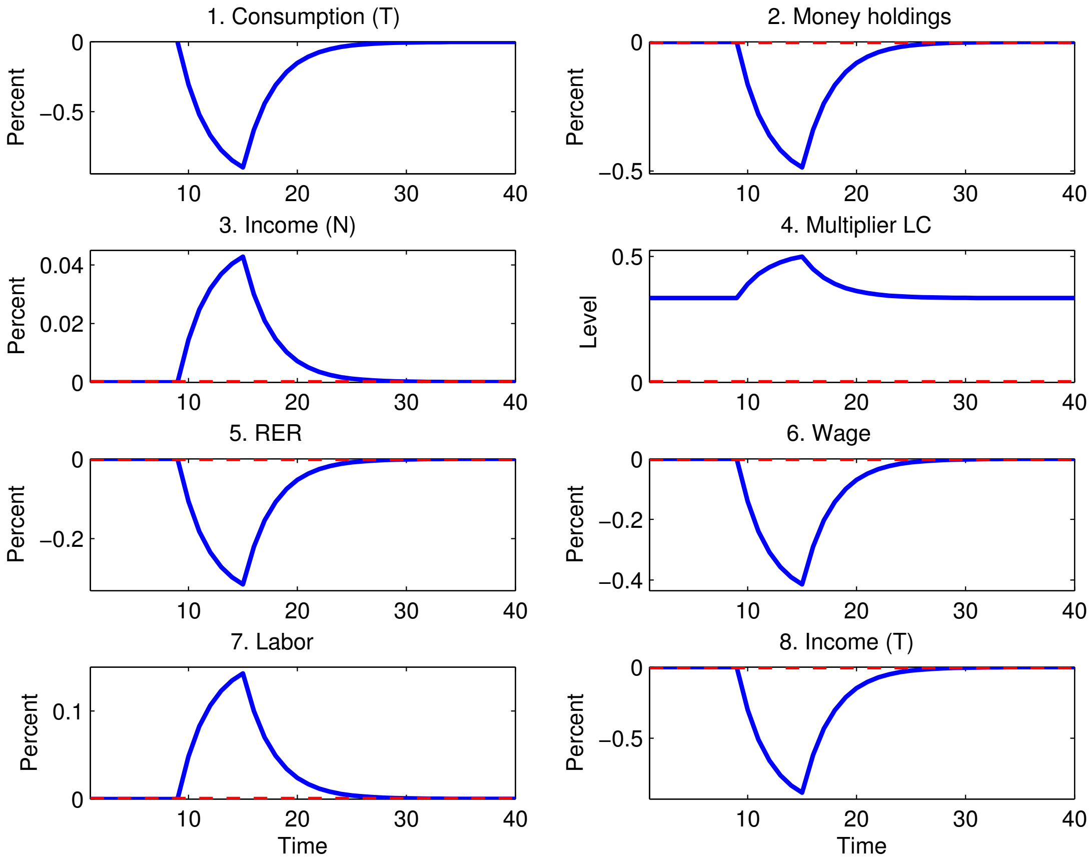
Parameter	Label	Value
γ	Risk aversion	1
ω	Share of tradables in consumption	0.3
η	Intratemporal elasticity of substitution between T and NT	3
ζ	Frisch elasticity of labour supply	0.5
α	Labour share in NT sector	0.3
β	Discount factor	0.945
r_m	Depreciation rate of money holdings	0.95
ξ	Share of T in liquidity constraint	[0,1]
ρ	Autocorrelation coefficient of exogenous process	0.7
σ	Standard deviation of exogenous process	0.3

Since the model features a fundamental source of nonlinearity, namely the endogenously binding liquidity constraint, a linear analytical closed-form solution cannot be obtained. We proceed to numerically solve the model using the piecewise linear algorithm proposed by Guerrieri and Iacoviello [2015]. Applied to the current setting, this solution method invokes the fact that the model can be characterized by at most two regimes: one where the liquidity constraint is binding, and another where it is slack. In the (non-stochastic) steady-state the liquidity constraint is slack, however whenever a shock hits the economy leading the liquidity constraint to become binding there is a regime shift. In the long run, the solution is expected to revert to the (non-stochastic) steady state regime. Moreover, within a given regime the solution is linear, which gives rise to a total of two different linear policy rules, one for each regime. Within a given regime, policy rules are computed using a second-order approximation. Guerrieri and Iacoviello [2015] show that this approach compares accurately to a global solution method such as value function iteration, and saves on computational time. The solution algorithm implicitly invokes a deterministic simulation, and thus implicitly assumes that agents in the environment have perfect foresight. This is not such a stringent assumption, since the shocks under consideration are only relevant on impact. It would be interesting to explore the effects of precautionary behavior on the agents' decision regarding money holdings and other intertemporal decisions. We do so in parallel work, currently in progress.

4.2 Results

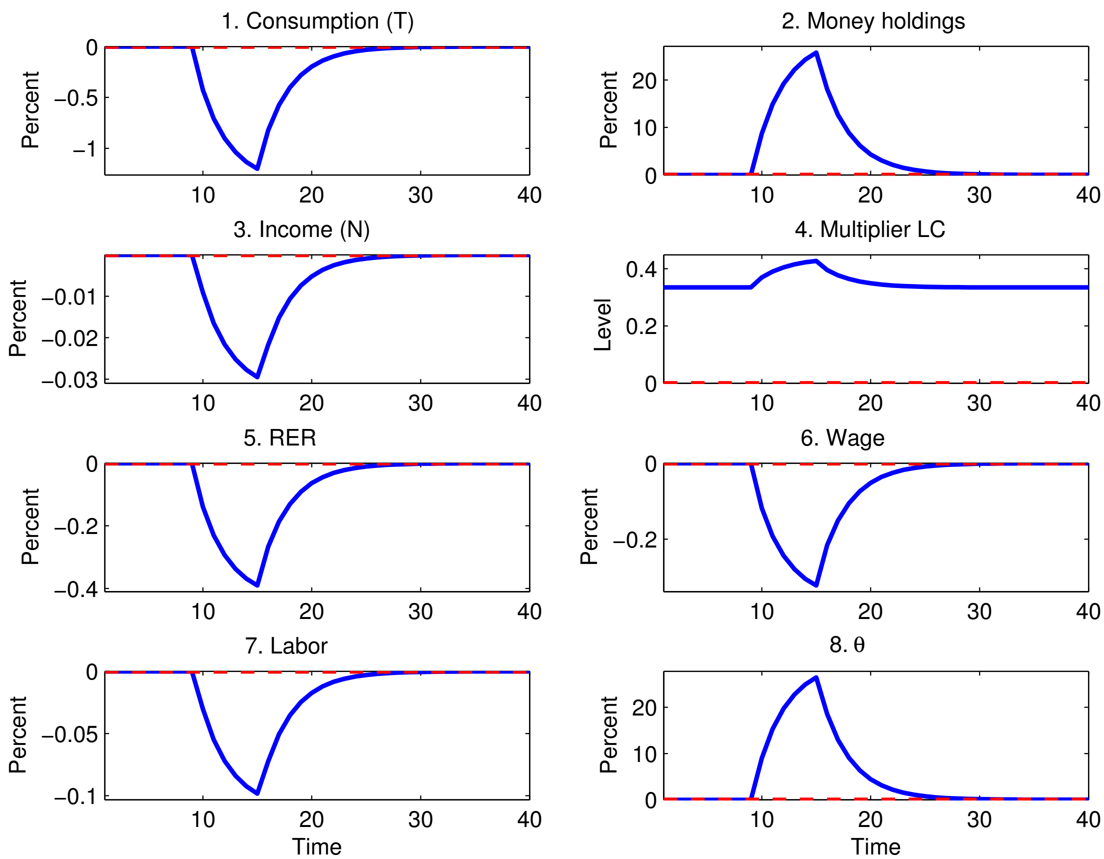
We begin by exploring the response of the economy to a shock in the tradable endowment. Similar to Korinek and Mendoza [2013] this can be interpreted as a collapse in the domestic production of tradable goods, or a shock to the terms of trade, resulting from external sources. Arguably, the responses following this type of shock, particularly in the case of Greece, are more reminiscent of the start of the 2010-2012 sovereign debt crisis. However, we illustrate the main effects here in order to contrast our findings with that of the literature on sudden stops. As can be seen in Figure 5 the drop in the endowment of tradables leads to a decline in the consumption of tradables and substitution towards nontradable goods (in equilibrium the consumption of nontradables is equal to the income of nontradable goods, denominated here in terms of tradables). This is a result of the decline in the real exchange rate, which makes nontradable goods less expensive relative to tradables. This finding is in line with the sudden stop literature, or other studies featuring this tradable-nontradable decomposition. Furthermore, the drop in the endowment of tradables also implies a reduction in the households' wealth, generating a negative wealth effect and hence driving households to work more at lower wages. Finally, due to the relative movement in the prices of consumption goods, the fall in the real exchange rate causes the liquidity constraint to become tighter and restricts the households' money holdings. The latter effect is the novelty introduced in our modelling environment.

Figure 5: Impulse response functions following a shock to the tradable endowment ($\xi = 0.5$)



The second exercise consists of exploring the economy's response to a positive shock to θ, i.e. a shock that requires agents to hold more money in order to fund a certain consumption level. We do so for three different values of ξ, which measures the share of tradables within the liquidity constraint: Figure 6 plots the economy's response to a positive shock to θ for $\xi = 0.5$, that is when tradables and nontradables have the same weight in the liquidity constraint. This yields a standard expression for the relative price of nontradables, p_t, given by (19), and serves as a theoretical benchmark. We can see that, in this case, p_t falls if and when the relative consumption of tradables drops, which is what happens after a positive shock to θ. A lower p_t results in a lower real wage, hence agents work less and in turn produce less. More importantly, following an increase in θ, agents need to convert more of their tradable endowment into money in order to consume. As a result, the consumption of tradables falls and the quantity of money rises. This reflects the experience in the Greek economy whereby a large number of households 'saved' their money holdings for an expected tightening of their future liquidity constraints.

Figure 6: Impulse response functions following a shock to the tightness of the liquidity constraint ($\xi = 0.5$)



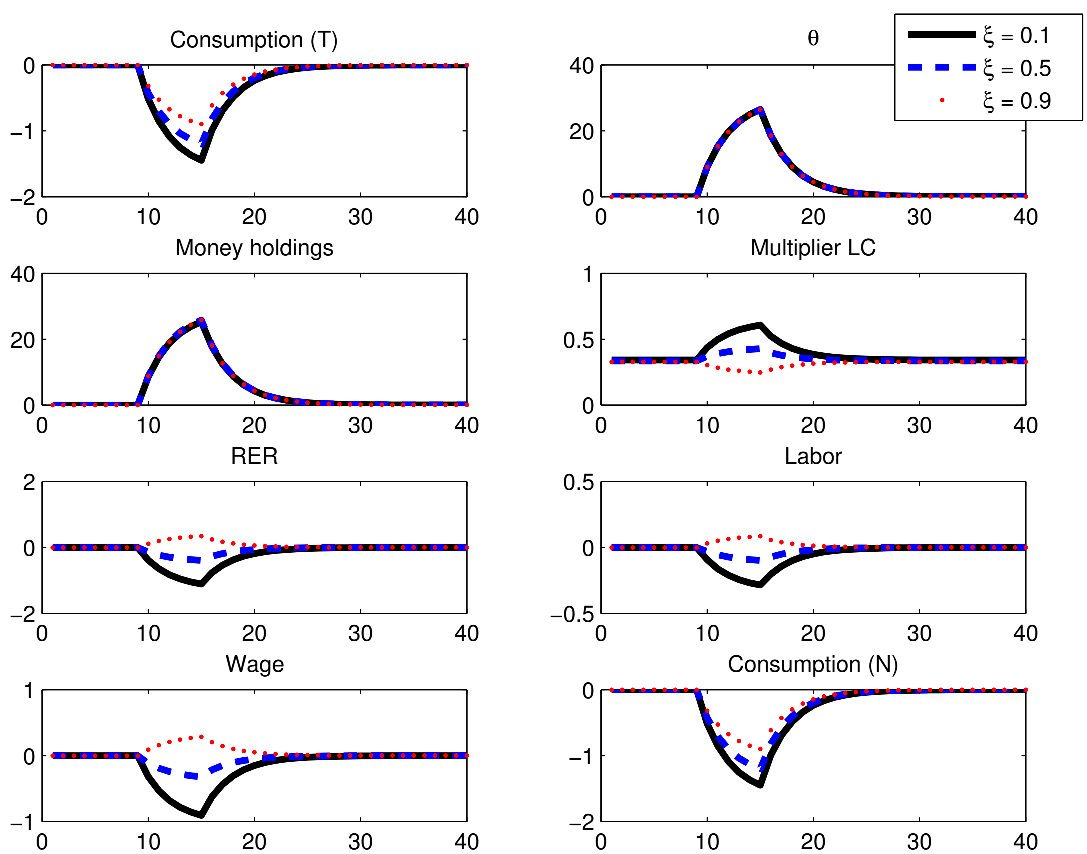
In turn, Figure 7 plots the simulated responses following a shock to θ for values of $\xi = \{0.1, 0.5, 0.8\}$. In our view, a higher value ξ is more plausible empirically when capital controls are in place, as most of the adjustment in consumption occurred via the tradable sector.

For a high enough weight of tradables in the liquidity constraint ($\xi = 0.8$) the response of p_t, given by (15), differs. In particular, p_t increases after a positive shock to θ. This is so because agents find it easier in relative terms to fund purchases of nontradables and they therefore demand more of them, which leads to an increase of their relative price. The increase in p_t drives wages up, and the production of nontradables follows suit.

An additional difference between the two cases of ξ concerns the response of the tightness of the liquidity constraint, ν_t. For $\xi = \{0.1, 0.5\}$, ν_t increases, whereas it drops—but remains positive—for $\xi = 0.8$. We can see from the Euler equation (17) that, when movements in $E_t \lambda_{t+1}$ are small enough or, like here, when r_m is high enough, ν_t comoves with λ_t, which is the Lagrange multiplier associated with the budget constraint. Since the consumption of nontradables rises and that of tradables does not fall too much in response to a positive shock to θ when $\xi = 0.8$, the marginal utility of tradable consumption decreases, and so will the multiplier on the liquidity constraint ν_t.

Finally, it is worth mentioning that the higher the elasticity of substitution between tradables and nontradables η is, the lower the threshold value of ξ, above which p_t rises in response to a positive shock to θ, becomes.

Figure 7: Impulse response functions following a shock to the the tightness of the liquidity constraint



5 Conclusion

Inspired by the recent imposition of domestic capital controls on the Greek economy, this paper has studied the effects of binding liquidity constraints in an economy with real money holdings. Building on a standard small open economy environment with two sectors (tradables and nontradables) and one real asset, which serves as a medium of exchange, we incorporate a liquidity constraint that requires the agents' consumption expenditure in the current period not to exceed a stochastic proportion of their money in the next period. A shock which causes the liquidity constraint to bind is interpreted in the model as the imposition of a 'domestic capital control regime' and causes agents to raise their money holdings and reduce their consumption of goods in view of scarce liquidity in the future. Our model also introduces an additional type of pecuniary externality, which arises due to the agents' inability to internalize the effects of their real money holdings on the movement of the real exchange rate.

On the policy front our framework is able to capture several stylized facts that have emerged since the onset of the sovereign debt crisis in Greece during the period 2010-2012 as well as the more recent times since the imposition of domestic capital controls in the final two quarters of 2015. The latest sectoral data available suggest that domestic capital controls are producing supply shortages in a number of tradable consumption sectors in Greece. We can capture such a decline in imported goods by specifying a liquidity constraint that is present on both tradable and nontradable goods with its tightening being endogenously affected by the movement in the real exchange rate. Furthermore, we can also replicate a number of more general data patterns pertaining to the recent growth slowdown in Greece as well as the movement of key price indicators.

In ongoing companion work, we extend our investigation to the following three fronts: (i) we characterize the equilibrium using global solution methods, which capture the precautionary behavior of the agents' decisions in view of future realizations of shocks and hence future movements of the multiplier on the liquidity constraint; (ii) we introduce debt into the model subject to an endogenous collateral constraint in order to explore the interaction between collateral and liquidity constraints via movements in the real exchange rate; (iii) a more accurate representation of stylized facts based on data disaggregated at the sectoral level will have to wait until the first quarter of 2016, when the full dataset will become available.

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A Appendix

Figure 8: Average rates of change (%) of the period January – October for the years 2013-2015 of the Industrial Production Index. *Source*: Hellenic Statistical Authority Press Release - 10 December, 2015

Base year: 2010=100.0

Branch code	Branch name	Average indices of the period Jan.-Oct.			Rate of change (%)	
		2015*	2014	2013	2015/2014	2014/2013
	OVERALL	**88.3**	**88.3**	**90.5**	**-0.02**	**-2.4**
B	**MINING AND QUARRYING**	**80.0**	**87.6**	**87.8**	**-8.6**	**-0.3**
05	Mining of coal and lignite	81.5	90.6	97.2	-10.1	-6.8
06	Extraction of crude petroleum and natural gas	59.4	56.8	65.5	4.5	-13.2
07	Mining of metal ores	77.3	85.3	82.3	-9.3	3.6
08	Other mining and quarrying products	79.9	84.7	71.3	-5.7	18.9
C	**MANUFACTURING**	**89.5**	**88.6**	**87.7**	**0.9**	**1.0**
10	Food	95.6	95.9	93.9	-0.3	2.1
11	Beverages	94.5	92.2	92.1	2.5	0.03
12	Tobacco products	116.2	94.4	102.4	23.1	-7.8
13	Textiles	61.3	60.7	69.1	1.0	-12.2
14	Wearing apparel	54.4	64.1	68.0	-15.2	-5.6
15	Leather and related products	45.0	54.7	62.3	-17.8	-12.1
16	Wood and cork	37.7	41.7	45.6	-9.5	-8.6
17	Paper and paper products	99.2	97.1	90.5	2.1	7.3
18	Printing and recording services	53.0	56.4	57.1	-6.1	-1.2
19	Coke and refined petroleum products	116.7	115.8	110.8	0.8	4.5
20	Chemicals and chemical products	95.8	94.8	93.0	1.0	1.9
21	Basic pharmaceutical products and pharmaceutical preparations	102.3	97.1	102.0	5.3	-4.8
22	Rubber and plastic products	91.9	89.1	87.9	3.1	1.4
23	Other non-metallic mineral products	54.2	56.1	55.5	-3.4	1.1
24	Basic metals	109.1	101.8	96.6	7.2	5.4
25	Fabricated metal products	75.4	80.1	79.5	-5.8	0.7
26	Computers, electronic and optical products	121.7	95.5	85.5	27.3	11.8
27	Electrical equipment	66.7	63.2	71.9	5.6	-12.1
28	Machinery and equipment n. e. c.	81.7	80.7	77.6	1.2	4.0
29	Motor vehicles, trailers and semi-trailers	54.5	58.8	57.9	-7.4	1.6
30	Other transport equipment	29.6	27.5	53.8	7.6	-48.9
31	Furniture	45.6	45.7	44.8	-0.3	2.0
32	Other manufactured goods	88.1	81.3	76.6	8.4	6.1
33	Repair and installation services of machinery and equipment	52.7	64.7	64.8	-18.6	-0.04
D	**ELECTRICITY**	**84.9**	**86.0**	**99.1**	**-1.2**	**-13.2**
35	Production and distribution of electricity	84.9	86.0	99.1	-1.2	-13.2
E	**WATER SUPPLY**	**99.3**	**97.2**	**98.3**	**2.2**	**-1.1**
36	Treatment and supply services of natural water	99.3	97.2	98.3	2.2	-1.1
	MAIN INDUSTRIAL GROUPINGS					
1	Energy	94.5	95.5	101.9	-1.0	-6.3
2	Intermediate goods	82.8	82.1	80.2	0.8	2.4
3	Capital goods	59.6	63.4	64.4	-6.0	-1.4
4	Consumer Durables	54.9	54.3	58.9	1.1	-7.8
5	Consumer Non-Durables	93.2	91.7	91.8	1.6	-0.1

* Provisional data

Notes:

1. The indices are calculated with infinite decimal figures and are rounded up to one decimal figure when published.
2. Percentage changes are calculated on the basis of indices with infinite decimal figures and are rounded up to one decimal figure when published.