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Shadow economies at times of banking crises: Empirics and theory ☆

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ABSTRACT

This paper investigates the response of the shadow economy to banking crises. Our empirical analysis, based on a large sample of countries, suggests that the informal sector is a powerful buffer, which expands at times of banking crises and absorbs a large proportion of the fall in official output. To rationalise our evidence, we build a dynamic stochastic general equilibrium model which accounts for financial and labour market frictions and for nominal rigidities. In line with the empirical literature on the shadow economy, we assume that in the informal sector access to external finance is limited, and the production technology is relatively more labour intensive. Following a banking shock in the official sector, the model predicts a large negative transmission to the unofficial economy that substantially dampens the overall effect of the shock.

1. Introduction

Banking crises are typically associated with a prolonged decline in output and employment (Rajan and Zingales, 1998; Kroszner et al., 2007; Cerra and Saxena, 2008; Dell'Ariccia et al., 2008; Reinhart and Rogoff, 2009b). One less investigated issue is the behaviour of the informal economy during such episodes. Recently some contributions suggesting that the relative size of the shadow economy might be on the rise in the aftermath of the 2007 crisis (Schneider and Buehn, 2012; Elgin and Oztunali, 2012), have found considerable echo in the press.[1]

Understanding the shadow economy adjustment to banking crises is important for several reasons. First it makes it possible to provide a better estimate of output and employment losses. Second, it has relevant policy implications. On the one hand, the existence of an informal sector may add resilience to the economy when times are hard. On the other hand, the erosion of the tax base greatly complicates the task of fiscal policy makers at a time of ballooning public deficits. In fact, revenue losses seem to be the main cause of the dramatic increase in debt-to-GDP ratios that typically follows the explosion of a banking crisis (Reinhart and Rogoff, 2009a).

This is the first paper where the shadow economy response to banking crises is analysed both empirically and theoretically. There are several macroeconomic methods for measuring the relative size of the shadow economy, all of which have shortcomings. For our purposes the widely used Multiple Indicator–Multiple Cause (MIMIC) approach would be inappropriate because shadow economy data sets based on the MIMIC method, such as Schneider et al. (2010), are too limited in the time series dimension of the sample. The so called Currency Demand Method (Feige, 1990; Tanzi, 1983), may cover a large sample of countries only if M1 monetary aggregates are used as a proxy for currency holdings. Unfortunately M1 is typically determined by central bank attempts to preserve liquidity in spite of the crisis. We therefore take an alternative route, based on the assumption that the rate of change in electricity consumption is a proxy for the growth rate of total economic activity (henceforth *TEAg*) (Schneider and Enste, 2000). We thus take the differential responses of *TEAg* and official output growth rates to banking crises as a broad indicator of shadow econ-

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[1] "A Lengthening Shadow" The Economist, August 2010 ; "Europe: Hidden Economy" , The Financial Times 8th June 2011; "Shadow economies all around the world: Model-based estimates" , Vox, available at http://www.voxeu.org.

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0378-4266/

omy dynamics. As a robustness check of our results we also consider the method that simply proxies the shadow economy share with the ratio of self-employed to the total labour force (Loayza and Rigolini, 2011).

For a large sample of countries and over a relatively long time span we find that following banking crises the *TEA* fall is very small relative to what we observe for the official output. Further, the *TEA* drop is never statistically significant if the electricity consumption growth series is filtered to control for variations in the relative price of electricity and for long-run sectoral output composition in the official economy. By contrast banking crises are followed by a deep contraction of gross capital formation in the official economy. This implies an increase in the electricity-consumption-to-GDP ratio which is particularly striking in light of the huge literature on the procyclical pattern of electricity consumption. In fact electricity consumption is used as a proxy for capacity utilisation in business cycle models, and as a leading indicator for business cycle conditions. In our view, this evidence indicates a potentially large shadow economy increase in response to banking crises. When we focus on labour market data we find that the share of self-employed workers strongly increases in response to the banking crisis. Even though the cyclical pattern of the unofficial economy cannot be directly observed, this evidence indicates a potentially large shadow economy increase in response to financial crises.

To rationalise our empirical results, we build a two-sector DSGE model that accounts for price stickiness, search frictions in the labor market, and for credit market frictions. Our characterisation of the shadow economy is consistent with two"stylised facts". The first is that firms operating in the shadow economy have access to a relatively more labour intensive production technology (Amaral and Quintin, 2006; Koreshkova, 2006). The second is that formal and informal financial sectors coexist but are typically characterised by different degrees of efficiency in channeling funds from households to firms: it is well known that the access of informal firms to outside finance is typically limited (Banerjee and Duflo, 2007; Madestam, 2008).

Following a banking shock in the official sector, our model predicts a disruption of capital formation in the official economy. This, in turn, is associated with a fall in official output and employment. The ensuing real wage fall in the official sector favours an increase in output and employment in the unofficial economy. The sectoral reallocation of employment causes a persistent increase in the marginal productivity of capital in the unofficial sector, and triggers a surge in unofficial investment. We obtain a large negative transmission effect: when the share of the shadow economy is low (12%) 20% of the official sector contraction is absorbed by the growth of the shadow sector, when the share of the shadow economy is high (40%) the figure raises to 68%.

Previous empirical evidence on the cyclical pattern of the shadow economy is mixed. Bajada (2003) and Giles (1997) find a procyclical relationship in Australia and New Zealand, respectively. A number of studies based on the MIMIC approach support the view that the shadow economy acts as a buffer, increasing its size in periods of recession (Bajada and Schneider, 2005; Schneider and Enste, 2000; Feld and Schneider, 2010). Our theoretical results do not fully confirm this view. In fact we find that technology shocks induce a positive correlation between sectoral outputs. Thus our model does not merely predict a countercyclical behaviour of the underground economy; on the contrary, it highlights a propagation pattern which is specific to banking shocks. Our theoretical contribution adds to a small but rapidly expanding literature. Business cycle models of the informal economy basically fall into two categories. In the first there are real business cycle models that incorporate an informal sector (Conesa et al., 2001; Busato and Chiarini, 2004; Granda-Carvajal, 2010). In the second there are models that focus on the labour market, assuming either search frictions (Bosch and Esteban-Pretel, 2012) or the dual labour market hypothesis (Fiess et al., 2010; Castillo and Montoro, 2010). None of these contributions incorporates financial frictions as important elements of business cycle fluctuations and the inter-sectoral transmission of shocks as we do in this paper. The only exception is Batini et al. (2011). Our paper differs from theirs in two key aspects: the first is the modeling strategy of financial frictions that here deliver an endogenous risk premium, while they assume exogenous risk premium shocks; the second is the focus on banking shocks, which are neglected in their contribution.

The remainder of the paper is structured as follows. Section 2 describes the data and methodology used in the empirical analysis. Section 3 presents the empirical results. Section 4 describes the theoretical model and illustrates the findings. Section 5 concludes.

2. Data and methodology

2.1. Measuring banking crises and total economic activity

We adopt the well known classification by Laeven and Valencia (2010), who focus on systemic banking crises excluding distress events that affected isolated banks.[2] Defining banking crises is often controversial, due to the lack of a consensual definition and the need of a certain degree of discretionary judgement. our choice is justified by the widespread use of the classification in the empirical literature.

2.2. Measuring total economic activity

There are several indirect approaches for measuring the shadow economy. All of them have shortcomings since the shadow economy is by definition unobservable.

- The Multiple Indicator–Multiple Cause (MIMIC) approach pioneered by Schneider is essentially a structural model where the shadow economy is estimated from a system of equations composed of economic and institutional variables. This approach is most appropriate in identifying the structural long-run relation between the official and the shadow economy. For our purpose it has two weaknesses. First it is very demanding in terms of data, and therefore it seems unsuitable for large cross country panel data. Second, being based on a structural model, it is less suitable in identifying the response of the shadow economy to shocks such as financial crises.
- The currency demand approach (CDA) is based on the assumption that the shadow economy is cash intensive and infers the behaviour of the informal economy from the demand for currency. Unfortunately, since central banks typically modify monetary aggregates to preserve liquidity in the aftermath of financial crises, using money supply growth as a proxy for shadow economy dynamics would cause serious identification problems.
- The percentage of the active labour force that is self-employed is sometimes used as a proxy for the relative size of the shadow economy (Loayza and Rigolini, 2011). As pointed out in La Porta and Shleifer (2008) the definition of self-employment does not include unpaid family workers whose contribution to informal production is probably high. Further, it is quite obvious that self-employment can be high for structural reasons which are

[2] More precisely the starting year of the crises is identified by (a) deposit runs, defined as a monthly percentage decline in deposits in excess of 5%, (b) the introduction of deposit freezes or blanket guarantees, and (c) liquidity support or central bank interventions, defined as the ratio of monetary authorities' claims on banks as a fraction of total deposits of "at least 5% and at least double the ratio compared to the previous year".

not related to the shadow economy. By contrast, the cyclical evolution of the self-employed share is likely to exhibit a strong correlation with the shadow economy share, even though it does not account for intensive margin effects.

- The electricity consumption approach takes electricity consumption growth as a proxy for total output growth (both formal and informal). For our purpose this method has several advantages. First, data on electricity consumption are quite precise and are available for a large panel of countries. Second, it is an ideal measure for capturing the effect of shocks because electricity consumption is a timely variable often used as a leading indicator for the business cycle. Third, unlike the CDA it is a measure whose correlation with observables such as official output appears unlikely to be affected by policy responses to the crises. The electricity consumption growth approach is often criticised because it typically requires base year estimates of the shadow economy level,[3] which are difficult to obtain and because unobservable energy-saving technological change may bias shadow economy estimates. None of these criticisms seems to apply here because we focus on the response of electricity consumption growth to banking crises and therefore (i) base-year estimates are unnecessary; (ii) it is difficult to imagine a short-run correlation between banking crises and the underlying rate of energy-saving technological change.

We therefore base our shadow economy estimates on the electricity consumption approach and then complement this evidence with an analysis of the response of the self-employed share to banking crises.[4] In our analysis we investigate whether our proxies for total output growth, i.e. our measures of electricity consumption growth, react to banking crises in a way which is different from that of official output growth. Then we take such differences as a proxy for the dynamics of the shadow economy, since it is implausible that significant changes (increases in our case) may occur in the short run in the ratio of electricity-consumption to official output ratio.

We consider two proxies of the growth of total economic activity based on electricity consumption. The first one is the simple growth rate of electricity consumption *TEAg*. The second one (*MTEAg*) is obtained filtering *TEAg* to remove the effects of variations in the relative price of electricity and of sectoral output composition in the official economy (Eilat and Zinnes, 2002; Onnis and Tirelli, 2010). The Appendix describes in greater detail the procedure used to construct these variables. We shall also use *MTEAg* to obtain two estimated series for the growth of the shadow economy. Following previous empirical contributions (Eilat and Zinnes, 2002; Lackó, 2000; Feige and Urban, 2008), the first estimate is simply the difference between *MTEAg* and the growth rate of official GDP; when presenting our results, we refer to this series as "shadow, large sample". As a robustness check, following Onnis and Tirelli (2010), the second estimate is obtained using base-year estimates of the shadow economy as a share of official GDP. This considerably restricts the sample of countries available for our analysis (49). We refer to this series as "shadow small sample" in the results.

Finally, data for the self-employment share are obtained from the ILO, the same dataset used by Loayza and Rigolini (2011). Unfortunately these are available for a limited number of countries over a restricted time series span. In fact we are left with 48 countries with the maximum time series going from 1984 to 2005.[5]

[3] The base-year problem is in fact common to the other approaches.

[4] The lack of systematic data on energy consumption at sectoral level prevents us from differentiating the impact of banking shocks on different industries

[5] Table A.1 summarises the information for each variable and Table A.2 describes the list of countries

2.3. Methodology

Our methodology for identifying the effects of banking crises follows Cerra and Saxena (2008), who in turn draw on the influential work by Romer and Romer (1989). We estimate the following autoregressive model:

$$Y_{i,t} = \alpha_i + \sum_{s=1}^{4}\beta Y_{i,t-s} + \sum_{s=0}^{3}\gamma DFC_{i,t-s} + \epsilon_{i,t} \tag{1}$$

where $Y = TEAg,\ MTEAg$ (or the other variables mentioned above) is the relevant measure of total or unofficial economic activity, *DFC* is a dummy variable for the presence of a banking crisis, and *i* is a country index. The model is estimated also for official GDP growth as a benchmark. The number of lags of both the dependent variable and the crisis dummy have been chosen to maximise the informativeness of the model.[6]

We estimate (1) using panel data that control for the presence of fixed effects, and allow for heteroskedasticity of the error term and for autocorrelation within groups (countries). Impulse response function and 95% confidence bands are obtained from 1000 Monte Carlo simulations (see the Appendix).

We also implement a Panel-VAR where the growth of GDP, total economic activity and banking crises are estimated jointly, the methodology is described in detail in the Appendix.

3. Empirical results

Table 1 reports the correlations between the different measures of formal and informal economy used in the paper. It is easy to see that: (i) official output growth correlates positively with both *TEAg* and *MTEAg*; (ii) there is a negative correlation between measures of the growth of the shadow economy and the growth of official output. In Table 2 we present panel Granger causality tests, finding two-way causality between total economic activity growth and official output growth.

The results of Table 2 convey the idea of a tight cyclical connection between measures of total economic activity and official output. In the following we show that such connection apparently breaks down in the aftermath of banking crises.

Fig. 1 shows the effect of banking crises on official GDP and on total economic activity obtained from estimates of Eq. (1).[7] The measured impact of banking crises on GDP confirms previous results (Cerra and Saxena, 2008). Crisis episodes have a long lasting and permanent effect on GDP, and the fall in official investment (which is the most energy-intensive component of aggregate demand) is even stronger (about 15%, not reported in the figures). Results are strikingly different when the analysis is replicated for the growth of total economic activity. The *TEA* drop is very limited, suggesting a potentially strong role of the shadow economy as a shock absorber in response to the crisis. Further, the response of *MTEA* is never significant. These results are confirmed when we split the sample into different subgroups following a per-capita income criterion.

Adding time dummies allows us to check whether crises reflect some other global shock common to all countries. The first panel of the last row of Fig. 1 shows that the results are unchanged. In addition we tested whether our results are driven by some extreme values. The second panel of the last row of Fig. 1 shows impulse responses excluding possible outliers in growth rates of total economic activity. Even in this case our benchmark estimates are confirmed. In addition the upper panel of Fig. 2 shows the results

[6] The four-year time lag is consistent with the literature estimating output responses at the same frequencies.

[7] In the following, for reasons of space, we present detailed results for *MTEA* leaving those for *TEA* to the Appendix.

Table 1
Pairwise correlations.

	GDPg	MTEAg	TEAg	Shadow g.	Share self-emp.
GDPg	1				
MTEAg	0.182***	1			
TEAg	0.198***	0.891***	1		
Shadow g.	−0.284***	0.633***	0.563***	1	
Share self-emp.	0.174***	0.269***	0.322***	0.106*	1

***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

Table 2
Granger causality tests.

	From GDP to MTEA	From MTEA to GDP	From GDP to TEA	From TEA to GDP
Lag 1	11.318***	4.070***	10.387***	3.527***
Lag 2	20.657***	5.591***	22.326***	3.548***
Lag 3	32.690***	19.901***	29.063***	12.013***
Lag 4	53.994***	60.378***	47.153***	49.620***

Wald statistic for panel Granger non-causality as in Dumitrescu and Hurlin (2012). Null hypothesis: Granger non-causality. ***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

obtained with Panel VAR estimates, which are very similar to our baseline results.

Finally, the lower panel of Fig. 2 shows impulse responses of the series "Shadow, large sample", "shadow small sample", and of the self-employed share. In all cases we obtain the prediction of a shadow economy increase.

3.1. Exogeneity of banking crises

The results of the previous section document clearly that there is a differential impact of banking crises on measures of official output and of measures of total economic activity. This differential effect is robust to the method chosen for measurement of total economic activity, to the estimation methodology and to the type of country considered (i.e. it emerges both in advanced and developing countries). We have also shown that this differential behaviour of official output and total economic activity is peculiar of banking crises since overall the two measures appear to be tightly connected over time but this relationship breaks down with the onset of banking crises.

Therefore, our argument follows the logic of the difference in difference approach typical of experimental literature with banking crises providing a natural experiment. In this case the problem of the possible endogeneity of banking crises is much less relevant.

However, we have also implemented additional checks. So far we based our analysis on the assumption that the dummy crisis is a "contemporaneously exogenous" event with respect to GDP or total economic activity growth. If crises are the result of weak economic activity, their impact would occur through the lagged effect of GDP (or total economic activity) and our results would be upward biased.

To control for potential endogeneity we implement two tests. First we estimate Eq. (1) imposing $DFC_{i,t-s} = 0$ for $s = 0$. In this way we assume that the crisis can only have a lagged effect on economic activity. The third panel of the last row of Fig. 1 shows that nothing changes. Second we test explicitly whether economic activity helps in predicting banking crises. To this end we ran a logit model where the crisis dummy is regressed on current and lagged values of the relevant variable. Table 3 shows that neither *TEAg* nor *MTEAg* help to forecast financial crises, while on the contrary there is a significant negative relationship between GDP growth and crises. Repeating the same exercise without the contemporaneous effect yields identical results. Therefore while official output losses reported in Fig. 1 may be underestimated, those of *TEAg* or *MTEAg* do not seem to suffer from endogeneity bias.

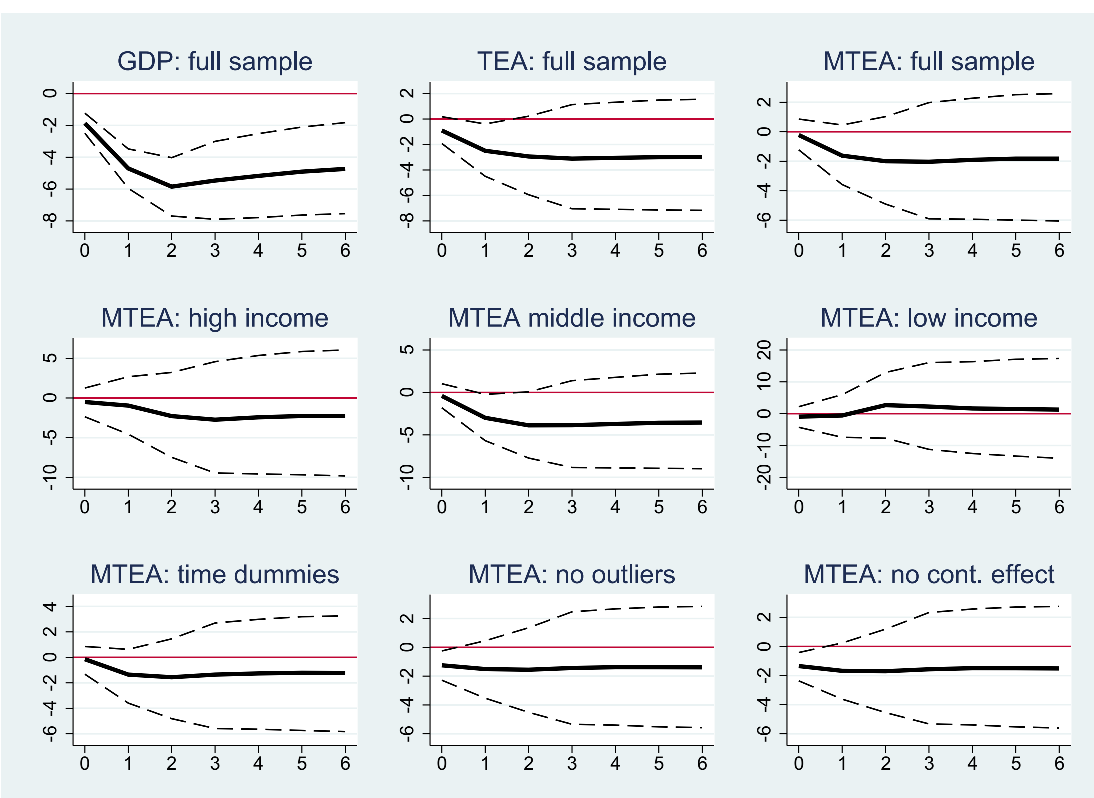

Fig. 1. Impulse responses to banking crises, cumulated losses. GDP, total economic activity (TEA) and modified electricity consumption (MTEA); overall and country groups.

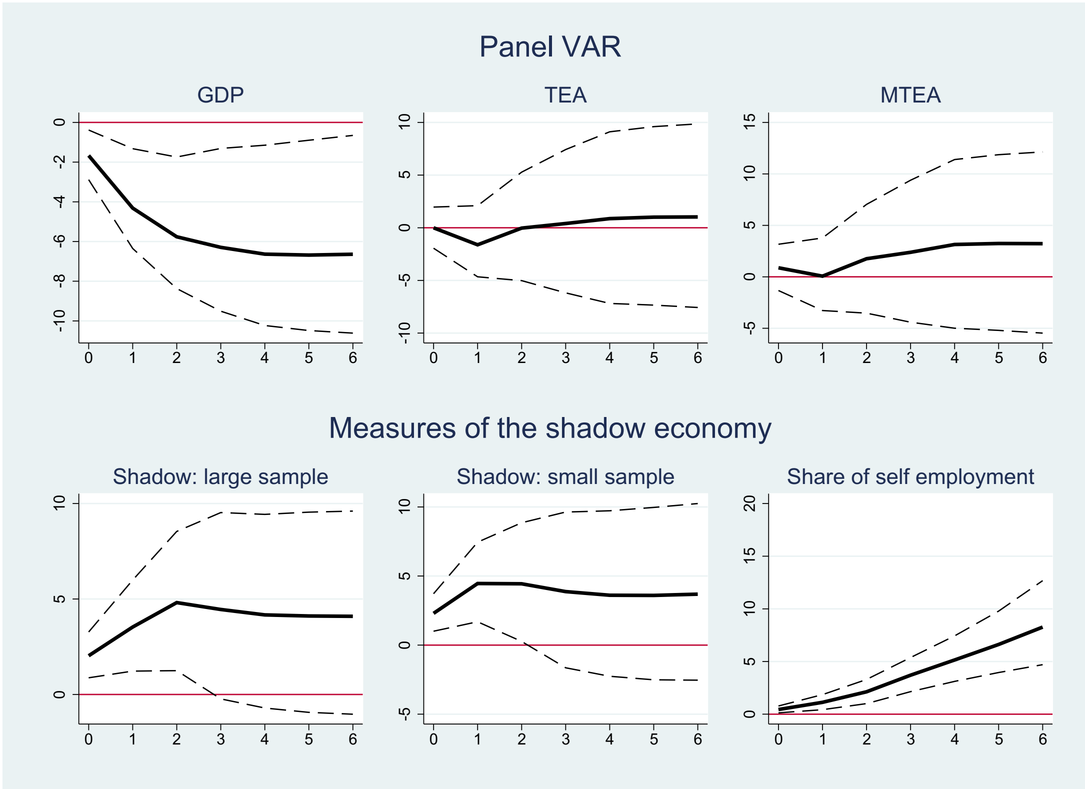

Fig. 2. Impulse responses to banking crises, cumulated losses.

Table 3
Predicting banking crises.

	GDP	TEA	MTEA
L_0	−0.060***	−0.01	−0.005
	−0.02	−0.01	−0.01
L_1	−0.01	−0.015	−0.006
	−0.02	−0.01	−0.01
L_2	−0.015	−0.01	−0.006
	−0.02	−0.01	−0.01
L_3	0.012	−0.005	−0.007
	−0.02	−0.01	−0.01
L_4	0.009	−0.003	−0.004
	−0.02	−0.01	−0.01
N. Obs	2788	2541	2541
N. of Count.	120	120	120

Note: Dependent variable is dummy for banking crisis, regressors are official GDP growth (col 1), total economic activity growth – TEA (col 2), total economic activity growth – MTEA (Col 3). $L_0 \ldots L_4$ denote regressors at lag 0–4. Estimation is panel logit random effect. Robust standard errors reported in parentheses. ***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

3.2. Are banking crises different?

As a final robustness check we consider the reaction of our shadow economy measures to crises of different origin. Fig. 3 shows the effect of currency and debt crises on output and on total economic activity. While the effects of debt crises are similar to those of banking crises, currency crises are associated to a drop in *TEA* (*MTEA*) that is indeed statistically significant and close to the fall in official GDP. Interpreting these results clearly is beyond the scope of the paper, but this evidence suggests that not all recessionary episodes induce a similar pattern in the responses of output and electricity consumption measures. This justifies our interest in a theoretical analysis of the shadow economy adjustment to banking crises.

4. Financial frictions and the shadow economy in a DSGE model

We build a DSGE model to account for both the official (o) and the underground (s) sectors of the economy.[8] A crucial role is played by the credit market, where we adopt the standard framework of the agency cost approach pioneered by Bernanke and Gertler (1989) and developed by Carlstrom and Fuerst (1997) – henceforth C–F. In our model a fraction $\eta$of the population – the entrepreneurs – have the ability to transform i consumption goods into $i\omega$ capital goods, where $\omega$is a random variable subject to idiosyncratic shocks. ωrealisations are entrepreneur's private information, generating standard agency issues. A fraction η^o of entrepreneurs operates in the official sector, the rest in the shadow economy. In each sector a capital mutual fund or "bank" (CMF^j, $j = o, s$) collects funds from the common pool of household savings and lends them to entrepreneurs.[9]

We depart from C–F in assuming that financial operations are costly: they entail a dissipation of resources, and are relatively larger in the informal sector. This allows us to delineate a situation where the financial sector of the shadow economy is relatively inefficient, i.e. unofficial economy entrepreneurs earn a relatively

[8] For reasons of space in this section we describe the key features of our model. The full derivation is available in the Online Appendix.

[9] Several studies document that funds originating in the official economy are then intermediated in the informal financial market and channeled into the unofficial sector of the economy (Conning and Udry, 2007; Madestam, 2008 and the studies cited therein).

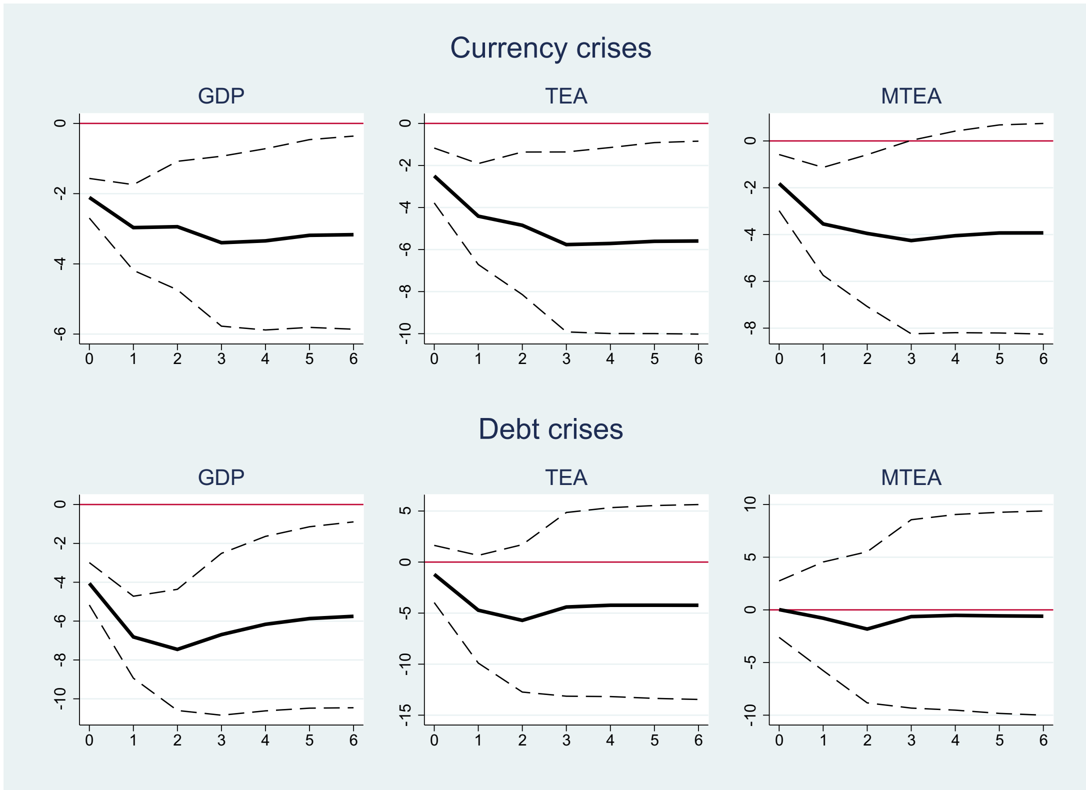

Fig. 3. Impulse responses to currency and debt crises, cumulated losses. GDP, total economic activity (TEA) and modified electricity consumption (MTEA).

smaller proportion of investment proceeds, and the fraction of external financing in this sector is relatively limited.[10]

Our characterisation of the financial market is admittedly crude in order to provide a satisfactory description of the banking sector in a general equilibrium framework. Nevertheless, it captures a key mechanism that drives the transmission of bank crises to the shadow economy, i.e. the large and persistent disruption to the process of capital accumulation in the official economy documented in Section 3.[11]

In both sectors perfectly competitive firms produce wholesale goods which are then sold to monopolistically competitive retail firms. Retail prices are sticky.

Following Zenou (2008) the labour market is characterised by search frictions in the official sector of the economy and by perfect competition in the unofficial sector.[12] There is a representative household, who has a large family structure. A fraction of the members in the household are employed in the official sector, the rest are either unemployed or employed in the unofficial sector. In line with Zenou (2008), only unemployed individuals can enter a new match with an employer in the official sector. We do not explicitly model flows between unemployment and employment in the informal sector, but we impose a stock equilibrium condition where in each period the outside option of an individual employed in the unofficial sector is equal to the value attached to unemployment status.

The sequence of events is standard from C–F.

- Official sector employment agencies hire workers and supply their services to wholesale firms in the official sector. Non-hired workers who decide not to search for future employment in the official sectors supply their labour services in the unofficial sector. Wholesale firms hire labour services and rent capital from households and entrepreneurs to produce consumption goods. Retail firms differentiate goods and adjust consumption prices. Firms choices are conditional to productivity shocks and to the monetary policy rule.
- Households choose consumption and the allocation of investment to financial intermediaries.
- CMFs lend consumption goods to entrepreneurs.
- Entrepreneurs use borrowed and own resources to create capital.
- The idiosyncratic shock of each entrepreneur is realised and the debt contract is enforced. Proceeds from creation of new investment goods are then split between households and entrepreneurs.
- Entrepreneurs choose their consumption.

In the model the inter-sectoral transmission of shocks typically occurs through flows in the factor services across the two sectors, driven by arbitrage conditions in the capital and labour markets.[13]

[10] De Soto (2000) forcefully argues that informal assets are much more difficult to leverage into loans than assets belonging to entrepreneurs operating in the official sector.

[11] The April 2014 IMF World Economic Outlook, p. 81, identifies "a sharp and persistent decline in investment rates in advanced economies since the global financial crisis."

[12] Other contributions assume a non-segmented, fully competitive labour market (Amaral and Quintin, 2006; Pratap and Quintin, 2006). This assumption is supported by Maloney (1999, 2004) and Pratap and Quintin (2006) who provide evidence against labour market segmentation. The WP version of the paper was based on the assumption of a competitive and fully integrated labour market.

[13] Assumptions about the steady state size of entrepreneurs and firms in the two sectors are just innocuous normalisations as long as we allow for capital and labour inter-sectoral flows for sake of simplicity we do not consider flows of firms, and entrepreneurs, between the two sectors over the business cycle.

4.1. Households

There is a continuum of mass $1-\eta$ of households who gather a continuum of mass one of family members who individually supply a fixed unit of labour, and are characterised by the utility function

$$U_t^i = E_t \sum_{k=o}^{\infty} \beta^k \{\ln (c_{t+k}^i - bc_{t+k-1})\}$$

where c^i is a consumption bundle, bc defines external consumption habits. Households members consume and, for each sector, own firms, hold physical capital, and choose their investment. As in Zenou (2008), individual members of the household inelastically supply one unit of labor in each period. Following Andolfatto (1996), we assume that household members perfectly share the risk of sectoral employment and unemployment outcomes. As a result consumption and investment decisions are identical across individuals.

Household preferences over the goods produced in the economy are defined over a two-sector consumption bundle $c_t = \left[(1-\alpha_c)^{\frac{1}{\varepsilon}}(c_t^o)^{\frac{\varepsilon-1}{\varepsilon}} + (\alpha_c)^{\frac{1}{\varepsilon}}(c_t^s)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$. Further, each c_t^j is also defined as a *CES* bundle $c_t^j = \left(\int_0^1 c_t^j(z^j)^{\frac{\sigma^j-1}{\sigma^j}} dz^j\right)^{\frac{\sigma^j}{\sigma^j-1}}$ and the corresponding price indexes are $P_t^{Rj} = \left(\int_0^1 \left(P_t^{Rj}(z)\right)^{1-\sigma^j} dz\right)^{\frac{1}{1-\sigma^j}}$ and $P_t = \left((1-\alpha_c)\left(P_t^{R,o}\right)^{(1-\varepsilon)} + \alpha_c\left(P_t^{R,s}\right)^{(1-\varepsilon)}\right)^{\frac{1}{(1-\varepsilon)}}$.

4.2. Labour market

Variables l_t^o, l_t^s define the number of employed workers employed in the official and unofficial sectors respectively. Individuals who are not hired in the official sector either take official sector unemployment status, which earns them the (real) unemployment subsidy, $\frac{P_t^{R,o}}{P_t} b^u$, [14] and allows ongoing search for next-period hire in the official sector, and employment in the unofficial sector at the competitive real wage rate $\frac{P_t^{R,s}}{P_t} w_t^s$, [15] where b^u, w_t^s denote real variables in terms of the official and unofficial sectoral price deflators.

To facilitate model tractability we assume that employment agencies post vacancies in the official labour market at the official output cost f_{pv}^{EA} and bargain the official sector product wage rate w_t^o with workers. Then they combine individual labour supplies into a labour input which is supplied to official sector wholesale producers at the competitive price P_t^{EA}, defined in terms of official sector goods. In the formal sector new matches per unit of time are determined by a standard technology

$$M_t = m(u_t)^{\varkappa}(V_t)^{1-\varkappa}$$

where V_t^o, u_t respectively define the number of vacancies in the official sector and unemployment. The probability that a vacancy z_t^V be filled therefore is:

$$z_t^V = \frac{M_t}{V_t} = m\left(\frac{u_t}{V_t}\right)^{\varkappa}.$$

Similarly, the probability that an unemployed individual gets a job in the official sector, z_t^{un}, is:

$$z_t^{un} = \frac{M_t}{u_t} = m\left(\frac{V_t}{u_t}\right)^{1-\varkappa}$$

Both probabilities are taken as given by employment agencies and household members. Real profits of the representative employment agency are defined as follows:

$$\Pi^{EA} = \left(P_t^{EA} - w_t^o\right) l_t^o - f_{pv}^{EA} V_t$$

Parameter ρ^s $(0 < \rho^s < 1)$ defines the exogenous probability that a match survives up to next period. The employment equation for each agency is:

$$l_t^o(s) = \rho^s l_{t-1}^o(s) + z_t^V V_t(s)$$

Profit maximisation implies the following hiring condition:

$$\frac{f_{pv}^{EA}}{z_t^V} = P_t^{EA} - w_t^o + \beta \frac{\lambda_{t+1}}{\lambda_t} \rho^s \frac{f_{pv}^{EA}}{z_{t+1}^V}. \tag{2}$$

where $\frac{f_{pv}^{EA}}{z_t^V}$ defines the marginal cost of hiring a worker and the r.h.s. of (2) is the marginal benefit, including both the price margin $P_t^{EA} - w_t^o$ and the discounted savings on posting a future vacancy, which are proportional to the match survival rate ρ^s and depend on the households stochastic discount factor, $\beta \frac{\lambda_{t+1}}{\lambda_t}$. Workers and employment agencies negotiate wages within a Nash bargaining framework. The real wage is set to maximise the product:

$$\left(v_t^{EA}\right)^{1-\vartheta} \left(v_t^{lo} - v_t^u\right)^{\vartheta} \tag{3}$$

where:

$$v_t^{EA} = \left(P_t^{EA} - w_t^o\right) + \beta \frac{\lambda_{t+1}}{\lambda_t} \rho^s v_{t+1}^{EA}$$

defines the value to the employment agency of hiring an additional worker, ϑ identifies the relative bargaining power of each party, and v_t^{lo}, v_t^u respectively define individual worker value of employment and unemployment.

$$v_t^{lo} = w_t^o + \beta \frac{\lambda_{t+1}}{\lambda_t} \left\{ \left[\rho^s v_{t+1}^{lo} + (1-\rho^s) v_{t+1}^u \right] \right\} \tag{4}$$

$$v_t^u = b^u + \beta \frac{\lambda_{t+1}}{\lambda_t} \left\{ z_{t+1}^{un} v_{t+1}^{lo} + \left(1 - z_{t+1}^{un}\right) v_{t+1}^u \right\} \tag{5}$$

Note that the option value of being employed in the unofficial sector does not enter (3) because we impose the stock equilibrium condition:

$$v_t^u = v_t^s \tag{6}$$

where

$$v_t^s = \frac{P_t^{R,s}}{P_t^{R,o}} w_t^s + \beta \frac{\lambda_{t+1}}{\lambda_t} v_{t+1}^s \tag{7}$$

defines the value to the individual of being employed in the unofficial sector.

Nash bargaining implies that (3) is maximised by

$$w_t^o = (1-\vartheta) b^u + \vartheta \left(P_t^{EA} + f_{pv}^{EA} \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{z_{t+1}^{un}}{z_{t+1}^V} \right) \tag{8}$$

where the worker obtains compensation for a fraction $(1-\vartheta)$ of the foregone unemployment benefit and also shares a fraction $\vartheta$of the employment agency current revenues P_t^{EA} and of discounted future savings on hiring costs.

4.3. Firms

In each sector $j(o,s)$, perfectly competitive (flex-price) firms produce wholesale goods *Ij* and sell them to retail producers *Rj* that differentiate products and are subject to price rigidity.

[14] The unemployment subsidy is financed by lump sum taxes levied on households.

[15] Note that $w_t^j, b, p_t^{EA}, f_{pv}^{EA}$ denote real variables in terms of the consumption price index.

Wholesale producers have access to the production technology:

$$y_t^j = \left(\exp\theta_t^j\right)\left(k_t^j\right)^{\alpha^j}\left(l_t^j\right)^{1-\alpha^j}$$

where y_t^j, k_t^j, l_t^j respectively define sector-specific output, capital and labour inputs, and θ_t^j captures a sectoral productivity shock. Sectoral real marginal costs, $mc_t^{l,j}$, are:

$$mc_t^{l,o} = \left(\frac{r_t^o}{\alpha^o}\right)^{\alpha^o}\left(\frac{\left(P_t^{EA}\right)}{(1-\alpha^o)}\right)^{1-\alpha^o} \tag{9}$$

$$mc_t^{l,s} = \left(\frac{r_t^s}{\alpha^s}\right)^{\alpha^s}\left(\frac{w_t^s}{(1-\alpha^s)}\right)^{1-\alpha^s}$$

where r_t^j defines the sectoral rental rate of capital.

To identify the sectoral inflation rates π_t^{Rj} we assume a sticky price specification based on Rotemberg (1982) quadratic cost of nominal price adjustment:

$$\frac{\varphi}{2}\left(\frac{P_t^{Rj}(z)/P_{t-1}^{Rj}(z)}{\left(\pi_{t-1}^{Rj}\right)^{\delta_\pi}} - 1\right)^2 \tag{10}$$

where $\varphi \geqslant 0$ is a measure of price stickiness, $\pi_t^{Rj} = \frac{P_t^{Rj}}{P_{t-1}^{Rj}}$ denotes the sectoral gross inflation rate and δ_π is a price indexation parameter. This allows to obtain a standard Phillips curve.

4.4. The financial contract

In each sector the financial contract is stipulated between a risk-neutral entrepreneur endowed with financial wealth n_t^j, and the sectoral CMF^j. Following the costly state verification approach, information about the entrepreneur-specific ωrealisations becomes available to the CMF^j at the monitoring cost μ^j. Here we make the additional assumptions that: *a)* for every funding project, the CMF^j is subject to a cost $\chi^j i_t^j$; *b)* when entering the borrowing relationship, the entrepreneur is subject to a cost $\kappa^j n_t^j$. These two assumptions will be used to characterise differences in the use of external finance across sectors.

The entrepreneur borrows $(i^j - (1-\kappa^j)n^j)$ and agrees to repay the loan at the gross rate $(1 + r^k)$; it is assumed for simplicity that $r^k = 0$ since CMF funding is intra-period. This implies that all rents accrue to entrepreneurs, net of the CMFs operational costs. To preserve the simplicity and tractability of the model, we assume that an entrepreneurs "union" is assigned the task of collecting individual contributions necessary to finance χ^j.

The contract is also defined by the pair $\left(i^j, \tilde{\omega}^j\right)$that maximises the entrepreneur's expected income subject to the CMF being indifferent between lending or retaining the funds. Note that $\tilde{\omega}^j$ defines both the default threshold and the payment rate accruing to the lender from non-defaulting entrepreneurs. When $\omega < \tilde{\omega}^j$ default occurs and the lender monitors. We assume that idiosyncratic productivity shocks are uniformly distributed with support $[\bar{\omega}, \underline{\omega}]$, and that defaulting entrepreneurs retain the fixed amount $\underline{\omega}$, so that in the next period they can borrow again.[16] Therefore CMF^j proceeds from shock realisations $\omega < \tilde{\omega}^j$ amount to $\omega - (\mu^j + \underline{\omega})$.

Finally, we define the entrepreneur contribution scheme necessary to ensure that CMFs operational costs are covered. (i) Only non-defaulting entrepreneurs contribute a fraction of the proceeds from their investment $i^j\omega$; (ii) the individual contribution of non-defaulting entrepreneurs is $\overline{\chi}^j$ unless the entrepreneur is characterised by shock realisations $\tilde{\omega}^j < \omega < \tilde{\omega}^j + \overline{\chi}^j + \underline{\omega}$. In this latter case the contribution amounts to $\max\{0, \omega - (\underline{\omega} + \tilde{\omega}^j)\}$ and the entrepreneur retains the amount $\underline{\omega}$ which allows him to borrow again in the next period.[17]

The optimal contract maximises $q_t^j i_t^j f\left(\tilde{\omega}_t^j\right)$ subject to $q_t^j i_t^j g(\tilde{\omega}^j) \geqslant (i_t^j - (1-\kappa^j)n_t^j)$, where q_t^j defines sector j consumption price of capital, and

$$f\left(\tilde{\omega}_t^j\right) = \phi\left(\frac{\overline{\omega}^2}{2} - \frac{\tilde{\omega}_t^{j2}}{2}\right) - \phi\left(\overline{\omega} - \tilde{\omega}_t^j\right)\tilde{\omega}_t^j + \phi\left(\tilde{\omega}_t^j - \underline{\omega}\right)\underline{\omega} - \chi_t^j \tag{11}$$

$$g(\tilde{\omega}_t^j) = \phi\left(\overline{\omega} - \tilde{\omega}_t^j\right)\tilde{\omega}_t^j + \phi\left(\frac{\tilde{\omega}_t^{j2}}{2} - \frac{\underline{\omega}^2}{2}\right) - \phi\left(\tilde{\omega}_t^j - \underline{\omega}\right)(\mu^j + \underline{\omega}) \tag{12}$$

respectively define the investment shares[18] accruing to the entrepreneur and to the CMF^j. [19]

Note that we set

$$\chi_t^s = \chi^s \tag{13}$$

$$\chi_t^o = \chi^o \exp\left(\upsilon_t^\chi\right) \tag{14}$$

where

$$\upsilon_t^\chi = \rho^\chi \upsilon_{t-1}^\chi + \xi_t^\chi; \xi_t^\chi i.i.d. \tag{15}$$

defines the financial shock to the official sector.

Formally, the contract is defined by the following first order conditions:

$$i_t^j = \frac{(1-\kappa^j)n_t^j}{1 - q_t^j g\left(\tilde{\omega}_t^j\right)} \tag{16}$$

$$q_t^j\left\{1 - \phi\left(\tilde{\omega}_t^j - \underline{\omega}\right)(\mu^j) + \phi\mu^j\frac{f\left(\tilde{\omega}_t^j\right)}{f'\left(\tilde{\omega}_t^j\right)}\right\} = 1 \tag{17}$$

where

$$f'\left(\tilde{\omega}_t^j\right) = -\phi\left(\overline{\omega} - \tilde{\omega}_t^j\right) + \phi\underline{\omega} \tag{18}$$

For any given q_t^j, conditions (16) and (17) identify the default threshold and the amount of investment, [20] where the term $\frac{(1-\kappa^j)}{1-q_t^j g(\tilde{\omega}_t^j)}$ defines the leverage ratio. Note that the CMFs operating in the two sectors borrow from the same pool of households, and are therefore constrained to guarantee the same return:

$$q_t^s g(\tilde{\omega}_t^s) = q_t^o g(\tilde{\omega}_t^o) \tag{19}$$

4.5. Entrepreneurs

Risk-neutral entrepreneurs, characterised by superscript e, maximise[21]:

$$U_t^{e,j} = E_t\sum_{k=o}^{\infty}(\beta\gamma)^k c_{t+k}^{e,j}$$

where $c^{e,j}$ is defined over the consumption bundle. Note that due to the identical preferences of the entrepreneurs operating in the two

[16] In fact it is well known that the financial contract is not well defined when the borrower's net worth is zero. An alternative assumption would be to have entrepreneurs supply their labour to firms, as in C–F.

[17] It would be straightforward to show that this characterisation of the contribution scheme allows us to preserve in our context the optimality of the simple contract defined in C–F.

[18] The fixed cost χ^j reduces rents, which are entirely appropriated by the entrepreneur.

[19] The term $\phi = (\bar{\omega} - \underline{\omega})^{-1}$ defines the density of the distribution.

[20] As shown in C–F, condition (16) denotes both individual and aggregate investment decisions.

[21] Allowing for entrepreneurs' risk aversion would make the model untractable while shifting the focus of the paper. Following C–F, we assume that $\gamma < 1$, so that entrepreneurs will never accumulate an amount of wealth such that the borrowing constraint does not bind.

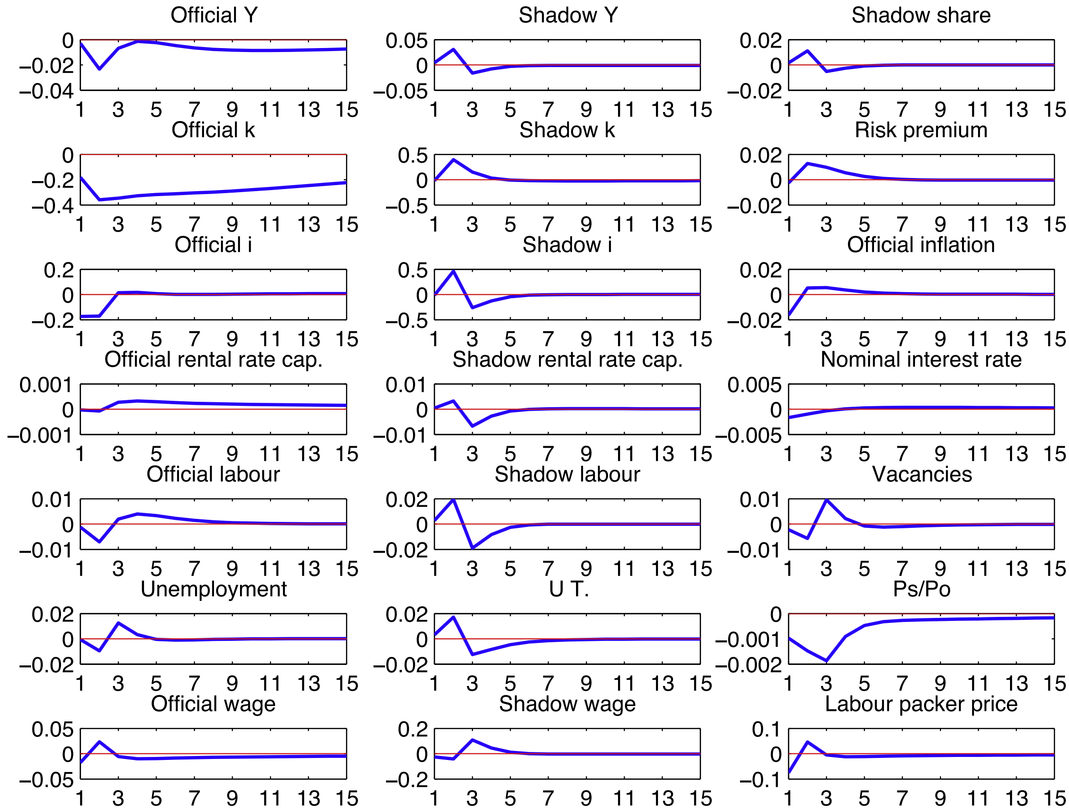

Fig. 4. Impulse responses to a financial shock. Low share of the shadow economy.

sectors and to the common pool of households' funds, the expected rate of return on the entrepreneurs' internal funds is unique.

4.6. Monetary policy

Monetary policy follows a standard Taylor rule augmented for nominal interest rate smoothing, and reacts to the inflation rate of the official consumption bundle.[22]

$$\frac{R_t}{R} = \left(\pi_t^{Ro}\right)^{\phi^\pi \rho^R} \left(\frac{R_{t-1}}{R}\right)^{(1-\rho^R)} \tag{20}$$

4.7. Model dynamics and inter-sectoral transmission

Figs. 4 and 5 report the IRFs to the financial shock defined in Eq. (15). For reasons of space we only comment results concerning the case where $SH = 12\%$ in steady state. IRFs associated to the high share case are qualitatively identical.

It is easy to see that the shock is followed by a large and persistent fall in capital, a sharp reduction in official investment, which in turn drives the official output fall. The model predicts an increase in the risk premium, $\frac{q^o_{t+1} f(\bar{\omega}^o_{t+1})}{1-q^o_{t+1} g(\bar{\omega}^j_{t+1})} - \frac{R_t}{\pi_{t+1}}$, a phenomenon typically associated to financial crises. The official rental rate of capital r^o_t is persistently higher in response to the shock.

Official sector firms react to the demand fall by lowering labour demand. This, in turn, is associated to a reduction in posted vacancies and in the labour packer price, P^{EA}_t. We observe a substantial rigidity of the official sector wage, that mildly falls on impact and then quickly recovers, overshooting its steady state value. Official wage dynamics are driven by P^{EA}_t and by the employment agencies discounted future savings on hiring costs (see Eq. (8)). These are determined by the labour market tightness index, $\frac{z^{un}_{t+1}}{z^V_{t+1}} = \frac{V_{t+1}}{u_{t+1}}$, that increases. This latter result might appear counterintuitive and deserves some further discussion. Following the official sector loss of employment, the labour market equilibrium is characterised by a reallocation of workers to the shadow economy sector and by a reduction in the number of unemployed individuals. This is necessary to preserve the equilibrium condition (6) in a situation where a vacancies have fallen. The predicted reduction in unemployment seems at odds with common wisdom, but one should bear in mind that official statistics on unemployment typically underestimate the possibility that individuals underreport their involvement in informal activities. As a matter of fact, the model would signal a drastic increase in unemployment if the total official sector employment loss were assigned to the pool of unemployed workers (see variable U.T. in Fig. 4).

The informal sector benefits from the increased availability of workers, and by a large inflow of capital. We also observe a worsening of the unofficial sector relative price that is explained by the divergent pattern of product wages in the two sectors and by the reduction in r^s_t which is caused by the persistent accumulation of capital. Relative investment and terms of trade dynamics unambiguously cause an increase in the shadow economy relative size, SH, that is also associated to an expansion in y^s_t (see (A.37) in the Appendix).

For a better understanding of the transmission mechanism, we implemented a sensitivity analysis on some key parameters (Table 4). We found that the economy is characterised by a qualitatively similar dynamic pattern but the amplitude of oscillations is wider if official and unofficial goods are close substitutes ($\varepsilon = 100$) and prices are flexible. This is intuitively plausible,

[22] In our simulations we also experimented with a monetary policy feedback on the current official output gap finding that our key results are entirely confirmed. For reasons of space we do not report here the impulse response functions obtained under this policy rule.

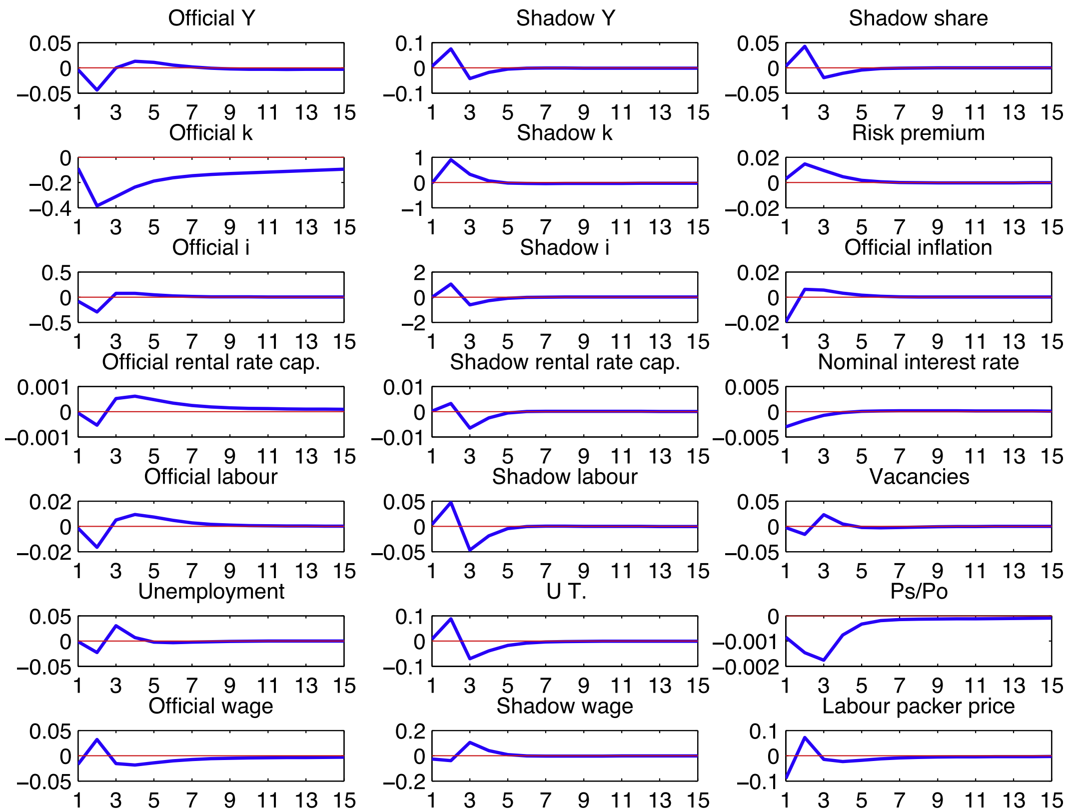

Fig. 5. Impulse responses to a financial shock. High share of the shadow economy.

Table 4
Sensitivity analysis: steady state shares of the shadow economy.

	Baseline	$\sigma^s = \sigma^o$	$\alpha^s = \alpha^o$	$\chi^s = \chi^o$	$b^u \uparrow 30\%$
High share	0.40	0.333	0.737	0.423	0.395
Low share	0.12	0.099	0.223	0.127	0.118

Table 5
Sectoral output correlations.

	Financial shock	Productivity shock
High share =	−0.81	0.89
Low share =	−0.24	0.90

because price flexibility and goods substitutability amplify the effects of relative marginal costs variations on relative demand for the two sectoral goods. By contrast, we could not detect any significant effect when we raised the capital income share in the unofficial sector. Our simulations show that neither the sign nor the amplitude of the transmission mechanism in response to banking shocks depends on the relative size of κ^s, μ^s and χ^s. [23]

The model is therefore able to predict a cushioning effect of the shadow economy of a credit market shock hitting the official economy. This result holds *irrespective* of the size of the shadow economy in steady state. In the case of the low share of the shadow economy 20% of the official sector contraction is absorbed by the growth of the shadow sector, in the case of the high share the figure raises to 68%.

It is interesting to compare these results with the consequences of a standard productivity shock in the official economy. In this case we obtain an increase in official output and a fall in official employment. This well-known effect is in line with a large body of theoretical and empirical literature (Canova et al., 2010). The fall in the real interest rate stimulates demand for unofficial goods, and the lower real wage allows the informal sector to increase employment. Contrary to what we observe for the credit shock, the transmission of the productivity shock is now *positive*. Table 5 presents sectoral correlations caused by the two different shocks.

[23] Details of relevant simulations available upon request.

5. Conclusions

Our empirical evidence suggests that the size of the shadow economy increases in the aftermath of banking crises. Our theoretical model allows us to highlight the transmission channels that might generate this result. Basically, the banking shock disrupts the formation of capital in the official economy, causing a reduction in official employment and a fall in the real wage that allows the unofficial sector to absorb more labour, thereby increasing the expected returns from unofficial capital formation.

Another important development would be to investigate the role of fiscal policy. Empirical research should highlight whether official and unofficial outputs were affected by different choices about public debt accumulation in response to crisis episodes. Developing a fiscal sector in our theoretical model could identify which policies should be implemented in response to banking crises.

Finally, our empirical findings show that currency crises cause a contraction of our total economic activity measures. This suggests that banking and currency crises might have profoundly different effects on the shadow economy. One possible explanation for this might be that currency crises have strong inflationary effects, which force the Central Bank to adopt a contractionary monetary policy stance, in sharp contrast with the interest rate reductions and liquidity expansions typically implemented in response to banking crises. In addition, the inflationary effects of currency crises probably erode the tax advantage of operating in the informal sector. Exploring these conjectures is the task of future research.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jbankfin.2014.09.017.

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