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Trust in the Monetary Authority

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Trust in the Monetary Authority*

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Abstract

Trust in policy makers fluctuates significantly over the cycle and affects the transmission mechanism. Despite this it is absent from the literature. We build a monetary model embedding trust cycles; the latter emerge as an equilibrium phenomenon of a game-theoretic interaction between atomistic agents and the monetary authority. Trust affects agents' stochastic discount factors, namely the price of future risk, and through this it interacts with the monetary transmission mechanism. Using data from the Eurobarometer surveys we analyze the link between trust and the transmission mechanism of macro and monetary shocks: empirical results are in line with theoretical ones.

JEL: E0, E5

Keywords: *trust evolutionary games, risk perception, monetary transmission mechanism.*

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1 Introduction

Economists, sociologists, and political scientists have convincingly shown that trust, namely the beliefs in others' reliability, affects growth, stability, and the business cycle¹ as it facilitates economic transactions², particularly financial ones³, and improves the functioning of institutions⁴. So far, the focus of the literature has been primarily on trust among agents involved in economic transactions or citizens served by institutions. Little has been written upon trust in large institutions, such as policy makers⁵, notwithstanding that it surely affects the transmission of macro and policy shocks. The efficacy of monetary policy in particular depends upon the ability to affect future expectations⁶, with the latter being linked to trust.

While credibility and the degree of commitment are intrinsic features of the policy making institutional design, trust pertains to agents' beliefs of the policy maker reliability as resulting from their mutual interaction and for a given degree of institutional commitment. Trust contains both a behavioral and a social component. The behavioral trust is the ex ante belief that agents place upon policy makers' reliability. The social component results from the equilibrium interaction of betrayal averse agents and randomly opportunistic policy makers. The equilibrium level of trust will ultimately affect agents' risk aversion, marginal utility, and stochastic discount factors. In a trust game a lower gain from a trusting behavior increases the risk dominance of the non-cooperative equilibrium and reduces the marginal degree of betrayal aversion in the population (or reduces the average level of trust). In turn, the endogenous decrease in the equilibrium level of trust increases absolute and relative risk aversion, as measured by a trust-adjusted Arrow-Pratt metric. Notice that while trust is not priced per se, it does eventually affect the shadow price that agents attach to risky outcomes, namely agents' stochastic discount factors. This is the sense in which it induces positive collective externalities. The endogenous nature makes trust a time-varying variable both in the long run and along the business cycle. Its business cycle fluctuations will eventually account for the mutual feedback with policy actions.

¹See Knack and Keefer [14], Alesina and La Ferrara [3], Aghion, Algan, Cahuc, and Shleifer [1].

²See Arrow [4].

³See Guiso, Sapienza, and Zingales [12].

⁴See Tabellini [22] and Algan and Cahuc [2].

⁵See Stevenson and Wolfers [21] for a survey data analysis based on Gallup.

⁶This aspect has been discussed extensively in recent months due to the emphasis given to the forward guidance policy.

Two novel aspects distinguish our work. First, we model the endogenous formation of trust in a game-theoretic interaction between a continuum of atomistic and betrayal averse agents who choose whether to trust (or not to trust) and a large opportunistic policy maker, who chooses whether to cheat or not to cheat. Notice that much of the previous literature analyzed the effects of exogenous changes of trust on the economy: not the reverse or the mutual causality. To model agents' uncertainty about policy maker opportunism, we assume that nature draws randomly the monetary advantage gained when cheating: the higher is the population probability of drawing the opportunistic policy maker, the lower is the threshold degree of betrayal aversion. In this respect, our model also draws upon the literature on evolutionary game theory in which equilibrium outcomes are determined by the frequency in which competing strategies are found in the population. Ultimately trust affects agents' stochastic discount factors, namely the shadow price that agents attach to risky outcomes. In a second step, we introduce trust-driven preferences within an aggregate dynamic model⁷: in this context trust translates into a time-varying variable which affects policy actions and is affected by them as well as from the macroeconomic equilibria. This brings us to the second novel aspect of our analysis: our macroeconomic model with endogenous trust formation allows us to account for the mutual causality between trust on the one side and economic outcomes and/or policy actions on the other. While our model has a more general applicability to policy analysis, in this paper we focus on trust towards the monetary authority and its link with the monetary transmission mechanism.

Our trust game abstracts from reputational considerations: agents and policy makers interact once and do not learn from repeated interactions. Although sequential interactions can determine coordinating behavior which are akin to trust, we aim at exploiting the effects that a given probability of opportunistic behavior in policy making has on agents' equilibrium perception of risk. In societies in which the probability of drawing the selfish policy maker is higher, citizens will be less trusting and even good policies might lose efficacy⁸. Second, we take policy institutions as given: more specifically, we assume that policy shall be conducted under commitment according to the mandate written in the formal statute. This of course does not exclude the possibility that nature

⁷We model monetary policy so as to be non-neutral.

⁸Notice also that we focus on the equilibrium trustworthy behavior for the economy/society as a whole rather than on ex post heterogeneity of trust levels within the society. The stochastic steady-state of our model is indeed calibrated around the threshold level of betrayal aversion as captured by the marginal trusting agent.

draws a more selfish policy maker: while central banks' credibility might be dictated and credited by the statutory rules of the mandate, reliability of its governor is ultimately a random personality trait.

Beyond the theoretical foundations, our paper aims at grounding quantitatively the effects and the importance of trust. We do so by examining the interaction of trust and the monetary transmission mechanism through both a quantitative exploration of our macro model and an empirical analysis.

We first conduct a quantitative assessment of the macro model, by simulating impulse response functions of our model to various shocks (a technology shock, a monetary policy shock, a supply side shock to inflation, and a trust shock). A number of results arise. We find, for instance, that a monetary restriction reduces trust on impact, as the performance of the economy provides an indirect signal of the policy maker reliability. A cost-push shock that increases inflation also reduces trust in the monetary authority: as inflation deviates from the announced policy target, agents perceive the monetary authority as less reliable. On the other side, a trust shock (an exogenous increase) is expansionary. Generally speaking, two main results characterize the transmission mechanism. First, an (exogenous) increase in trust generally reduces the shadow price of future risk, as measured by the stochastic discount factor, and increases aggregate demand as households' propensity to consume increases. Second, an increase in the equilibrium level of trust (as triggered by any other shock) tends to reduce (compared to the standard macro model) future inflation expectations as agents are more confident about the monetary authority's ability to control future expectations. At last, we compare our model to an equivalent macro model without trust: we find that the presence of time-varying trust works as an additional propagation mechanism as the responses of all macroeconomic variables (to all shocks) are more amplified.

The empirical analysis examines the interaction between trust, macroeconomic variables, and monetary policy using data from the Eurobarometer surveys. We focus on the euro area: the newly created central bank provides a natural experiment to assess the role of evolving trust. Several challenges arise in our empirical analysis. The first is an intrinsic endogeneity between the two sets of variables: the efficacy of monetary policy and its control over future expectations are high when the monetary authority is trustworthy; on reverse a successful monetary policy does increase the

level of public trust. A second issue lies in the distinction between long run and short run effects. Generally speaking, monetary policy has short run effects, hence, if a link exists between trust and monetary policy then it must become apparent at high frequencies. To account for this fact, we first de-trend our measure of trust. In a second step, we establish the link between the cyclical component of trust (net of the long run determinants) and the monetary transmission mechanism. Our empirical analysis highlights three main findings. First, a positive shock to trust increases real GDP and improves the inflation-output trade-off. This finding captures the lubricant role of trust as celebrated in Arrow [4]. Second, an increase in trust reduces inflation and generally loosens the monetary stance. Overall, the transmission mechanism of the trust shock, as well as of the monetary policy and of the inflation shock, are in line with the ones featured by our model.

The rest of the paper is as follows. Section 2 presents the model, which includes the trust game as well as the full-fledged dynamic monetary model with the endogenous determination of trust. Section 3 discusses model results. Section 4 provides empirical evidence of the link between trust and monetary policy and section 5 concludes. Appendices, figures, and tables follow.

2 The Model

The eventual goal is that of introducing endogenous trust formation into an otherwise standard macro model. We start by outlining the trust game between the agents populating the economy and the monetary authority.

2.1 Baseline Trust Game

The interaction between the agents in the economy and the monetary authority is modeled as a trust game. We start by a simple setup⁹ in which there is a single agent and a single monetary authority and perfect knowledge about their respective types. Later on we will extend the game by considering a continuum of agents with unitary mass on the one side and a single monetary authority with randomly chosen type on the other.

The baseline game is an extensive form two stage trust game in which each player has perfect knowledge of his own and the other player's type. The game can be described mathematically by the

⁹See also Güth and Kliemt [11].

following tuple $\langle N, H, P, (\succeq_i) \rangle$ which describes players, histories, player functions, and preferences. The players $N = \{1, 2\}$ are an agent, player 1, who can play the actions $a_1 = \{T, NT\}$ where T denotes "trust" and NT denotes "not to trust", and the monetary authority, player 2, whose actions are $a_2 = \{TW, NTW\}$, with TW being trustworthy behavior and NTW being the non trustworthy behavior. The set of possible histories is given by $H = \{\emptyset, (NT, NTW), (T, TW), (T, NTW)\}$, where \emptyset indicates the initial node. Player 1 is the proposer, while player 2 is the responder, therefore the player functional form, which assigns a player to each node (or history h) of the game, reads as follows: $P(\emptyset) = 1, P(h) = 2$. We denote by x_h the payoff of player 1 after each history and by y_h the payoff of player 2. Payoffs are assigned as follows: (x_1, y_1) for history $h = (NT, NTW)$, (x_2, y_2) for history $h = (T, TW)$, and (x_3, y_3) for history $h = (T, NTW)$. The game has one Nash equilibrium and the extensive form of the game is depicted in figure 1.

Proposition 1. *Under the preference ordering $(T, TW) \succ_1 (NT, NTW) \succ_1 (T, NTW)$ and $(T, NTW) \succ_2 (T, TW) \succ_2 (NT, NTW)$ the history (NT, NTW) represents the subgame perfect Nash equilibrium while the history (T, TW) is Pareto dominant.*

Proof. The above preference ordering implies the following restrictions on the payoffs: $y_1 < y_2 < y_3$ and $x_3 < x_1 < x_2$. Using backward induction and conditional on player 1 playing T player 2 will choose to play NTW . In anticipation player 1 will choose to play NT as $x_3 < x_1$.

The preference ordering defined above is meant to capture the tension between coordination and competition arising in the trust game. If the agents would choose the equilibrium by maximizing the joint surplus, they would indeed choose (T, TW) . Player 2, however, has the advantage of the second mover and has an incentive to exploit that advantage as $y_2 < y_3$.

2.2 Extended Trust Game

The above game has a predictable equilibrium and does not capture the evolving nature of trust. Therefore we extend the game to capture the idea that the equilibrium level of trust does depend upon the game-theoretic interaction of heterogeneous players' types. More specifically, we assume that agents in the economy feature differential costs of betrayal and that nature can draw policy maker types with different degrees of reliability. Atomistic agents in our economy remain the first

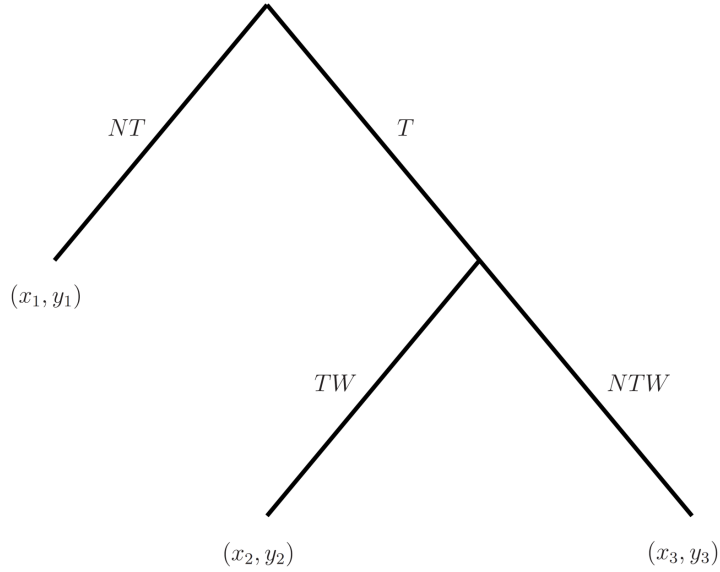


Figure 1: Graphical illustration of the baseline trust game.

movers. However, we now add incomplete information in that we assume that they do not know ex ante the degree of policy maker reliability and should therefore choose their move under uncertainty.

There is a continuum of atomistic agents, the first movers. Agents are symmetric except for their individual degree of betrayal aversion, i.e. the dis-utility they receive from being cheated. Each agent $i \in \mathcal{O}$ is uniquely identified by the corresponding degree of betrayal aversion, b , which is uniformly distributed over the unitary interval, $[0, 1]$. Notice that the cost of betrayal only materializes conditional on player 2, the policy maker, playing NTW .

Assumption 1. *The payoff of player 1 under the history $h = (T, NTW)$ is $x_2 - b$.*

The heterogeneity introduced above is crucial in ruling out extreme coordination equilibria, in which all agents decide either to trust or not to trust. Those equilibria would indeed deliver aggregate levels of trust of 100% or 0%, respectively. Our goal is instead to obtain an intermediate level of trust which is ex post endogenously determined by the players' interaction.

Definition 1. *We define the aggregate level of trust as the fraction of the population who trusts the policy maker $\tau \in (0, 1)$. This fraction is identified by the threshold player i whose cost of betrayal, \bar{b} , gives the mass of trusting agents as $\tau = \int_0^{\bar{b}} db$.*

We introduce randomization in the central bank type. In every period the nature draws stochastically the central banker's type, which features different degrees of reliability with the latter being captured by the monetary gain achieved when playing the *NTW* action.

Assumption 2. *The payoff of the central bank under the history $h = (T, NTW)$ is the sum of a deterministic payoff y_3 and of a stochastic component ϕ with zero mean. The dispersion ϕ is assumed to be drawn from a continuous uniform distribution over the range $[-m, m]$ with $m > 0$ such that the probability density function is $1/2m$.*

Notice that we are abstracting from reputational costs. In every period nature randomly draws a new type of policy maker and there is no memory on the side of the atomistic agents. In this context assumption 2 ensures that in finite repetitions of the game the central bank will not choose to play always either *TW* or *NTW*.

In principal, both central bank payoffs in the case followed by the agent choosing *T* can be made stochastic by adding dispersions ϕ_1 and ϕ_2 such that the resulting payoffs are $y_2 + \phi_1$ when the central bank chooses *TW* and $y_3 + \phi_2$ when the central bank chooses *NTW*. For the central bank's decision, however, only the difference between the two payoffs $y_3 - y_2 + \phi_2 - \phi_1$ is relevant. Therefore, we redefine $\phi_2 - \phi_1 \equiv \phi$ without loss of generality.

Notice that the assumption of lack of memory is sensible in the case of monetary policy. In the statutes of most central banks the governor is appointed for a fixed term, so contrary to politicians he does not face reputational costs in re-elections. Once the central banker is appointed and since atomistic agents are uncertain about the type, the equilibrium of the game is determined by comparing expected payoffs which are unconditional to past histories or to future expectations of the course of actions: this is explained below in this section. Later on the game of interaction will be inserted within a full-fledged infinite horizon macro model in which the fraction of trusting agents will become time-varying and will depend upon macroeconomic conditions, which are an indirect signal of the central banker reliability: a fall in the fraction of trusting agents will have the consequence of reducing the efficacy of the monetary policy stance.

We shall now reconsider the determination of the subgame perfect equilibrium based on the new random payoffs structure. As in the baseline game each single atomistic agent decides, as first

mover, whether to play T or NT . If the agent decides to play NT , the central bank will respond NTW and the game ends with payoffs (x_1, y_1) . Conditional on choosing T , the central bank has the choice between playing TW , with resulting payoffs (x_2, y_2) , or NTW , with payoffs $(x_2 - b, y_3 + \phi)$. We shall now introduce the following assumption that will allow us to retain a positive probability for both either the (T, TW) or the (NT, NTW) equilibrium.

Assumption 3. $y_1 < y_3 < y_2$ and $x_1 < x_2 < x_1 + 1$.

Lemma 1. *Conditional on T in expectation, TW is a dominant strategy for the central bank.*

Proof. The result follows from the assumption that $y_3 < y_2$. As the random variable ϕ has zero mean, in expectation playing TW is a dominant strategy for the central bank as $y_2 > y_3 + \frac{1}{2m} \int_{-m}^m \phi d\phi$.

Lemma 2. *The probability that the central bank will play NTW increases with the variability of the distribution of ϕ .*

Proof. Conditional on T and for given realization of ϕ , the central bank chooses to play NTW when $y_2 < y_3 + \phi$. Hence the probability of playing NTW is given by $P(\phi > y_2 - y_3) = \int_{y_2 - y_3}^m \frac{1}{2m} d\phi = \frac{1}{2} - \frac{y_2 - y_3}{2m}$. This probability rises when m increases and since the variance of the distribution, which is $\frac{m^2}{3}$, only rises when m increases, it follows that the probability of choosing NTW increases with the variance of the distribution of ϕ .

The above lemma has a simple intuition: when the variance of central banker's types increases the fraction of unreliable ones increases too.

Lemma 3. *The strategy T will not be a dominant strategy for all agents in the economy.*

Proof. Betrayal aversion, b , lies in the unit interval. The assumption that $x_1 < x_2$ implies that for the least betrayal averse agent T is a dominant strategy. For the most betrayal averse agent, however, the assumption $x_2 < x_1 + 1$ implies that T is no dominant strategy anymore.

The extensive form of the extended trust game is depicted in figure 2.

Recall that the game features incomplete information on the side of agents, as they do not know with certainty the type of central banker that the nature will draw. For this reason, each

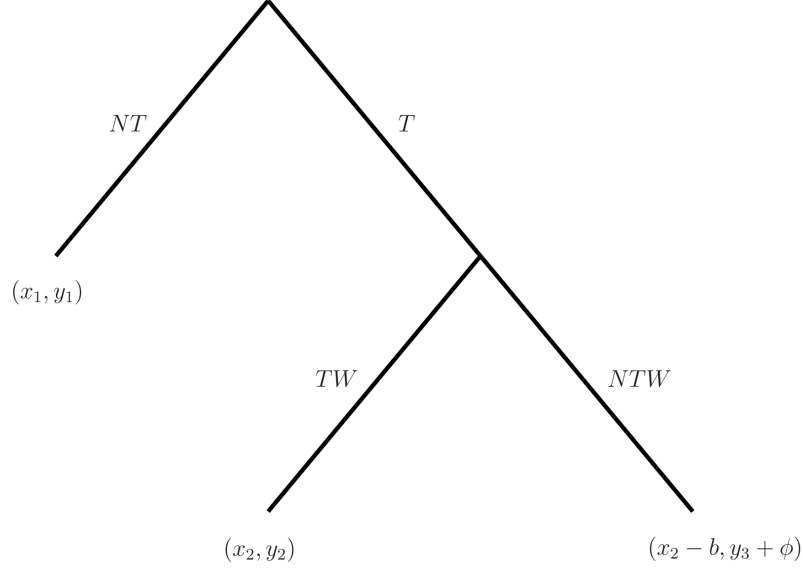


Figure 2: Graphical illustration of the extended trust game.

agent will choose optimally its action by comparing expected payoffs based on prior probability densities.

The agent will trust, T , if the expected payoff of doing so is larger than or equal to x_1 and vice versa. The expected payoff of choosing to trust, T , for the agents, $E\{\Pi_A\}$, is given by:

$$\begin{aligned} E\{\Pi_A\} &= x_2 F(y_2 - y_3) + (x_2 - b)[1 - F(y_2 - y_3)] \\ &= x_2 \int_{-m}^{y_2 - y_3} \frac{1}{2m} d\phi + (x_2 - b)[1 - \int_{-m}^{y_2 - y_3} \frac{1}{2m} d\phi], \end{aligned}$$

where $F(\cdot)$ denotes the cumulative distribution function conformable with the distributional assumption of ϕ . Noting that $F(x) = (x + m)/2m$ for $x \in [-m, m]$, it then follows that:

$$E\{\Pi_A\} = x_2 \left(\frac{y_2 - y_3 + m}{2m} \right) + (x_2 - b) \left(\frac{y_3 - y_2 + m}{2m} \right). \quad (1)$$

Lemma 4. *Agents will choose T if:*

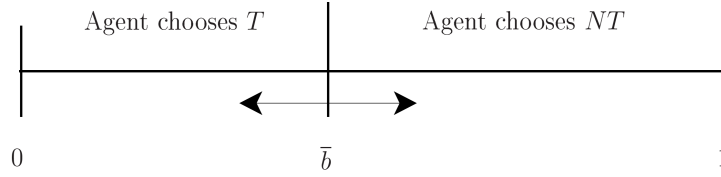


Figure 3: Graphical illustration of the relation between the degree of betrayal aversion, b , and the agents' decisions.

$$0 \leq b \leq \frac{2m(x_2 - x_1)}{y_3 - y_2 + m} \equiv \bar{b}. \quad (2)$$

Proof. The proof of the above lemma follows from the fact that T is the dominant strategy if $E\{\Pi_A\} \geq x_1$, while NT is dominant if $E\{\Pi_A\} < x_1$. Recall that in our economy there is a continuum of agents and that $b \in [0, 1]$ identifies the degree of betrayal aversion of each individual agent: the threshold, \bar{b} , therefore identifies the marginal agent (hence the overall fraction of agents) which will choose to trust.

Assumption 4. *It is assumed that $m > y_2 - y_3$.*

The above assumption guarantees that $\bar{b} = \frac{2m(x_2 - x_1)}{y_3 - y_2 + m} > 0$. The support, $[-m, m]$, of the uniform distribution for ϕ must be chosen so that the central bank has an incentive to choose NTW at least for some high realizations of ϕ . Depending on the specific value of b , the agent will either decide to trust or not to trust. This relation is depicted in figure 3.

Corollary 1. *The fraction of agents τ that plays T will solely be determined by the degree of betrayal aversion of the marginal agent, \bar{b} . More precisely:*

$$\tau = \bar{b}. \quad (3)$$

Proposition 2. *In the subgame perfect Nash equilibrium of the one-shot game with incomplete information (and also the one of finitely many repetitions of the game) the strategy profile of player 2, given $\tau = \bar{b}$, reads as follows:*

$$(\sigma_2 \mid \tau = \bar{b}) = \left\{ \begin{array}{ll} TW & \text{if } y_2 \geq y_3 + \phi \\ NTW & \text{if } y_2 < y_3 + \phi \end{array} \right\}.$$

Proof. The subgame perfect equilibrium is found by backward induction. In the second period, given the fraction of agents that chooses to trust, $\tau = \bar{b}$, and for given realization of ϕ , the central bank will then play *TW* against *NTW* if and only if $y_2 \geq y_3 + \phi$. In the first period, given the prior beliefs on the realization of ϕ , the fraction of agents that chooses to trust is given as from Corollary 1.

Notice that the outcome of the subgame perfect Nash equilibrium crucially depends upon the degree of betrayal aversion. The lower the degree of betrayal aversion, the higher is the single agent's payoff when the central bank is not trustworthy. Also, the higher is the degree of betrayal aversion of the marginal agent, the higher is the fraction of agents that decides to trust.

2.3 Payoffs Aggregation

Before embedding our trust game into a standard monetary model, we need to compute the agents' aggregate payoffs. As all agents are symmetric except for b , aggregation delivers the following realized payoff for the representative agent, R^A :

$$\begin{aligned} R^A &= \int_0^{\bar{b}} x_2 db - \int_0^{\bar{b}} b I[\phi > y_2 - y_3] db + \int_{\bar{b}}^1 x_1 db \\ &\Leftrightarrow \bar{b} x_2 - \frac{I[\phi > y_2 - y_3] \bar{b}^2}{2} + (1 - \bar{b}) x_1, \end{aligned} \quad (4)$$

where $I[.]$ denotes an indicator function that is equal to one if $\phi > y_2 - y_3$ and zero otherwise. Note that the indicator function produces a discontinuity in this expression. However, $I[.]$ can be approximated by a continuous transition function which renders standard approximation techniques feasible. The transition function may read $t \equiv t(\phi, y_2, y_3, \nu) = 1/[1 + \exp(-\nu(\phi - y_2 + y_3))]$ with $\nu > 0$. For $\nu \rightarrow \infty$, $t(\phi, y_2, y_3, \nu) \rightarrow I[\phi > y_2 - y_3]$ ¹⁰.

The realized payoff of the central bank, R^{CB} , reads as follows:

$$\begin{aligned} R^{CB} &= \int_0^{\bar{b}} y_2 db + \int_0^{\bar{b}} (y_3 - y_2 + \phi) I[\phi > y_2 - y_3] db + \int_{\bar{b}}^1 y_1 db \\ &\Leftrightarrow \bar{b} y_2 + \bar{b} (y_3 - y_2 + \phi) I[\phi > y_2 - y_3] + (1 - \bar{b}) y_1. \end{aligned} \quad (5)$$

¹⁰See similarly Bayoumi et al. [5].

2.4 Implementing the Trust Game in a Macro Model

Our goal is to embed the trust game within a standard monetary/macro model. To this purpose, the next task is the formulation of aggregate preferences whose associated payoffs feature a ranking comparable to the one assumed in the extended version of the trust game.

As explained earlier the assumption $x_2 > x_1$ is crucial to obtain well behaved equilibria, both in the baseline and also the extended trust game. Having two distinct payoffs x_1 and x_2 , however, complicates the implementation of the trust game within an aggregate/macro model. To simplify things we therefore introduce the following assumption.

Assumption 5. $x_2 \equiv \theta x_1$ and that $\theta > 1$.

The above assumption ensures that $x_2 > x_1$. The parameter θ represents the benefits for agents of coordinating on the cooperative trustworthy equilibrium. The higher θ , the higher the monetary payoff when playing the T strategy.

Notice that the central bank's payoffs parameters will not directly enter the agents' behavioral equations. We can therefore impose the following simplifying assumption.

Assumption 6. $y_3 - y_2 \equiv \psi_2 < 0$.

Given the above assumption it is possible to define $\psi_1 \equiv \frac{2m(\theta-1)}{\psi_2+m} = \frac{\bar{b}}{x_1}$. Since $m > -\psi_2$ from assumption 4 then $\psi_1 > 0$.

Lemma 5. *Given assumptions 5 and 6, the aggregate fraction of trusting agents is given by:*

$$\bar{b} = \tau = \psi_1 x_1 \tag{6}$$

and the aggregate agents' payoff is given by:

$$R^A = \alpha_1 x_1 + \alpha_2 \tau x_1 - \alpha_3(\phi) \tau^2, \tag{7}$$

where $\alpha_1 = 1$, $\alpha_2 = \theta - 1$, and $\alpha_3(\phi) = I[\phi > -\psi_2]/2$.

Proof. The calculation of the aggregate payoff in the above lemma is obtained as follows:

$$\begin{aligned}
R^A &= \tau\theta x_1 - \frac{I[\phi > -\psi_2]}{2}\tau^2 + (1-\tau)x_1 & (8) \\
&= x_1 + (\theta-1)\tau x_1 - \frac{I[\phi > -\psi_2]}{2}\tau^2 \\
&= \alpha_1 x_1 + \alpha_2 \tau x_1 - \alpha_3(\phi)\tau^2.
\end{aligned}$$

To provide direct implementation of the above lemma, let's assume that each agent in the extended trust game has the following exponential Bernoulli utility function $U^j(C) = 1 - e^{-\sigma C} \equiv x_1$, where C denotes consumption, j refers to the location of the agent on the unit interval, and σ is the coefficient of absolute risk aversion.

After rearranging and adding a time subscript, t , as well as an additive trust shock process, ε_t^τ ¹¹, the key expressions are given by:

$$\bar{b}_t = \tau_t = \psi_1(1 - e^{-\sigma C_t}) + \varepsilon_t^\tau \quad (9)$$

$$U^A(C_t, \tau_t, \phi_t) = \tilde{\alpha}_1(\tau_t, \phi_t) - \tilde{\alpha}_2(\tau_t)e^{-\sigma C_t}, \quad (10)$$

where $\tilde{\alpha}_1(\tau_t, \phi_t) = \alpha_1 + \alpha_2\tau_t - \alpha_3(\phi_t)\tau_t^2$ and $\tilde{\alpha}_2(\tau_t) = \alpha_1 + \alpha_2\tau_t$. To understand the effect of trust overall and on the marginal utility we resort on the following two lemmas.

Previous literature (see, for instance, Guiso, Sapienza, and Zingales [12]) pointed at the link between risk aversion and exogenous changes in trust. In our model, trust is an endogenous time-varying variable. As one would indeed expect there is a double causality by which a decrease in trust increases risk aversion and as agents become more averse to losses they also experience a loss in confidence on the efficacy of macroeconomic policy. Despite this it is of interest to assess also in our model the effects of exogenous changes in trust on risk aversion. This can be done by conducting comparative static analyses between risk aversion and the main deep parameter characterizing trust, namely θ . Recall that ceteris paribus, the higher θ , the higher is the fraction of trusting agents. We can therefore assess the link between marginal utility, risk aversion, and θ .

¹¹Later on, we will calibrate the parameters of this stochastic process based on estimates of an AR(1) process for the euro area using aggregate survey data.

Lemma 6. *The derivative $\partial U^A(C_t, \tau_t, \phi_t)/\partial \theta > 0$ when $\phi_t \leq -\psi_2$ and the central bank chooses to play TW. In the opposite case where $\phi_t > -\psi_2$, the sign of the partial derivative depends upon the levels of C_t and τ_t and is positive when $2\alpha_2(1 - e^{-\sigma C_t}) > \tau_t$.*

Proof. Depending on the specific realization of ϕ_t , the partial derivative of $U^A(C_t, \tau_t, \phi_t)$ with respect to θ reads as follows:

$$\frac{\partial U^A(C_t, \tau_t, \phi_t)}{\partial \theta} = \begin{cases} 2\tau_t(1 - e^{-\sigma C_t}) - \frac{\tau_t^2}{\alpha_2}, & \text{when } \phi_t > -\psi_2 \\ 2\tau_t(1 - e^{-\sigma C_t}), & \text{when } \phi_t \leq -\psi_2 \end{cases}. \quad (11)$$

$2\tau_t(1 - e^{-\sigma C_t}) > 0$, while $2\tau_t(1 - e^{-\sigma C_t}) - \frac{\tau_t^2}{\alpha_2} > 0$ if and only if $2\alpha_2(1 - e^{-\sigma C_t}) > \tau_t$.

Intuitively, an increase in θ and therefore an increase in trust increases the welfare of the representative agent, provided that the uncertainty surrounding the central banker's type is not too large.

Corollary 2. *The second derivative of the utility function with respect to θ is positive when $\phi_t \leq -\psi_2$. When $\phi_t > -\psi_2$, the sign of the partial derivative depends upon the levels of C_t and τ_t and is positive when $2\alpha_2(1 - e^{-\sigma C_t}) > \tau_t$.*

Changes in the aggregate level of trust induced by changes in θ will also influence the risk aversion of the representative agent. We measure absolute risk aversion with the Arrow-Pratt metric, where we define $ARA_t \equiv -\frac{\frac{\partial^2 U^A(C_t, \tau_t, \phi_t)}{\partial C_t^2}}{\frac{\partial U^A(C_t, \tau_t, \phi_t)}{\partial C_t}}$. In our model the latter can be computed as follows:

$$ARA_t = -\frac{[2\alpha_3\tau\psi_1 - \alpha_1 - \alpha_2\psi_1 - \alpha_2\tau]\sigma + [3\alpha_2\psi_1 - 2\alpha_3\psi_1^2]\sigma e^{-\sigma C_t}}{\alpha_1 + \alpha_2\psi_1 - 2\alpha_3\tau\psi_1 + \alpha_2\tau - \alpha_2\psi_1 e^{-\sigma C_t}}. \quad (12)$$

Lemma 7. *Evaluated at the steady-state of consumption and for the calibrated primitive trust model parameters $\theta = 1.28$, $\psi_2 = -0.345$, and $m = 0.5$, the derivative $\partial ARA(C_t, \tau_t, \phi_t)/\partial \theta < 0$.*

As we will eventually analyze trust in a general equilibrium business cycle model, the above metric will depend upon the parameter calibration. For the baseline calibration (see calibration section for a detailed description of the parameter choice) we uncover the negative relation between

ARA_t and trust as detailed in lemma 7. Intuitively, an increase in θ and therefore an increase in aggregate trust reduces risk aversion of the representative agent. This result parallels the one previously found in the literature which analyzed the link between risk aversion and exogenous changes in trust in partial equilibrium models.

Equations 9 and 10 together summarize the aggregate payoff of the trust game and shall be added to a standard monetary model to account for the link between equilibrium trust and the policy transmission mechanism. Few considerations are worth notice at this stage. The level of consumption, C_t , determines the betrayal aversion of the marginal agent in the economy, \bar{b}_t . This in turn determines the aggregate level of equilibrium trust, τ_t , using equation 9. Notice indeed that trust in our model is a time-varying variable that fluctuates in response to shocks: a shock to technology, a change in the monetary policy stance, or an exogenous increase in prices, all trigger a change in public trust towards the policy maker. Second, fluctuations in the aggregate equilibrium level of trust affect the utility of the representative agent through their impact on 10, hence they will affect the agents' stochastic discount factors, namely the subjective price of risk. Intuitively, when aggregate trust increases, the price of future risk falls. Changes in the price of future risk do affect the strength of the transmission mechanism. This is also the sense in which the monetary transmission mechanism, operating via the impact of the policy rate on the agents' consumption Euler and/or firms' future profits, changes when the level of aggregate trust changes. We will return on this point later.

2.5 Aggregate Economy

The underlying macro model is an otherwise standard monetary model. Sticky prices are introduced to account for non-neutral effects of monetary policy¹². The economy consists of a representative household, a representative final good-producing firm, a continuum of intermediate good-producing firms, and a monetary authority. The equilibrium level of trust enters the preferences of the representative households as per the aggregate utility function derived above.

Although the macro model is a fully dynamic one we shall recall that the underlying game is

¹²We have introduced our trust game also in an alternative setup in which monetary non-neutrality is obtained through liquidity effects with cash-in-advance constraints. Results on this are not reported for brevity, but the main conclusions specifically related to the interaction between trust and the monetary transmission mechanism remain valid within the alternative monetary model.

played once and under the assumption of lack of memory. This allows us to maintain the structure of the game unchanged across periods, notwithstanding the fact that the trust variable will change over time as it displays as a function of aggregate demand. As the mass of trusting atomistic agents changes in response to macroeconomic conditions, the aggregate marginal utility, hence the stochastic discount factor, will change too as per Lemma 6 in the previous section. The ensuing time variations in the marginal utility will have an impact on the strength and persistence of the monetary transmission mechanism.

2.5.1 Household

There is an infinitely lived representative household who maximizes the expected discounted sum of utilities

$$E_0 \sum_{t=0}^{\infty} \beta^t [U^A(c_t, \tau_t, \phi_t) + \varkappa \log(1 - n_t)], \quad (13)$$

where $0 < \beta < 1$ is a constant discount factor, c_t , τ_t , and n_t denote consumption, aggregate central bank trust, and labor hours, respectively. E_0 is the expectations operator conditional on information available at time 0 and ϕ_t is the realization of the stochastic dispersion of the central bank type. Real income in period t is composed of wage income, $\frac{W_t}{P_t}n_t$, bond holdings including interest rate payments, $(1 + i_{t-1})\frac{B_{t-1}}{P_t}$, and real aggregate firm profits, Ξ_t , as firms are assumed to be owned by the representative household. Notice that in our specification with a separable utility trust affects the consumption utility but not the labor dis-utility: see Appendix A that specifies the circumstances under which this assumption is valid.

The household's budget constraint in real terms reads

$$c_t + \frac{B_t}{P_t} \leq w_t n_t + (1 + i_{t-1}) \frac{B_{t-1}}{P_t} - T_t + \Xi_t, \quad (14)$$

where P_t is the price level, $w_t = \frac{W_t}{P_t}$, and T_t denotes lump sum real tax payments. Maximizing 13 subject to 14 with respect to c , n , and B gives rise to the following first order conditions:

$$U_{c,t}^A = \beta E_t U_{c,t+1}^A \left(\frac{1 + i_t}{\pi_{t+1}} \right) \quad (15)$$

$$U_{c,t}^A = \frac{\varkappa}{w_t(1 - n_t)}, \quad (16)$$

where lower case letters denote real variables, $\frac{P_{t+1}}{P_t} \equiv \pi_{t+1}$, and U_c^A is the marginal utility of consumption which depends upon the evolution of trust:

$$\tau_t = \psi_1(1 - e^{-\sigma C_t}) + \varepsilon_t^\tau. \quad (17)$$

Notice that the fluctuations in trust affect agents' stochastic discount factors through its effect on the marginal utility of consumption. We will return on this point later.

Notice also that by the consumption Euler equation it follows that the Fisher equation reads $1 + r_t = \frac{1+i_t}{\pi_{t+1}}$ with r_t being the real interest rate.

2.5.2 Final Good Firm and Intermediate Good Firms

There is a representative final good-producing firm that operates under the following production technology $y_t = \left[\int_0^1 y_t(i)^{\frac{(\varepsilon-1)}{\varepsilon}} di \right]^{\frac{\varepsilon}{(\varepsilon-1)}}$ and uses $y_t(i)$ units of each intermediate good $i \in [0, 1]$ in order to produce y_t units of the final good. Profit maximization then implies the final good-producing firm's demand for variety i :

$$y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} y_t, \quad (18)$$

where the parameter ε represents the demand elasticity of individual varieties.

Each intermediate good-producing firm i has monopolistic power and leverage in setting the price. In changing prices it faces a quadratic cost equal to $\frac{\vartheta}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2$ where the parameter ϑ captures the degree of nominal price rigidity. The higher ϑ , the more costly are price changes for the individual firm and the more sluggish is the adjustment of nominal prices. The case of flexible prices is nested and requires setting $\vartheta = 0$. Each firm i assembles $n_t(i)$ units of labor from the representative household in period t in order to operate a production technology for a distinct variety i of an intermediate good:

$$F(n_t(i)) = y_t(i). \quad (19)$$

Each firm chooses a sequence $\{n_t(i), P_t(i)\}$, taking the nominal wage, W_t , as given in order to

maximize expected discounted real profits:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\frac{P_t(i)}{P_t} y_t(i) - mc_t(i) y_t(i) - \frac{\vartheta}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 \right] \quad (20)$$

subject to the final good-producing firm's demand constraint for each variety i . $\Lambda_{0,t} \equiv \beta^t \frac{U_{c,t}^A}{U_{c,0}^A}$ is the household's stochastic discount factor and $mc_t(i)$ the real marginal cost associated with firm i . Firms owned by the household discount future profits through a stochastic discount factor with the latter being affected by trust. An increase in trust induces a reduction in future expectations of inflation, which in turn through the Euler on consumption, 15, triggers a fall in the stochastic discount factor. As firms perceive the policy makers as more reliable and capable of anchoring future expectations of inflation, they become less concerned about future profits and tend to link prices more to current macroeconomic conditions.

The following first order conditions hold, after aggregation and after imposing a symmetric equilibrium:

$$w_t = mc_t F_{n,t} \quad (21)$$

$$(\pi_t - 1)\pi_t = \beta E_t \frac{U_{c,t+1}^A}{U_{c,t}^A} (\pi_{t+1} - 1)\pi_{t+1} + \frac{\varepsilon y_t}{\vartheta} \left(mc_t - \frac{\varepsilon - 1}{\varepsilon} \right), \quad (22)$$

where F_n denotes the marginal product of labor.

The last expression is the nonlinear forward-looking Phillips curve in which deviations of the real marginal cost from its steady-state value are the driving force of inflation. Notice that the evolution of trust affects the Phillips curve and inflation through the firms' stochastic discount factor: as it declines in response to an increase in trust the dependence of current inflation from the future one declines, while its dependence from current marginal costs conditions rise.

2.5.3 Equilibrium Conditions and the Monetary Authority

Equilibrium in the goods market requires that the production of goods equals the sum of private consumption, public spending, and the costs associated with price changes:

$$y_t = c_t + g_t + \frac{\vartheta}{2} (\pi_t - 1)^2. \quad (23)$$

The monetary authority sets the short-term nominal interest rate, $1 + i_t$, according to a Taylor rule of the form:

$$\ln \left(\frac{1 + i_t}{1 + i^{ss}} \right) = b_\pi \ln \left(\frac{\pi_t}{\pi^{ss}} \right) + b_y \ln \left(\frac{y_t}{y^{ss}} \right) + \varepsilon_t^m, \quad (24)$$

where i^{ss} , π^{ss} , and y^{ss} denote steady-state values of the respective variable and ε_t^m is a mildly persistent additive interest rate shock.

Definition 2. A competitive equilibrium in our economy is a sequence of variables

$\{y_t, c_t, n_t, mc_t, \tau_t, \pi_t, i_t\}_{t=0}^\infty$ that, for given initial wealth, B_0 , and for given sequence of prices $\{w_t\}_{t=0}^\infty$, (i) solves the household's maximization problem, hence equations 15 and 16 and the No-Ponzi condition on wealth, (ii) solves the firm maximization problem, hence equations 21 and 22, (iii) solves the resource constraint of the economy, given by equation 23, (iv) is compatible with the evolution of trust, given by equation 17 and as resulting from the memory less trust game of interaction between the agents forming the household and the monetary authority, (v) and in which the nominal policy rate is set according to the policy rule given by equation 24.

2.5.4 Calibration and Shock Processes

Preference parameters. Time is measured in quarters. Labor hours are normalized to unity and the parameter \varkappa is calibrated such that the steady-state value of labor hours, n^{ss} , is equal to 0.3. The discount factor β is calibrated to 0.99, a value compatible with a 4% annual rate of interest. Risk aversion of the atomistic agents in the extended trust game is calibrated to 2, generating a degree of relative risk aversion at the steady-state that is consistent with estimated values (see, for instance, Goeree and Holt [9], Goeree et al. [10], and Holt and Laury [13] from experimental evidence).

Production parameters. Production is given by a Cobb-Douglas function $F(n_t) = y_t = a_t n_t^\alpha$ with $\alpha = 1$. Calibration of the Phillips curve is done by comparing the slope of the log-linear version of the Phillips curve presented above with the log-linear version of the Phillips curve under the Calvo-Yun approach, for which the slope coefficient can be expressed as $\frac{(1-\hat{\vartheta})(1-\beta\hat{\vartheta})}{\hat{\vartheta}}$. We set the demand elasticity $\varepsilon = 6$ (compatible with a monopolistic mark-up of 1.2 which is in line with the data), and given a value of $\hat{\vartheta} = 0.75$ (consistent with most empirical evidence on the average

length of price adjustment), equating the slope coefficients of the two Phillips curves delivers a value $\vartheta = \frac{y^{ss}\hat{\vartheta}(\varepsilon-1)}{(1-\vartheta)(1-\beta\vartheta)} \approx 17.5$.

Trust parameters. The parameter ν in the transition function $t(\phi_t, \psi_2, \nu)$ is chosen to be 300 as in Franses and van Dijk [8] which produces a smooth approximation of the indicator function $I[\cdot]$. The remaining primitive trust parameters ($\theta = 1.28$, $\psi_2 = -0.345$, $m = 0.5$) are calibrated in order to contemporaneously satisfy the following conditions. First, the parameter values shall be consistent with the extended trust game. Second, the steady-state level of aggregate trust, τ^{ss} , matches the unconditional long-run average of aggregate ECB trust (see below).

Monetary policy parameters and shock processes. The Taylor rule coefficients, b_π and b_y , are set equal to 1.5 and 0.5/4, respectively. The shocks considered include standard macro shocks (i.e. technology, monetary policy, and cost-push shocks) as well as a novel trust shock. Aggregate productivity follows a stationary AR(1) process of the form $a_t = a_{t-1}^{\rho_a} \exp(\varepsilon_t^a)$, where its steady-state value, a^{ss} , is normalized to unity; following the RBC literature $\rho_a = 0.95$, and $\sigma_a = 0.008$. The steady-state value of government expenditures, g^{ss} , is calibrated such that $\frac{g^{ss}}{y^{ss}} = 0.25$. The autocorrelation coefficient of the monetary policy shock, ρ_m , and the standard deviation of the i.i.d. interest rate shock, σ_m , are set to 0.2 and 0.006, respectively, as in Rudebusch [18]. The cost-push shock has a standard deviation of 0.01 and an autocorrelation coefficient of 0.9 as in Smets and Wouters [20]. Finally, the trust shock is estimated through an AR(1) model with drift using a semi-annual time series of aggregate ECB trust based on the Eurobarometer survey data. The time series contains data for all 17 euro area countries from 1999:S1 to 2011:S1. Each country is considered in the sample from the country's respective entry to the euro area. The functional form showing the (highly significant) point estimates reads as $e_t^\tau = 0.101 + 0.844e_{t-1}^\tau + \varepsilon_t^\tau$. Recall, however, that we simulate a quarterly model. Hence, the parameter estimates of the AR(1) process using semi-annual data need to be adjusted accordingly. Let a circumflex denote variables with quarterly data frequency. An equivalent AR(1) model can then be formulated as $\hat{e}_t^\tau = (1 + \rho_\tau)d + \rho_\tau^2 \hat{e}_{t-2}^\tau + \rho_\tau \hat{e}_{t-1}^\tau + \hat{\varepsilon}_t^\tau$, where d and ρ_τ refer to drift and autocorrelation coefficient of the AR(1) model with quarterly data frequency, respectively. Given the equivalence of both models, it follows that $d = 0.053$, $\rho_\tau = 0.92$, and $\sigma_\tau = 0.045$ provided that the estimated variance of the regression residuals is equal to 0.004. The adjusted parameters imply an unconditional long-run average of

aggregate ECB trust of 0.65. The calibration of the trust model parameters is chosen such that the steady-state level of aggregate trust, τ^{ss} , matches this value.

3 Quantitative Analysis

We now simulate our model in response to a number of shocks to assess the link between trust and the transmission mechanism of macroeconomic and policy shocks. We will consider traditional macroeconomic and policy shocks (technology, monetary policy, and cost-push shocks) as well as the newly estimated trust shock.

Figure 5 shows impulse responses of selected variables to a one standard deviation increase in technology for given policy stance and trust parameters: each panel compares the impulse response under the model with trust (solid line) and under the standard macro model with sticky prices (dashed line). This shock is helpful in understanding what is the contribution of endogenous trust building onto a standard macro model. An increase in technology rises production and consumption demand: all this is standard in macro models and empirical evidence. The increase in output and consumption in turn increases welfare and the fraction of agents who trusts the policy maker as per equation 9. As trust rises, the agents expect bigger declines in future expectations of inflation compared to the standard macro model: this in turn allows the monetary authority to loosen the policy stance by more, still in comparison to the standard macro model. Generally speaking, all variables show higher volatility and persistence in the model with time-varying trust relative to the standard macro model. This is so since there is a feedback loop between good policy and trust: when the policy hits the target, agents' trust improves; this in turn promotes the efficacy of the policy action. The monetary policy in our model is pro-cyclical in response to productivity shock: as production increases, the monetary authority tries to take full advantage of the improved frontier possibility by accommodating aggregate demand. The degree of pro-cyclicality and the ability to boost aggregate demand increase when trust responds (positively) to (positive) productivity shocks. In the model with endogenous trust building the business cycle becomes more responsive when increasing the parameter θ , namely the gains from coordination: see Appendix B for details and figure.

Figure 6 shows impulse responses of selected variables to a one standard deviation increase in

the policy rate, again by comparing the models with and without trust. Once again, the fall in production and consumption, following the contractionary policy, reduces the level of trust as per equation 9. The ensuing increase in the stochastic discount factor, the price of future risk, reinforces the contractionary effects of the increase in the policy rate. The model impulse responses show once again that the fluctuations are more amplified in the model with time-varying trust compared to the traditional macro model. For this shock, as trusts declines, agents expect even larger output drops: this triggers larger falls in inflation expectations. In response to the larger drop in output the monetary authority dampens the contractionary effects of the initial shock (compared to the standard macro model) through the response of the Taylor rule.

Figure 7 shows impulse responses of selected variables to a one standard deviation increase in the price mark-up. This can be interpreted as a cost-push, hence we expect the model to deliver an output contraction and an increase in inflation. This occurs but once again all variables show higher volatility and persistence in the model with time-varying trust. The shock depresses output and consumption and decreases the fraction of agents who trusts the policy maker as per equation 9.

Finally figure 8 shows impulse responses of selected variables in our model to the newly estimated trust shock. The increase in trust is largely expansionary. Generally speaking, output increases and inflation falls, the latter due to the fall in inflation expectations. We can examine the interaction between the evolution of trust and monetary policy by analyzing the consumption Euler equation, which can be written as follows:

$$1 = \beta E_t \frac{U_{c,t+1}^A}{U_{c,t}^A} \left(\frac{1 + i_t}{\pi_{t+1}} \right).$$

From the impulse responses following a trust shock we know that the nominal interest rate decreases and the real interest rate $1 + r_t$ increases (not shown as a separate impulse response). As a result, the stochastic discount factor decreases. This can only happen if inflation expectations decrease over proportionally relative to the decrease in the nominal interest rate. This is what we would expect following (positive) trust shocks. Intuitively, as trust rises, the price of future risk falls: as a consequence, households increase their consumption demand. As the agents perceive an improvement in the inflation-output trade-off, inflation falls in anticipation despite the increase in

aggregate demand.

4 Empirical Evidence

The aim of the empirical analysis is to evaluate the link between trust and macroeconomic performance in general and between trust and the monetary transmission mechanism more specifically. Our trust variable will be constructed using the answers from the Eurobarometer surveys. Some econometric issues deserve discussion.

First, we shall distinguish between the long run determinants and the short run fluctuations in trust. Previous empirical analysis focused on long run effects (such as GDP growth) of exogenous changes in trust and assessed the power of well entrenched institutions in promoting trust building. Our focus is on the mutual link between trust and policy actions which manifests at short run business cycle frequencies. Hence, we de-trend (with Hodrick-Prescott filter) our proxy variable for trust in order to disentangle the short run fluctuations of trust net of the long run determinants. In the second stage, we assess the link between trust and monetary policy using time series analysis.

A second issue to consider is the potential endogeneity between macroeconomic performance and time-varying trust. A high level of trust may increase the willingness of households to consume and of firms to invest. On the other hand, good macroeconomic performance might be an indicator of the well-functioning of macroeconomic policy, which in turn improves agents' beliefs in the policy maker reliability. This mutual causality implies that regressing a measure of macroeconomic and/or monetary policy indicators on a measure of trust or vice versa is inappropriate. We address the temporal endogeneity issue by employing VAR estimation techniques.

Our empirical analysis will also analyze the effects of a novel shock to trust. For this reason, a third issue arises related to the identification assumptions of such a shock. In this respect, we maintain a conservative agnostic view by resorting on Generalized Impulse Response Functions (see Koop et al. [15] and Pesaran and Shin [16]). We will return on this point later on.

4.1 Eurobarometer Surveys and Macroeconomic Data

We use data from Eurobarometer surveys which are conducted on behalf of the European Commission at least twice a year in all European Union (EU) member countries for a sample period

that goes from 1999:S1 to 2011:S1. The surveys cover a rich set of demographic characteristics in order to monitor the social and political attitudes of households in all EU member countries. More specifically, we combine a selected set of 25 Eurobarometer surveys in order to build a unique semi-annual repeated cross section from 1999 to 2011. One strength of the surveys is that several questions on attitudes towards European institutions are asked at least twice a year, which makes it possible to construct our main variable of interest, namely the perceived trust in the ECB, in all data sets. The surveys ask the participants:

“And, for each of them, please tell me if you tend to trust it or tend not to trust it? (READ OUT): The European Central Bank”

The survey participants are then given the choice between the three possible answers: “1, Tend to trust”, “2, Tend not to trust”, and “3, Do not know”. Macroeconomic variables are obtained from Eurostat. Semi-annual GDP measures are calculated using quarterly data on seasonally adjusted chain-linked real GDP (reference year: 2000), while the inflation rate refers to the semi-annual change in the Harmonized Index of Consumer Prices (HICP). The Euro Over Night Index Average (EONIA) rate refers to the average rate within the respective semester. Semester data were constructed following Roth et al. [17] in order to match the Eurobarometer surveys with macroeconomic data. Table 2 contains summary statistics of the variables used.

4.1.1 Estimation Strategy

As mentioned earlier, we expect the trust variable to feature both long run and short run dynamics. Ultimately, however, we are interested in explaining, through a time series analysis, the link between trust (net of long run dynamics) and macroeconomic fluctuations and/or monetary policy rates, which manifests at business cycle frequencies. To disentangle those two components, we aggregate our binary measure of trust, obtained through survey data, on a country and time period basis and de-trend the resulting time series using the Hodrick-Prescott filter (standard smoothing parameter of 400). In the second stage, we assess the link between trust and monetary policy using standard time series analysis. The cyclical component of trust is also included in a VAR estimation together with standard macro indicators in order to explain the link with the business cycle and the monetary

transmission mechanism.

4.1.2 Time Series Analysis of Trust: Main Issues and Results

To start in figure 9, we show the evolution of the aggregated trust variables for a selected number of countries (Germany, France, Italy, Greece, and Spain) and for the whole sample period 1999:S1 to 2011:S1. The variable shows significant fluctuations with persistent cycles in all countries. In each panel we also inserted two vertical lines corresponding to two financial crises dates: the ones of 2001 and 2007-2008 (data are NBER and CEPR business cycle dates, respectively). It is interesting to notice that in all countries the levels of trust declined after the crises. The decline is particularly evident and persistent after the 2007-2008 crisis as this was more severe. In Greece, for instance, the decline became even sharper after the start of the sovereign debt crises. This movements signal that agents tend to associate the reliability of the policy maker, in this case the common monetary authority, to the performance of the economy.

Second, it is instructive to examine how and to what extent the trust variable co-moves with the cycle. Table 1 shows coefficients of correlation between GDP (y_t) and ECB trust (τ_t) using semi-annual leads and lags. y_t and τ_t refer to Hodrick-Prescott filter de-trended real GDP and semi-annual ECB trust. The cyclical components have been normalized by the respective trend values in order to account for between country heterogeneity. The number shows that the contemporaneous, lagged, and lead correlations are all positive. An increase in macroeconomic conditions improves the beliefs of the agents about the monetary authority reliability and vice versa an increase in trust, by increasing consumers' and investors' confidence, tends to boosts output growth.

	τ_{t-1}	τ_t	τ_{t+1}
y_t	0.238	0.335	0.259

Table 1: Coefficients of correlation between GDP (y_t) and ECB trust (τ_t) using semi-annual leads and lags.

Next we use the cyclical component of trust in a VAR estimation. As mentioned earlier, the empirical assessment of the link between trust on the one side and macroeconomic and monetary policy variables on the other is done using VAR estimation. This allows us to partly address the temporal double causality between the two sets of variables. We rely on standard VAR models of

the form:

$$Y_t = A(L)Y_{t-1} + BX_t + \varepsilon_t, \quad (25)$$

where Y_t and X_t are vectors of endogenous and exogenous variables, respectively. $A(L)$ is a matrix polynomial of order k in the lag operator L , B is a coefficient vector conformable with the dimension of X_t , and ε_t are the regression residuals. As the semi-annual sample for the euro area is rather short (1999:S1-2011:S1), country-based VAR estimations are not feasible. Therefore we estimate VAR models on pooled data, controlling for country-specific heterogeneity, and assuming slope homogeneity¹³.

The VAR models are estimated using ECB trust and several macroeconomic indicators. Here we focus on a parsimonious VAR specification which includes ECB trust, real GDP, HICP inflation, and the policy rate. Several robustness checks have been conducted: the main findings highlighted here remain robust across different specifications. A few additional notes are worth mentioning regarding the VAR specification and the choice of variables. We proxy the policy rate for the euro area using the EONIA rate. There are several reasons for which the EONIA rate is a good proxy of the monetary stance. One, among many others, is that this rate is well suited to capture the monetary stance in times of crisis. Recently, indeed the Eurosystem has experienced a significant number of unconventional monetary policy measures¹⁴. The EONIA rate fell much below the interest rate on the main refinancing operations, showing that this rate is particularly responsive to monetary conditions. Finally, the sample is split into two, the full sample and the non-crisis sample. A dating of the beginning of the current crisis is to a certain extent arbitrary. We date the beginning of the crisis conservatively and define the financial distress of August 2007 (inter alia associated with the United States subprime mortgage market and severe tensions in interbank markets around the globe) as the starting point of the active phase of the crisis¹⁵. The general specification for the VAR will therefore include ECB trust, real GDP, HICP inflation, and the EONIA rate. In what follows, we focus on the empirical impulse response functions for the non-

¹³A similar procedure is in Ciccarelli et al. [6].

¹⁴Among other things, commercial banks in the euro area were offered liquidity assistance through a fixed-rate tender procedure with full allotment at the interest rate on the main refinancing operations starting in October 2008.

¹⁵See, for instance, Duchin et al. [7]. The fieldwork of the Eurobarometer 68.1 survey was conducted in September and October 2007. As such, we assign data corresponding to the second semester of 2007 (i.e. 2007:S2) to the crisis period.

crisis sample. There are several widely accepted reasons for excluding crises from those business cycle analyses. In our particular case we also observe that fluctuations of macro and financial variables during the crisis period are *inter alia* mostly driven by a financial shock that is in fact exogenous to our VAR model and cannot be modeled in light of the rather limited semi-annual sample for the euro area. It shall further be noted that during the recent financial and sovereign debt crises, both ECB trust and real GDP fell substantially below the respective trend value and the euro area experienced an unprecedented loosening of the monetary stance. The resulting strong positive correlation of the key model variables, as generated through factors that are exogenous to our VAR model, would bias the estimation results. Finally, notice that the VAR specification contains one lag for each endogenous variable.

One last issue related to the VAR specification concerns the shock identification. There is limited conventional wisdom or little economic theory that would justify one particular Cholesky ordering for further impulse response inference. For this and other reasons, we decided to resort upon the Generalized Impulse Response Functions methodology (GIRF hereafter). Appealing properties of GIRF, compared to orthogonalized impulse response functions in the spirit of Sims [19], are that GIRF do not require an orthogonalization of shocks using the Cholesky decomposition and that the ordering of the endogenous variables in the VAR model is irrelevant for further inference. In order to calculate GIRF, single elements of the residual vector are shocked and the effects of all other shocks are integrated out using the distribution of residuals. See Appendix C for a description of the methodology.

Results of the Time Series Analysis: Figures 10 to 12 show generalized impulse responses of selected variables to one standard deviation innovations to the EONIA rate, HICP inflation, and ECB trust, respectively. The impulse responses following those three shocks allow for a direct comparison with the theoretical model impulse responses¹⁶. Impulse responses (solid line) are shown together with +/- two standard deviations confidence bands (dashed lines). Theoretical impulse responses to monetary policy, cost-push, and trust shocks are indicated in the corresponding plots by asterisks. In commenting the results of the simulations we will also evaluate the ability of the

¹⁶We did not consider to compare the impulse response functions to a GDP shock in the VAR (something which would be available) with the impulse response functions to a productivity shock in the model as the matching would be ambiguous. A shock to GDP in the data would also capture exogenous movements in aggregate demand.

model in fitting the transmission mechanism highlighted by the empirical analysis. Notice, however, that the comparison between the VAR GIRF and the model impulse responses will obviously not be perfect as the latter are orthogonalized while the former are not. We will therefore focus on a qualitative comparison (the direction of the impulse responses) and of the overall transmission mechanism of shocks between the data and the model. We will discuss the cases in which the model and the VAR estimates are close also in quantitative terms.

A shock to the EONIA rate significantly depresses ECB trust upon impact and persistently increases the EONIA rate up to semester six. Real GDP falls below trend starting in semester three while the shock turns out to be expansionary in the very short run. The fall in trust following a contractionary monetary policy mirrors quite precisely the theoretical equivalent. Notice that our results also entail the so-called price puzzle, namely the short-run increase in prices following a monetary contraction, that has been frequently documented in previous empirical research on monetary policy shocks in a VAR framework.

A shock to HICP inflation depresses both ECB trust and output in the short run. The theoretical equivalent (impulse response to the cost-push shock shown through asterisks) is able to replicate those findings. A one-time increase in ECB trust has three main effects. First, it significantly increases real GDP from semester five until nine: an increase in public confidence provides an expansionary boost to the economy akin to that triggered by the Keynesian animal spirits. An increase in ECB trust also reduces the prospects of future inflation growth: the public believes that the monetary authority is able to control future inflation more closely and at the expenses of lower output costs. The output-inflation trade-off improves. In anticipation inflation falls and the gain in credibility allows the monetary authority to loosen the monetary stance. Hence, the EONIA rate is significantly reduced. We attribute this finding once again to the fact that an increase in trust improves the inflation-output trade-off and in turn it enlarges the scope for maneuvering a loosening of the policy stance¹⁷. The theoretical impulse responses are again consistent with the

¹⁷We performed a number of robustness exercises, non-reported for brevity but available upon request. We repeated the estimations for instance by replacing the EONIA rate with either the ECB's interest rate on the main refinancing operations (which refers to the minimum bid rate or the fixed rate depending on the respective time period) or the Euro Interbank Offered Rate (EURIBOR) with a maturity of 3 month. Results remain qualitatively and generally quantitatively unaffected. Notice, however, that the EURIBOR carries additional information compared to the EONIA rate or the interest rate on the main refinancing operations. Hence, related results are more difficult to interpret and compare to our specific model.

VAR evidence. In particular, the theoretical impulse responses to trust shocks also show persistent reductions of inflation and the policy rate whose magnitude are similar compared to the empirical counterparts. A shock to ECB trust is, also in line with model results, expansionary. However, the effect seems to be smaller in the data. This can be explained by the fact that our GIRF also contain elements from the other shock distributions that tend to dilute the effect of each individual shock.

As a further robustness exercise, we analyzed impulse responses to orthogonalized shocks using the Cholesky decomposition in the spirit of Sims [19]. Figures for this are reported in a separate appendix available upon request. As stated before, the ordering of our ECB trust variable is not straightforward. We fix the ordering of the standard macro variables in way that it is consistent with the VAR literature. More precisely, we order output first followed by inflation and then the policy rate. Hence, four alternative ordering positions of ECB trust are to be analyzed.

For the shock to HICP inflation, impulse responses for output and the policy rate are as expected, namely output is significantly reduced and the EONIA rate increases significantly up to semester two in all cases. For the trust response, two out of the four orderings show the significant reduction in ECB trust following the exogenous increase in prices as was the case for GIRF while the reduction is insignificant in the remaining two cases.

A shock to the EONIA rate significantly depresses output regardless of the variable ordering. In all cases the price puzzle also observed with GIRF materializes while the policy rate response turns negative in the medium run.

Finally and most importantly, orthogonal ECB trust shocks significantly loosen the monetary stance as was the case before regardless of which of the four orderings is used. Similarly, a trust shock is expansionary in the medium run in all cases. Inflation falls, significantly so in two out of the four cases. Summing up, key results inferred from GIRF also carry over when using orthogonal shocks. One generally valid message is that the trust shock is expansionary and loosens the policy stance regardless of the Cholesky ordering at hand.

5 Conclusions

Large crises tend to revive the idea that trust in large institutions and policy making is highly sensitive to aggregate conditions and fluctuates at high frequencies. We conduct an empirical analysis showing the two way causality between public trust in policy making and the efficacy of the monetary policies. We laid down a simple macroeconomic model which relies on game-theoretic foundations of the aggregate equilibrium level of trust. The quantitative results of the model, which are in line with our empirical evidence, help us to deepen the understanding of the link between trust and the monetary transmission mechanism.

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Appendix A. Utility Specification

Notice that in the basic and the extended trust game, the individual agents solely base their decisions to trust or not to trust on payoff differences. Assume, for instance, that the central bank

plays TW with probability one and that the agents' payoffs are as stated in the main text. It will then be beneficial for the individual agent to choose T if:

$$x_2 - x_1 \geq 0$$

and vice versa.

Assume that there is a representative agent who optimally chooses aggregate labor supply, n , that is distributed equally among the agents and inelastically across strategy profiles in the trust game (i.e. regardless of the agents'/the central bank's decisions). Denote this individual labor supply as $\tilde{n}^j = \tilde{n} \forall j$ where j refers to the location of the agent on the unit interval. Furthermore, assume that $v(\tilde{n})$ is an increasing function in \tilde{n} representing the dis-utility of supplying labor, that individual agents are homogeneous with respect to $v(\tilde{n})$, and that the dis-utility of labor enters additively in the agents' utility functions. In the same setup as before, it then follows that it is beneficial for the individual agent to choose T if:

$$x_2 - v(\tilde{n}) - [x_1 - v(\tilde{n})] = x_2 - x_1 \geq 0$$

and vice versa. Hence, incorporating labor in such a way does not affect the agents' decisions in the trust game and can therefore be abstracted from at this stage.

Appendix B. Impulse Responses for Different Values of θ

Additional insights of the effect of trust on the transmission of shocks can be gained by inspecting impulse responses to technology shocks for different values of θ . Recall that this a primitive parameter in the determination of trust: as θ increases, agents are more prone to coordinate and the average level of trust in the economy rises. The figure shows the impulse responses of selected variables to a one standard deviation technology shock for the model with trust and for different values of θ . As θ rises, all variables become more responsive to the shock: an increase in the average level of trust reduces risk aversion (as shown in Lemma 7); households' consumption demand becomes then more responsive to shocks as the consumption smoothing desire is dampened. As a result, the productivity boom is more pronounced under a high value of θ , which implies a high average level of trust.

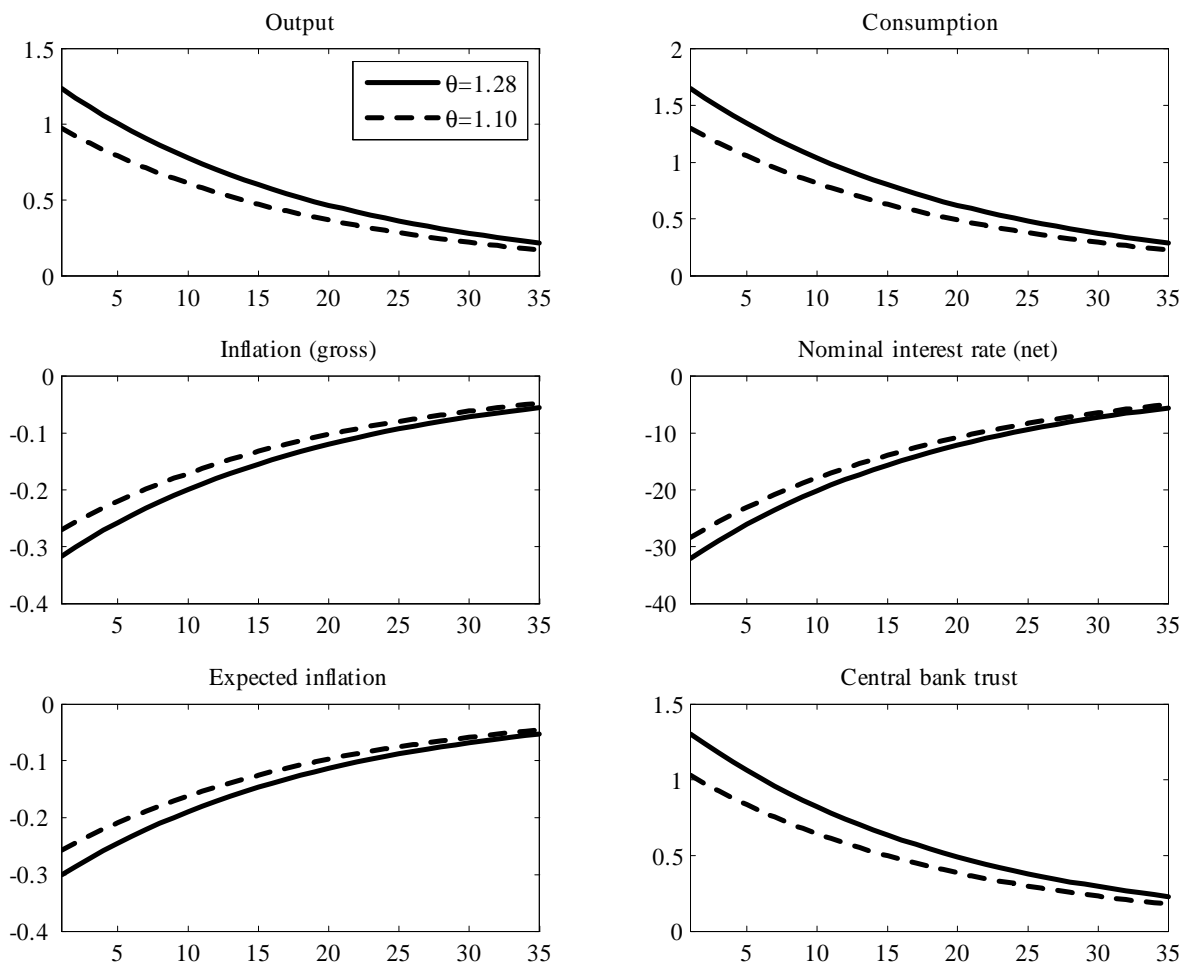


Figure 4: Impulse responses of selected variables for different values of θ to technology shocks.

Appendix C. Generalized Impulse Response Functions

Consider a VAR model of the form:

$$Y_t = \sum_{i=1}^k A_i Y_{t-i} + B X_t + \varepsilon_t, \quad t = 1, \dots, T, \quad (26)$$

where Y_t and X_t are vectors of endogenous and exogenous variables, respectively. A_i , $i = 1, \dots, k$, and B denote coefficient vectors conformable with the dimensions of Y_t and X_t , and ε_t are the regression residuals. Provided that Y_t is covariance stationary, the VAR model can equivalently be expressed as an infinite moving average process

$$Y_t = \sum_{i=0}^{\infty} \Phi_{\varepsilon,i} \varepsilon_{t-i} + \sum_{i=0}^{\infty} \Phi_{X,i} X_{t-i}, \quad t = 1, \dots, T. \quad (27)$$

Consider that only one element of the residual vector is shocked and that the effects of the other shocks are integrated out using the distribution of residuals. More precisely, consider a shock to the j -th element of the residual vector, ε_{jt} , of size δ_j . The generalized impulse response function of Y_t is then given by

$$E(Y_{t+n} | \varepsilon_{jt} = \delta_j, \Omega_{t-1}) - E(Y_{t+n} | \Omega_{t-1}), \quad (28)$$

where E is the expectations operator and Ω_{t-1} denotes available information at time $t - 1$. For a multivariate normal distribution of the residual vector, ε_t , and $\delta_j = \sqrt{\sigma_{jj}}$ it can be shown that the generalized impulse response reduces to

$$\frac{\Phi_{\varepsilon,n} \sum e_j}{\sqrt{\sigma_{jj}}}, \quad n = 0, 1, \dots, \quad (29)$$

where σ_{jj} denotes the standard deviation of the j -th residual and e_j is a selection vector whose elements are zero except for the j -th element which is equal to unity. This generalized impulse response measures the effect of a one standard deviation shock to the j -th equation at time t on the expected values of Y_t at time $t + n$.

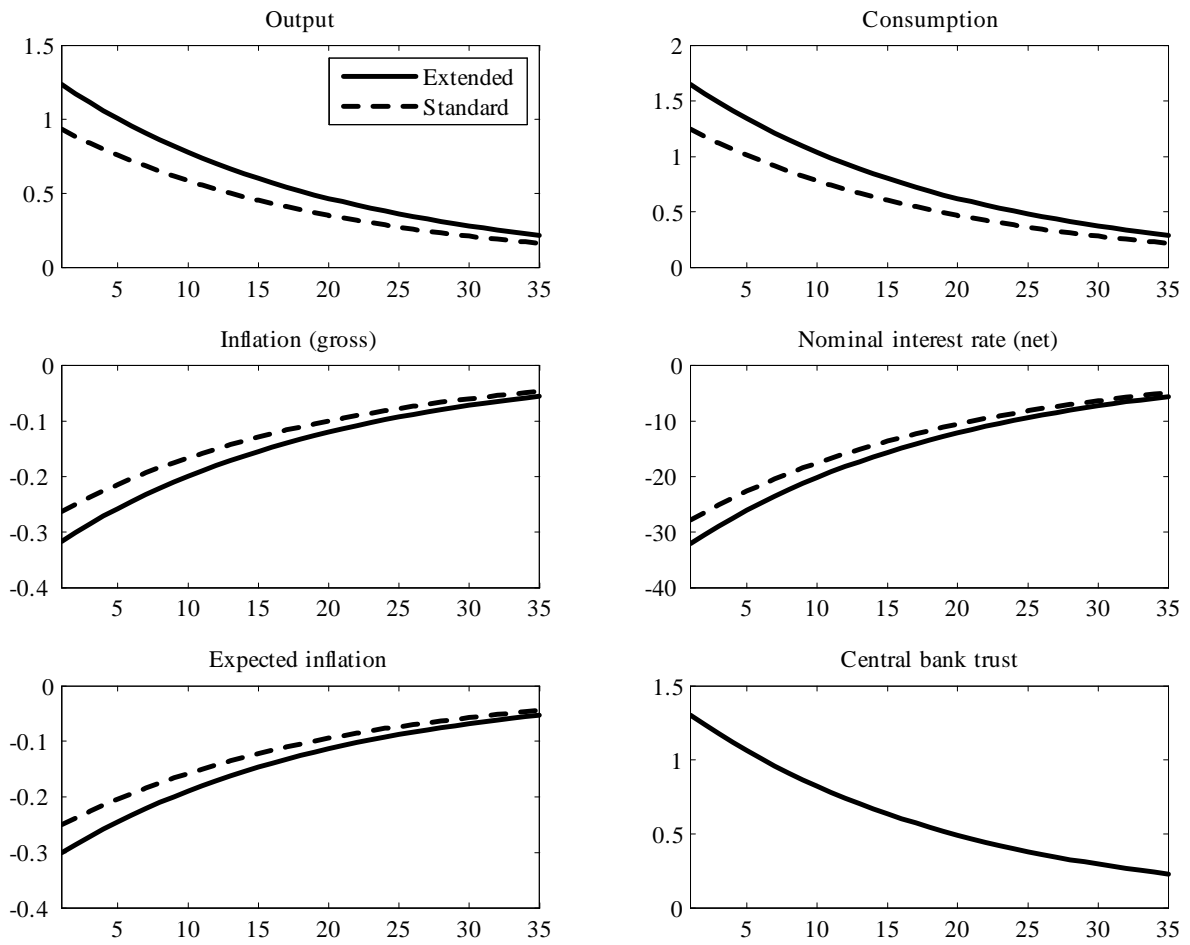


Figure 5: Impulse responses of selected variables to technology shocks.

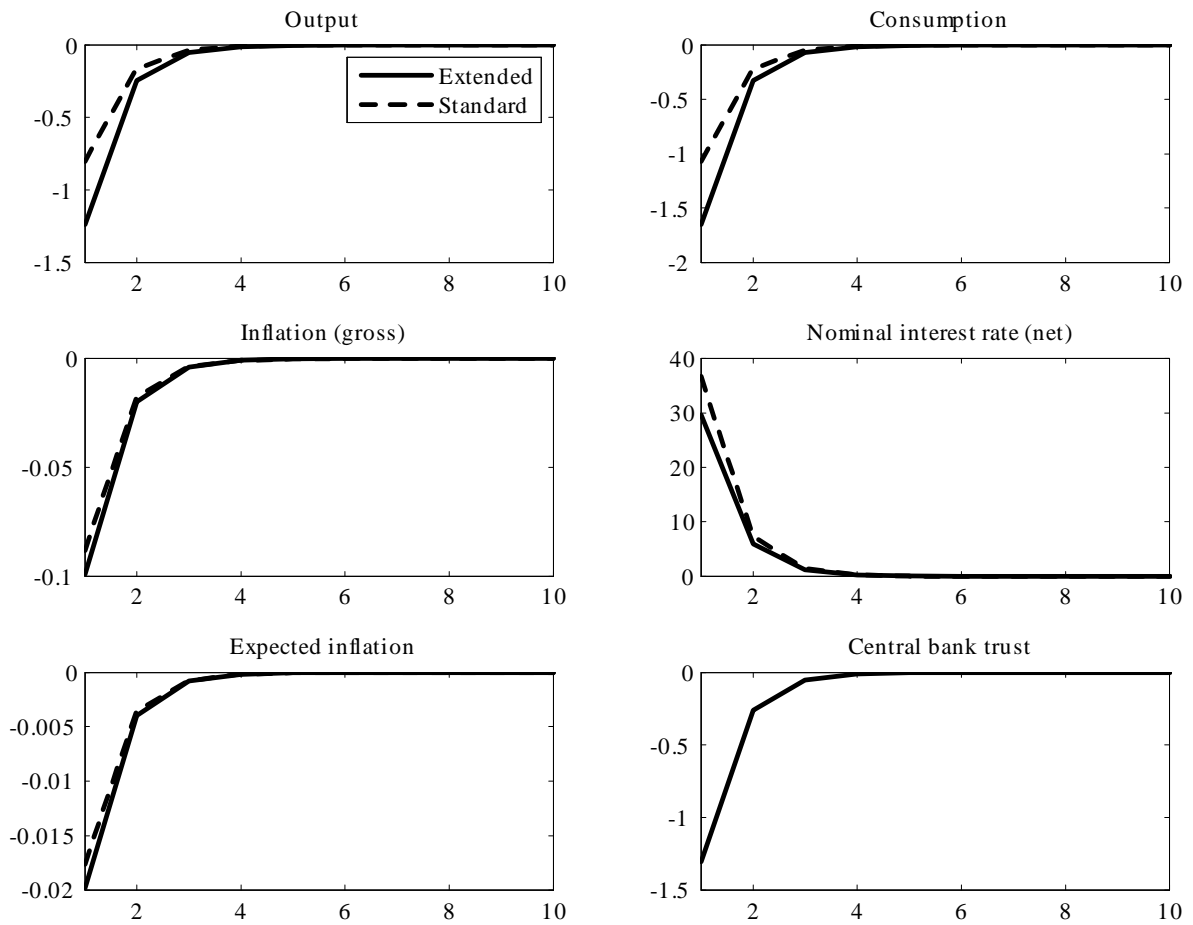


Figure 6: Impulse responses of selected variables to monetary policy shocks.

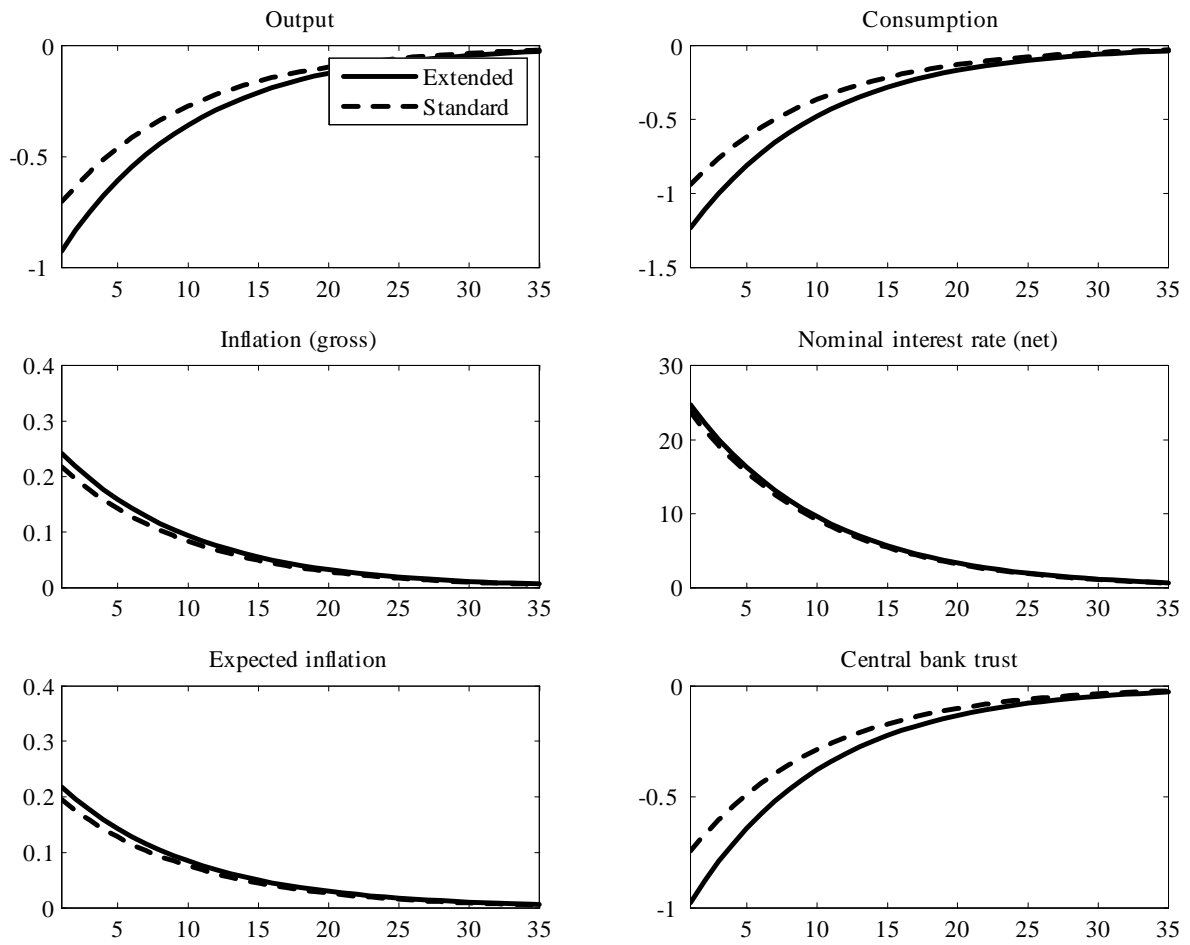


Figure 7: Impulse responses of selected variables to cost-push shocks.

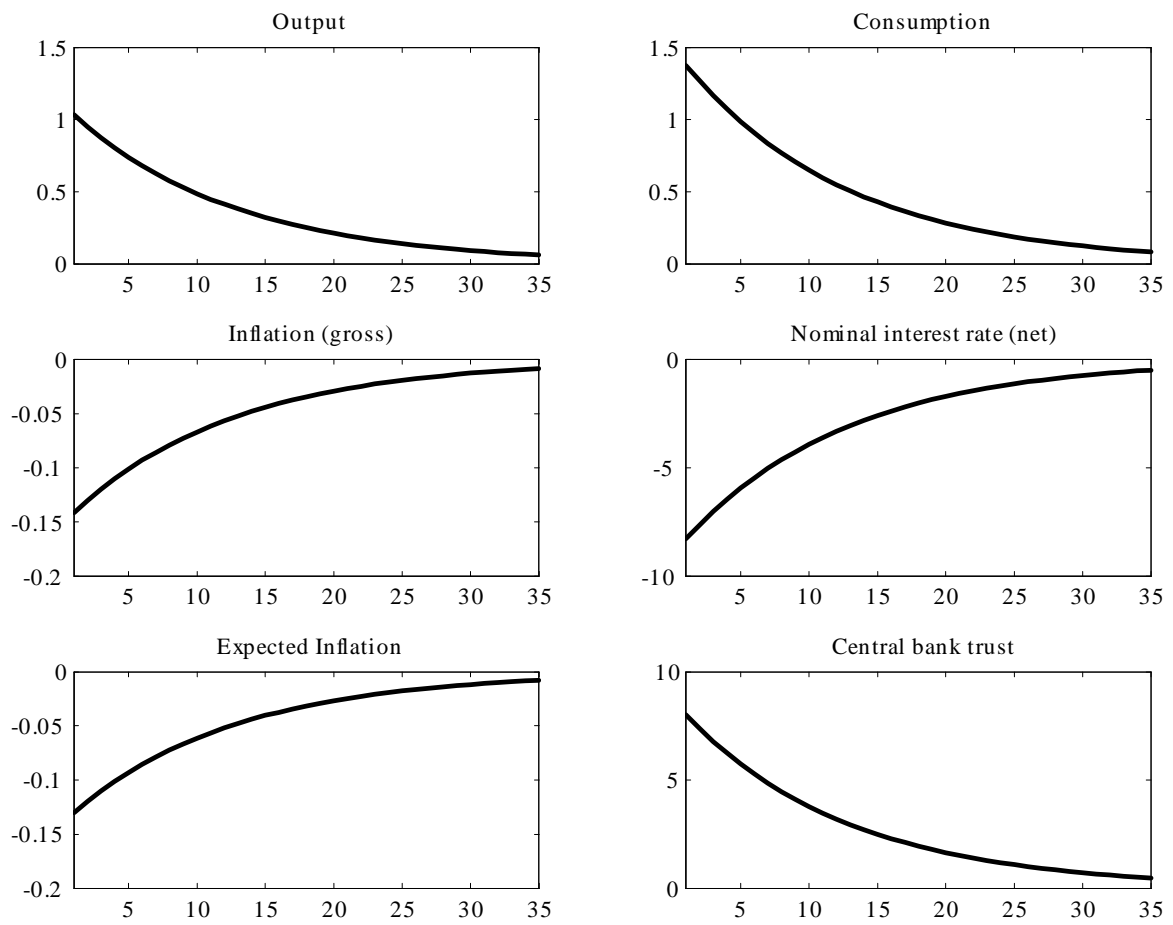


Figure 8: Impulse responses of selected variables to trust shocks.

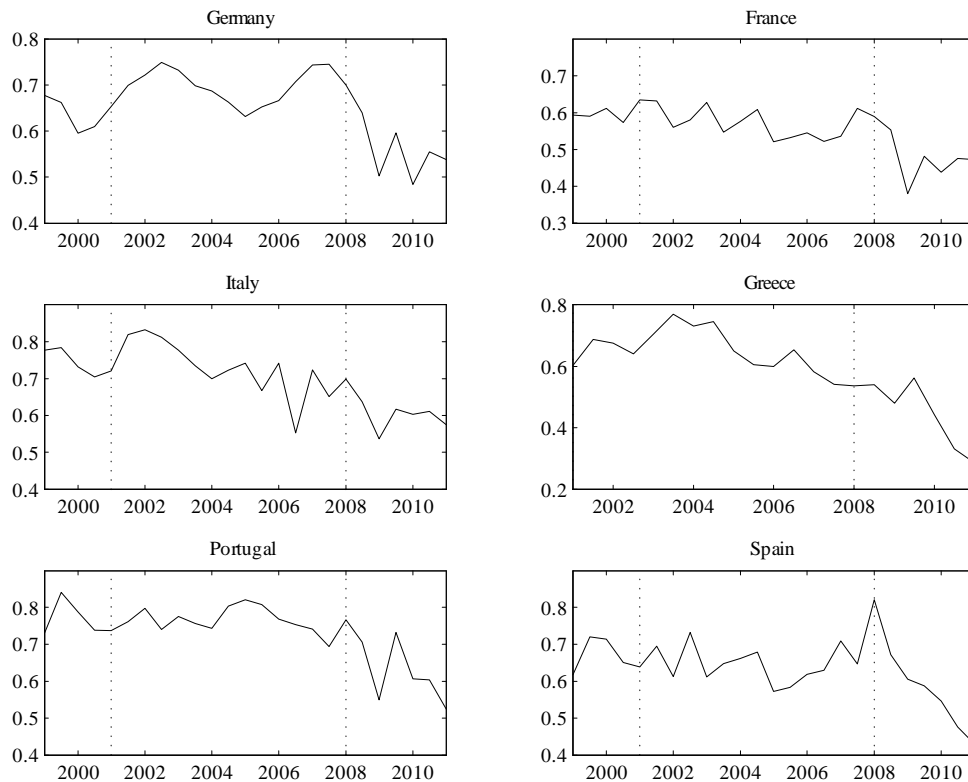


Figure 9: Evolution of ECB trust for selected countries used in the study and the whole time period from 1999:S1 to 2011:S1. Vertical lines represents the business cycle dates corresponding to the financial crises of 2001 and 2007-2008 (data are NBER and CEPR business cycle dates, respectively).

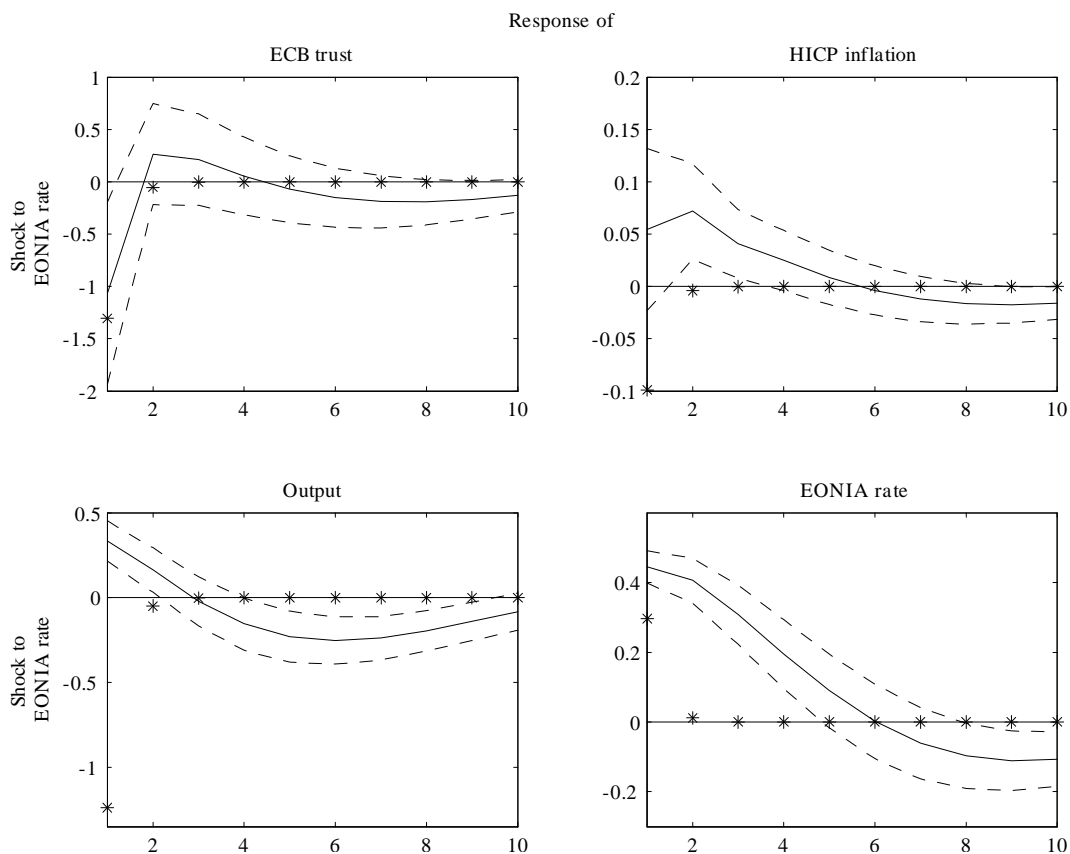


Figure 10: Empirical impulse responses (Part I). The figure presents selected impulse responses to a one standard deviation innovation to the EONIA rate. Endogenous variables are HP filter detrended ECB trust and real GDP, HICP inflation, and the EONIA rate. Mean impulse responses (solid line) are calculated following Pesaran and Shin [16] and are shown together with \pm two standard deviations confidence bands (dashed lines). The VAR was estimated on pooled data controlling for country-specific time-constant heterogeneity and assuming slope homogeneity. The sample covers the time period 1999:S1 to 2007:S1. Theoretical impulse responses to monetary policy shocks are indicated by asterisks.

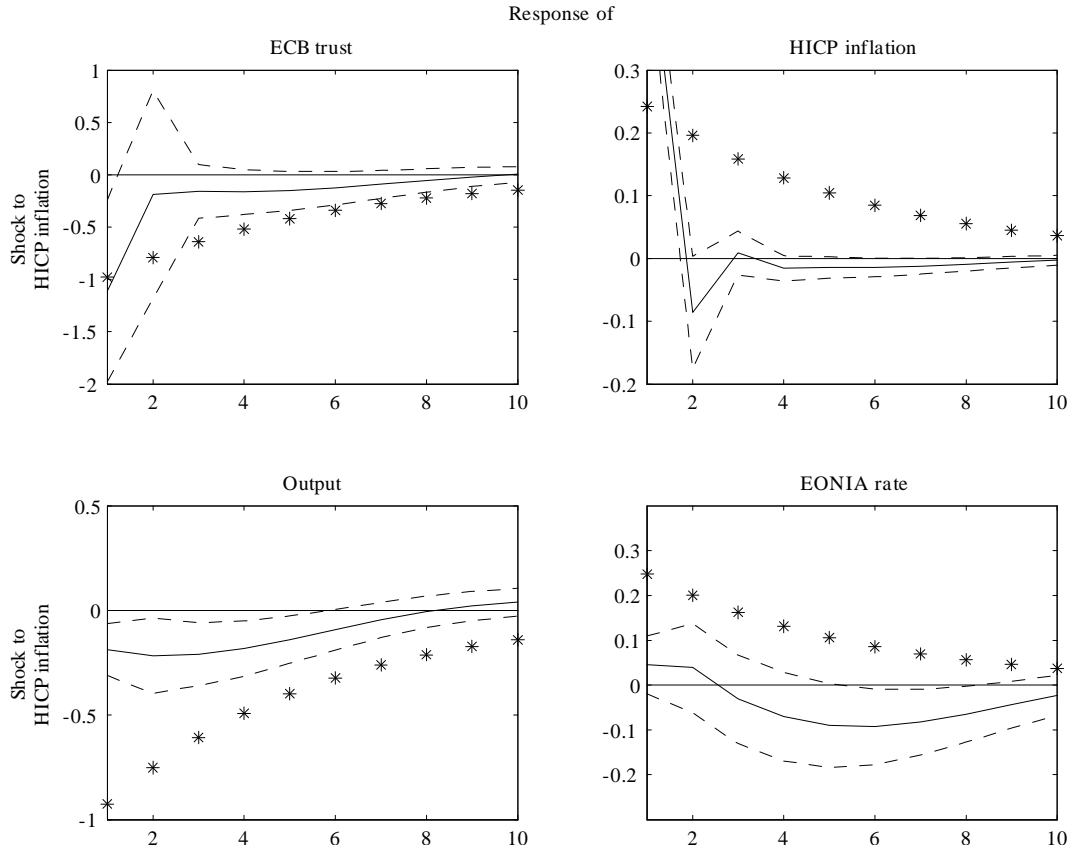


Figure 11: Empirical impulse responses (Part II). The figure presents selected impulse responses to a one standard deviation innovation to HICP inflation. Endogenous variables are HP filter detrended ECB trust and real GDP, HICP inflation, and the EONIA rate. Mean impulse responses (solid line) are calculated following Pesaran and Shin [16] and are shown together with \pm two standard deviations confidence bands (dashed lines). The VAR was estimated on pooled data controlling for country-specific time-constant heterogeneity and assuming slope homogeneity. The sample covers the time period 1999:S1 to 2007:S1. Theoretical impulse responses to cost-push shocks are indicated by asterisks.

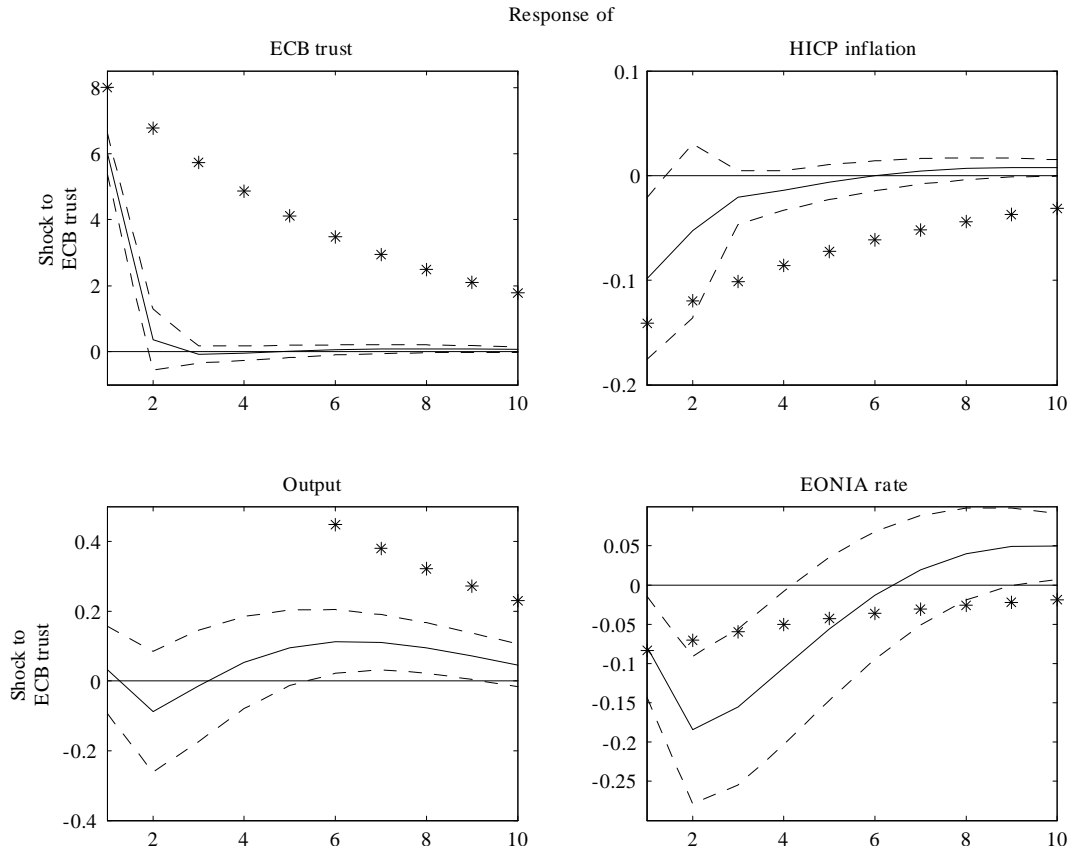


Figure 12: Empirical impulse responses (Part III). The figure presents selected impulse responses to a one standard deviation innovation to ECB trust. Endogenous variables are HP filter de-trended ECB trust and real GDP, HICP inflation, and the EONIA rate. Mean impulse responses (solid line) are calculated following Pesaran and Shin [16] and are shown together with \pm two standard deviations confidence bands (dashed lines). The VAR was estimated on pooled data controlling for country-specific time-constant heterogeneity and assuming slope homogeneity. The sample covers the time period 1999:S1 to 2007:S1. Theoretical impulse responses to trust shocks are indicated by asterisks.

Variable	Full				Non-Crisis					
	Observ.	Mean	S.D.	Min	Max	Observ.	Mean	S.D.	Min	Max
ECB trust (HP)	324	-0.001	0.073	-0.241	0.325	201	0.000	0.059	-0.186	0.129
GDP (HP)	324	0.000	0.021	-0.076	0.073	201	-0.001	0.014	-0.042	0.057
HICP inflation	324	1.116	0.921	-2.438	5.006	201	1.158	0.653	-0.276	3.231
EONIA rate	324	2.673	1.318	0.375	4.925	201	3.047	0.881	2.030	4.925

Table 2: The table presents summary statistics for the macroeconomic indicators and ECB trust used in the VAR estimation. (HP) refers to Hodrick-Prescott filter de-trended series (standard smoothing parameter of 400). The cyclical components are normalized by the respective trend value in order to account for between country heterogeneity. The non-crisis sample covers the time period 1999:S1 to 2007:S1. Hence, the beginning of the active phase of the crisis coincides with the financial turmoil of August 2007 inter alia associated with the United States subprime mortgage market and severe tensions in interbank markets around the globe (see, for instance, Duchin et al. [7]).

Study Number	Title	Year	Version
ZA 5481	Eurobarometer 75.3	2011	1.0.0, 01.09.2012, doi:10.4232/1.10768
ZA 5449	Eurobarometer 74.2	2010	1.1.0, 08.06.2011, doi:10.4232/1.10707
ZA 5234	Eurobarometer 73.4	2010	1.0.0, 23.11.2010, doi:10.4232/1.10197
ZA 4994	Eurobarometer 72.4	2009	3.0.0, 03.02.2012, doi:10.4232/1.11141
ZA 4973	Eurobarometer 71.3	2009	3.0.0, 03.02.2012, doi:10.4232/1.11135
ZA 4819	Eurobarometer 70.1	2008	3.0.1, 17.11.2010, doi:10.4232/1.10193
ZA 4744	Eurobarometer 69.2	2008	4.0.0, 18.10.2011, doi:10.4232/1.10992
ZA 4565	Eurobarometer 68.1	2007	4.0.0, 09.09.2010, doi:10.4232/1.10126
ZA 4530	Eurobarometer 67.2	2007	2.0.0, 18.12.2009, doi:10.4232/1.10068
ZA 4526	Eurobarometer 66.1	2006	1.0.0, 13.04.2010, doi:10.4232/1.4526
ZA 4506	Eurobarometer 65.2	2006	1.0.0, 13.04.2010, doi:10.4232/1.4506
ZA 4414	Eurobarometer 64.2	2005	1.0.0, 13.04.2010, doi:10.4232/1.4414
ZA 4411	Eurobarometer 63.4	2005	1.0.0, 13.04.2010, doi:10.4232/1.4411
ZA 4229	Eurobarometer 62.0	2004	1.0.0, 13.04.2010, doi:10.4232/1.4229
ZA 4056	Eurobarometer 61.0	2004	1.0.0, 13.04.2010, doi:10.4232/1.4056
ZA 3938	Eurobarometer 60.1	2003	1.0.0, 13.04.2010, doi:10.4232/1.3938
ZA 3904	Eurobarometer 59.1	2003	1.0.0, 13.04.2010, doi:10.4232/1.3904
ZA 3693	Eurobarometer 58.1	2002	1.0.0, 13.04.2010, doi:10.4232/1.3693
ZA 3639	Eurobarometer 57.1	2002	1.0.0, 13.04.2010, doi:10.4232/1.3639
ZA 3627	Eurobarometer 56.2	2001	1.0.0, 13.04.2010, doi:10.4232/1.3627
ZA 3507	Eurobarometer 55.1	2001	1.0.0, 13.04.2010, doi:10.4232/1.3507
ZA 3387	Eurobarometer 54.1	2000	1.0.0, 13.04.2010, doi:10.4232/1.3387
ZA 3296	Eurobarometer 53.0	2000	1.0.0, 13.04.2010, doi:10.4232/1.3296
ZA 3204	Eurobarometer 52.0	1999	1.0.0, 13.04.2010, doi:10.4232/1.3204
ZA 3171	Eurobarometer 51.0	1999	1.0.0, 13.04.2010, doi:10.4232/1.3171

Table 3: The table presents the Eurobarometer data sets used. We combine a selected set of 25 Eurobarometer surveys which include our main variable of interest “Trust in the European Central Bank”. The surveys are conducted on a semi-annual basis and are obtained from the “GESIS-Leibniz-Institute for the Social Sciences’ in Cologne, Germany.

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