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SAFE Working Paper Series No. 14

Center of Excellence **SAFE Sustainable Architecture for Finance in Europe**

A cooperation of the Center for Financial Studies and Goethe University Frankfurt

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Trust in the Monetary Authority*

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First draft: September 2012. This draft: February 2013.

Abstract

The efficacy of monetary authority actions depends primarily on the ability of the monetary authority to affect inflation expectations, which ultimately depend on agents' trust. We propose a model embedding trust cycles, as emerging from sequential coordination games between atomistic agents and the policy maker, in a monetary model. Trust affects agents' stochastic discount factor, namely the price of future risk, and their expectation formation process: these effects in turn interact with the monetary transmission mechanism. Using data from the Eurobarometer survey we analyze the link between trust on the one side and the transmission mechanism of shocks and of the policy rate on the other: data show that the two interact significantly and in a way comparable to the obtained in our model.

JEL: E0, E5

Keywords: *trust evolutionary games, trust driven expectations, monetary transmission mechanism.*

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1 Introduction

A large literature has shown that trust affects growth, stability and the business cycle¹: trust facilitates economics transactions², particularly financial ones, and improves the functioning of institutions³. So far the literature has focused 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 makers, although the effectiveness of economic policies largely depend upon that. The efficacy of monetary policies in particular depends upon the ability of the policy maker to affect agents' future expectations: the latter is tightly linked to trust. Equally credibility and accountability of central banks are endogenously determined by the level of trust in the monetary authority. Importantly trust in policy makers tends to fluctuates with the business cycle: crises for instance tend to disrupt it.

We provide a model in which trust (in the monetary authority) is determined endogenously within a sequential coordination game between a large number of atomistic agents and one large player, the policy maker: the equilibrium level of trust affects preferences and the stochastic discount factor, namely the subjective pricing of future risk, which in turn affect agents' expectation formation and the monetary transmission mechanism.

We begin by examining the interaction between trust, macroeconomic variables and monetary policy using data from the Eurobarometer survey. We focus our attention on the euro area: the newly created central bank provides a natural experiment to assess the role of evolving trust. The mere occurrence of the monetary policy relinquishing by a number of countries materializes and requires as necessary condition the existence of trust in the newly created monetary authority. Several technical 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 exist between trust and monetary policy then it must become apparent at high frequencies: for

¹See Knack and Keefer [15], Alesina and La Ferrara [2], Stevenson and Wolfers [23] among others.

²See Arrow [5].

³See Guiso, Sapienza and Zingales [13].

this reasons we use a two stage procedure. First we assess the link between trust and a number of long run socio-economic characteristics; in a second step we establish the link between short run fluctuations in trust and the monetary transmission mechanism. We employ a number of econometric techniques to deal with this and other econometric issues. Our empirical analysis highlights three main findings. First, the variable that is closely related to the ECB's mandate, namely HICP inflation deviation from the target level, directly affects trust building. Our analysis suggests that a one-time deviation from the mandate, i.e. a policy that results in a one-time increase in inflation beyond the implicit target level, has a persistent and negative impact on the trust-building process. Second, we find that also other variables, such as GDP growth, which are not directly within the ECB mandate, can have an impact on the level of trust. Overall, we shall conclude that a model with trust building should account for the dependence of trust upon policy and macroeconomic variables. Third, a positive shock to trust is associated with an increase in the real interest rate: as the monetary authority becomes more trustworthy, inflation expectations fall and the real rate raises (for given nominal rate).

To rationalize our empirical findings we construct a model in which trust emerges as an equilibrium outcome of an sequential coordination game between a continuum of atomistic agents and the monetary authority⁴. We embed the game outlined within a standard monetary model to analyze the link between trust and the monetary transmission mechanism. The equilibrium level of trust affects preferences and through this it affects the stochastic discount factor, namely the price of future risk. Generally speaking an increase in trust reduces the price of future risk and increases aggregate demand: both households' propensity to consume and firms' propensity to hire increase. More specifically when the degree of monetary authority trustworthiness increases, agents experience a fall in inflation's expectation and perceive an improvement of the inflation-output trade-off. We find that the transmission of shocks and monetary policy in our model is generally in line with the one found in the data.

The rest of the paper is as follows. Section 2 provides empirical evidence of the link between trust and monetary policy. Section 3 presents the model, which includes the trust game between the agents and the monetary authority as well as the link with the rest of the aggregate model

⁴We assume that the monetary authority acts under commitment due to the mandate written in its statute: in this way we are able to isolate the effects of trust from that of lack of credibility.

economy. Section 4 discusses model results. Section 5 concludes. Appendices, figures and tables follow.

2 Empirical evidence

The aim of our 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 survey.

Few main issues deserve discussion in relation to our empirical analysis.

The first lies in the distinction between long run and short run effects. Most of the previous empirical analysis on trust have focused on its long run effects (for instance on GDP growth) and have assessed the power of well entrenched institutions in promoting trust building. Our aim is to assess the link between trust and monetary policy, hence our focus is on short run fluctuations at business cycle frequencies. For this reason we need to isolate the long run determinants from the short run fluctuations of trust. We do so through the following two step procedure. In a first step and using micro-econometric techniques, we regress our proxy variable for trust on a number of socio-economic characteristics: the fitted regression accounts for the long run determinants of trust, while the fitted residual, which we label *net trust*, can explain its short run fluctuations. In the second stage we assess the link between *net trust* and monetary policy using traditional time series analysis.

A second issue to consider is the potential endogeneity between macroeconomic performance and trust. A high level of trust in economic institutions 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 economic institutions, which in turn triggers an increase in their trustworthiness. This double-way causality implies that regressing a measure of macroeconomic and/or monetary policy indicators on a measure of trust or vice versa is un-appropriate. We address the temporal endogeneity issue by employing VAR estimation techniques.

Our empirical analysis will also consider a shock to trust. A third issue then concerns the choice of the identification assumptions. In this respect we maintain a conservative agnostic view and deal with this issue by resorting on Generalized Impulse Response Functions. We will return

on this point later on.

2.1 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. The survey covers 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 survey 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 European Central Bank (ECB), in all data sets. Specifically, 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”. The surveys also contain substantive information on survey participants’ socio-economic characteristics which proves useful in the process of calculating aggregate trust statistics (see section 2.2). Macroeconomic variables are obtained from Eurostat and Thomson Reuters Datastream. Semi-annual GDP growth rates are calculated using quarterly data on seasonally adjusted chain-linked real GDP, 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. [20] in order to match the Eurobarometer surveys with macroeconomic data.

Table 1 contains a description of the dataset and tables 2 and 3 contain summary statistics for a number of variables.

2.1.1 Aggregate Trust Statistics and Long Run Determinants of Trust

Our first task lies in constructing a trust variable using the binary measure resulting from the Eurobarometer surveys: the latter shall be indeed transformed into a continuous variable.

First, a straightforward way would be to simply calculate the average level of trust for each country and time period. However, whether or not an individual does trust the ECB has an inherently subjective component. Hence, socio-economic factors are likely to play a predominant role in the trust-building process. The resulting average level of trust is therefore necessarily related to an individual with average socio-economic characteristics (e.g. average gender, average occupation, and average education): neglecting such links may not be desirable. Indeed in this case fluctuations in the level of trust may very well partly reflect long-run dynamics. As we are interested in explaining short-run dynamics of, for instance, key monetary policy rates, it is reasonable to first generate a time series reflecting short-run dynamics of aggregate trust in the ECB.

In this respect, we assume that individual socio-economic characteristics are the drivers of the average or long-run level of trust, respectively. We use those characteristics in order to extract the component of trust that is not due to individual traits (i.e. the component of trust that is mostly associated with short-run dynamics). The binary trust variable, obtained through the survey data, is first regressed on this set of socio-economic indicators. The unexplained components (i.e. the regression residuals) can then be aggregated on a country/time period basis. The new time series of aggregated residuals constitutes a new measure of trust net of individual traits (in what follows referred to as *net trust*) which can be incorporated in the second stage VAR estimation.

Concerning the two-stage estimation strategy, it is essential to have the most accurate coefficient estimates on the first stage that are subsequently used in order to calculate the aggregated regression residuals for the second stage. Therefore, much attention has to be paid to the choice of the methodology used in the first stage. We use the most complex, or fully-saturated, linear probability model (LPM) that incorporates a separate parameter for each cell defined by the values of the covariates. Hence, the model includes binary independent variables for mutually exclusive and exhaustive categories such that each individual in the population can be assigned exactly one category. It is appealing to estimate such a model in the first stage as it fits the conditional expectation function (CEF) denoted by $E[y|X]$, with X being a vector of initial covariates perfectly. Furthermore, the fully-saturated model is non-parametric and requires much less restrictive functional form assumptions compared to the case where the binary dependent variable is modelled in a nonlinear way. This is in particular true for probit or logit estimation procedures. Fitted values

(i.e. predicted probabilities⁵) of individuals in cell i are simply equivalent to a_i/n_i , where a_i is the sum of the binary dependent variable and n_i the number of observations within cell i , respectively. Hence, fitted values obtained from such a model exactly match empirically observed cell frequencies conditional on the values of the covariates⁶. We restrict ourselves to a parsimonious set of socio-economic indicators used in the first stage estimation that nevertheless includes the most relevant socio-economic characteristics. Those characteristics are gender (male, female), marital status (couple, single, divorced, widowed), employment status (employed, self-employed, retired, unemployed), educational attainment (less than high school degree, high school degree, college degree), and political orientation (left-wing political view, center- or right-wing political view). In order to be able to capture nonlinearities in the age response as suggested by microeconomic studies, age is controlled for using multiple categories. A detailed variable description and summary statistics can be found in tables 1 up to 3.

In order to illustrate the importance of socio-economic characteristics in the trust-building process, table 4 presents the results of a non-saturated LPM only including the main effects of interest⁷. Notice however that the net trust variable used in the subsequent time-series analyses is instead based on the results from the fully-saturated model. In table 4 (1) we present the results for the socio-economic characteristics whereas in table 4 (2) we additionally include country fixed effects, which absorb most of the country-wide differences. As expected, we find that socio-economic characteristics influence the trust-building process significantly. Being a couple or single compared to being widowed seem to be a trust-building characteristic. Males have a higher probability of trust compared to females. The probability of trust in the ECB of unemployed citizens is lower compared to those who are employed. The better educated individuals are, the more likely it is that they have trust in the ECB. A college degree, for instance, increases the probability of trust in the ECB, whereas individuals, whose political views are to the left of the political spectrum, are

⁵Fitted values can be interpreted as probabilities given that fully-saturated LPM produce fitted values that are always inside the unit interval (Wooldridge [25]). This, however, need not be the case for LPM in general.

⁶For fully-saturated models that include a considerable number of categorical variables, generating a variable for cell-membership for each observation in the sample and then calculating conditional cell averages of the binary trust variable in contrast to performing regression analyses is a computationally less demanding way of calculating fitted values or predicted probabilities. For more information on fully-saturated models see, for instance, Angrist and Pischke [4] and Wooldridge [25].

⁷The inclusion solely of the main effects of interest imposes the restriction that all interaction effects between the initial covariates are zero and hence the model is not an admissible estimator of the CEF in the first stage.

less likely to show trust.

Before proceeding with the time-series analysis at business cycle frequencies, it is nevertheless of interest to comment on the long run evolution of trust across main euro area countries. Figure 8 shows the evolution of trust in the ECB and ECB net trust for selected countries used in our study. One feature of the data is that even though the combined Eurobarometer surveys do not constitute a panel, but rather a repeated cross section (the surveys do not follow the same individuals over time), fluctuations of ECB net trust to a large extent mirror those of the original trust in the ECB variable. For each country, both series are almost perfectly correlated indicating that the composition of survey participants across different Eurobarometer surveys is similar.

2.1.2 Link between Trust and the Monetary Transmission Mechanism

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:

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

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 sample for the Euro area countries is rather short (1999:S1-2011:S1), country-based VAR estimations are not feasible. Therefore we estimate VAR models on pooled panel data, controlling for country-specific heterogeneity and assuming slope homogeneity in line with Ciccarelli et al. [10].

The VAR models are estimated using ECB net trust and several macroeconomic indicators. Here we consider real GDP growth, and HICP inflation. Notice that the ECB has adopted an implicit inflation target of (below but close) to 2 percent: for this reason it is reasonable to believe that the response of trust to changes in inflation is asymmetric across the whole support of inflation. Therefore, we use HICP inflation deviation from the target level as endogenous variable: this is consistent with agents' beliefs that the central bank objective does penalize inflation deviation from

the target. Finally, 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 measures⁸. As a result we observed a substantial reduction of the EONIA rate below the interest rate on the main refinancing operations (Beirne [9], and Trichet [24]). This proves that the EONIA is more responsive to unconventional monetary measures compared to other market rates.

Furthermore, in order to assess whether certain features of the data are crisis-specific, the sample is split into two, the crisis and the non-crisis samples. A dating of the beginning of the current crisis, however, is to a certain extent arbitrary. We date the beginning of the crisis conservatively and define 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 as the starting point of the active phase of the crisis (see, for instance, Angelini et al. [3], Duchin et al. [11], and Trichet [24]). 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. Dating the beginning of the crisis accordingly is not only in line with the literature but ensures that enough observations, corresponding to the crisis period, are available such that VAR estimations for the crisis period are feasible. This will be of particular importance in order to analyze whether certain features of the data are due to the occurrence of the financial crisis.

We consider two variants of our VAR specification. In the first variant (labeled Model 1) the endogenous variables are ECB net trust as defined above, real GDP growth, HICP inflation deviation from the target level, and the EONIA rate (whole sample). In the second variant (labelled Model 2) the endogenous variables are ECB net trust as defined before, real GDP growth, and the EONIA rate (crisis sample only).

If feasible, the VAR lag length k is determined using the Schwarz Information Criterion (SIC). The reason for this choice is twofold. First, the SIC consistently estimates the true lag length of a VAR model. Second, the penalization for additional lags of the endogenous variables is higher

⁸Among 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.

compared to alternative information criteria (see Lütkepohl [16]). This property is appealing since our sample for the Euro area is rather short: there is then a concrete risk that the selected VAR lag length is higher than the true lag length⁹.

The models are evaluated by means of impulse response functions. We follow the methodology of generalized impulse response functions (GIRF) introduced by Koop et al. [14] for nonlinear models and Pesaran and Shin [17] for linear models. Appealing properties of GIRF, compared to orthogonalized impulse response functions in the spirit of Sims [22], 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 particular the latter feature is important in our case as there is limited conventional wisdom or little economic theory that would justify one particular Cholesky ordering for further impulse response 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. The mean impulse response is shown together with +/- two standard deviations confidence bands such that roughly 95 per cent of observations lie within these intervals, assuming normally distributed impulse responses.

2.1.3 Results of the Time Series Analysis

We start by examining the results arising from the first VAR specification considered, namely that of Model 1. Impulse response functions to one standard deviation innovations can be found in figures 9 and 10: the first figures show impulse responses of selected variables to shocks to GDP growth and to the EONIA rate, while the second figure shows impulse responses to shocks to net trust and to the deviation of inflation from the target.

A shock to GDP growth only mildly affects inflation deviation from the target level and significantly increases the EONIA rate and ECB net trust. As expected an increase in GDP growth favorably affects public confidence in the monetary authority. A shock to the EONIA rate only mildly affects ECB net trust and inflation deviations from the target level, but depresses real GDP growth significantly in the short run. So to speak unexpected deviation in the monetary policy stance do not disrupt public confidence in the monetary authority. A one-time increase in

⁹In cases where the total number of available observations restricts the number of endogenous variables and in particular the VAR lag length, the VAR specifications contain one lag for each included endogenous variable.

ECB net trust has two main effects. First it increases GDP growth up to semester three, before turning negative up to semester ten: an increase in public confidence provides an expansionary boosts to the economy akin to that triggered by the Keynesian animal spirits. An increase in net trust also reduces the prospects of future inflation growth: the public believes that the monetary authority is able to control future inflation better and at the expenses of lower output costs. In anticipation inflation falls on impact. The gain in credibility allows the monetary authority to loosen the monetary stance on impact, although the nominal rate turns positive after the second semester to counterbalance the inflationary pressures stemming from the increase in GDP. At last we consider a shock (an increase) to inflation deviation from the target: this shock persistently reduces ECB net trust. Inflation is the variable that most directly enters into the ECB mandate: deviations from the target can disrupt public confidence. The fall in trust depresses real GDP. The monetary authority fights the initial increase in inflation by raising the nominal rates on impact, but after two quarters it must loosen the policy stance in order to counterbalance the fall in output.

Next we examine the results arising from the specification of Model 2. Selected impulse response functions to one standard deviation innovations are reported in figure 11. The effects of a positive shock to ECB net trust are similar to the ones obtained from the first specification: the main difference lies in the fact that GDP growth turns negative at the eighth semester. Similar results compared to the first specification are obtained also for the other shocks considered.

At least three findings are interesting so far. First, variables that are not related to the ECB's mandate or variables that are outside its direct or indirect control, like real GDP growth, should be irrelevant for the trust-building process, while our analysis show that they are also important determinants of trust. One explanation for this relies on the assumption of bounded rational agents¹⁰, whose level of confidence in the authority is affected by a number of other indicators. GDP growth can for instance provide anchoring to beliefs formation. Second, the variable that is closely related to the ECB's mandate is HICP inflation deviation from the target level. Our analysis suggests that a one-time deviation from the mandate, i.e. a policy that results in a one-time increase in inflation beyond the implicit target level, has a persistent and negative impact on the trust-building process. Hence, the issue of trust in the ECB is of particular importance for the

¹⁰See Barberis and Thaler [6] for an overview of the literature on behavioral finance.

conduct and the effectiveness of monetary policy as credibility and trust are closely connected (see, for instance, Barro and Gordon [7]). Decision makers have to take this persistent impact on trust into account when deciding about future monetary policy that has the potential of letting inflation deviate from its implicit target level. Third, an exogenous increase in trust allows the monetary authority to reduce the policy rate on impact; the monetary policy turns however contractionary soon after. As trust improves agents expect the monetary authority to be able to strike a better balance between inflation and output growth in the future. This gain in credibility allows the monetary authority to partly ease the policy rate on impact. The increase in GDP, following an increase in trust, however forces the monetary authority to increase the policy rate in order to control inflationary pressures.

We further perform a number of robustness exercises, non-reported for brevity but available upon request. We analyze whether results are robust to different measures of trust and to different proxies of the monetary policy stance. Results remain qualitatively the same when we replace the *net trust* with the aggregate trust statistics. Moreover we repeat regressions by replacing the EONIA rate alternatively with the ECB’s interest rate on the main refinancing operations (the ECB Policy Rate, which refers either to the minimum bid rate or the fixed rate depending on the respective time period) and the Euro Interbank Offered Rate with a maturity of 3 month (EURIBOR 3m). Once again results are qualitatively similar to the ones outlined above. Furthermore, results remain robust when we estimate Model 1 using the crisis sample: in this case the number of parameters to be estimated relative to the total number of available observations is rather high in this case, hence results are less reliable.

3 The Model

To rationalize our empirical results we build a macro model embedding a trust game between a continuum of atomistic agents and a policy maker. The game is outlined in what follows. The underlying monetary model embeds standard assumptions: monetary policy stance affects aggregate demand through the Euler equation and due to the assumption of sticky prices. We maintain those standard assumptions, as our goal is to highlight the difference in the transmission mechanism when time-varying trust is included in the model.

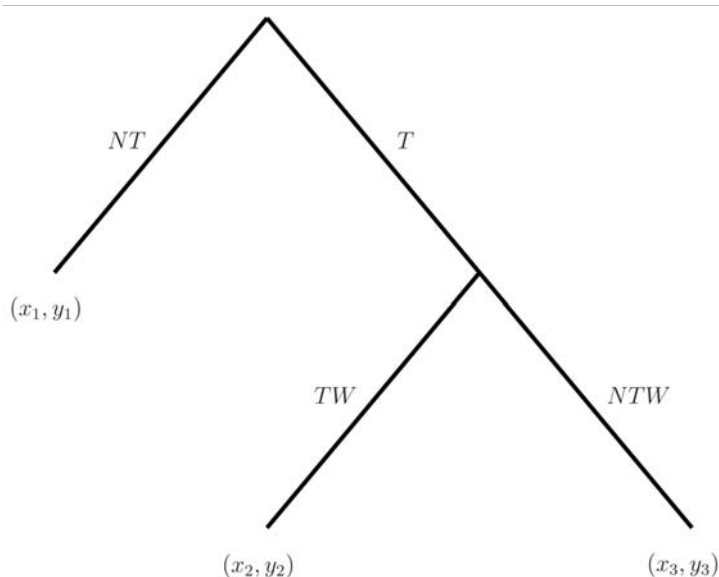


Figure 1: Graphical illustration of the baseline trust game.

3.1 Baseline Trust Game

The setup of the baseline two-entity trust game is as follows. Player 1 (the proposer) decides whether to trust (T) or not to trust (NT) player 2 (the responder). If player 1 plays NT , the game ends with payoffs (x_1, y_1) , where x denotes the payoff of player 1 and y the payoff of player 2, respectively. Conditional on choosing T , player 2 has the choice between responding trustworthy (TW), with resulting payoffs (x_2, y_2) , or not trustworthy (NTW), with payoffs (x_3, y_3) . We follow the standard literature on trust games and assume that $y_1 < y_2 < y_3$ and $x_3 < x_1 < x_2$. The extensive form of the game is depicted in figure 1 below. By backward induction, the (Pareto inferior) subgame perfect Nash equilibrium of the one-shot game (and also the one of finitely many repetitions of the game) is (NT, NTW) with resulting payoffs (x_1, y_1) .

3.2 Extended Trust Game

We now extend the game by considering a continuum of atomistic agents on the one side of the game and one single player, namely the policy maker, on the other side. Player 1 is a single atomistic agent in the economy and player 2 is a policy maker, more specifically the central bank in our

case. Assume that all agents are alike except for their preferences provided that the central banks responds with a not trustworthy action, *NTW*. More precisely, agents are heterogeneous concerning their individual degree of betrayal aversion, i.e. the dis-utility they receive from being cheated. Consider that there is a continuum of agents and that each single agent is uniquely identified by the corresponding degree of betrayal aversion $b \in [0, 1]$. Hence, each agent is associated with a point on the unit interval. Note that betrayal aversion only affects the agent's payoff when the central bank decides to play *NTW*. This assumption also helps to rule out extreme coordination equilibria, in which all agents decide either to trust or not to trust: those equilibria would indeed deliver aggregate level of trusts of 100% or 0%, respectively. Therefore, the extended specification allows for an aggregate level of trust, namely the fraction of the population who trusts the policy maker, which lies strictly within the unit interval $\tau \in (0, 1)$.

In order to ensure that the central bank does not always choose either *TW* or *NTW* in finitely many repetitions of the game, the central bank type is assumed to be stochastic. In every period the nature draws stochastically the central banker's preferences¹¹: in this case the payoff of the central bank under the *NTW* action is the sum of a deterministic payoff y_3 and of a stochastic component ϕ with zero mean.¹² The dispersion ϕ is assumed to be drawn from a continuous uniform distribution over the range $[-h, h]$ with $h > 0$ such that the probability density function reads $1/2h$.

Each single agent decides whether to choose *T* or *NT*. If the agent decides to play *NT*, 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 $(x_2 - b, y_3 + \phi)$.

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

Lemma 1. *The central bank plays TW in the majority of the periods.*

The proof of the above lemma follows directly from the assumption that $y_1 < y_3 < y_2$. As the random variable ϕ has zero mean, in expectation playing *TW* is a dominant strategy for the

¹¹Alternatively one can think of the agents as being uncertain about the central banker's preferences, so that the payoff of the game needs to account for such random outcomes.

¹²In 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 such that we end up with the payoffs stated in the main text.

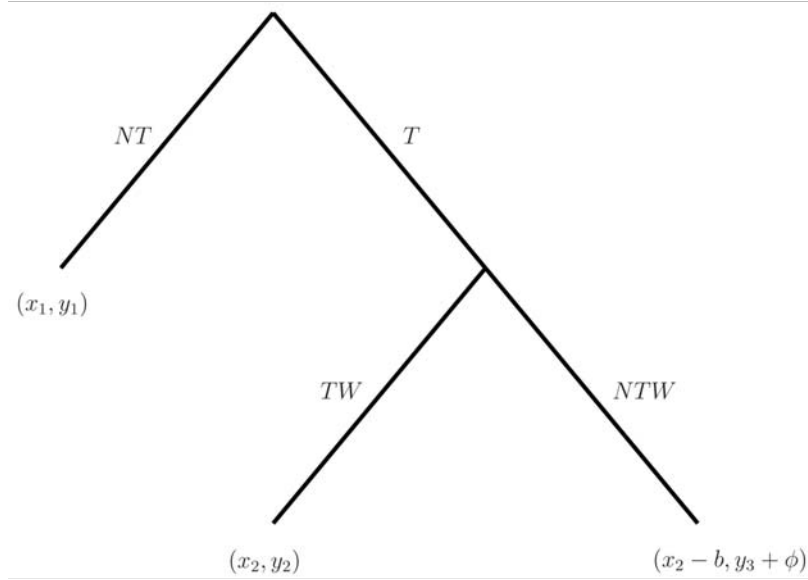


Figure 2: Graphical illustration of the extended trust game.

central bank. The fraction of times in which the trustworthy strategy is played will depend upon the variability of random payoff.

Lemma 2. *The action T is not a dominant strategy for all agents in the economy with probability one.*

The proof of the Lemma 2 follows directly from the assumption that $x_1 < x_2$ and $x_2 - 1 < x_1$.

The extensive form of the extended two-entity trust game is depicted in figure 2 below. 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 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:

$$E(\Pi_A) = \tag{2}$$

$$x_2 P(\phi \leq y_2 - y_3) + (x_2 - b) P(\phi > y_2 - y_3) = \tag{3}$$

$$x_2 F(y_2 - y_3) + (x_2 - b)[1 - F(y_2 - y_3)], \tag{4}$$

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

$$E(\Pi_A) = x_2 \left(\frac{y_2 - y_3 + h}{2h} \right) + (x_2 - b) \left(\frac{y_3 - y_2 + h}{2h} \right). \quad (5)$$

Lemma 3. *Agents will choose T if:*

$$0 \leq b \leq \frac{2h(x_2 - x_1)}{y_3 - y_2 + h} \equiv \bar{b}. \quad (6)$$

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 2. *It is assumed that $h > y_2 - y_3$.*

The above assumption guarantees that $\bar{b} = \frac{2h(x_2 - x_1)}{y_3 - y_2 + h} > 0$. The support, $[-h, h]$, 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:*

$$\tau = \bar{b}, \quad (7)$$

The subgame perfect Nash equilibrium of the one-shot game (and also the one of finitely many repetitions of the game) is found through 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

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

then play TW against NTW if and only if $y_2 > y_3 + \phi$. 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 sub-game perfect Nash equilibrium crucially depends upon the degree of betrayal aversion. The lower the degree of betrayal aversion, the higher is agents' payoff when the central bank is not trust-worthy and the higher is the fraction of agents who decide to trust ex ante.

3.3 Aggregation and Representative Agent

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

$$\begin{aligned} & \int_0^{\bar{b}} x_2 db - \int_0^{\bar{b}} b I[\phi > y_2 - y_3] db + \int_{\bar{b}}^1 x_1 db \\ \Leftrightarrow & \bar{b} x_2 - \frac{I[\phi > y_2 - y_3] \bar{b}^2}{2} + (1 - \bar{b}) x_1, \end{aligned} \quad (8)$$

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.¹³

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

¹³The 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 $\nu \rightarrow \infty$, $t(\phi, y_2, y_3, \nu) \rightarrow I[\phi > y_2 - y_3]$. See, for instance, Rieth [19] or Bayoumi et al. ??.

$$\begin{aligned}
& \int_0^{\bar{b}} y_2 db + \int_0^{\bar{b}} (y_3 - y_2 + \phi) I[\phi > y_2 - y_3] db + \int_{\bar{b}}^1 y_1 db \\
\Leftrightarrow & \bar{b} y_2 + \bar{b} (y_3 - y_2 + \phi) I[\phi > y_2 - y_3] + (1 - \bar{b}) y_1.
\end{aligned} \tag{9}$$

3.4 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 3. $x_2 \equiv \theta x_1$ and that $\theta > 1$.

The above assumption ensures that $x_2 > x_1$.

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 4. $y_3 - y_2 \equiv \psi_2 < 0$.

Given the above assumption it is possible to define $\psi_1 \equiv \frac{2h(\theta-1)}{\psi_2+h} > 0$, also since $h > -\psi_2$ due to Assumption 2.

Lemma 4. *Given assumptions 3 to 4, the aggregate fraction of trusting agents is given by:*

$$\bar{b} = \tau = \psi_1 x_1 \tag{10}$$

and the aggregate agents' payoff is given by:

$$R^A = \alpha_1 x_1 + \alpha_2 \tau x_1 - \alpha_3(\phi) \tau^2, \tag{11}$$

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

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

$$\begin{aligned}
R^A &= \tau\theta x_1 - \frac{I[\phi > -\psi_2]}{2}\tau^2 + (1 - \tau)x_1 \\
&= x_1 + (\theta - 1)\tau x_1 - \frac{I[\phi > -\psi_2]}{2}\tau^2 = \\
&= \alpha_1 x_1 + \alpha_2 \tau x_1 - \alpha_3(\phi)\tau^2
\end{aligned} \tag{12}$$

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 $U^j(C) = 1 - e^{-rC} \equiv x_1$, where C denotes consumption, j refers to the location of the agent on the unit interval, and r is the coefficient of absolute risk aversion.

After rearranging and adding a time subscript t , as well as an additive trust shock process $\varepsilon_{\tau,t}$ ¹⁴, the key expressions are given by:

$$\bar{b}_t = \tau_t = \psi_1(1 - e^{-rC_t}) + \varepsilon_{\tau,t}, \tag{13}$$

$$U^A(C_t, \tau_t, \phi_t) = \tilde{\alpha}_1(\tau_t, \phi_t) - \tilde{\alpha}_2(\tau_t)e^{-rC_t} \tag{14}$$

where $\tilde{\alpha}_1(\tau_t, \phi_t) = \alpha_1 + \alpha_2\tau_t - \alpha_3(\phi_t)\tau_t^2$ and $\tilde{\alpha}_2(\tau_t) = \alpha_1 + \alpha_2\tau_t$.

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

$$\frac{\partial U^A(C_t, \tau_t, \phi_t)}{\partial \tau_t} = \begin{cases} \alpha_2(1 - e^{-rC_t}) - \tau_t, & \text{when } \phi_t > -\psi_2 \\ \alpha_2(1 - e^{-rC_t}), & \text{when } \phi_t \leq -\psi_2 \end{cases}. \tag{15}$$

Lemma 5. *The derivative $\partial U^A(C_t, \tau_t, \phi_t)/\partial \tau_t > 0$ 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 $\alpha_2(1 - e^{-rC_t}) > \tau_t$.*

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

¹⁴Later 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.

Corollary 2. *The second derivative of the utility function with respect to τ_t is negative when $\phi_t \leq -\psi_2$ and zero otherwise.*

An increase in trust raises consumption demand as the impact of uncertainty is less severe; this in turn decreases the marginal utility of consumption.

The aggregate utility functions defined above, 14, shall satisfy standard concavity assumptions as they will be used in recursive optimization problems.

Lemma 6. *The condition $0 < \psi_1(\theta - 1) \leq 1/2$ is a necessary and sufficient condition for the concavity of the utility function 14.*

In the numerical simulation, we will either ensure that the inequality stated in lemma 6 is fulfilled or that consumption is in the range where the utility function of the representative agent is concave.

Equations 13 and 14 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 13. Notice indeed that trust in our model is a time-varying variables that fluctuates in response to shocks: a shock to technology, a change in the monetary policy stance or an exogenous increase in aggregate demand, all trigger a change in public trust toward the policy maker. Second fluctuations in the aggregate equilibrium level of trust affect the utility of the representative agent through its impact on 14, hence it will affect the agents' stochastic discount factor, 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.

3.5 Aggregate Economy

The underlying macro model is an otherwise standard monetary model. Sticky prices are introduced to account for non-neutral effects of monetary policy¹⁵. 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, hence affecting the stochastic discount factor.

3.5.1 Household

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

$$E_0 \sum_{t=0}^{\infty} \beta^t [U^A(c_t, \tau_t, \phi_t) + \varkappa \log(1 - n_t)], \quad (16)$$

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 t 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 appendix 1 explains the assumptions that allow us to neglect the effect of heterogeneity in betrayal aversion on the labour supply. Hence, the household's budget constraint in real terms reads

$$c_t + \frac{B_t}{P_t} \leq \frac{W_t}{P_t}n_t + (1 + i_{t-1})\frac{B_{t-1}}{P_t} - T_t + \Xi_t, \quad (17)$$

where P_t is the price level and T_t denotes real tax payments. Maximizing 16 subject to 17 with respect to c , n , and B gives rise to the following optimality conditions:

$$U_{c,t}^A = \beta E_t U_{c,t+1}^A \left(\frac{1 + i_t}{\pi_{t+1}} \right) \quad (18)$$

¹⁵We have introduced our trust game also in an alternative set-up 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 related to the interaction between trust and the monetary policy remain valid within the alternative monetary model.

$$U_{c,t}^A = \frac{\varkappa}{w_t(1 - n_t)} \quad (19)$$

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. Notice that the fluctuations in trust affect the marginal utility of consumption and through this the stochastic discount factor which enters the consumption Euler. We will return on this point later.

Note 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.

3.5.2 Final good firm

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 order to produce y_t units of the final good. Profit maximization then implies the final good-producing firm's demand for variety i :

$$y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} y_t, \quad (20)$$

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

3.5.3 Intermediate good firms

Each intermediate good-producing firm $i \in [0, 1]$ 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:

$$F(n_t(i)) = y_t(i). \quad (21)$$

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:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\frac{P_t(i)}{P_t} y_t(i) - mc_t(i) y_t(i) - \frac{\vartheta}{2} \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right)^2 \right] \quad (22)$$

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

$$w_t = mc_t F_{n,t} \quad (23)$$

$$(\pi_t - 1)\pi_t = \beta E_t \frac{U_{c,t+1}^A}{U_{c,t}^A} (\pi_{t+1} - 1)\pi_{t+1} + \frac{\varepsilon y_t}{\vartheta} \left(mc_t - \frac{\varepsilon - 1}{\varepsilon} \right), \quad (24)$$

where F_n denotes the marginal product of labor.

The last expression is the non-linear 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. We will return on this point later in section 4.

3.5.4 Resource Constraint

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:

$$y_t = c_t + g_t + \frac{\vartheta}{2} (\pi_t - 1)^2. \quad (25)$$

3.5.5 Monetary Authority

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

$$\ln \left(\frac{1 + i_t}{1 + i^{ss}} \right) = b_\pi \ln \left(\frac{\pi_t}{\pi^{ss}} \right) + b_y \ln \left(\frac{y_t}{y^{ss}} \right) + \varepsilon_t^m, \quad (26)$$

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.

3.5.6 Calibration and Shock Processes

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. We assume a Cobb-Douglas production 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 $\vartheta = \frac{y^{ss}\hat{\vartheta}(\varepsilon-1)}{(1-\hat{\vartheta})(1-\beta\hat{\vartheta})} \approx 17.5$. The Taylor rule coefficients b_π and b_y are set equal to 1.5 and 0.5/4, respectively. The parameter ν in the transition function $t(\phi_t, \psi_2, \nu)$ is chosen to be 300 as in Franses and van Dijk [12] which produces a smooth approximation of the indicator function $I[\cdot]$. The remaining trust model parameters ($\theta = 1.28$, $\psi_2 = -0.35$, $h = 0.5$) are calibrated in order to contemporaneously satisfy the following three conditions. First, the parameter values shall be consistent with the extended trust game. Second the utility function of the representative agent shall be well-behaved for non-negative consumption quantities. Third, the steady-state level of aggregate trust τ^{ss} matches the unconditional long-run average of aggregate ECB trust (see below). The shocks considered include the standard macro shocks (i.e. technology, monetary policy, and government spending) 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, $\rho_a = 0.95$, and $\sigma_a = 0.008$. ε_t^a is an i.i.d. productivity shock. Log-government expenditures are modeled exogenously and evolve according to $\ln\left(\frac{g_t}{g^{ss}}\right) = \rho_g \ln\left(\frac{g_{t-1}}{g^{ss}}\right) + \varepsilon_t^g$, where the steady-state value g^{ss} is calibrated such that $\frac{g^{ss}}{y^{ss}} = 0.25$. ε_t^g is an i.i.d. government spending shock with standard deviation σ_g . We follow Perotti [18] and set $\rho_g = 0.9$ and $\sigma_g = 0.007$. 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 [21]. 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 0.654. The calibration of the trust model parameters is chosen such that the steady-state level of aggregate trust τ^{ss} matches this value.

4 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. In commenting the results of the simulations we will also evaluate the ability of the model in fitting the transmission mechanism highlighted by the empirical analysis presented above.

We will consider traditional macroeconomic and policy shocks (technology, government spending and monetary policy shocks) as well as the newly estimated trust shock.

Figure 4 shows impulse responses of selected variables to a 1% increase in technology for given policy stance and trust parameters. An increase in technology rises production and consumption demand. This in turn increases welfare and the fraction of agents who trust the policy maker as per equation 13. It is also worth highlighting the difference in the shock transmission between our model and the traditional sticky price model. In the latter, an increase in technology produces an increase in output and aggregate demand; as prices are sticky firms react to the increase in demand by saving on employment, which falls, and by reducing the marginal cost. In the model

with time-varying trust, the stochastic discount factor falls by more than in the standard sticky price model: as trust raises the price of future risk falls. This has two implications. First, firms discount future profits more heavily, hence they front load production decisions. This, in the model with time-varying trust, results in an increase in employment. Second, a fall in the stochastic discount factor downgrades the impact of future expectations of inflation on the current one as per equation 24. In response to a technology shock inflation falls today, but raises in the future: in the traditional macro model this can be achieved, consistently with equation 24, only through a fall in the marginal cost and employment. In the model with time-varying trust future inflationary pressures have a milder impact on current inflation, hence current deflation does not necessarily imply a fall in employment.

Figure 5 shows impulse responses of selected variables to a 1% increase in the policy rate. Once again the fall in production and consumption, following the contractionary policy, reduces the level of trust as per equation 13. The ensuing increase in the stochastic discount factor, the price of future risk, reinforces the contractionary effects of the increase in the policy rate. Notice that the fall in trust, following a contractionary monetary policy, is consistent with the VAR evidence presented in section 2. The effect in the data however is milder than the one obtained in the model.

Figure 6 shows impulse responses of selected variables to a 1% increase in government spending. Due to a traditional crowding out effect consumption falls; this in turn reduces trusts as per equation 13. Fluctuations in trust in response to government spending shocks are milder than the ones obtained in response to other macroeconomic shocks, hence its impact on the business cycle is rather unimportant in this case.

Finally figure 7 shows impulse response functions of selected variables to the newly estimated trust shock. The increase in trust is largely expansionary. We can examine the interaction between the evolution of trust and the 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 IRF). 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 a positive central bank trust shock. Intuitively as trust raises, the price of future risk falls: as a consequence households increase their consumption demand and firms increase their demand for employment. As the agents perceive an improvement in the inflation-output trade-offs, inflation falls in anticipation despite the increase in aggregate demand.

Notice that consistently with the empirical evidence presented above a positive trust shock is expansionary as it increases output. The VAR evidence however shows that the policy rate falls on impact only for a very short period of time, while this is not the case in the model. Clearly the background monetary model which we use is very stylized: a number of additional effects which are not considered here could explain this discrepancy.

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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6 Appendix 1

Note 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 before. 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 individual 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 disutility of supplying labor, that individual agents are homogeneous with respect to $v(\tilde{n})$, and that the disutility 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.

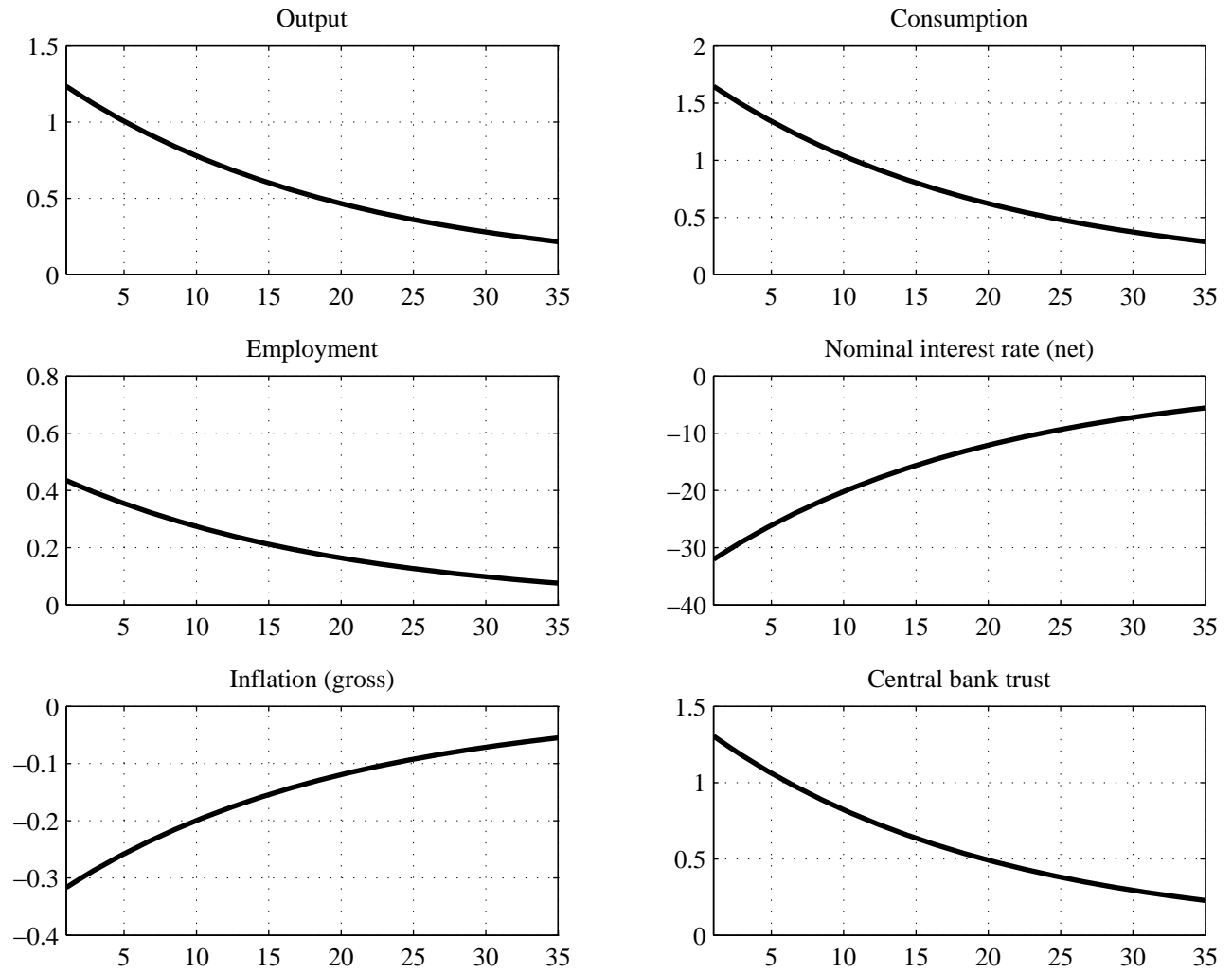


Figure 4: Impulse responses of selected variables to technology shocks.

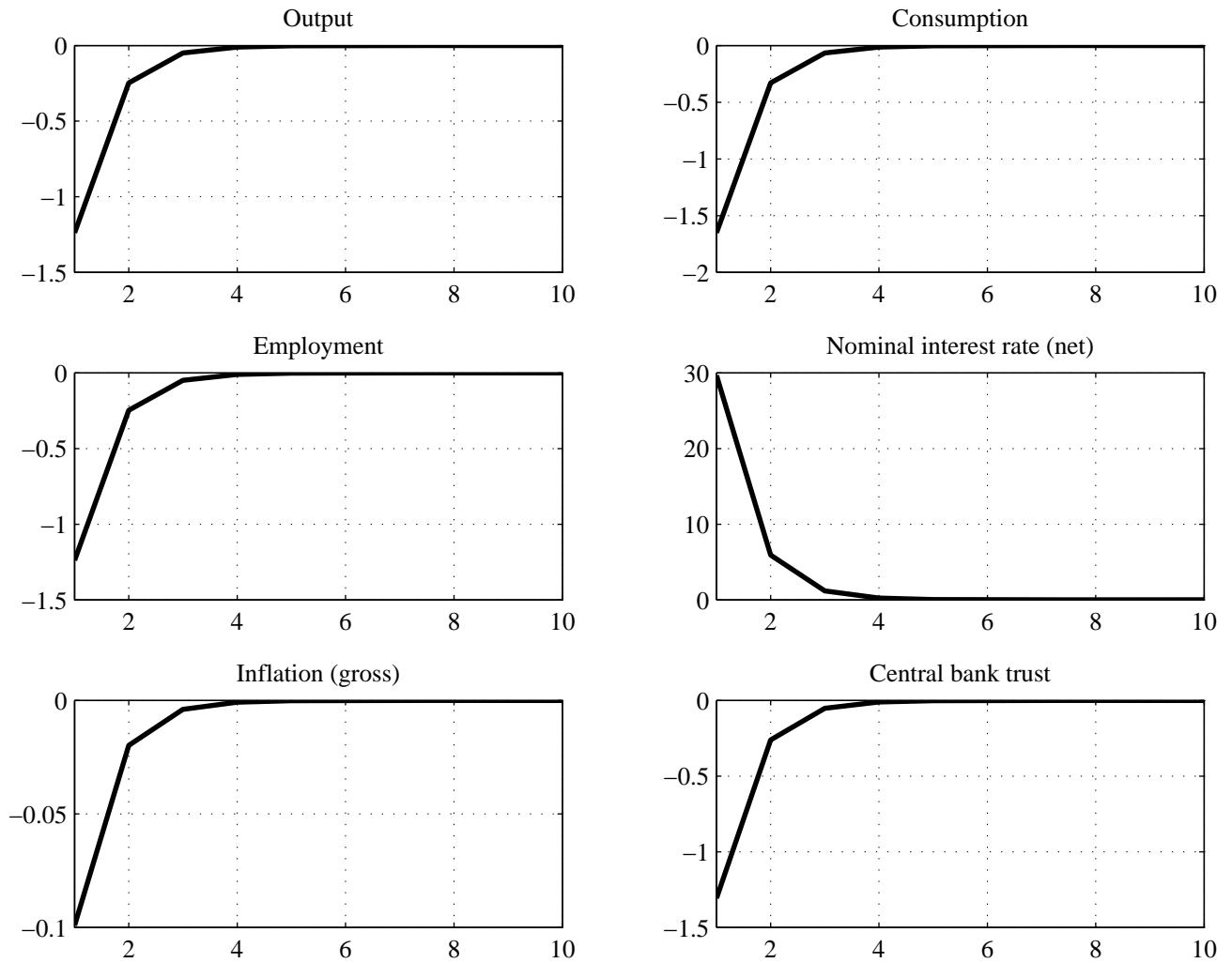


Figure 5: Impulse responses of selected variables to monetary policy shocks.

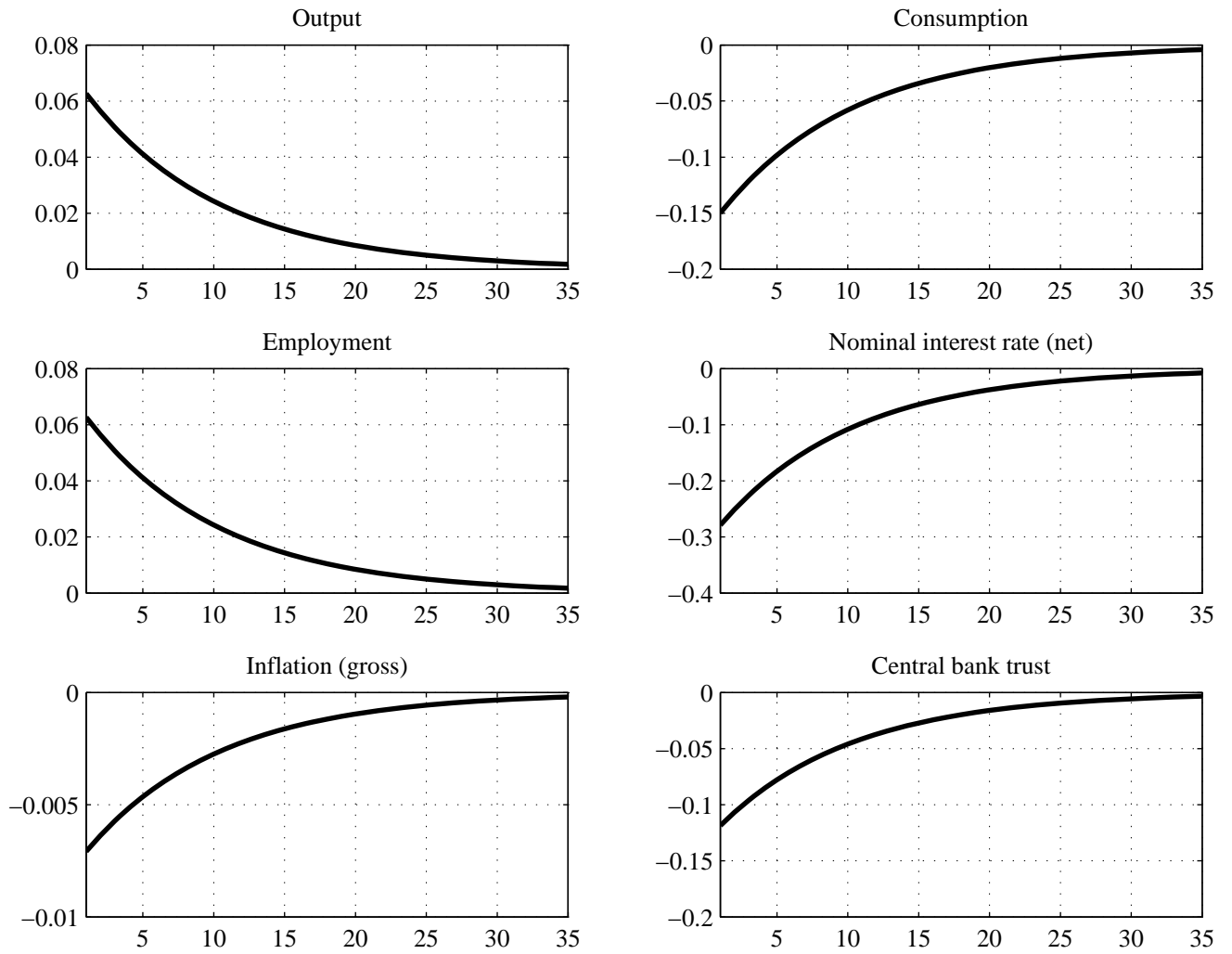


Figure 6: Impulse responses of selected variables to government spending shocks.

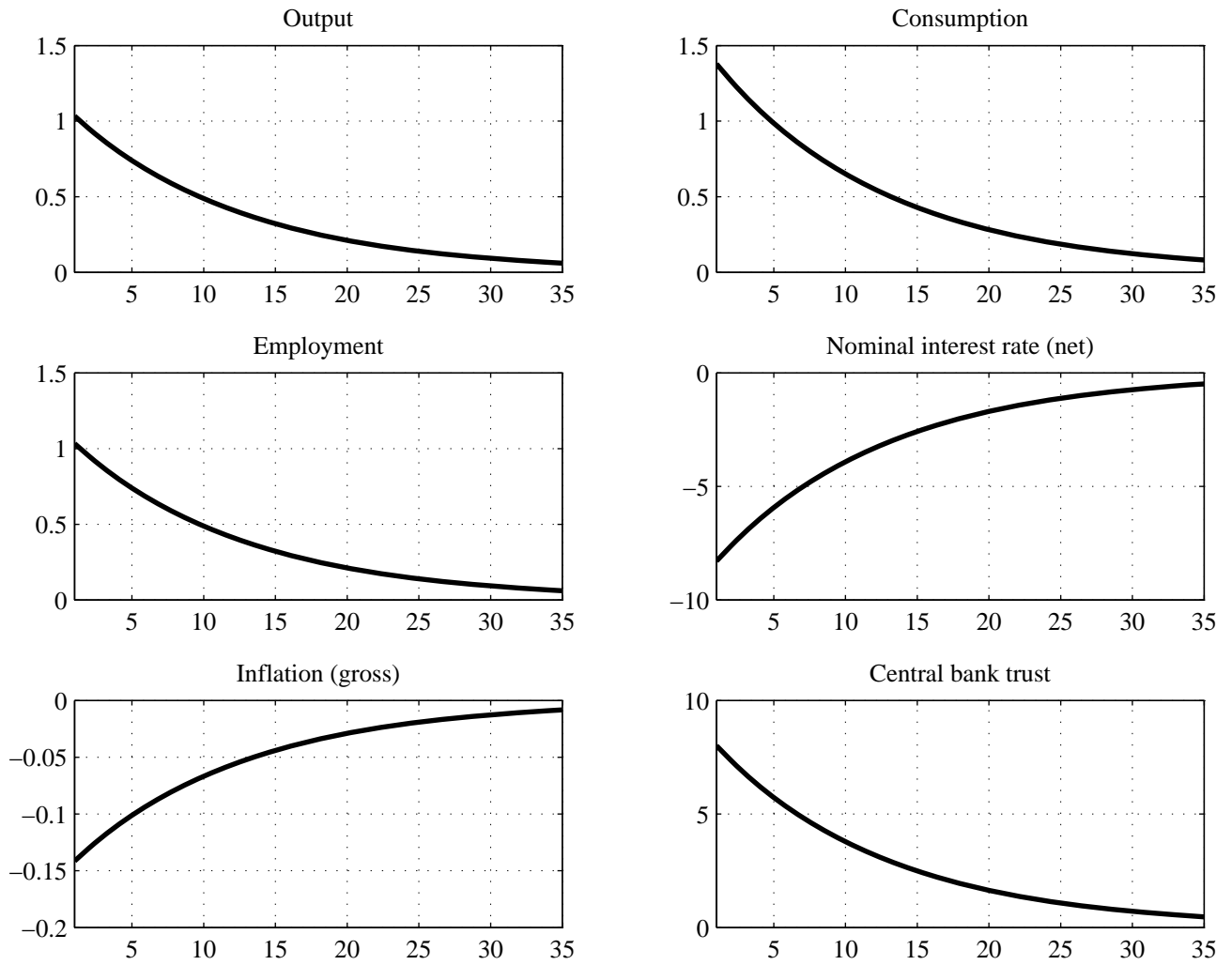


Figure 7: Impulse responses of selected variables to trust shocks.

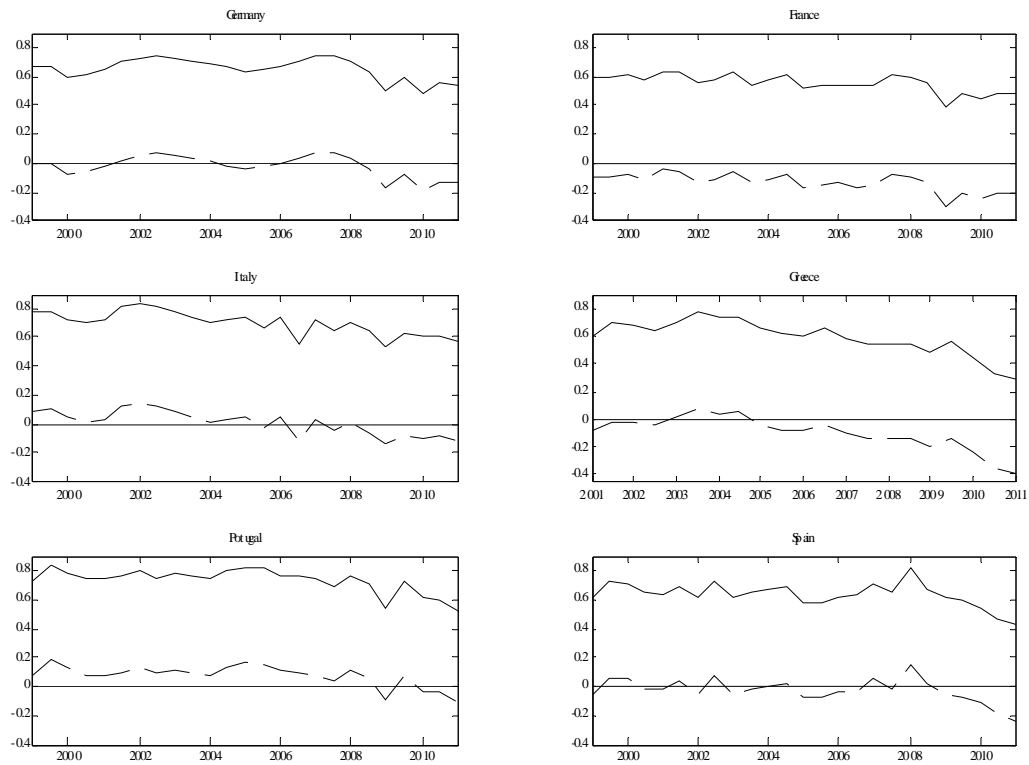


Figure 8: Evolution of trust in the ECB and ECB net trust. The figure presents the evolution of trust in the ECB (solid line) and ECB net trust as defined before (dashed line) for selected countries used in the study and the whole time period from 1999:S1 to 2011:S1.

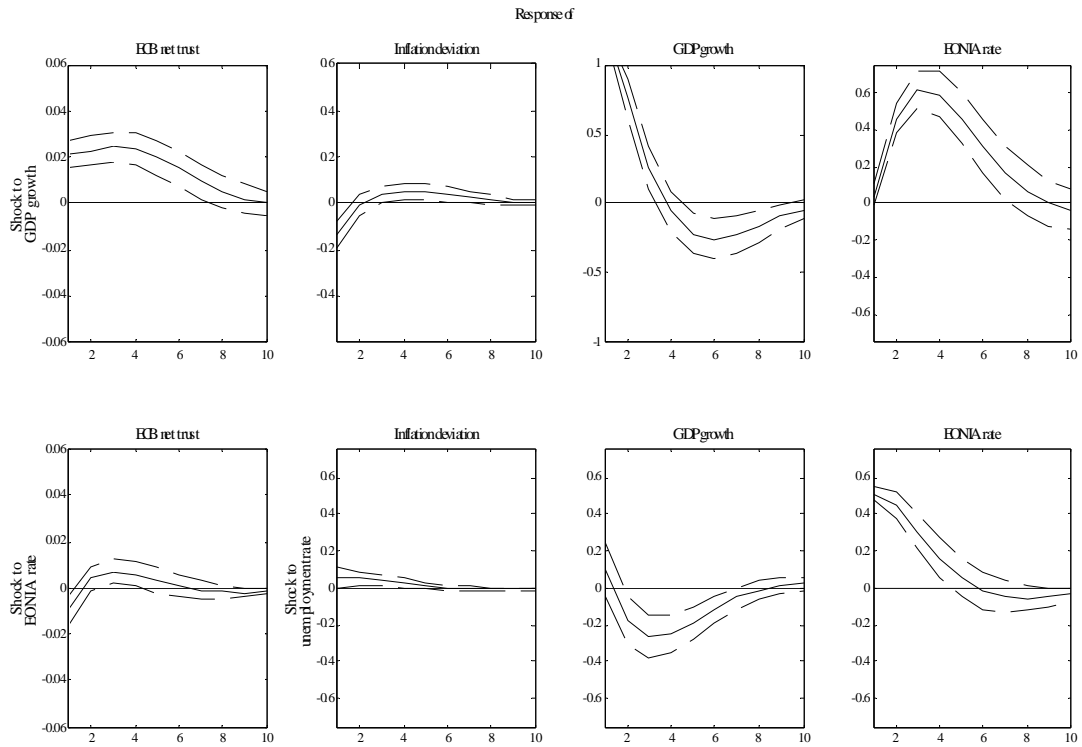


Figure 9: Impulse Responses (VAR-Model 1, part I). The figure presents selected impulse responses to one standard deviation innovations. Endogenous variables are ECB net trust as defined before, real GDP growth, HICP inflation deviation from the target level, and the EONIA rate. Mean impulse responses are calculated following Pesaran and Shin (1998) and are shown together with \pm two standard deviations confidence bands. The VAR was estimated on pooled panel data controlling for country-specific time-constant heterogeneity and assuming slope homogeneity. The sample covers the time period 1999:S1 to 2011:S1.

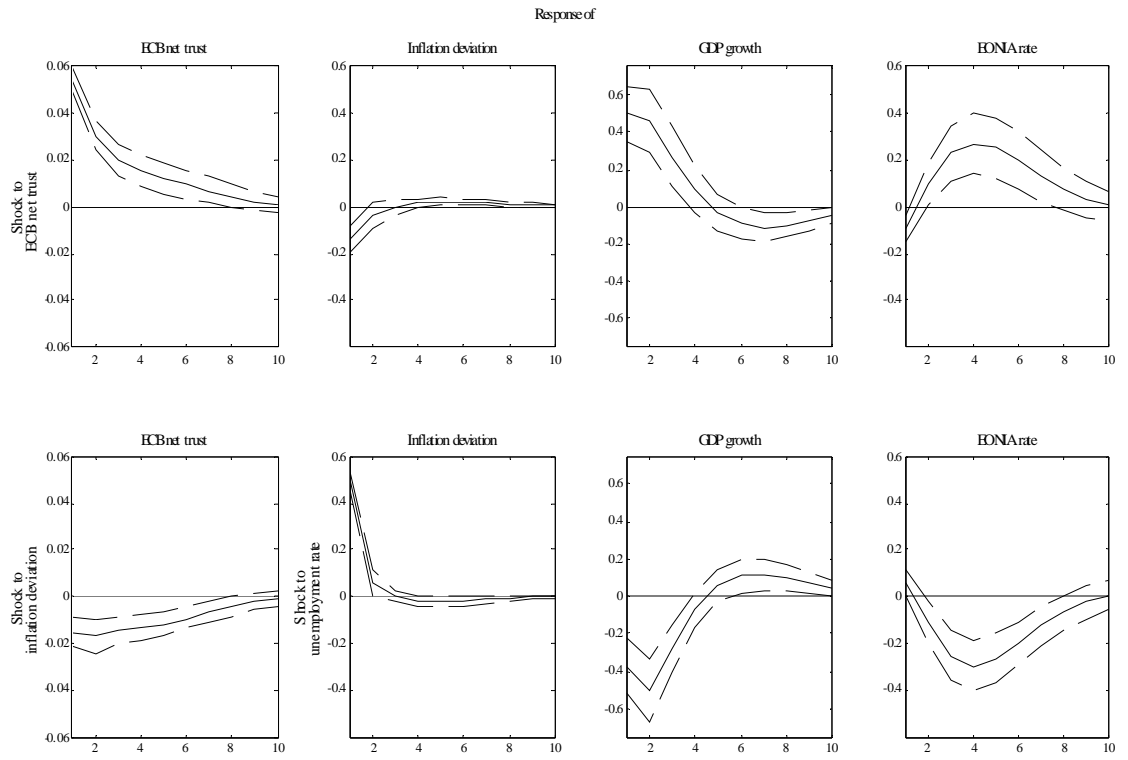


Figure 10: Impulse Responses (VAR-Model 1, part II). The figure presents selected impulse responses to one standard deviation innovations. Endogenous variables are ECB net trust as defined before, real GDP growth, HICP inflation deviation from the target level, and the EONIA rate. Mean impulse responses are calculated following Pesaran and Shin (1998) and are shown together with \pm two standard deviations confidence bands. The VAR was estimated on pooled panel data controlling for country-specific time-constant heterogeneity and assuming slope homogeneity. The sample covers the time period 1999:S1 to 2011:S1.

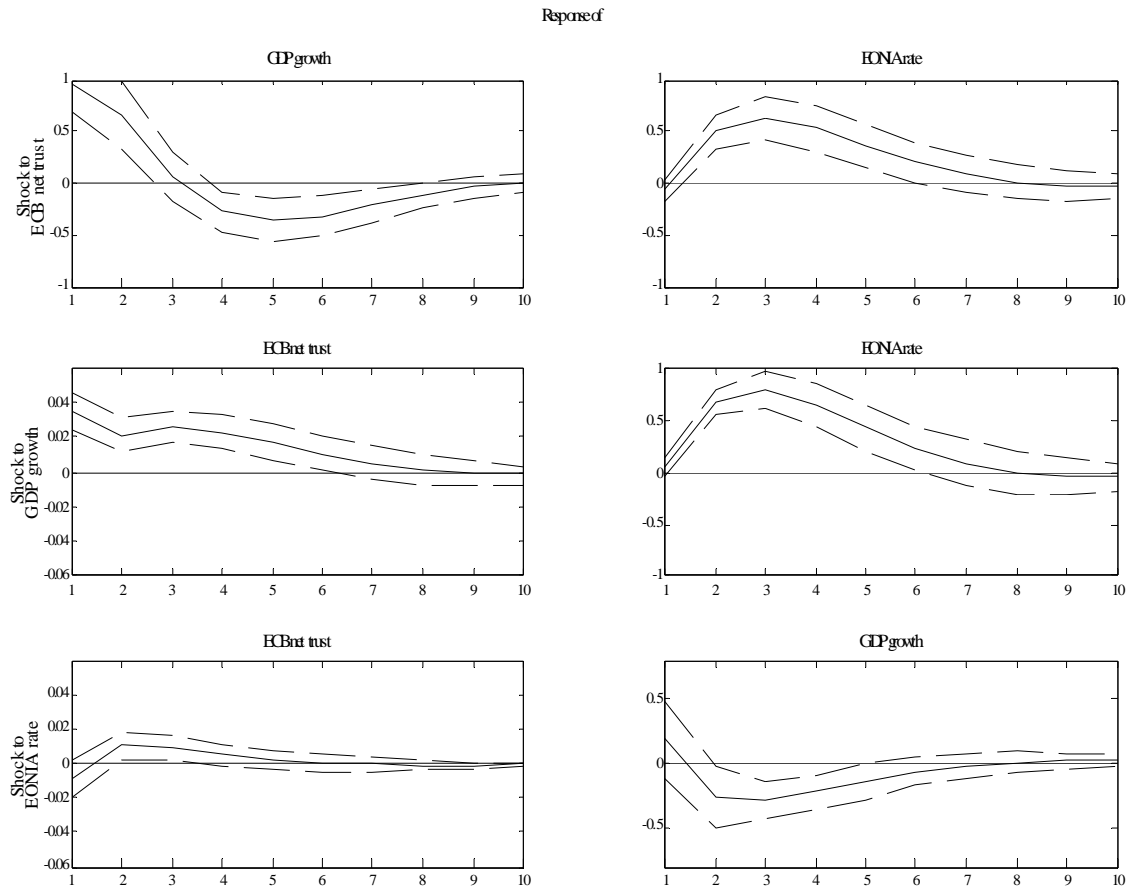


Figure 11: The figure presents selected impulse responses to one standard deviation innovations in Model 2. Endogenous variables are ECB net trust as defined before, real GDP growth, and the EONIA rate. Mean impulse responses are calculated following Pesaran and Shin (1998) and are shown together with +/- two standard deviations confidence bands. The VAR was estimated on pooled panel data controlling for country-specific time-constant heterogeneity and assuming slope homogeneity. The crisis sample covers the time period 2007:S2 to 2011:S1.

Table 1 Variable Description

The table presents a description of the variables used in the first-stage and second-stage estimation. For the sake of parsimonious exposition, the respective reference group is not displayed in the case of categorical variables.

Variable	Description	Source
Trust in the ECB	A dummy variable indicating whether or not the respondent tends to trust the European Central Bank.	Eurobarometer
Age34	A dummy variable indicating that the age of the respondent was less than or equal to 34 years.	Eurobarometer
Age35_64	A dummy variable indicating that the age of the respondent was larger than 34 and less than or equal to 64 years.	Eurobarometer
Male	A dummy variable indicating whether the respondent is male or female.	Eurobarometer
Couple	A dummy variable indicating that the respondent is married, remarried, or currently living with partner.	Eurobarometer
Single	A dummy variable indicating that the respondent has never or previously lived with a partner.	Eurobarometer
Divorced	A dummy variable indicating that the respondent is currently divorced or separated.	Eurobarometer
Self Employed	A dummy variable indicating that the respondent is currently self-employed.	Eurobarometer
Retired	A dummy variable indicating that the respondent is currently retired or unable to work due to illness.	Eurobarometer
Unemployed	A dummy variable indicating that the respondent is temporarily not working, a student, or responsible for ordinary shopping only.	Eurobarometer
High School Degree	A dummy indicating that the respondent was between 15 and 17 years old when full time education was completed. If the respondent was still in full time education at the time the survey was conducted, the education level corresponding to the respondent's current age was assumed.	Eurobarometer
College Degree	A dummy variable indicating that the respondent was more than 17 years old when full time education was completed. If the respondent was still in full time education at the time the survey was conducted, the education level corresponding to the respondent's current age was assumed.	Eurobarometer
Political Position Left	Respondents place themselves on a scale ranging where 1 represents left-wing and 10 right-wing political views. The dummy variable indicates that the respondent has placed herself either in category 1, 2, 3, or 4.	Eurobarometer
GDP Growth	Semi-annual growth rates constructed using data on seasonally adjusted chain-linked quarterly real gross domestic product (reference year: 2000).	Eurostat
HICP Inflation Deviation	Absolute difference between the semi-annual rate of change of the Harmonized Index of Consumer Prices constructed using monthly data (reference year: 2005) and the European Central Bank's implied implicit semi-annual inflation target of 0.995 per cent assuming constant compounding.	Eurostat
Unemployment Rate	Semi-annual unemployment rates constructed using quarterly seasonally adjusted data.	Eurostat
ECB Policy Rate	Semi-annual interest rates on the European Central Bank's main refinancing operations (either minimum bid rate or fixed rate depending on the respective time period) calculated using quarterly data.	Eurostat
EONIA Rate	Semi-annual effective overnight reference rates for the Euro calculated using quarterly data on the Euro Over Night Index Average.	Thomson Reuters Datastream
EURIBOR 3m	Semi-annual effective reference rates for the Euro calculated using quarterly data on the Euro Interbank Offered Rate (maturity: 3 month).	Thomson Reuters Datastream

Table 2 **Summary Statistics – Part I**

The table presents summary statistics for trust in the ECB and the socio-economic characteristics used in the first-stage fully-saturated linear probability model estimation. A detailed variable description can be found in table 1. For the sake of parsimonious exposition, the respective reference group is not displayed.

First Stage					
Variable	Observations	Mean	S.D.	Min	Max
Trust in the ECB	241,131	0.690	0.462	0.000	1.000
Age34	241,131	0.271	0.445	0.000	1.000
Age35_64	241,131	0.535	0.499	0.000	1.000
Male	241,131	0.499	0.500	0.000	1.000
Couple	241,131	0.645	0.479	0.000	1.000
Single	241,131	0.198	0.399	0.000	1.000
Divorced	241,131	0.077	0.266	0.000	1.000
Self Employed	241,131	0.089	0.285	0.000	1.000
Retired	241,131	0.248	0.432	0.000	1.000
Unemployed	241,131	0.223	0.416	0.000	1.000
High School Degree	241,131	0.185	0.388	0.000	1.000
College Degree	241,131	0.586	0.492	0.000	1.000
Political Position Left	241,131	0.323	0.468	0.000	1.000

Table 3 Summary Statistics – Part II

The table presents summary statistics for the macroeconomic indicators and the resulting ECB net trust used in the second-stage VAR estimation. A detailed variable description can be found in table 1. The crisis sample covers the time period 2007:S2 to 2011: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, Angelini et al., 2011, Duchin et al., 2010, and Trichet, 2010).

Second Stage															
Variable	Observ.	Mean	S.D.	Min	Max	Observ.	Mean	S.D.	Min	Max	Observ.	Mean	S.D.	Min	Max
	Full Sample					Non-Crisis Sample					Crisis Sample				
ECB Net Trust	325	0.007	0.102	-0.395	0.202	201	0.032	0.084	-0.165	0.202	124	-0.033	0.115	-0.395	0.195
GDP Growth	325	0.971	1.708	-6.288	5.647	201	1.532	1.171	-1.256	5.647	124	0.062	2.026	-6.288	4.482
HICP Inflation	325	1.120	0.922	-2.438	5.006	201	1.158	0.653	-0.276	3.231	124	1.058	1.241	-2.438	5.006
HICP Inflation Deviation	325	0.701	0.611	0.001	4.011	201	0.542	0.397	0.001	2.236	124	0.960	0.785	0.001	4.011
Unemployment Rate	325	7.495	3.093	1.850	20.600	201	7.238	2.747	1.850	14.600	124	7.911	3.556	3.050	20.600
ECB Policy Rate	325	2.650	1.155	1.000	4.750	201	2.938	0.862	2.000	4.750	124	2.184	1.398	1.000	4.125
EONIA Rate	325	2.667	1.321	0.375	4.925	201	3.047	0.881	2.030	4.925	124	2.050	1.647	0.375	3.971
EURIBOR 3m	325	2.899	1.311	0.709	4.923	201	3.085	0.854	2.038	4.923	124	2.597	1.787	0.709	4.843

Table 4 Multivariate OLS Regressions - Socio-economic Characteristics

The table presents estimation results from multivariate ordinary least squares regressions. Values of the t-statistics are in parentheses. Standard errors were corrected for heteroscedasticity as LPM residuals are heteroscedastic by construction. ***, **, * denote significance at 1%, 5%, and 10%, respectively.

Variables	Dependent: Trust in the European Central Bank			
	(1)		(2)	
Age34	-0.036 (-8.871)	***	-0.028 (-6.922)	***
Age35_64	-0.033 (-9.675)	***	-0.031 (-9.312)	***
Male	0.026 (13.456)	***	0.026 (13.419)	***
Couple	0.030 (7.643)	***	0.029 (7.388)	***
Single	0.021 (4.544)	***	0.020 (4.445)	***
Divorced	-0.026 (-5.012)	***	-0.021 (-4.115)	***
Self Employed	-0.006 (-1.813)	*	0.005 (1.479)	
Retired	-0.010 (-3.207)	***	-0.004 (-1.285)	
Unemployed	-0.020 (-7.707)	***	-0.021 (-8.060)	***
High School Degree	0.045 (14.640)	***	0.037 (11.815)	***
College Degree	0.112 (44.587)	***	0.108 (41.125)	***
Political Position Left	-0.049 (-24.220)	***	-0.042 (-20.551)	***
Constant	0.632 (128.700)	***	0.601 (109.633)	***
Country Fixed Effects	No		Yes	
Observations	241,131		241,131	

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