Deposit Withdrawals*

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October 22, 2020

Abstract

This paper develops a new approach to identify and quantify different motives for deposit withdrawals. Exploiting variation in the cost of withdrawal induced by the maturity expiration of time-deposits, we identify withdrawals due to liquidity needs, deteriorating of fundamentals and expectation about withdrawal behavior of other depositors. Using daily micro-data from a large Greek bank we show that early deposit withdrawal probability quadruples in response to a policy uncertainty shock that doubled the short-run CDS price of Greek sovereign bonds. About two-thirds of this increase is driven by direct exposure to deteriorating fundamentals with the remainder due to changes in expectations of withdrawal behavior of other depositors. We estimate depositor compensation to remain in the bank and find that depositors would have had to be offered annualized returns exceeding 50% to prevent withdrawals during episodes of high uncertainty.

JEL Classification Codes: D12, D81, G21, O16.
Keywords: depositor withdrawals, policy uncertainty, time deposits, bank runs.

*We thank seminar participants at the Stanford GSB Economics Lunch and Finance Lunch, Junior Five Star Conference, London School of Economics Finance Lunch, Cornell University Finance Lunch, UC Berkeley, Bank of England, NYU- NY Fed Conference, Western Finance Association 2020, INSEAD, Goethe University, Stockholm School of Economics, WAPFIN Conference, CEPR Gerzensee Summer Symposium, New York Fed and NYU Stern Conference on Financial Intermediation, Lund University, VU Vienna, Frankfurt School of Business, University of Alberta, European Banking Center Network Conference. Seru and Tsoutsoura gratefully acknowledge financial support from the Fama-Miller Center for Research in Finance. We also thank Peter DeMarzo, Matthew Gentzkow, Yiming Ma (discussant), Philip Strahan (discussant). We thank Menaka Hampole and Yin Xiao for excellent research assistance. All errors are our own. Please send correspondence to roblesga@stanford.edu.

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1 Introduction

The global financial crisis saw runs on several prominent banks and financial intermediaries. It reopened fundamental old debates on the rationale of a banking system with run-prone deposits (e.g., Diamond and Dybvig (1983), Goldstein and Pauzner (2005)) as well as on policies that provide stability in the wake of uncertainty (e.g., Drechsler, Savov, and Schnabl (2018); Egan, Hortaçsu, and Matvos (2017)).[1] Banking regulation that seeks to tackle these issues relies on isolating motives driving depositor withdrawals during uncertain and quiet times. Theoretical work has made big strides on this front categorizing depositor withdrawal into reasons related to liquidity needs (idiosyncratic motive), deteriorating fundamentals due to bank solvency or currency risk (fundamentals related motive) and expectations about withdrawal behavior of other depositors (strategic complementarity related motive). However, empirical work that isolates and quantifies these motives during periods of heightened uncertainty – and studies the effects of policy responses – has been very limited. One main obstacle in credible research design is identifying whether withdrawals are a direct consequence of deteriorating fundamentals or also an indirect effect of changing expectations about withdrawal behavior of other depositors (see, for example, Morris and Shin (2004) and He and Manela (2016)).

This paper aims to fill this important gap by developing a new approach to identify and quantify different motives for deposit withdrawals. Our approach is based on tracking, at the individual level and at a daily frequency, early withdrawals of time-deposits. We exploit variation in the cost of withdrawal induced by the maturity expiration of time-deposits, we identify withdrawals due to liquidity needs, deteriorating of fundamentals and expectation about withdrawal behavior of other depositors.

Time-deposit micro-data and our research design provides three key ingredients for characterizing and quantifying deposit withdrawal motives. First, early withdrawals of time-deposits – i.e., withdrawals before maturity – carry a measurable monetary penalty. This allows us to quantify depositors' willingness to pay to withdraw. Second, the monetary cost of withdrawing a time-deposit drops discontinuously at the maturity date, with such dates distributed evenly over our sample period. Third, our research design exploits surprise announcement of policies that can – with some uncertainty – impact fundamentals of the bank after a specific implementation date. The richness of our data allows us to construct group of depositors whose time-deposits mature before and after the implementation date to isolate withdrawals due to fundamental motive. Moreover, focusing on withdrawals of depositors that mature before the implementation date that affects banks fundamentals allow us to isolate strategic motive for withdrawal. Combining these elements allows us to quantify how much depositors need to be compensated to *not* remain in the bank when exposed to

[1] Several theories have also been proposed on advantages that such deposits provide to the financial system during quiet and "sleepy" periods (e.g., Hanson et al. (2015)).

fundamental and strategic motive following periods of heightened uncertainty.

To better map our setting to theoretical work, we develop a motivating framework to understand the drivers of time deposit withdrawals, both in quiet times and in periods with heightened uncertainty with deteriorating fundamentals. Every period before maturity, each depositor decides whether to withdraw her time deposit. The depositor chooses to withdraw before maturity if the payoff from early withdrawal exceeds the expected value of the time deposit at maturity. Early withdrawal payoffs depend on an idiosyncratic, depositor-specific shock (e.g., liquidity needs) and a monetary cost (e.g., a penalty for prematurely liquidating an asset). On the other hand, the expected value of a time deposit at maturity depends directly on fundamentals (e.g., any factor affecting the probability of getting a haircut at maturity) as well on withdrawals by other depositors (i.e., strategic complementarities). The latter is taken to be a function of fundamentals, following the global games literature.[2] This simple framework allows us to think through the effects of changes in fundamentals on depositor behavior. In particular, we focus on the case in which some depositors are exposed to deteriorating fundamentals, while others do not. Our framework allows us to disentangle the direct effect of worse fundamentals from the indirect effect of strategic complementarities.

We implement our approach using daily deposit-level data with detailed contract characteristics on the entire universe of time-deposit accounts for retail customers of a large Greek bank (The Bank henceforth). The data spans the 2014-2015 period, during which the surprise announcement of an election that increased the risk of radical left-wing policies was followed by a 30% decline of deposits in the banking system. Time-deposits are an economically relevant source of funding in Greece, representing 62% of all Greek bank deposits by households.[3] This high prevalence of time-deposits is not unique to Greece. In Euro area country banks, close to 50% of domestic private non-financial deposits are time-deposits with a maturity over one year.[4]

We start by establishing new stylized facts on time-deposit withdrawal behavior in *quiet times*, the earlier period of our sample period when uncertainty (measured as the default risk of the The Bank and of Greek sovereign bonds) was at its lowest. We use this period as a benchmark for depositor behavior when there are good fundamentals (and fundamental-motivated withdrawals were negligible). Also, aggregate banking sector deposits and deposits at The Bank were growing during this period, which allows assuming that early withdrawals due to strategic complementarities were also negligible. We use early withdrawals during this

[2]The intuition is that if a sufficiently large number of depositors withdraw early (e.g., due to deteriorating fundamentals), the bank may become illiquid and the remaining depositors may get a haircut on their deposits. Therefore, depositors may decide to withdraw early if they expect other depositors to do the same.

[3]See Bank of Greece report on deposit markets, available at https://www.bankofgreece.gr/Pages/en/Statistics/rates_markets/deposits.aspx

[4]See, for example, ECB report on Changes in Bank Financing Patterns, available at: https://www.ecb.europa.eu/pub/pdf/other/changesinbankfinancingpatterns201204en.pdf?3afe7cf6dc78e23e1c8b5201d0dc51ae

period to characterize withdrawal behavior motivated by depositors' idiosyncratic liquidity needs. We find that, on average, about 0.04% of depositors withdraw time deposits early on a daily basis. Aggregating this average over a year implies that 10.12% of time-deposits are withdrawn early due to liquidity reasons.[5] The cost paid by depositors for early withdrawals during quiet times, measured as a forgone annualized return over the deposit amount, is on average 17% and can be as high as 65% for some depositors. These magnitudes imply that depositors exhibit a high willingness to pay to withdraw deposits for liquidity reasons.

Next we use the surprise announcement of a large policy uncertainty event in the second half of our sample to measure deposit withdrawals due to strategic and fundamental motives. The announcement of a Presidential election in Parliament occurred on December 8, 2014, and increased the likelihood of the opposition party taking control of government and implementing radical left-wing policies. The impact of the increased risk on the financial system was large, with the price of the 6-month CDS on Greek sovereign bonds increasing by 136% and the stock market dropping by 12%.

The policies included in the opposition party's agenda implied a deterioration in fundamentals affecting the value of deposits (e.g., caused by Greece leaving the Euro zone and the conversion of deposits from Euros to a new Greek currency, the nationalization of the banking sector). However, these policies could only be implemented when (and if) the opposition party came to power. Due parliamentary process implied that the earliest the opposition party could take control of government was on late January 2015, six weeks after the announcement. Thus, the announcement was followed by six-week interim period during which none of the policies affecting the fundamental value of deposits could take place. Our empirical strategy to disentangle deposit withdrawals sensitivities to fundamental and strategic motives exploits this heterogeneity of the impact of the announcement on withdrawal behavior across borrowers.

The announcement contains information that affects depositors' perceived exposure of time-deposits to a future deterioration of fundamentals, but its effect was heterogeneous across deposits of different maturity dates. Deposits that matured during the interim period faced no additional deterioration in fundamentals after the announcement. These deposits could be held to maturity and withdrawn without penalty before new polices could take place. Deposits maturing after the interim period, on the other hand, could only avoid changes in fundamentals by withdrawing before maturity. Thus, worse fundamentals induces *early* withdrawals of deposits that mature after the interim period, but does not induce early withdrawals for deposits that mature within it. While there is differential exposure to fundamentals deteriorating in our research design, all depositors are exposed to strategic complementarities: the possibility that a large enough number of *other* deposits are with-

[5]Yearly deposit withdrawals equal 0.04% times 253 days in which the Bank was opened in 2014.

drawn and the bank fails. Deposits that mature in the interim period face no fundamental motives and can (at no cost) wait to maturity. However, to avoid strategic complementarities such depositors may also withdraw early. Thus, strategic complementarities induce early withdrawals of all deposits, independently of their maturity date.

To identify withdrawals due to strategic complementarities we measure changes in withdrawal probabilities during the three weeks before and after the announcement of future potential policy changes, on the subsample of deposits maturing in the interim period (before policy changes can take place). We implement this test as a difference-in-difference specification where we account for time-series patterns in liquidity-driven withdrawals using depositor behavior in quiet times. The identifying assumption is that liquidity-driven withdrawals and bank fundamentals do not change during the three-week period after the announcement, for which we provide supporting evidence.

Our estimates imply that strategic complementarities following the announcement increased depositors' propensity withdraw early by 70% relative to the quiet times baseline. The magnitude of strategic complementarities on withdrawals varies in the cross section of depositors and contract characteristics. We find that our effect is driven by (1) male depositors, (2) deposits with larger balances, (3) withdrawals outside of Athens, and (4) deposits with six-month maturities. We also find a strong spatial autocorrelation in withdrawal behavior of depositors across nearby branches in the Northern region of Greece after the announcement. Before that event there is no evidence of depositor withdrawal behavior being correlated across space. After the event, we observe clusters across branches in particular areas in the country, which are not explained by depositors political views, income or demographics. Since strategic withdrawals can be fueled by observing the withdrawal behavior of other depositors (e.g., observing depositor queues in the local bank branch), it is reasonable for them to be spatially correlated. We also find evidence indicating that the observed heterogeneity in the magnitude of strategic withdrawals can be predicted ex-ante using observable characteristics of the borrower base.

To identify withdrawals due to the direct effect of deteriorating fundamentals, we measure the change in withdrawal probability around the announcement of the general election date, on two subsamples: 1) deposits that matured after the new policies could be implemented (exposed to fundamental and strategic motives), and 2) deposits that matured during the interim period (exposed to strategic motives only). Differencing across the two subsamples identifies the change in withdrawal probability due to fundamental motives alone. We implement this estimation as a triple-difference to account for time patterns of liquidity withdrawals using a counterfactual set of depositors during the quiet period. Our estimates imply that the deterioration of fundamentals induced depositors to increase by 200% the probability of early withdrawal, relative to the quiet times baseline, almost three times the effect on withdrawals of the increase in strategic motives. In contrast to withdrawals induced by strategic motives, fundamental withdrawals do not exhibit significant heterogeneity. The magnitude of the effect of fundamental motives on withdrawals varies little in the cross section of depositors, contract characteristics or geography, relative to its average level. This finding is reassuring of our fundamental-strategic withdrawal decomposition, since there is no a priori rationale to expect fundamental motives to have a heterogeneous effect on withdrawal behavior. All the cross sectional heterogeneity in our setting is due to strategic withdrawals.

We next turn to quantifying depositor compensation to prevent early withdrawals. To back out a measure of monetary compensation, we first estimate a cost-elasticity of withdrawals in quiet times, using the discontinuity around interest repayment dates for identification (around these dates the cost of early withdrawal drops to zero). We estimate a cost-elasticity of withdrawing deposits early of 1.54. The estimate implies that a decline in the penalty for early withdrawal equivalent to 1% of the deposit amount, increases the early withdrawal probability by 120%. Using this figure we ask the question: how much would The Bank have to pay depositors to prevent the withdrawal probability from increasing during the high uncertainty period (relative to quiet times)? We find that preventing withdrawal probabilities from increasing for a three-week period would have cost The Bank 2.38% of the value of deposits, which would have implied a cost of capital (at an annualized rate) exceeding 50%. This estimate is likely to be a lower bound on the cost of stabilizing deposits through prices, given that deposit interest increases can signal trouble to depositors and trigger further withdrawals. Thus, the cost of deposit stabilization through prices during periods of high policy uncertainty is very high, even in the absence of a panic-induced deposit run.[6]

All our estimates are short-run deposit withdrawal elasticities. The fundamental and strategic motives for withdrawals plausibly increase as bank deposits shrink. Moreover, our estimates pertain the early withdrawal of time-deposits, which entail an all-or-nothing decision that carries a monetary penalty. Regular deposits, in contrast, can be partially withdrawn with no penalty. Thus, our estimates are likely a lower bound on the withdrawal elasticity of regular deposits over longer horizons. To gauge external relevance of our estimates as well as to assess their plausibility, we perform two exercises. First, we compare the deposits demand elasticity implied by our quiet-times estimates to those obtained in other settings. Our estimates imply an interest rate-demand elasticity of time deposits of 0.48, very close to the insured-deposit demand elasticity of 0.56 obtained in Egan, Hortaçsu, and Matvos (2017) using US deposit data. Second, we consider how well our characterization of depositor behavior under aggregate uncertainty extrapolates to other settings. We scale the magnitude of withdrawals to other high-uncertainty events using sovereign bond CDS prices.

[6] There is recent evidence indicating that banks do attempt to prevent deposit withdrawals by changing deposit rates (Acharya and Mora (2015), Chavaz and Slutzky (2018)). In our setting such attempts either did not occur or were insufficient: six months after our analysis period the newly elected government imposed a €60-per-day withdrawal limit to slow down deposit outflows.

Our estimates imply that a 1% increase in the 6-month sovereign default risk is associated with a 0.5% increase in withdrawal probability due to strategic motives, and a 7.1% increase in withdrawal probability for fundamental motives. Using these elasticities we find that our estimates predict a significant fraction of deposit withdrawals in other high-uncertainty episodes in Greece during our analysis period, in a prominent episode of policy uncertainty in Italy (spring and summer of 2018), and in well-known episodes high uncertainty over bank fundamentals in other countries (e.g., Northern Rock in UK and Washington Mutual in US).

Our paper is related, but distinct, from recent empirical work using micro-data to characterize runs on banks (Iyer and Puri (2012); Iyer, Puri, and Ryan (2016)) and other financial institutions (Schmidt, Timmermann, and Wermers (2016)).[7] Although the strategic motive for withdrawals is the main driver of run episodes, our analysis is novel in that we characterize depositors' strategic motivations before a full-scale panic run or coordination failure occurs. Doing so is important because, as emphasized in recent work (see, e.g., He and Manela (2016), Ahnert and Kakhbod (2017) and Schliephake and Shapiro (2018)), real-life bank run episodes have a dynamic dimension to deposit flows that is typically ignored in academic work.[8] Our work is also unique in that we not rely on taking an ex ante stance on whether withdrawals are driven by fundamental or strategic uncertainty. On the contrary, our empirical approach allows distinguish the motivations behind depositor withdrawals from the data.

Our paper also contributes to the empirical literature on economic and policy uncertainty. Recent empirical papers show negative real and financial effects of uncertainty on firm incentives (Nick Bloom, Bond, and Van Reenen (2007), Nicholas Bloom (2009), Bachmann, Elstner, and Sims (2013), and Nicholas Bloom et al. (2018), with a review in Nicholas Bloom (2014)). Households also react to uncertainty. When exposed to greater uncertainty, households increase their savings and work more hours (see, e.g., Giavazzi and McMahon (2012)). Our paper contributes to this literature by analyzing depositors reactions to policy uncertainty. There is also a strand of work measuring policy uncertainty through different indexes (see, e.g., Jurado, Ludvigson, and Ng (2015), Baker, Nicholas Bloom, and Davis (2016)), fiscal uncertainty using time-varying volatility of tax and spending processes (see, e.g., Fernández-Villaverde et al. (2015)) and economic uncertainty measured by differences in implied volatility between short- and long-maturity options (Dew-Becker, Giglio,

[7] Runs on repo and asset-backed commercial paper (ABCP) for shadow banks have also been documented (see, e.g., Gorton and Metrick (2012), Acharya, Schnabl, and G. Suarez (2013), Covitz, Liang, and G. A. Suarez (2013), and Schroth, G. A. Suarez, and Taylor (2014)).

[8] Outside bank runs, Lorenzoni and Werning (Forthcoming) theoretically rationalize the slow-moving dynamics commonly observed around debt crises. With counted exceptions (e.g., Angeletos, Hellwig, and Pavan (2007)) most of the literature on bank runs and coordination failures ignores the time dimension. For some salient examples of a theoretical discussion of information-based runs, see Bryant (1980), Diamond and Dybvig (1983), Postlewaite and Vives (1987), Rochet and Vives (2004), and Goldstein and Pauzner (2005)). For examples of a theoretical analysis of runs based on coordination problems, see, Jacklin and Bhattacharya (1988), Chari and Jagannathan (1988), Calomiris and Kahn (1991), Chen (1999), and Diamond and Rajan (2001)).

and B. T. Kelly (2018)). Our main specifications differ from these approaches in that we do not attempt to measure the magnitude of the increase in policy uncertainty. Instead we consider our exposure measure to be a dummy variable, that is, depositors are either exposed to strategic or fundamental uncertainty or both. Moreover, in our setting, depositors are uncertain about which policy will the government implement if elected.[9] In the final part of the paper, where we evaluate whether our estimates extrapolate to other bank-run episodes we use changes in CDS prices to measure uncertainty.

The rest of the paper proceeds as follows. Section 2 develops a motivating framework introducing the key motives for deposit withdrawals. Section 3 describes the data and the institutional setting for both quiet and uncertain times. Section 4 describes our empirical strategy to estimate fundamental and strategic withdrawal motives. Section 5 presents our results. Section 6 uses out estimates to quantify depositor compensation. Finally, Section 7 concludes.

2 Motivating Framework

In what follows, we formalize depositor motives for withdrawals in our setting and describe the elasticities that we will later isolate in our empirical strategy.

2.1 Setting

Consider a bank that has time deposit contracts with a continuum of small depositors. The contracts are of fixed maturity. Depositors enter into these contracts with the bank at different points of time ($t = 0, 1...$). Every period before their time deposit matures, each depositor decides whether to withdraw her deposit or wait until maturity. In particular, a depositor with a time deposit maturing at period T decides to withdraw her deposit at time t ($< T$) if the payoff of withdrawing early is greater than the expected value of the time deposit at maturity.

2.1.1 Payoff from Early Withdrawal

Time deposits withdrawn at time t before maturity date T incur an early withdrawal cost κ_t^T.[10] That is, prematurely liquidating a time deposit implies getting a haircut on its value. A depositor may accept the haircut if she has high liquidity needs or a better outside option

[9] Other papers have considered political uncertainty as uncertainty about which political party will be elected (e.g., for the options market, B. Kelly, Pástor, and Veronesi (2016)).

[10] Most time deposit contracts have a monetary penalty if withdrawn before maturity. This penalty is usually a function of the interest rate r_T and the time to maturity ($\Delta T \equiv T - t$). There can be also non-monetary costs associated with early withdrawals, e.g., time spent in the bank.

for investment. We model a depositor's benefits from early withdrawal as a deposit-specific idiosyncratic shock ϵ_{it}.

Let $W_{it}^T(\kappa_t^T, \epsilon_{it})$ denote deposit i's payoff from withdrawing at time t a time deposit maturing at date T. We assume higher costs of withdrawal lower depositors' payoffs of early withdrawal. That is, $\frac{\partial W_{it}^T}{\partial \kappa_t^T} < 0$. Similarly, we assume that a higher liquidity shock leads to higher depositor's payoffs from early withdrawal. That is, $\frac{\partial W_{it}^T}{\partial \epsilon_{it}^T} > 0$.

2.1.2 Expected Value at Maturity

The expected value of a time deposit at maturity date T depends on *fundamentals* at that time. In our setting, *fundamentals* capture all factors affecting the fundamental value of the time deposit at maturity T. These factors include all aspects that impact bank's solvency and the performance of its loan portfolio and investments, such as house price growth, unemployment, currency risk, re-denomination risk, and capital controls. Let θ_t^T denote fundamentals. A decrease in theta represents a deterioration of current and future fundamentals – i.e., any time period before the maturity date – such that depositors are more likely to get a haircut on the value of their time deposits at maturity T. We assume the value of θ_t^T is publicly observable and time-varying.

The expected value of a time deposit may also depend on other depositors' withdrawal behavior. If a sufficiently large number of depositors withdraw at t $(< T)$ and the bank has limited reserves, the bank may become insolvent. In such case, depositors remaining in the bank may get a haircut on the value of their time deposits. We define this interaction with other depositors' withdrawal behavior at time t as *strategic complementarities* and denote it by γ_t. Similarly to previous work on strategic complementarities (e.g., Goldstein and Pauzner (2005)), strategic complementarities at t depend on fundamentals. We formalize this dependency by allowing strategic complementarities to be a function of fundamentals such that $\gamma_t(\theta_t)$, where θ_t is a vector of fundamentals and $\frac{\partial \gamma_t}{\partial \theta_t^T} < 0$ for all maturities $T > t$.

For a given level of fundamentals (θ_t) and strategic complementarities (γ_t), we define the expected value of a time deposit i with maturity T at time t as $V_{it}^T(R_i, \theta_t^T, \gamma_t(\theta_t))$, where R_i is the interest rate on the time deposit. In our setting, fundamentals affect the expected value of deposits both *directly* and *indirectly*. The direct effect of fundamentals is the change in the expected value of the time deposit due to changes in depositor's own fundamentals (θ_t^T). We assume the expected value of a time deposit with maturity T decreases as fundamentals for maturity T decrease. That is, $\frac{\partial V_{it}^T}{\partial \theta_t^T} > 0$. Concurrently, the indirect effect of fundamentals is the change in the expected value of the time deposit due to changes in fundamentals of *other* time depositors ($\theta_t^{T'}$ with $T' \neq T$). We assume the expected value of a time deposit with maturity T decreases as fundamentals for time deposits of maturity T' decreases. That is, $\frac{\partial V_T}{\partial \theta_t^{T'}} = \frac{\partial V_{it}^T}{\partial \gamma_t} \frac{\partial \gamma_t(\theta_t^T, \theta_t^{T'})}{\partial \theta_t^{T'}} > 0$.

Time depositors have different exposures to fundamentals depending on their maturity dates, meaning that θ_t^T is maturity-specific. However, all time depositors face the same (contemporaneous) strategic complementarities. That is, $\gamma_t(\theta_t)$ is common across all maturities at time t.

2.1.3 Depositor Choice at Time t

Sections 2.1.2 and 2.1.1 describe the payoff from early withdrawal and the expected value of a time deposit, respectively. We can now define depositor's withdrawal decision at time t. A depositor holding time deposit i with maturity T will behave at time t such that:

$$Withdrawal_{it}^T = \begin{cases} 1 & \text{if } V_{it}^T\left(R_i, \theta_t^T, \gamma_t(\theta_t)\right) \leq W_{it}^T\left(\kappa_t^T, \epsilon_{it}\right) \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

That is, depositor i withdraws at time t ($< T$) if the payoff of early withdrawal is higher than the expected value of the deposit at maturity T. Given individual depositors' early withdrawal decisions in equation 1, the aggregate fraction of early withdrawals at any time t for maturities T for a given level of fundamentals is:

$$Total\,Withdrawals_t^T \equiv s_t^T = \sum_{i \in T} \mathbb{1}[V_{it}^T\left(R_i, \theta_t^T, \gamma_t(\theta_t)\right) \leq W_{it}^T\left(\kappa_t^T, \epsilon_{it}\right)] \tag{2}$$

where $\frac{\partial s_t^T}{\partial \theta_t} < 0$, $\frac{\partial s_t^T}{\partial \gamma_t} > 0$, $\frac{\partial s_t^T}{\partial \kappa_t^T} < 0$ and $\frac{\partial s_t^T}{\partial r_T} < 0$.

2.2 Changes in Fundamentals

So far we have described depositors' early withdrawal behavior for a given level of fundamentals, which can vary across different maturity dates. In this section we study how depositor withdrawal behavior changes with fundamentals.

Similarly to Goldstein and Pauzner (2005), we consider different cases depending on the level of fundamentals. When fundamentals are sufficiently high for all time depositors (i.e., high values of θ_t^T for all T), all else equal, each depositor's dominant strategy is to wait until maturity, regardless of other depositors' withdrawal strategies. Therefore, in such a scenario, idiosyncratic shocks (ϵ_{it}) are the only reason to withdraw before maturity (see equation 1). We denote this region with high fundamentals as *quiet times*.

When fundamentals are sufficiently low for all time depositors (i.e., low values of θt_T for all T), each depositor's dominant strategy is to withdraw before maturity, regardless of other depositors' withdrawal strategies. In such a scenario, the expected haircut on the face value of deposits at maturity exceeds the costs of early withdrawal, such that all depositors of all maturities want to withdraw (see equation 1). We denote this region with low fundamentals as *doomsday*.

There is a middle region in the value of fundamentals, between *quiet times* and *doomsday*, where the behavior of other depositors matters for a depositor's decision to withdraw early. In this section, we focus on this middle region. In particular, we consider a deterioration of fundamentals such that we transition from quiet times (i.e., high fundamentals) to this middle region.

Given our setting, changes in fundamentals can have different effects across depositors depending on their maturity dates. Some maturities T can be *directly* affected by changes in their θ_t^T, while other maturities T' may not be *directly* affected (i.e., $\theta_t^{T'}$ remains unaffected). However, depositors of all maturities (i.e., both T and T') are *indirectly* affected via strategic complementarities $\gamma_t(\theta_t^T, \theta_t^{T'})$.

Next we consider how changes in fundamentals affecting some maturities, but not others, will change deposit withdrawals, both through these direct and indirect effects.

2.2.1 Two Types of Maturities: Exposed and Nonexposed

Consider the case where there are only two types of time deposit contracts. They are identical in every way except for their maturity dates. Differences in maturity dates generate differences in exposure to fundamentals over time. We analyze the effects of an (unexpected) shock that deteriorates fundamentals for some deposits, but not others. That is, one type of deposits is *exposed* to the deterioration of fundamentals, while the other type is *nonexposed*. Let θ_t^E and θ_t^{NE} denote fundamentals for *exposed* and *nonexposed* groups, respectively. Without loss of generality, we assume that *exposed* deposits have a later maturity date than *nonexposed* deposits. In the analysis that follows, we consider exposed deposits to mature after T_E and nonexposed deposits to mature before T_E.

Although *nonexposed* deposits do not see their fundamentals changed, the expected value of their deposit is still affected. Strategic complementarities depend on fundamentals of all depositors at any time t ($< T$). Thus, both *exposed* and *nonexposed* deposits face the same strategic complementarities, with $\gamma_t^E = \gamma_t^{NE} = \gamma_t(\theta_t^E, \theta_t^{NE})$.

Panel A in Figure 1 plots the expected value at maturity for time deposits of *exposed* and *nonexposed* maturities when fundamentals are high (i.e., *quiet times*). With high values of fundamentals, expected values of deposits across maturities are fairly similar and constant over time. In this extreme case where fundamentals are high (and strategic complementarities are negligible), the expected value of the deposit is the principal plus the accrued interests.

Panel B in Figure 1 plots the fraction of early withdrawals for *exposed* and *nonexposed* maturities with the same fundamentals as Panel A in Figure 1. In addition, Panel B in Figure 1 assumes that payoffs of early withdrawal remain constant over the length of the contract, i.e., constant cost of withdrawal (i.e., $\kappa_t^T = \kappa_T$ for all t) and constant distribution of idiosyncratic shocks (i.e., $E_t(\epsilon_t) = E(\epsilon_t)$ and $Var_t(\epsilon_t) = Var(\epsilon_t)$ for all t).[11]

2.2.2 (Asymmetric) Deterioration of Fundamentals

Consider now that at t_0 fundamentals (unexpectedly) deteriorate for *exposed* deposits but not for *nonexposed* deposits. In our setting, time deposits face asymmetric exposure to fundamentals depending on their maturity dates. [12] More specifically, after t_0 fundamentals deteriorate for *exposed* maturities, increasing the probability they will get a haircut on the value of their deposit. That is, $\Delta\theta_{t_0}^E = \theta_{t_0}^E - \theta_{t_{pre}}^E < 0$. fundamentals for the *nonexposed* deposits remains the same. That is $\Delta\theta_{t_0}^{NE} = \theta_{t_0}^{NE} - \theta_{t_{pre}}^{NE} = 0$.

2.2.3 Total Effect: Combination of Direct and Indirect Effects

Facing lower fundamentals has the following *total* effect on the value of *exposed* deposits. First, it decreases the expected value of time deposits with *exposed* maturities (i.e., downwards shift of green line in Panel A in Figure 2 such that $\Delta V_E(\Delta\theta_{t_0}^E) < 0$). Second, it increases the fraction of withdrawals for *exposed* deposits (i.e., upwards shift of green line in Panel B in Figure 2 such that $\Delta Withdrawals_E(\Delta\theta_{t_0}^E) > 0$). Notably, the shifts in expected value and fraction of withdrawals comprise the total effect, which includes both direct and indirect effects.

As discussed earlier, *nonexposed* deposits do not experience any changes in their fundamentals. Thus, they do not see any direct change in the expected value of their deposits based on deteriorating fundamentals. However, as will become evident, these depositors may experience changes in the expected value of their deposits based on strategic complementarities.

The fact that *exposed* depositors may start to withdraw their deposits – due to worsening fundamentals for them – may trigger preemptive withdrawals by *nonexposed* depositors. Lower fundamentals for *exposed* maturities at t_0, *indirectly* affects *nonexposed* maturities in two ways. First, it decreases the expected value of time deposits with *nonexposed* maturi-

[11]In Appendix A we discuss how the nature of payoffs and probabilities change if these assumptions are relaxed.

[12]In our empirical setting, which we further explain in Section X, *exposed* deposits have maturity dates after an election date T_E, and *nonexposed* deposits have maturity dates after the election date T_E. In particular, there is an *unexpected* announcement at time t_0 revealing a positive probability that the party running ahead in the polls will – once in power after election date T_E – implement new measures affecting fundamentals of depositors (e.g., capital controls). However, such policies could only be implemented and go in effect after the election date T_E. Till that event, under the normal course, the bank was solvent and able to meet its obligations. This discontinuity in the implementation of new policies generates differential exposure of time depositors to fundamentals, depending on their maturity dates. Put another way, time deposits with maturity dates after the election (*exposed*) face worse fundamentals than time deposits maturing before the election (*nonexposed*).

ties (i.e., downwards shift of blue line in Panel A in Figure 2, such that $\Delta V_{NE}(\Delta\theta_{t_0}^{NE}) = \Delta V_{NE}(\Delta\gamma_{t_0}) < 0$). Second, it increases the fraction of withdrawals for *nonexposed* maturities, by decreasing the expected value of deposits at maturity (i.e., upwards shift of blue line in Panel B in Figure 2, such that $\Delta Withdrawals_E(\Delta\theta_{t_0}^{NE}) = \Delta Withdrawals_E(\Delta\gamma_{t_0}) > 0$).

Since there is no direct effect on *nonexposed* deposits, the indirect effect of a deterioration of fundamentals on the fraction of early withdrawals is equivalent to the overall effect on the value of deposits for *nonexposed* deposits. We can then isolate the direct effect of change in fundamentals on withdrawals by differencing the fraction of withdrawals of *exposed* and *nonexposed* deposits (i.e., difference between shifts of green and blue lines in Panel B in Figure 2). The key here is that both the *exposed* and *nonexposed* deposits experience the same effects due to strategic complementarities.

3 Data, Institutional Setting, and Descriptive Statistics

3.1 Data

Our dataset consists of time deposit accounts for the universe of retail customers of a large Greek bank. Standard contracts for time deposits are characterized by a fixed maturity period over which depositors cannot withdraw funds without incurring a monetary penalty. Time deposit contracts in our bank do not allow for the possibility of partial withdrawals. Each day, a time depositor faces two choices: do nothing (and keep waiting until maturity) or withdraw the entire deposit amount before maturity. In case of an early withdrawal, depositors lose all accrued interests since the last interest payment. This forgone income is deposit-specific and varies over time, being a function of interest rates, account amounts and the number of days left to maturity.

We observe each time deposit at a daily level from January 1, 2014, to March 31, 2015. Each observation has information on account features (interest rate, currency, origination and maturity dates) and depositor characteristics (gender, age, relationship with the bank, income, education). There are additional details on the branch that originated each deposit (postcode, branch ID). Table 1 shows summary statistics describing the key variables in our data. The average deposit amount is €57,281 and the average interest rate is almost 2%. Time deposits in our sample have an average maturity of almost six months, with the most popular contracts having a maturity length of one, three, six and twelve months. 77% of accounts are denominated in Euros.

Time depositors have an average age of 65 years and are 45% female.[13] The average

[13] We do not observe whether the account has multiple depositors. All depositor characteristics in our data correspond to those of the main account holder. Given the average age of depositors and the large presence of our bank in rural areas, it seems likely that, when there is a couple owning the time deposit, the main holder is male.

income of time depositors (as declared in their tax return) is €25,363, while the average income in Greece in 2013 was €8,879 for individuals and €17,270 for households (ELSTAT). Thus, time depositors tend to be among the high earners. Almost one-third of time depositors have at least another credit product with the bank, mainly a mortgage, a consumer loan or a credit card. Depositors tend to hold their time deposits for over two years, renewing them an average of five times. Finally, our bank operates at a national level and has an extensive branch network, which is heterogeneous in size and density across regions.

3.2 Deposit Withdrawals in Quiet Times

Our analysis sample period includes periods of (relative) tranquility and turmoil in Greek financial markets. In this subsection we present stylized facts from depositor withdrawal behavior when policy uncertainty is low, between January and November 2014. The decline in economic uncertainty in Greece, which had been high since the financial crisis, led to the country's return to international markets during 2014. Figure E.1 in Appendix E shows the CDS prices on sovereign bonds and the sovereign bond spreads from 2008 to 2015. Spreads during early and mid 2014 were at their lowest since the financial crisis. We take this period as benchmark to characterize depositor behavior in *quiet times*.

3.2.1 General Withdrawal Patterns (Quiet Times)

Despite the monetary cost associated with early withdrawal, in Panel B of Table 1 we observe that, on average, 0.04% of time deposits are withdrawn early per day, an annualized rate of 10.12%.[14] The forgone annualized return from these early withdrawals is on average 17% and can be as high as 65% for withdrawals that occur close to the maturity date (for an example of forgone return calculation see next subsection). The high incidence of early withdrawals and depositors' high willingness to pay to break time deposits are new stylized facts to both academics and regulators. For example, under Basel III it is common to exclude term deposits from cash outflow calculations for Liquidity Coverage Ratios because it is presumed that depositors are unwilling to pay the associated penalty to withdraw. These stylized facts suggest that deposits are less slow-moving than commonly assumed.

Withdrawal behavior is also heterogeneous across depositors and account characteristics. Figure 3 plots 1) the distribution of time deposits in our sample across subgroups based on deposit and depositor characteristics, and 2) the fraction of early withdrawals over the same subgroups. Early withdrawals are more common in accounts with lower interest rates and longer maturity length. Depositors with more products with the bank (for example,

[14] We classify as early withdrawals those withdrawals that occur at least five days before maturity. This gap of at least five days is because whenever a time deposit matures on a day that is weekend or holiday, the withdrawal is recorded on the earliest business day close to the maturity day.

mortgages, loans and credit cards) are also more likely to withdraw. We do not find a differential effect in withdrawal behavior across education and age groups. Female and male depositors also have the same fraction of early withdrawals. We also do not observe patterns across origination and maturity dates. Panels A and B in Figure 4 plot the total number of time deposits originated in a given week and the total number of time deposits maturing during the same period. Depositor behavior related to choosing when to open a time deposit and when this deposit matures does not seem to be strategic, on average.

3.2.2 Withdrawals around Maturity Expiration (Quiet Times)

Deposit withdrawals exhibit a non-monotonic behavior over the duration of the contract. Figure 5 shows the fraction of early withdrawals as a function of days to maturity for the most common maturity lengths: six and twelve months. We observe that the relationship between early withdrawals and time to maturity has an inverted-U shape. Depositors are less likely to withdraw at the beginning and end of their maturity period. The non-monotonic withdrawal behavior over the life of the deposit reflects the benefits and costs of liquidity-motivated deposit withdrawals. A depositor will make a time deposit if she does not foresee having a need for the cash in the very short-run, which explains why withdrawals are very infrequent early in the life of a deposit. The probability of unexpected liquidity needs increases over time, consistent with the withdrawal probability increasing over the initial life of the deposit.

The opportunity cost of withdrawing a time deposit, on the other hand, increases as the maturity date approaches. Withdrawing a deposit early is equivalent to taking a loan for the remaining maturity of the deposit, at a monetary cost equal to the promised interest. For example, suppose a depositor makes a six-month term deposit of €100 at a 2% annualized interest rate. If she holds the deposit until maturity, in six months she receives €101. Withdrawing the deposit two weeks before maturity is equivalent to paying €1 of interest to borrow €100 for two weeks, or borrowing at an annualized rate close to 30%. If the depositor withdraws one week before maturity, the implied interest rate of the loan approaches 70%. It is thus expected that the probability of early withdrawals drops as the deposit approaches maturity.

As the example illustrates, withdrawals within the last couple of weeks of the deposit maturity date can only be rationalized if depositors exhibit very high discount rates. Interest rates exceeding 50% are not uncommon in pawnbrokers, payday lenders or other high-cost lenders that serve liquidity constrained borrowers. The difference is that, while typical high-cost loans are for small amounts usually below €1,000, the average time deposit in our sample exceeds €50,000. This implies that the opportunity cost of on early withdrawals can be substantial, especially when the withdrawal occurs during the last month of the deposit maturity.

3.2.3 Withdrawals around Biannual Interest Payments (Quiet Times)

Aside from paying time-deposit interest at maturity, The Bank also pays accrued interests at two calendar dates in the year: January 1 and July 1. On these dates, all accounts receive all the interest accrued up to that date. Suppose depositor makes a one-year time deposit in March 1 on year t and holds it to maturity until February 28 on year $t+1$. During the length of her contract the depositor will receive three interest payments. The first will consist of all accrued interests between March and June and will be paid on July 1 of year t. The second payment, on January 1 of year $t+1$, will account for all accrued interest between July and December of year t. Finally, at maturity on February 28 on year $t+1$, the depositor will receive accrued interests for January and February of year $t+1$, plus the principal.

If a time depositor decides to withdraw her balance before maturity, she will lose all the interest accrued since the latest of three dates: deposit origination date, January 1, or July 1. Accrued interest is calculated using a non-linear formula that depends positively on interest rates, Euribor rates and deposit amounts, and positively with time since origination or last repayment (whichever date happened last). Since the only penalty from withdrawing early a time deposit is the forgone interest, the interest payment schedule implies that the cost of early deposit withdrawals drops to zero on January 1 and July 1 of every year. Consider a time deposit that has accumulated €100 as accrued interests by June 30. If the depositor decides to withdraw on that day, she would receive only the principal. If she withdraws a day later, on July 1, she receives the principal plus €100.

The fundamental hypothesis behind the empirical research design in this paper is that depositors' withdrawal behavior is sensitive to the monetary penalty associated with early withdrawals. If this hypothesis is true, then deposit withdrawals should change discontinuously around interest payments dates. Panel A in Figure 6 illustrates the discontinuity by plotting accrued interests (in Euros) and the fraction of outstanding time deposits that are withdrawn early by week, during the four weeks before and after interest payments on July 1, 2014. We observe that the cost of early withdrawal drops from an average of €500 during the week before the interest repayment date, to zero the day after. Deposit withdrawals exhibit a similar discontinuous pattern: the probability of early withdrawal, which is relatively stable during the four weeks prior to the interest payment date, increases by 40% during the week following the interest payment date. Panel B in Figure 6 plots the cost of early withdrawal expressed as a forgone annualized rate of return, calculated as in the example in the previous subsection. The plot shows that the forgone return due to early withdrawal increases exponentially as the interest payment date approaches, and drops to zero after the date. The magnitude of the drop is large: the average forgone return falls from 50% to zero on July 1, which provides depositors with an incentive to postpone early withdrawals until after accrued interests are paid.[15] Aside from validating our working hypothesis, we use this discontinuity below to evaluate depositors' willingness to pay to withdraw.

3.3 Policy Uncertainty Events

The analysis that follows focuses on depositor behavior in response to the policy uncertainty surrounding the election of the anti-austerity, left-wing party Syriza to the Greek Presidency on January 2015. Leading up to the election, the incumbent and challenging political parties had radically different stances regarding the bailout conditions imposed on Greece by the European Union and the International Monetary Fund. The incumbent conservative party, New Democracy, argued in favor of continuing austerity measures and Greece's continuation in the European Union. The opposition party, Syriza, supported the renegotiation of Greece's debt and, if better conditions were not agreed upon, proposed the Nationalization of the banking sector and Greece leaving the European Union (the prospective occurrence of this event was labeled *Grexit* in the press).[16]

We exploit two events that occurred in relatively rapid succession in the six weeks preceding the election of the left-wing party President. The first event was the surprise announcement by the incumbent Prime Minister to bring forward by two months the Presidential election. The announcement occurred on December 8, 2014, hereafter t_1. This announcement was unprecedented, as it was the first time a Presidential election in Greece had taken place before the end of the incumbent's term.[17]

The announcement at t_1 initiated a period during which Parliament would attempt to elect a new President and, if failed to form a majority, Parliament would be dissolved and a snap election would be called. During the six-week period that followed t_1, a government without the backing of a majority in Parliament had no capacity or authority to make new policy. This period would end on January 25, 2015 (hereafter t_E), with the majority of a newly elected Parliament selecting Alexis Tsipras, leader of Syriza, for President. Thus, during the period between t_1 and t_E there was absolute certainty that no new policy could

[15] A foregone interest payment of €500 is equivalent to 28% of the median monthly income of time depositors of the Bank.

[16] Syriza's *Radical Left Manifesto* supported the nationalization of banks, and promised "an audit of the public debt and renegotiation of interest due and suspension of payments until the economy has revived and growth and employment return".

[17] In Greece, the President is elected for a five-year term by the Parliament. The nominated candidate must achieve a supermajority (200 out of 300 votes) during the first and second rounds. If these were to fail, then the candidate would only need 180 votes in the third, and final, round. From 1974 to 2008, all Presidential elections were successful with at least the two largest parties reaching a consensus. In 2009, however, the opposition party threatened to challenge the government's Presidential candidate, and early elections were announced before even the Presidential vote had taken place. In December 2014, tensions continued between the government and the opposition party, and for the first time a Presidential election was announced before the end of the incumbent's term.

be implemented before t_E, but there was substantial uncertainty about the type of policy that would be implemented after t_E.

The second event occurred on December 30 2015 (hereafter t_2), 22 days after t_1 and 26 before t_E, when the incumbent Prime Minister announced that the elections to select the members of the new Parliament would occur in t_E. Both the timing of t_2 and the selected date for the polls (t_E) were earlier than expected. The Prime Minster had 10 days after the Parliament failed to form a government to call the election date, and instead call the date a day after. And the poll had to take place within 30 days of the announcement and instead the poll was called for 26 days later. As a result, the announcement at t_2 implied that the election would occur at a date that was two weeks before expected. Panel A in Figure 7 summarizes the key events taking place during this period and their political consequences.

The timing and close proximity of the events provide useful variation in exposure of time-deposits to fundamentals due to policy uncertainty. A time-deposit maturing after t_E could only avoid this policy uncertainty by withdrawing early and paying the penalty. These maturities were *exposed* to a deterioration in their fundamentals and the expected value of their deposit was affected. On the other hand, a time-deposit that matured before t_E could avoid policy uncertainty at no cost. A depositor could simply wait until maturity and withdraw her deposit with no penalty before the new set of policies could be implemented. These maturities were *not* exposed to a change in their fundamentals. However, deposits maturing before t_E did saw the expected value of their deposit affected because of strategic complementarities: the possibility that enough depositors withdrew before t_E to make the bank fail. The only way to avoid a haircut because of strategic complementarities was to withdraw as early as possible (before maturity) at a penalty.

In the next section we describe in detail how we use the timing of the announcements and the maturity dates of deposits to construct a research design to differentiate fundamental and strategic motives for deposit withdrawals. But before we provide some stylized facts around the policy uncertainty events.

3.4 Stylized Facts around Policy Uncertainty Events

The surprise announcement and the failed Presidential election led to significant political turmoil in Greece.[18] Depositor withdrawal behavior changed significantly after the surprise announcement at t_1. Panel A in Figure 9 plots the daily fraction of early withdrawals over our sample period. Before t_1, early withdrawals account for an average of 0.04% of total time deposits per day. After t_1, the percentage of early withdrawals rises steadily, and average daily withdrawal rates reach 0.28% of total accounts, seven times the rate during the quiet period before the announcement. The flight of time-deposits was not exclusive to our bank.

[18] See, for example: http://www.bbc.co.uk/news/world-europe-30495578

Panel B in Figure 9 plots the relative decline in the level of deposits of our bank and of the entire Greek banking sector. Both series follow the same trend, indicating that system-wide deposit withdrawals followed the announcement. The plot for the banking system deposits is always below the plot for the bank in our analysis, indicating that the rest of the banking system lost deposits at a rate faster than our bank after t_1.

The news that triggered the decline in deposits were also a surprise to other market participants. The 6-month CDS price on Greek sovereign bonds increased by 136% after the announcement at t_1 (see Figure 8, Panel A). CDS prices rose even further three weeks later, at t_2, when the Presidential election failed and the election date was announced. The Athens stock exchange dropped 13% on t_1, being its biggest one-day fall since December 1987.[19] Figure 8, Panel B, plots the cumulative abnormal returns for Athens Stock Exchange when compared to FTSE Euro 100 during this period. As expected there was a significant drop on the day of the announcement and a subsequent decline in Greek returns afterwards.

The characteristics of deposits and depositors withdrawing early also changed after t_1. Panel B in Table 1 summarizes depositor characteristics and account features for the average early withdrawal before and after t_1 (Panels A and B, respectively). Deposits that are withdrawn early are for larger amounts, lower rates, and a higher proportion are denominated in Euros during the uncertainty period after t_1. After t_1 depositors withdrawing early have, on average, a longer relationship with the bank and a larger fraction of them are bank employees.

These changes suggest that the large increase in policy uncertainty increased depositors' willingness to pay for the cost of withdrawing early. In the next section we present our empirical approach to identify the different motives driving early withdrawals during this period of policy uncertainty in Greece.

4 Fundamental and Strategic Withdrawal Motives

Our empirical approach uses the staggered maturity date of time deposits to disentangle the different motivations for deposit withdrawals during the uncertainty period that followed the events described in the previous section. The goal is to distinguish empirically how policy uncertainty affects deposit withdrawals through fundamental motives (triggered by increased direct exposure to deteriorating fundamentals) and strategic motives (triggered by expectations about how other depositors will respond to deteriorating fundamentals), from early withdrawals due to idiosyncratic liquidity needs by depositors. Panel B in Figure 7 maps the events to the different exposures and motives depositors face. We discuss each in turn below, but first we relate our empirical strategy to the motivational framework introduced in Section 2.

[19] See, for example: https://www.theguardian.com/world/2014/dec/09/stock-markets-tumble-as-greece-calls-election

4.1 Mapping Empirical Strategy to Framework

In this section we map our empirical strategy to the framework described in section X. There are two key elements we need to match: (1) unexpected change in fundamentals affecting some deposits but not others; and (2) group of deposits exposed and nonexposed to the change in fundamentals.

In the framework, we model an (unexpected) shock to fundamentals as a deterioration in *theta* affecting some deposits. In the empirical strategy we exploit two shocks to fundamentals. The first one is the surprise announcement at t_1. The second one is the announcement at t_2 of the election date t_E. Effectively, both announcements unexpectedly *exposed* maturities maturing after the election date t_E to a deterioration of fundamentals. Because these maturities are now exposed, the nonexposed maturities also faced strategic complementarities, despite not seeing their fundamentals deteriorated. In the empirical strategy, we quantify the magnitude of this deterioration of fundamentals using changes in CDS prices.

In our empirical setting, the equivalent to *nonexposed* and *exposed* in the framework are deposits with maturities before and after the election date t_E, respectively. *Exposed* deposits see their fundamentals deteriorated after t_1 and t_2, which decreases the expected value of their deposits. *Nonexposed* deposits see their expected values drop after t_1 and t_2 exclusively because of strategic complementarities. Panel A in Figure 10 plots these changes, in the same way we did in our framework in Section X. The main difference with the framework is that our announcements t_1 and t_2 changed the election date to t_1^E and t_2^E, respectively. It is these unexpected changes in the election date that made *nonexposed* maturities to be *exposed*. The change in expected values of *exposed* maturities is captured by the difference between the green lines before and after the announcements. These changes capture both direct and indirect effects. The change in expected values of *nonexposed* maturities is measured by the difference between the blue lines before and after the announcements. These changes represent the (indirect) effect of strategic complementarities. We can back out the change in expected values due exclusively to the direct effect of fundamentals as the difference between expected values of *exposed* and *nonexposed*.

4.1.1 Mapping Regression Coefficients to the Framework

Our regression coefficients capture changes in the share of withdrawals with respect to changes in fundamentals that affect some deposits but not others depending on their maturity date. We identify the direct effect of fundamental motives for withdrawals as the change in withdrawals for *exposed* maturities after a change in their own fundamentals (total effect) minus the change in withdrawals for *nonexposed* maturities after a change in fundamentals for long-term maturities (indirect effect):

$$\beta_{fundamental} \equiv -\frac{\partial Share\,Withdrawals_t^{E}}{\partial \theta_E} - \frac{\partial Share\,Withdrawals_t^{NE}}{\partial \theta_E}$$

We identify strategic complementarities as the change in withdrawals for *nonexposed* maturities after a change in fundamentals for exposed maturities. We capture this by:

$$\beta_{strategic} \equiv \frac{\partial Share\,Withdrawals_t^{NE}}{\partial \theta_E^1, \theta_{NE}^1}$$

Similarly to Section 2, Panel B in Figure 10 plots how announcements at t_1 and t_2 changed the shares of early withdrawals for exposed and nonexposed deposits. In this case, to match the data, we allowed for heterogeneous withdrawal costs (κ) and heterogeneous idiosyncratic shocks (ϵ) across depositors. We provide additional details in Appendix X.

Panels A and B in 10 assume that the deterioration of fundamentals for *exposed* deposits after the announcements t_1 and t_2 happened *all things equal*. In order to maintain the ceteris paribus assumption in the empirical strategy we need to control for deposit patterns described in subsection 3.2. To do so, the research design relies on building an appropriate *quiet times* counterfactual for depositor behavior. We showed in subsection 3.2 that depositors' willingness to pay to withdraw deposits is high even when aggregate uncertainty is low. Our design captures how the willingness to pay increases when policy uncertainty is high relative to a quiet times benchmark. We also showed in subsection 3.2 that depositor withdrawal behavior follows an inverted U-shape with deposit maturity and that withdrawals jump discontinuously semiannually on interest payment dates. To account for these patterns, we select the quiet times benchmark to have the same time-to-maturity and time-to-interest-payment than the deposits affected by policy uncertainty. In fact, this inverted U-shaped pattern maps almost one-to-one with the modelling of share of withdrawals in Appendix X, and which we use to construct Panel B in Figure 10. We describe the details of how we construct these counterfactuals below.

Finally, we could have potentially calculated both $\beta_{strategic}$ and $\beta_{fundamental}$ for both t_1 and t_2. That is, to separately identify fundamental and strategic motives you would only need one shock according to our motivating framework. In our empirical setting, we are fortunate to get two unexpected shocks, and therefore can improve identification by separately considering each of the shocks for different purposes. In Section X we do provide results for the other coefficients, that is, we report $\beta^1_{strategic}$ and $\beta^1_{fundamental}$ for both t_1, and $\beta^2_{strategic}$ and $\beta^2_{fundamental}$ for t_2. We do emphasize that we believe $\beta^1_{fundamental}$ and $\beta^2_{strategic}$ to require stronger assumptions for identification, and that is why we focus our empirical analysis on $\beta^1_{strategic}$ and $\beta^2_{fundamental}$.

4.2 Identification of Fundamental Motives

Deposits with maturity dates after the election in t_E faced policy uncertainty, because changes in policies affecting the bank's and the country's fundamentals (e.g., Grexit, capital controls) could be implemented by the new government before the deposits could be withdrawn without penalty. These deposits also faced strategic complementarities, since the increase in withdrawals could be anticipated and so could the likelihood of a bank failure. To identify changes in withdrawal behavior due exclusively to changes in fundamentals due to exposure to policy uncertainty we look at changes in withdrawal behavior before and after the announcement at t_2. In particular, we compare the withdrawal behavior of deposits that mature during the two weeks after t_E (exposed to both changes in fundamentals and strategic complementarities) with the withdrawal behavior of deposits that mature during the two weeks before t_E (facing only to strategic complementarities).[20]

Because the exact date of t_E was announced three weeks earlier, on t_2, we implement this comparison by estimating the change in the share of early withdrawals during the three weeks before and after t_2, for deposits that mature after t_E relative to those that mature before t_E. Recall that the announced election date t_E was two weeks earlier than expected. This means that, before t_2, all deposits maturing in the four week window surrounding t_E were only expected to be exposed to strategic complementarities. The announcement of the exact date on t_E revealed that deposits maturing after t_E were also exposed to changes in fundamentals due to policy uncertainty. Thus, the change in withdrawal behavior for deposits maturing after t_E around the announcement will capture the effect of deteriorating fundamentals due to policy uncertainty.

The starting point for our estimation is a difference-in-differences specification around t_2 and across nonexposed and exposed groups maturing before and after t_E, respectively. Our research design must also account for time series patterns of early withdrawals that would occur in the absence of aggregate uncertainty (due to liquidity needs). We showed in Section 3.2.2 that there is an inverted U-shape relationship between days to maturity and withdrawal behavior. We also showed in Section 3.2.3 that early withdrawals decline sharply before days when accrued interests are paid. One of such days, January 1, falls between t_1 and t_E. To account for the time series variation induced by time-to-maturity and time-to-interest-payment we construct a counterfactual group of deposits around the interest payment date

[20] Since the new policies could only take place after t_E, deposits that matured before t_E were *not* exposed to changes in fundamentals due to policy uncertainty. Depositors could wait until maturity to withdraw their deposit with no penalty before any of the new policies could be implemented. However, the value of these nonexposed deposits could be at risk if, in anticipation of the policy changes after the election, a large enough amount of deposits were withdrawn. These deposit outflows from other depositors could put the bank's liquidity in peril and trigger its failure. As we argued in the introduction, the expectation that the policy announcement would trigger early withdrawals by some depositors before t_E was rational. In particular, deposits that mature after t_E, which can only avoid policy uncertainty by withdrawing early (with a penalty) before t_E. We show in the subsection X that this expectation was correct.

on July 1 2014, when there were no abnormal levels of policy uncertainty. We construct a counterfactual by selecting a sample of deposits around another interest payment date, July 1 2014, using the same criteria used to select the deposits around t_2 and t_E. Since t_2 occurs the same day as an interest payment date, we set $t_2^{Placebo}$ to July 1 to construct the counterfactual. And since t_E occurs three weeks after t_2, we set $t_E^{Placebo}$ to a date three weeks after $t_2^{Placebo}$. Figure 12 illustrates the main events and maturity periods that we use to construct the subsamples of deposits that are affected by both fundamental and strategic motives, strategic motives alone, and the counterfactual groups.

We implement this research design estimating the following triple-differences specification:

$$\begin{aligned} Withdrawal_{it} \;=\;& \beta_0 + \beta_1\, Uncertainty_i + \beta_2\, Exposed_i + \beta_3\, Post_t \\ &+ \beta_4\, Uncertainty_i \times Exposed_i + \beta_5\, Uncertainty_i \times Post_t \\ &+ \beta_6\, Post_t \times Exposed_i + \; \beta_{Fundamental}\, Uncertainty_i \times Exposed_i \times Post_t \\ &+ \gamma' X_{it} + \varepsilon_{it}\ , \end{aligned} \tag{3}$$

where the dependent variable $Withdrawal_{it}$ is a dummy equal to one if deposit i is withdrawn before maturity in day t. $Uncertainty_i$ is an indicator variable equal to one for the deposits maturing in the four weeks before and after t_E (heightened uncertainty period), and zero for the deposits maturing in the four weeks before and after $t_E^{Placebo}$ (quiet times counterfactual period). This variable identifies the deposits during the heightened risk period versus those in quiet times. $Exposed_i$ is a dummy equal to one if deposit i matures after t_E in the uncertainty period, equal to one if deposit i matures after $t_E^{Placebo}$ in the counterfactual group, and zero otherwise. In the uncertainty period, this variable distinguishes deposits exposed to both changes to fundamentals and strategic complementarities from those nonexposed to changes in fundamentals but facing strategic compelementarities. $Post_t$ is a dummy equal to one for the period after t_2 for exposed deposits, and in the period after $t_2^{Placebo}$ in the counterfactual group. X_{it} is a set of covariates controlling for depositor characteristics and account features. ε_{it} is an error term. The coefficient β_7 is the triple-differences estimate of the effect of fundamental policy uncertainty on the probability of early deposit withdrawals.

To evaluate the comparability of the deposits exposed to uncertainty and those in the counterfactual group, Panel A in Table 3 shows the fraction of early withdrawals for both groups. We show the withdrawal probability separately for three subperiods of the uncertainty exposure period: before t_1, between t_1 and t_2, and between t_2 and t_E (and the corresponding for the counterfactual period). During the first two subperiods of the uncertainty exposure period, the withdrawal probability moves in tandem for deposits exposed to policy and strategic complementarities, and deposits exposed to strategic complementarities only.

The same is true for the first two subperiods of the counterfactual deposits. This is akin to a parallel trends test, which demonstrates that there is no unobserved selection bias driving the evolution of early withdrawals of the deposits exposed to deteriorating fundamentals due to policy uncertainty and those that are not. This is expected, since the selection into the two groups is based exclusively on whether the deposits mature before and after t_E. The maturity of these deposits was decided months in advance, while the date t_E is only revealed with three weeks in advance.

Remaining identification concerns relate to potential differences in the interest paid in the uncertainty exposure period relative to the counterfactual. Difference in the interest rate would affect the size of the penalty for early withdrawals. Identification requires that the average interest payment to be the same in across the two periods for each subgroup of deposits. Table 3, Panel B shows that the interest payments do not vary across all four group of depositors in the period before t_2. Moreover, as in the estimation of the effect due to strategic complementarities, we also need to assume that idiosyncratic withdrawals remain the same before and after t_2 and $t_2^{Placebo}$. That is, we assume that the three data patterns described in Section 3.1 remain the same before and after the events. Finally, in order to isolate the fundamental motives, we need to assume that strategic complementarities did not change differentially for depositors whose deposits mature between t_2 and t_E and depositors whose deposits mature after t_E. The results presented in appendices B and C validate these assumptions.

4.3 Identification of Strategic Motives

After the surprise announcement at t_1 and the new election date at t_E depositors faced different fundamentals depending on their maturity dates, as described in Section 3.3. Since the new policies (Grexit, deposit freezes, nationalization of the banking sector) could only take place after t_E, deposits that matured before t_E, were *not* exposed to changes in fundamentals due to policy uncertainty. Depositors could wait until maturity to withdraw their deposit with no penalty before any of the new policies could be implemented. However, the value of these nonexposed deposits could be at risk if, in anticipation of the policy changes after the election, a large enough amount of deposits were withdrawn. These deposit outflows from other depositors could put the bank's liquidity in peril and trigger its failure. As we argued in the introduction, the expectation that the policy announcement would trigger early withdrawals by some depositors before t_E was rational. In particular, deposits that mature after t_E, which can only avoid policy uncertainty by withdrawing early (with a penalty) before t_E. We show in the next subsection that this expectation was correct.

Thus, our empirical approach to identify the effect of strategic complementarities builds on calculating the change in the early withdrawals during the three weeks before and after the announcement at t_1, for the subsample of time-deposits that mature three weeks before t_E. Restricting the analysis to withdrawals that occur three weeks after the announcement ensures that bank fundamentals (e.g., asset quality) or determinants of depositors liquidity demand (e.g., employment) did not change relative to the pre-announcement period (we provide evidence consistent with this in the results section). Conditioning on the subsample of deposits that mature between three weeks before t_E ensures that these deposits could be withdrawn at no cost before any new policy could be implemented and thus were not exposed to changes in fundamentals. Even though date t_E was uncertain at t_1, we showed in Section 3.3 that t_E occurred two weeks before it was expected to occur. This implies that depositors at t_1 would have correctly inferred that they could withdraw deposits with no penalty before the policies were implemented. The upper panel in Figure 11 shows the time periods and maturity dates that we use to select the sample of deposits affected by strategic complementarities.

Our research design must also account for time series patterns of early withdrawals that would occur in the absence of aggregate uncertainty (due to liquidity needs). We showed in Section 3.2.2 that there is an inverted U-shape relationship between days to maturity and withdrawal behavior. We also showed in Section 3.2.3 that early withdrawals decline sharply before days when accrued interests are paid. One of such days, January 1, falls between t_1 and t_E. To account for the time series variation induced by time-to-maturity and time-to-interest-payment we construct a counterfactual group of deposits around the interest payment date on July 1 2014, when there were no abnormal levels of policy uncertainty. We select the counterfactual deposit group around a placebo date $t_1^{Placebo}$, in using the same criteria the sample of deposits facing strategic complementarities is selected around t_1. Since t_1 occurs three weeks before an interest payment date (January 1 2015), the placebo date is set three weeks before July 1 2014. The lower panel in Figure 11 shows the time periods and maturity dates used to select the counterfactual deposit subsample.

We implement the estimation using the following difference-in-differences specification:

$$Withdrawal_{it} = \delta\, Uncertainty_i + \lambda\, Post_t + \beta_{Strategic}\, Uncertainty_i \times Post_t + \gamma' X_{it} + \epsilon_{it} \quad (4)$$

where the dependent variable $Withdrawal_{it}$ is a dummy equal to one if deposit i is withdrawn at day t. Since we only include in the estimation deposits that mature after the six-week sample period around t_0, any withdrawal during the sample period is an early withdrawal. $Uncertainty_i$ is an indicator variable equal to one for deposits with maturities in the three weeks after t_2 (and before t_E)) when there was uncertainty about policy changes. $Uncertainty_i$ is equal to zero for the deposits maturing in the counterfactual group three weeks after $t_2^{Placebo}$ (and before $t_E^{Placebo}$). $Post_t$ is a dummy equal to one for the period after t_1 for the deposits exposed to strategic complementarities, and for the period after ${t_1^{Placebo}}_0$

for the counterfactual group. X_{it} is the set of covariates accounting for depositor and account characteristics. ϵ_{it} is an error term. The coefficient β is difference-in-differences estimate that captures the change in early withdrawal behavior due to strategic motives.

To verify that the behavior of depositors facing strategic complementarities and the counterfactual ones are comparable, Panel A of Table 2 shows the fraction of deposits withdrawn early before t_1 and $t_1^{Placebo}$, respectively. Early withdrawals account for 0.40% of deposits for both groups of deposits (over a three-week window). This implies that the pool of depositors and account characteristics in both groups are not significantly different from each other.

Our interpretation of β assumes that any additional withdrawals after t_1 are driven exclusively by changes in depositors' expectations about other depositors' withdrawal behavior. To rule out alternative interpretations we need to test whether during the three weeks following t_1 there are (1) changes in the banks' fundamentals, and (2) changes in factors contributing to idiosyncratic liquidity withdrawals. To test (1), we check that measures of liquidity, maturity mismatch, and funding costs remained constant during our sample period (see Appendix B). To test (2) we verify that unemployment rates and pension payments also remained constant during the analysis period (see Appendix C).

5 Results

We first discuss the results of the effect of strategic conplementarities on deposit withdrawal probabilities. Then, we present the estimates for exposure to a deterioration in fundamentals. For both set of results, we perform heterogeneity analysis across account, depositor and geographical characteristics. We include all detailed tables in Appendix D.

5.1 Fundamental and Strategic Motives

Strategic. The estimation results from specification 4 are presented in Panel B in Table 2. The point estimates on the difference-in-differences estimate is 0.0027, significant at the 10% level, and robust to the inclusion of controls for observable account (deposit amount, maturity, interest rate, currency) and depositor (age, gender, bank employee, other products with the bank, previous renewals) characteristics. The estimate captures the change in the probability of withdrawals during three-week periods before and after the announcement of the increased future policy uncertainty, estimated on deposits that mature before the new policies can take place (relative to a quiet times counterfactual). Relative to the baseline three-week withdrawal probability in the pre-period (0.4% from Panel A in Table 2), the estimate implies that depositors are 68% more likely to pay the penalty and withdraw early because of strategic complementarities.

Fundamentals. Table 4 reports estimates from Equation 4. The triple-differences point estimate is 0.012, significant at the 1% level, and robust to the inclusion of controls. The coefficient captures the difference in the probability of withdrawal between deposits that face fundamental and strategic motives, and those that face strategic motives only. The magnitude reflects a three-week withdrawal probability, and implies a 192% increase relative to the quiet times baseline.

Magnitudes. Our estimates of the strategic-induced and fundamental-induced increases in withdrawal probability are additive. Their combined effect implies an increase in the three-week withdrawal probability of 1.3 percentage points, or 22.7% of time deposits if it had remained constant over a year. The magnitude of estimates, although inherently partial equilibrium due to the estimation using difference-in-differences, are aligned with the magnitude of the overall decline in The Bank's deposits during the analysis period. During the six weeks following the announcement, the early withdrawal probability of all The Bank's time-deposits increased by 300% relative to the quiet times baseline. The combined short-run effect of strategic and fundamental motives for withdrawals captured by our estimates implies a 270% increase in withdrawal probabilities, which explain 90% of the total. Finally, our estimates capture by construction the short-run effects on withdrawal probabilities. This is likely to be an underestimate of the overall effect over a longer period, especially of the strategic effect. As the deposit base deteriorates, the risk of further withdrawals leading to a bank failure increases, which in theory should increase strategic-motivated withdrawals.

Deposit Heterogeneity. Panel A in Tables D.1 and D.2 presents estimates for subsamples based on account and depositor characteristics. Columns (1) and (2) split the sample by gender. Withdrawal behaviors across men and women are only statistically different when faced with changes in their expectations of other depositors' behavior. When exposed to such changes, men are, on average, more likely to withdraw their deposits before maturity. Columns (3) and (4) split the sample by deposit size (above or below the median deposit amount of 35,000€). Once again, accounts with greater deposit amounts only react differently from accounts with smaller deposit amounts when affected by changes in expectations of the behavior of others. Columns (5), (6) and (7) divide our sample by maturity length. Six-months deposit contracts are the ones driving the results for strategic motives, while for fundamental motives we find that behavior of three-months and six-months contracts are statistically different from the one-year contracts. Finally, Columns (8) and (9) show that in both cases there is no differential effect of deposits in Euros and foreign currencies.

Panel B in Tables D.1 and D.3 shows estimates for subsamples defined on the basis of depositor-bank relationships. Columns (1) and (2) compare depositors with other financial products with the bank (mortgages, loans, and credit cards) with depositors with no other products with the bank. This split only has a differential effect after t_2 and exposure to changes in fundamentals. Depositors with other products are significantly more likely to withdraw than those with no additional products. Columns (3) and (4) look at the number of years the depositor has hold at least one time deposit with the bank. Depositors with less than two years holding a time deposit with the bank are significantly more likely to withdraw early after both t_1 and t_2. Finally, Columns (5) and (6) consider the number of times the time deposit account has been previously renewed. This has no differential effect in any of the specifications.

Geographical Heterogeneity. Table D.5 compares results for Athens with the rest of the country. This split of the data does not show a significant heterogeneity in the probability of early withdrawals for fundamental motives. However, strategic motives for withdrawals show substantial geographical heterogeneity. Most of the effect through strategic motives is driven by depositors outside the Greek capital. Table D.6 differentiates between depositors in large and small branches. Once again, while the fundamental motivation for deposit withdrawals does not vary significantly in the cross section of branches, large branches seems to explain the entirety of the strategic motivation for withdrawals. Although mostly suggestive these heterogeneity results are consistent with the underlying mechanisms driving the two motivations for withdrawals. If all depositors are observing the same fundamentals, there is no reason for the results to vary in the cross section (as long as the cost of withdrawals are constant across locations). However, strategic motives for withdrawals are self-reinforcing and may lead to multiple equilibria. Depositors in large branches may have observed longer lines of fundamental-driven withdrawals, which could have triggered larger numbers of strategic-driven withdrawals to go to the bank.

We consider whether the geographical patterns in the strategic motives may be driven by differences in depositors' views about the left-wing policies that could be implemented after t_E. Table D.7 shows results across municipalities that favored Grexit versus those that did not. We find no differential withdrawal behavior across these types of regions. In line with the results on borrower heterogeneity, observable characteristics do not seem to drive the observed differences in the strategic motivation for withdrawals.

To explore whether there is any suggestive evidence of *contagion* we test for the presence of clusters in withdrawal behavior across nearby branches. Figure A.4 plots the spatial autocorrelation across branches, measured by local Moran's I_i and using as weighting matrix the inverse of the distance between branches. We find that after the surprise announcement at t_1 there was a significant change in spatial autocorrelation in the northern region of Greece. This correlation in withdrawals of nearby branches in this region is exclusive to the period between t_1 and t_2. This spatial autocorrelation disappears after t_2.

6 Depositor Compensation

In our analysis so far we have not taken advantage of the fact that time deposits withdrawn early incur a monetary penalty. The goal of this section is to use this monetary cost to provide estimates of depositor compensation for strategic and fundamental motives. Put differently, we would like to estimate how much should the bank increase interest rates on its time deposits after a deterioration in fundamentals, in the hope of preventing early withdrawals. To do so we combine the reduced form estimates in the previous section with an estimate of the cost elasticity of withdrawals.

6.1 Cost-Elasticity Estimation

We estimate an elasticity of withdrawal probabilities to the cost of withdrawing in quiet times. We express the cost of withdrawing either in Euros, or as an annualized forgone return on the deposit amount. To estimate the elasticity we exploit the discontinuity in accrued interests on July 1, 2014, described in subsection 3.2.3. Intuitively, the estimate is obtained from scaling the magnitude of the change in the withdrawal probability around the discontinuity by the size of the drop in the cost of withdrawing. We use this elasticity to calculate the interest rate elasticity of demand for time deposits.

The cost of withdrawing early time-deposits drops to zero biannually on interest payment dates (see Figure 6, Panel B). We use that discontinuity in time of the cost of withdrawal to estimate the cost-sensitivity of the probability of early withdrawal. We cannot use a simple before-after comparison of withdrawal probabilities (event study) because withdrawals have a non-monotonic relationship with time to maturity (see subsection 3.2.2). To account for these patterns we calculate the change in withdrawal probabilities around an interest payment date relative to the change in withdrawal probability of deposits with the same time-to-maturity in a random date with no interest payment.

We implement this comparison using two subsamples of deposits. The first subsample includes the time deposits maturing in a three-week window starting three-weeks after the interest payment date during quiet times, July 1 2014. In this subsample, any deposit withdrawal that occurs in the three weeks before and after July 1 2014 is an early withdrawal. The second subsample, used to control for the time varying patterns in withdrawal probabilities, is selected the same way around an arbitrary date with no interest payment. For this exercise we used October 1 2014, but the results are robust to this choice. Specifically, the control subsample includes time deposits maturing in a three-week window starting three-weeks after October 1 2014. By construction, deposits in the control subsample have the same days-to-maturity as those in the subsample around the interest payment date. Figure 13 shows the main dates that we use in this section for both subsamples. Both subsamples contain deposits that mature in quiet times, when fundamental and strategic uncertainty are low.

Panel A of Table 5 shows the fraction of early withdrawals as a percentage of total time deposits for the interest payment and the control subsamples, before and after July 1 and

October 1, respectively. We observe that withdrawal behavior is not significantly different across subsamples before July 1 and October 1, with 0.54% depositors withdrawing early in the interest payment subsample and 0.56% in the control subsample. The fraction of early withdrawals in the interest payment subsample increases substantially after July 1. The percentage of withdrawals rises to 0.86% after the interest payment date. In the control subsample the probability of withdrawal drops after October 1 to 0.46%. This fall in the control group matches the inverted U-shape pattern we described in subsection 3.2.2, and it is common across other months when no interest payments were made.

We implement the estimation with the following difference-in-differences specification:

$$Withdrawal_{it} \quad = \quad \delta \; InterestPay_i + \lambda \; Post_t + \beta \; InterestPay_i \times Post_t + \gamma' X_{it} + \epsilon_{it} \;, \qquad (5)$$

where the dependent variable *Withdrawal* is a dummy equal to one if deposit i is withdrawn at time t (all withdrawals are before maturity by construction). *InterestPay* is a dummy equal to one if the deposit is in the subsample constructed around the interest payment date, and zero if the deposit is in the control subsample. *Post* refers to the three weeks after July 1 in the interest payment subsample, and after October 1 for the control subsample. X_{it} is a vector of covariates of observable depositor and account characteristics. ϵ_{it} is an error term. The coefficient β is a difference-in-differences estimate of the effect of a drop in the monetary cost of withdrawing on the early withdrawal probability.

Results from estimating Equation 5 are reported in Table 5, Panel B. Column (1) shows estimates for the baseline specification without covariates. The estimated coefficient β is 0.0088, significant at the 1% level, and robust to the inclusion of controls. It captures the increase in withdrawal probability when the cost of withdrawal drops to zero, and represents an increase of 154% relative to the baseline withdrawal probability.

To gauge the economic magnitude of our estimate, however, it is important to make two considerations. The first is that the baseline probability of withdrawals is high to begin with: the baseline implies that over 14% of time deposits are withdrawn over a year. To obtain a willingness to pay figure, we calculate the monetary cost of withdrawal during the three weeks before the interest payment date to be €494 in accrued interests, or 1.29% of deposit amount.[21] A reduction in the cost of withdrawal of 1% of the deposit amount increases by 119% the probability of early withdrawal. Similarly, in quiet times, a reduction of €100 in the cost of withdrawal increases by 31.2% the probability that a depositor withdraws early. And second, the calculations based exclusively on the size of the penalty tend to understate depositor's willingness to pay to withdraw for idiosyncratic reasons (or to overstate the sensitivity of withdrawal probabilities to changes in the cost), because they ignore the

[21] Also, foregone interest payment of €494 is equivalent to almost 28% of the median monthly income of time depositors of the Bank.

opportunity cost of waiting.[22]

Our estimates imply a demand elasticity of deposits to changes in the cost of withdrawal of 1.5, which translates into an interest rate-demand elasticity of time deposits of 0.48 for the average deposit balance and rate.[23] These figures are inside the very large range of demand elasticity estimates in other settings. For example, Dick (2008), using U.S. Call Report data for the period 1993–1999, finds a demand elasticity of deposits to the interest rate between 2 and 3. Egan, Hortaçsu, and Matvos (2017), using deposit level data for 16 of the largest US retail banks over the period 2002–2013, obtain demand elasticity estimates of 0.56 for insured deposits and 0.16 for uninsured deposits.

6.2 Depositor Compensation for Fundamental and Strategic Motives

Elasticities are useful to provide estimates of the magnitude of the monetary costs paid by depositors for withdrawing early. Intuitively, we can rephrase it as the interest rate that depositors are willing to accept *not* to withdraw before maturity. In this section, we estimate the increase in interest rates (during quiet times) that would have induced the change in withdrawals observed after the deterioration of fundamentals in our setting. This will give us estimates of depositor compensation, that is, a measure of the additional payment required to keep depositors from withdrawing in response to a deterioration of fundamentals. This latter number is useful to understand the cost of stabilizing deposits.

The exercise delivers the following results. To generate in quiet times the same increase in the withdrawal probability due to strategic motives obtained in Subsection 5.1, the cost of withdrawal would have had to drop by €293 (0.77% of deposit amount and 26% in forgone return). Similarly, to generate the increase in the withdrawal probability due to fundamental motives, the cost of withdrawal would have had to drop by €612 (1.61% of deposit amount and 72% forgone return). Combined, the figures imply that to prevent withdrawal probabilities from increasing during the three-week period after event that triggered the heightened uncertainty, The Bank would have had to offer depositors a payment of 2.38% of the value of their deposits, or an annualized return exceeding 50%. This rate vastly exceeded The Bank's marginal cost of funding from the ECB at the time (below 5%).

Note that depositors' are heterogeneous in their willingness to pay to withdraw. If the bank could identify the marginal borrowers, those that are most willing to withdraw in the

[22] Recall from the discussion in Subsection 3.2.2 that withdrawing shortly before maturity date implies depositors use very large discount rates. For example, withdrawing a deposit of value D one week before maturity for a penalty of 1% of D is equivalent to paying an interest of $0.01 \times D$ to borrow $0.99 \times D$ for a week, which corresponds to an annualized interest rate of 68%. The average cost of early withdrawal during the three weeks before the interest payment date, expressed in terms of forgone returns, is 41%.

[23] A 75% change in the cost of withdrawal expressed as an annualized rate (a decline of 10 percentage points of a baseline of 41), leads to a 37% decline in deposits. The cost semi-elasticity using this figure implies that a 10 percentage point drop in the forgone return from withdrawing, induces a 37% increase in the withdrawal probability.

presence of aggregate uncertainty, the cost of preventing withdrawals would be substantially reduced by only offering higher returns to them. But our results on heterogeneity suggest that borrowers' propensity to withdraw in response to fundamentals deteriorating is difficult to predict using observables. Thus, the cost of preventing withdrawals is very high partly because it entails transferring rents to infra-marginal depositors.

6.3 Quantification Using CDS Prices

Our approach to separate strategic- and fundamental-driven withdrawals is not specific to Greece. We can potentially implement our methodology when analyzing other bank-run episodes where there is an unexpected event that deteriorates fundamentals and may cause depositors to withdraw because of strategic and fundamental motives.

To perform such extrapolation and compare our estimates to other episodes we need to scale the magnitude of the aggregate uncertainty increase during the Greek episode from where we obtain our estimates. A natural candidate for a measure of the aggregate uncertainty increase is the change in the Greek sovereign bond CDS price. We consider the magnitude of CDS prices changes after events at t_1 and t_2.

For our strategic-driven estimates, we consider the 136% increase in the short-run CDS price in the week after t_0 (used to estimate strategic motivations). We use this change as a basis to scale the estimated 68% increase in strategic-induced withdrawal probability. Thus, when we extrapolate strategic motives to other settings, we assume that the elasticity of strategic-driven withdrawal probabilities to the CDS price to be 0.5 (a 1% increase in CDS price leads to a 0.5% increase in the withdrawal probability).

For our estimates when depositors face fundamental uncertainty, we use that during the week following t_A (used to estimate fundamental motivations), the 6-month sovereign bond CDS price increased 27%. We use this change to scale the estimated 192% increase in fundamental-induced withdrawal probability to other episodes. Thus, we assume that the elasticity of fundamental-driven withdrawal probabilities to the CDS price to be 7.1.

Combined, the two elasticities imply that a 1% increase in the 6-month sovereign default risk is associated with a 7.6% increase in the withdrawal probability, the majority of which is due to fundamentals.

7 Discussion and Conclusion

In this paper we isolate and quantify deposit withdrawals due to three different motives: liquidity, exposure to changes in fundamentals, or expectations about how other depositors will behave. Using individual-level, daily frequency time deposit data, we develop a new approach that uses variation induced by maturity expiration of time deposits around the large policy uncertainty events. The goal is to differentiate between deposit withdrawals due to direct exposure to fundamentals deteriorating and those due to expectations about behavior of other depositors. After a policy uncertainty shock that doubled the short-run CDS price of Greek sovereign bonds, we find that early deposit withdrawals quadrupled. According to our estimates, two-thirds of this increase are due to direct exposure to fundamentals, while the remainder is driven by the indirect effect of strategic complementarities.

First, our estimates provide useful insights on policies to stabilize deposits through prices during periods if high policy uncertainty. Our setting helps to understand the slow, dynamic nature of deposit withdrawals in recent bank runs and in many countries over the last years. Our estimates imply that in order to prevent the increased deposit withdrawals around the three week period around the event, would cost The Bank 2.38% of the value of the deposits, which implies a more than 50% cost of capital (annualized). In fact, we have seen banks increasing their deposit rates to attract depositors at the beginning of periods with abnormal high levels of deposit withdrawals. Moreover, we provide insights into the heterogeneity in depositors' behavior due to the heterogeneity in idiosyncratic risk, and the opportunity costs of withdrawal.

Second, our approach can be interpreted as a proof of concept for theoretical work on global games in banking. Our estimates are an empirically test of whether withdrawals due to strategic complementarities are a relevant concern in the data and whether they are quantitatively important.

Third, even if our framework and empirical strategy use staggered maturities and fundamentals happening in the future, our approach applies to more general settings. For example, consider the case in which deposit contracts are homogeneous (e.g., demand deposits with no maturities) and the bank has no screening mechanism to differentiate across depositors. How reliable are our estimates when discussing demand deposits instead of time deposits? Well, in out setting, the combined effect of strategic and fundamental motives for withdrawals implied captured by our estimates explains 90% of the total withdrawals The Bank experienced during the period around the events.

We can also apply our estimates to a situation in which fundamentals change instantly (e.g., exactly at the time of the announcement), affecting all depositors at the same time. In this collapsed (as opposed to staggered) setting, our estimates can predict the overall increase in withdrawals and the total amount that the bank would require to keep depositors in the bank. To assess the plausibility of the magnitude of our estimates and their external validity, we perform a series of extrapolation exercises to other episodes where there was a change in fundamentals after a surprise announcement. In particular, we evaluate whether our estimated elasticities can predict a significant fraction of deposit withdrawals in other recent bank-run episodes: the Italian crisis in the summer of 2018, and the runs on Northern Rock and Washington Mutual. We find that, although we underestimate the magnitude of withdrawals in all three events, our estimates are sensible and within the observed outcomes (see Appendix F for details on our quantification exercise).

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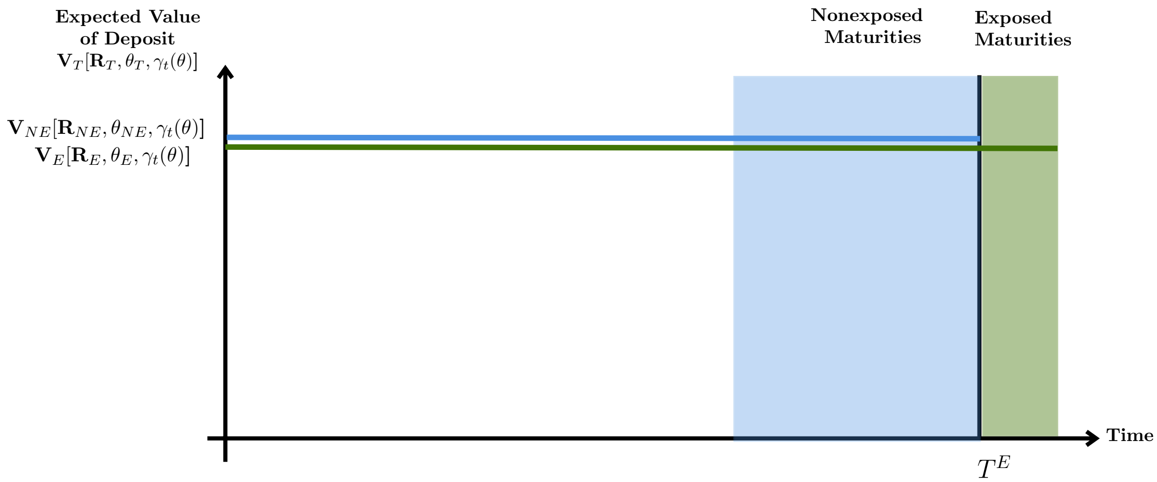
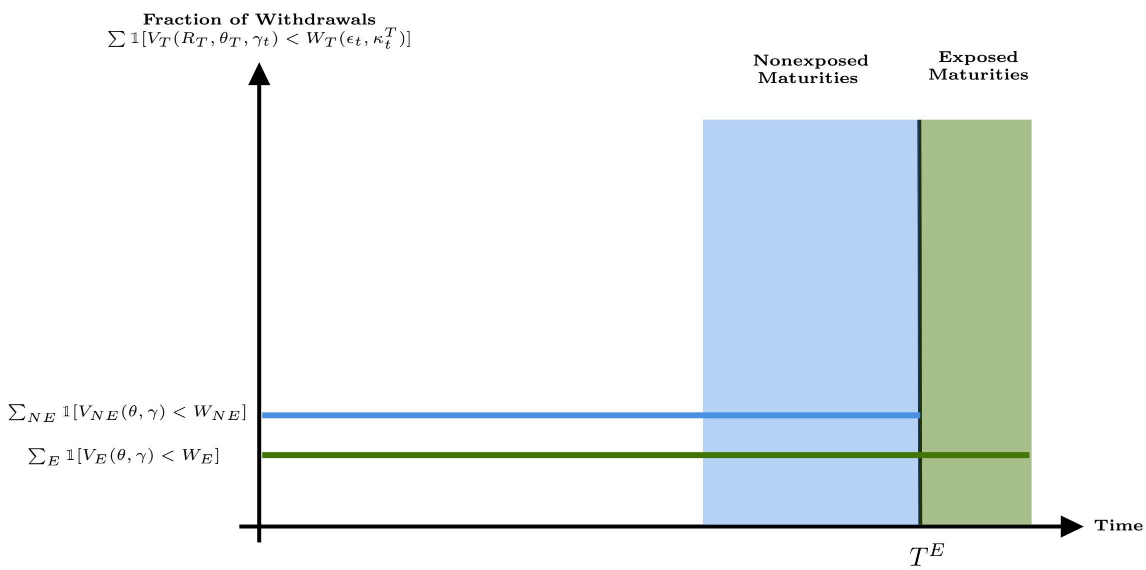
Figure 1: Framework in Quiet Times

PANEL A: Expected Value of Deposit for Exposed and Nonexposed Maturities



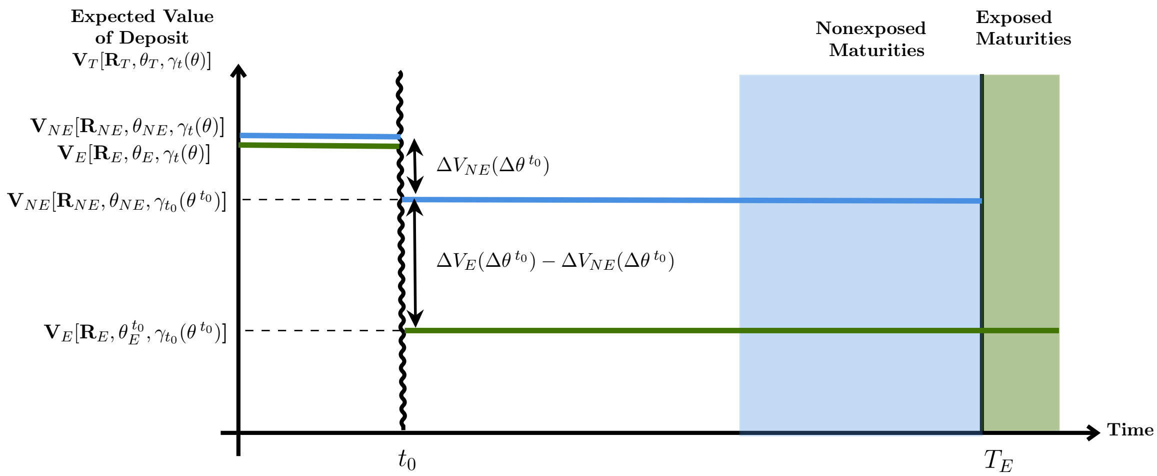
PANEL B: Fraction of Early Withdrawals for Exposed and Nonexposed Maturities



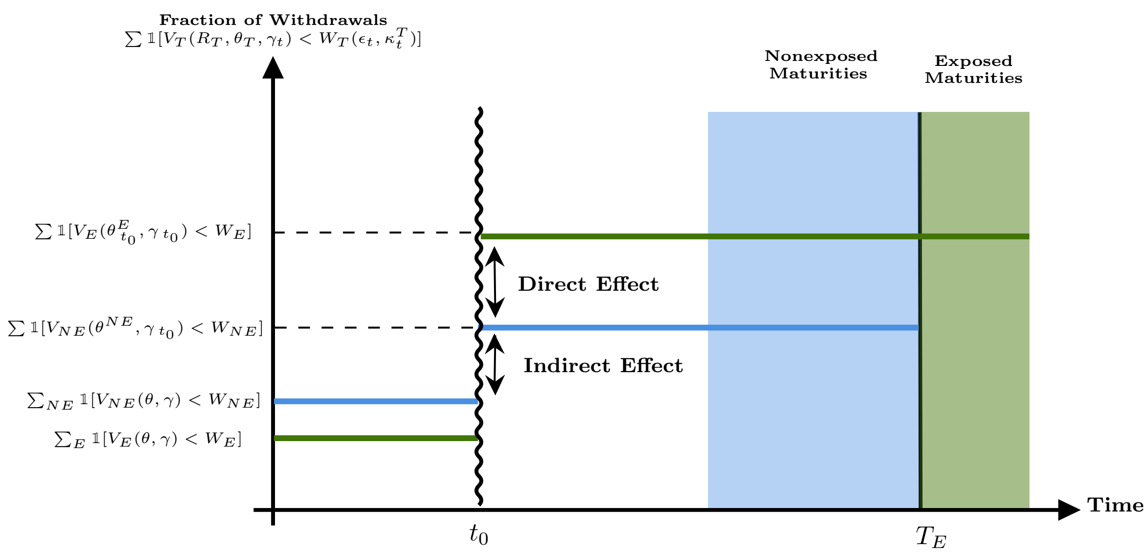
Notes:

Figure 2: Framework with Deteriorating Fundamentals for Exposed Maturities

PANEL A: Expected Value of Deposit for Exposed and Nonexposed Maturities

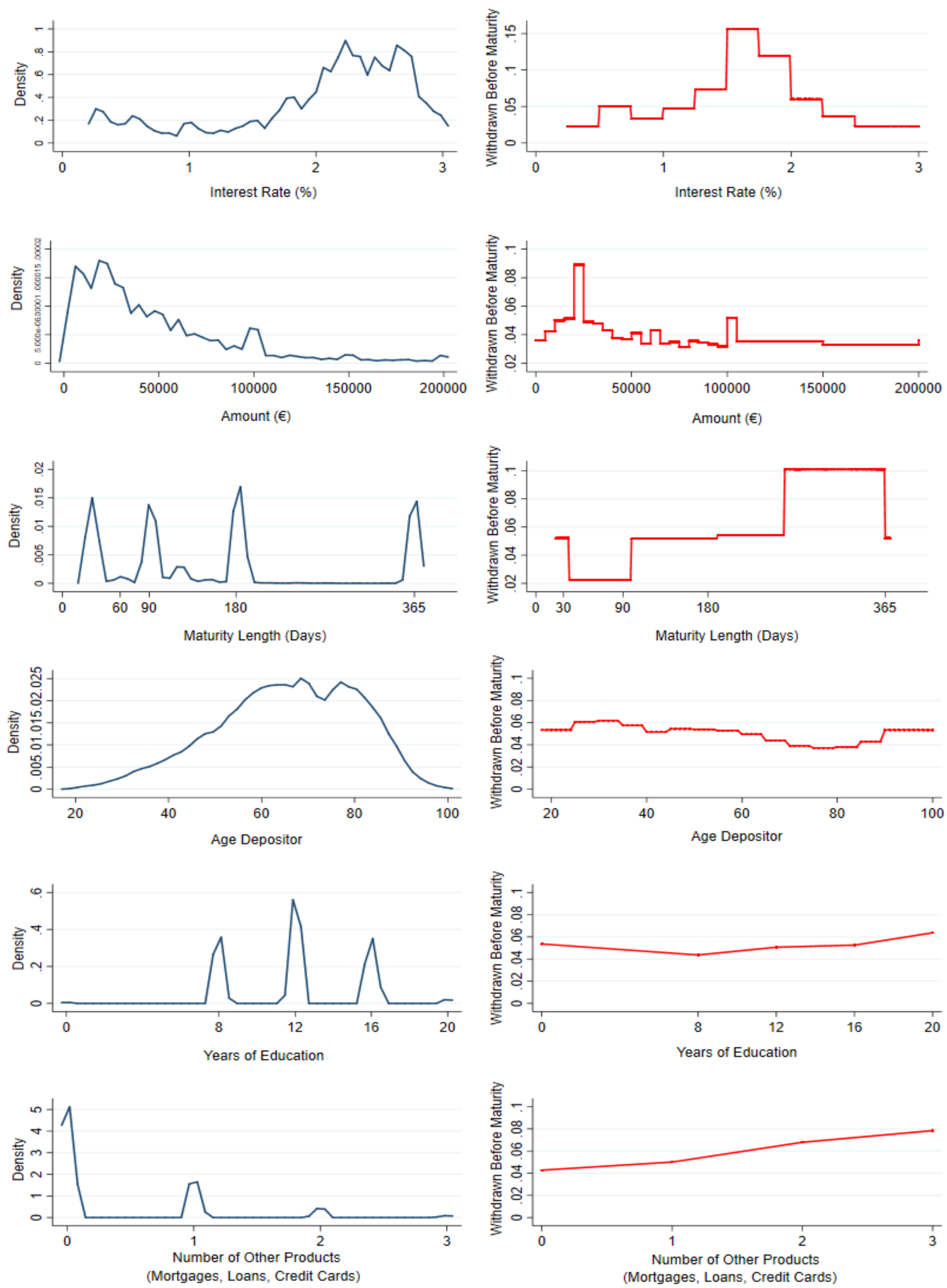


PANEL B: Fraction of Withdrawals for Exposed and Nonexposed Maturities



Notes:

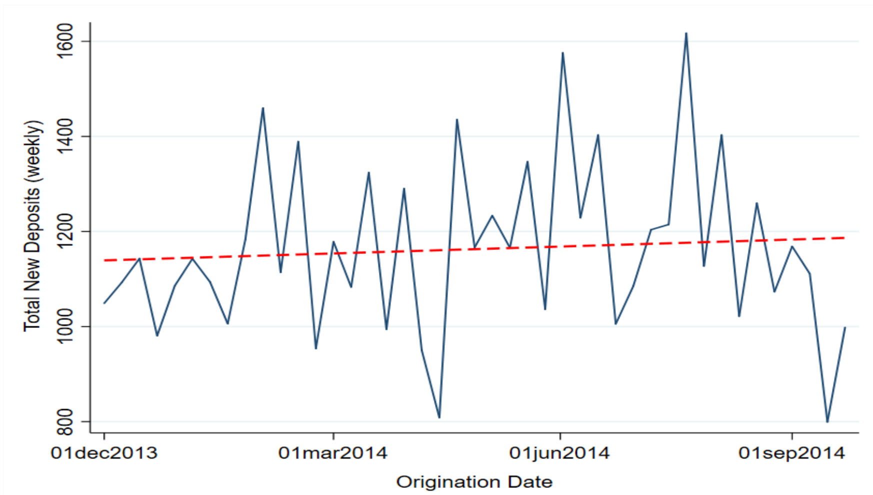
Figure 3: Distribution of Depositor Characteristics and Withdrawal Behavior



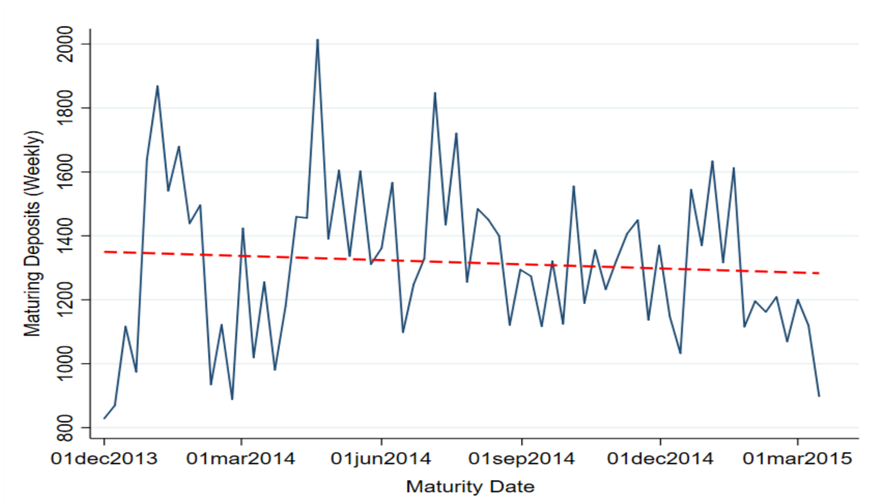
Notes: Figures use daily data for all time deposits from a large Greek bank between January and November 2014. Figures on the left plot density distributions of characteristics for time deposits (interest rates, deposit amount, maturity length) and depositors (age, education, other products with the bank). Figures on the right plot the fraction of time deposits withdrawn before maturity across time deposit and depositor characteristics. We calculate the fraction of withdrawals before maturity by dividing the number of time deposits withdrawn prior to their maturity dates over the total number of deposits originated over this period (Jan-Nov 2014).

Figure 4: Deposits' Origination and Maturity Dates

PANEL A: Time Deposits Originated Each Week

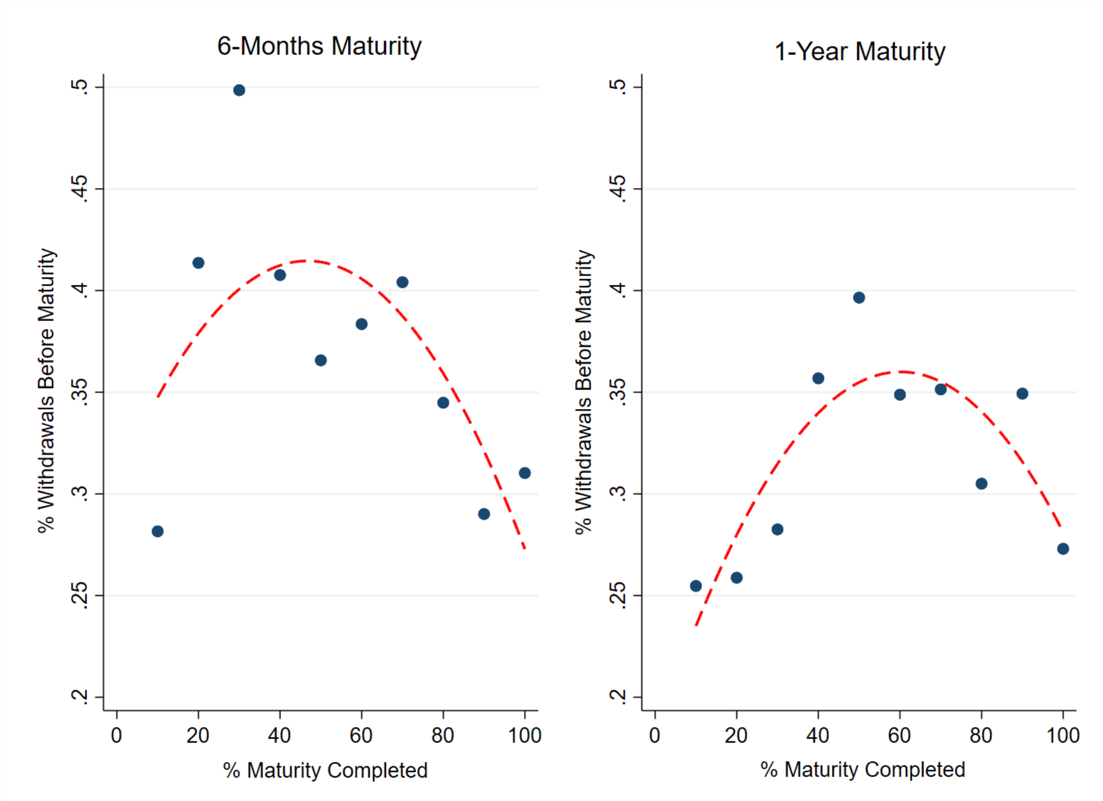


PANEL B: Time Deposits Maturing Each Week



Notes: Panel A uses daily data for all time deposits from a large Greek bank originated between December 2013 and October 2014. The figure plots originations of time deposits (aggregated at a weekly level), measured by total new time deposits at the Bank in a given week. Panel B uses daily data for all time deposits from a large Greek bank maturing between December 2013 and March 2015. The figure plots time deposits maturing in a given week, measured by the total number of time deposits with maturity dates within a week. The red dashed line in Panels A and B fits a linear trend using fitted values from an OLS regression of new and maturing time deposits, respectively, over a weekly trend. Both trends are not significantly different from zero. The time period in Panel A shows no pattern in originations during our quiet times (before December 2014). The time period in Panel B shows no patterns in maturity choices both in quiet and uncertain times (after December 2014).

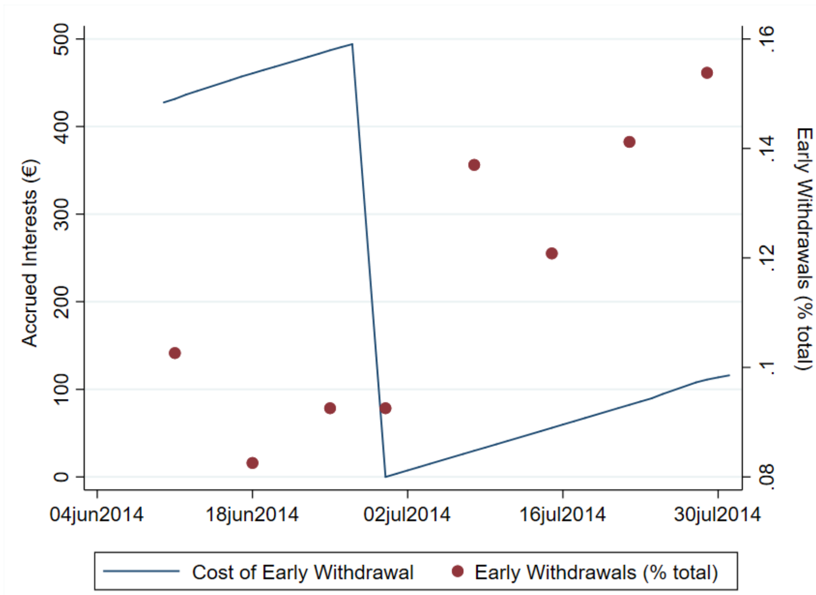
Figure 5: Withdrawals and Time to Maturity



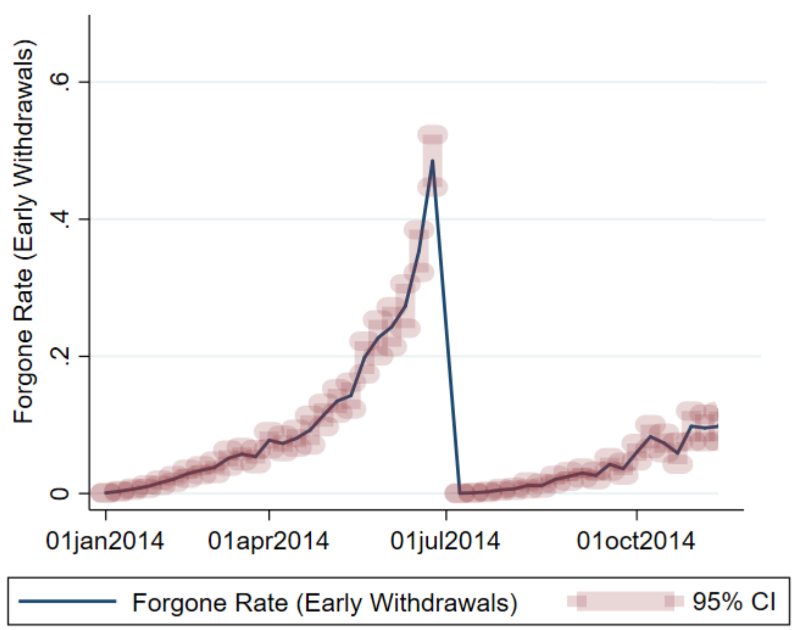
Notes: The figure to the left considers time deposits with maturity length of six months and the one to the right looks at time deposits with maturity length of one year (which, as shown in Figure 3, are the most popular maturity choices). Both figures plot the percentage of time deposits withdrawn before maturity across groups depending on the percentage of maturity completed at the time of withdrawal. For example, a time deposit with a six-month maturity that is withdrawn two months after origination has completed 33% of its maturity at the time of withdrawal. We round up to the nearest tenth, so this time deposit is included in the category of 30% maturity completed. The red dashed line in both figures plots fitted values from an OLS regression of percentage of time deposits withdrawn before maturity over percentage of maturity completed and percentage of maturity completed squared. The sample period is January-October 2014.

Figure 6: Payment of Accrued Interests and Foregone Returns

PANEL A: Accrued Interests and Fraction of Withdrawals Before Maturity



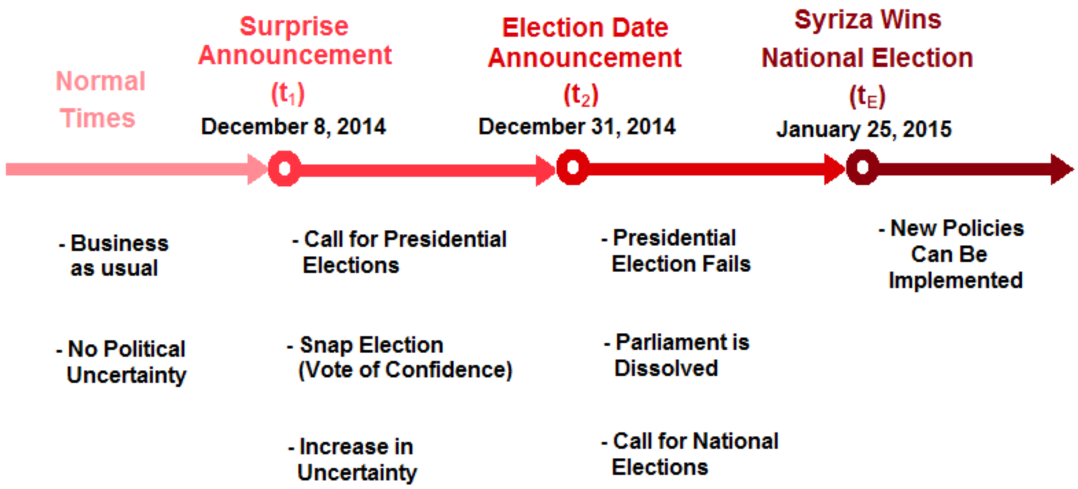
PANEL B: Foregone Returns when Withdrawing Before Maturity



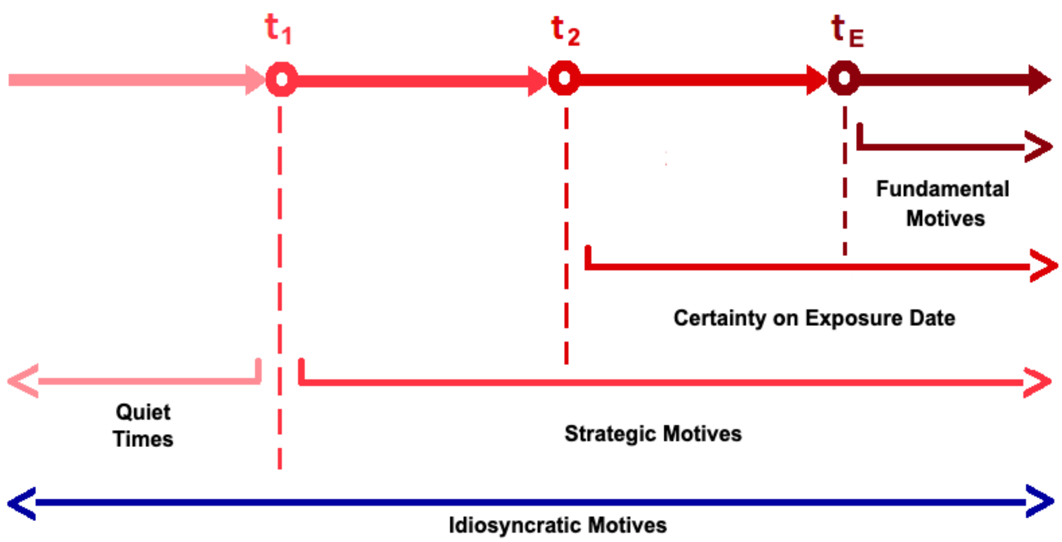
Notes: The solid line in Panel A plots average accrued interests for all time deposits at a daily frequency between June 7 and July 31, 2014. The dots in Panel A plot percentage of deposits withdrawn before maturity each week for the same time period. On July 1, the Bank pays accrued interests to all time deposits. Panel B plots the foregone rate of return for time deposits at a weekly frequency between January 1 and December 1, 2014.. We calculate foregone interests as *(Interest Forgone/Interest Received)ˆ(365/Days to Maturity)*, where *Interest Forgone* is accrued interests at the time of withdrawal and *Interest Received* is interest payments at maturity. The shaded area represents 95% confidence intervals.

Figure 7: Main Events and Withdrawal Motives

PANEL A: Key Dates and Events



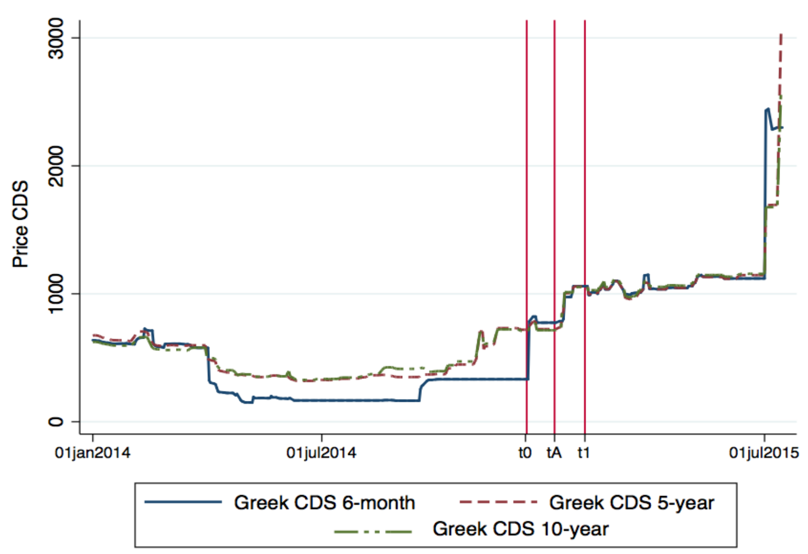
PANEL B: Key Dates and Withdrawal Motives



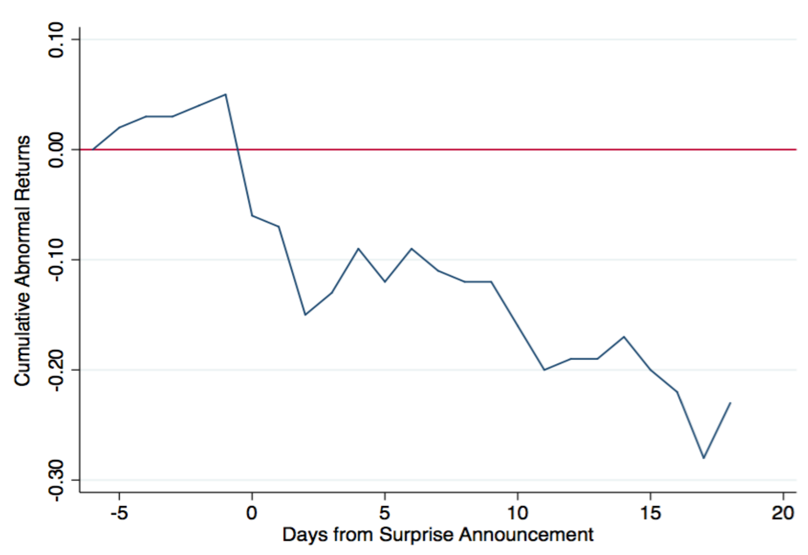
Note: Panel A presents the key dates in our analysis and lists the main events that took place in our period of heightened uncertainty. Panel B relates our three main events (t_1, t_2 and t_E) to different withdrawal motives faced by time depositors with maturities around these events. Before t_1, withdrawals of these depositors are driven only by idiosyncratic motives. After t_1, these depositors also have additional strategic motives, driven by changes in their expectations of other depositors' behavior. After t_2, depositors receive news about their exposure to policy uncertainty. Finally, after t_E they also face deteriorating fundamentals in the form of new policies being implemented by the new government.

Figure 8: CDS Prices and Cumulative Abnormal Returns

PANEL A: Price of Greek CDS for Different Maturities



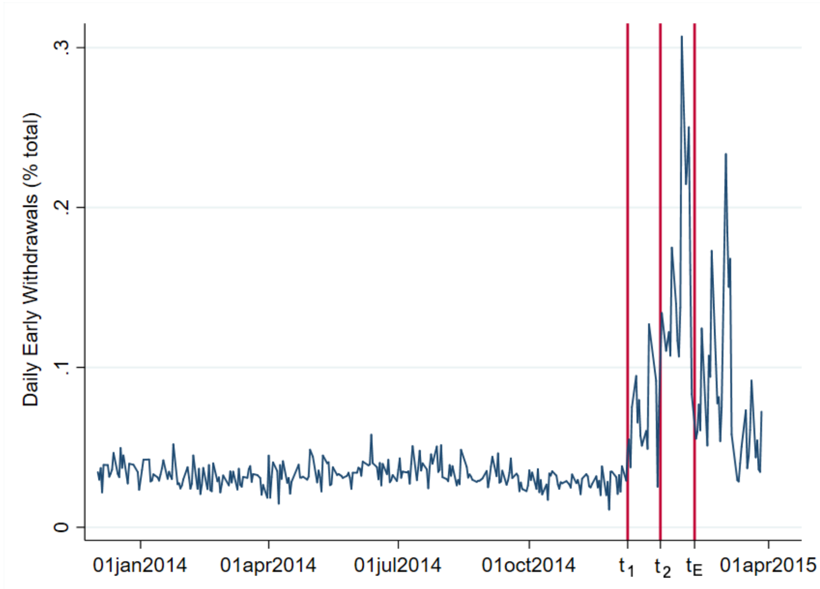
PANEL B: Cumulative Abnormal Returns for Athens Stock Market



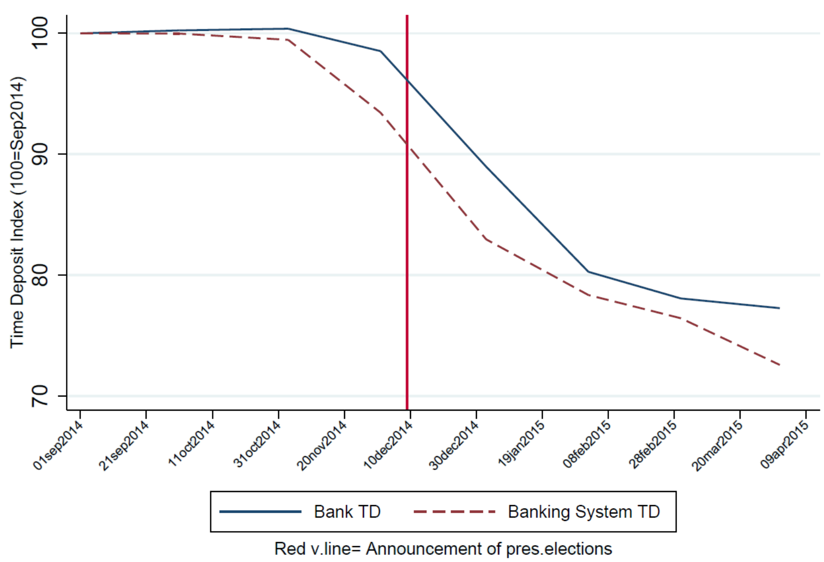
Notes: Panel A shows CDS prices for Greek sovereign bonds with six-month, five-year and ten-year maturities. The red vertical line corresponds to the surprise announcement of presidential elections on December 8, 2014 (t_1). The green vertical line refers to the announcement of national elections on January 1, 2015. The black vertical line corresponds to the national elections on January 25, 2015 (t_E). Panel B plots cumulative abnormal returns for Athens Stock Exchange with respect to FTSE Euro 100 over an event window starting 5 days prior to the surprise announcement on December 8, 2014 (t_1) until 17 days after. Daily abnormal returns are calculated as the residuals of regressing Athens Stock Exchange returns on FTSE Euro 100 returns and a constant over a period that runs between 60 days prior to the event at t_1 up to 5 days prior to the event at t_1. The daily abnormal returns are summed over the event window to derive the cumulative abnormal returns.

Figure 9: Time Deposit Withdrawals

PANEL A: Daily Percentage of Time Deposits Withdrawn Before Maturity



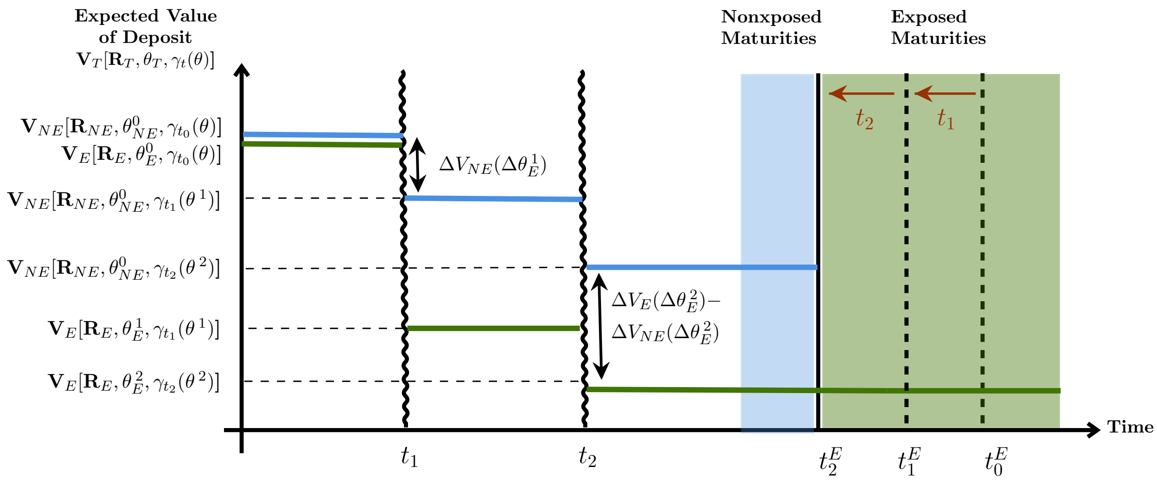
PANEL B: Time Deposits in Overall Greek Banking System



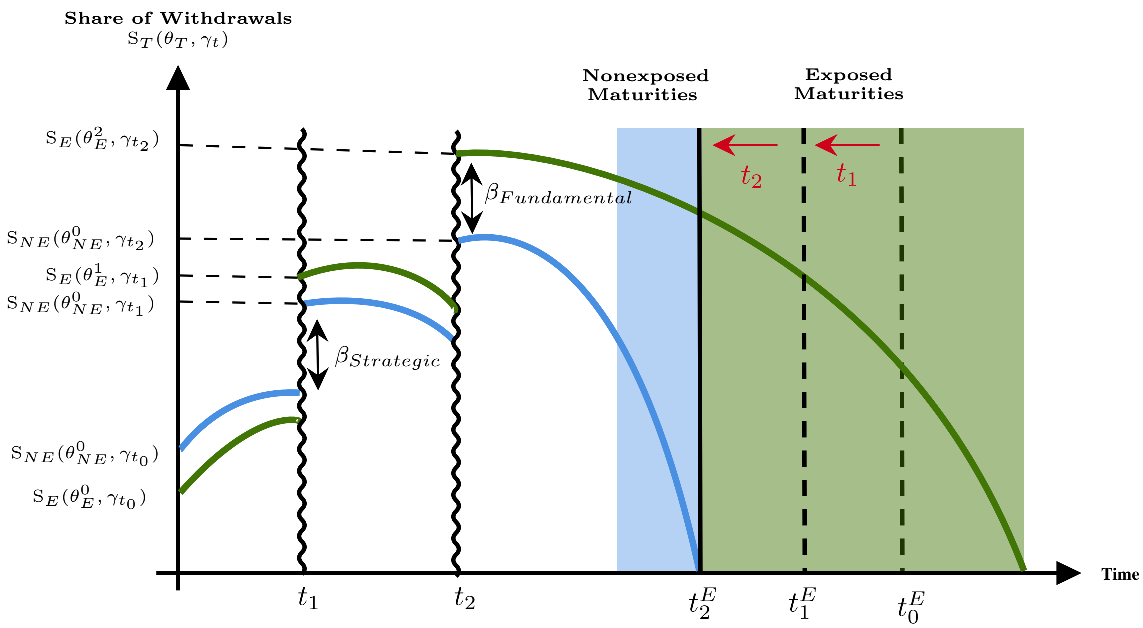
Note: Panel A plots time deposits withdrawn before maturity expressed as a percentage of total time deposits. The percentage is calculated at a daily frequency between January 1, 2014 and March 31, 2015. The red vertical lines correspond to: the surprise announcement of presidential elections on December 8, 2014 (t_1); the announcement of national elections on January 1, 2015 (t_2); and the national elections on January 25, 2015 (t_E). Panel B plots changes in total time deposits between September 2014 (normalized to 100) and April 2015. The solid blue line represents changes in the Bank's time deposits, while the dashed red line plots changes in time deposits in the overall Greek banking system. The vertical line corresponds to t_1.

Figure 10: Mapping Framework to Empirical Strategy

PANEL A: Expected Value of Deposit for Exposed and Nonexposed Maturities

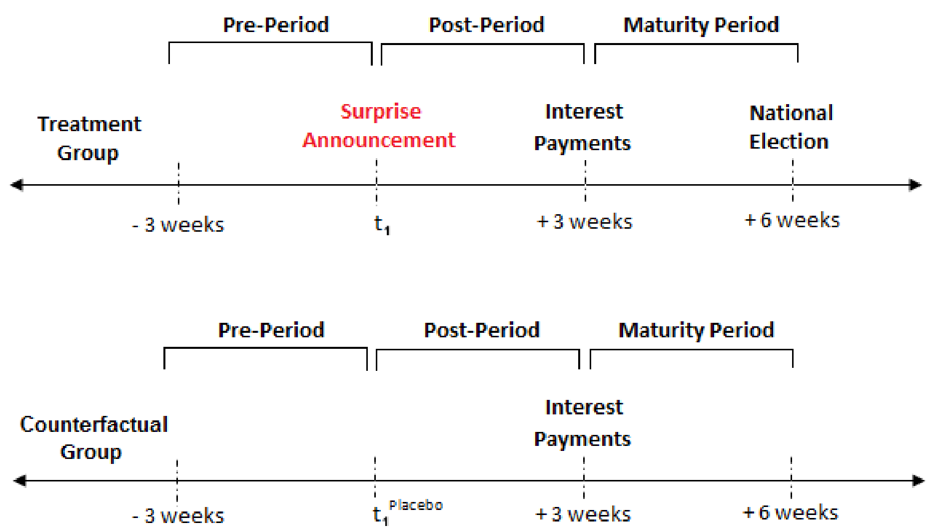


PANEL B: Fraction of Withdrawals for Exposed and Nonexposed Maturities



Note:

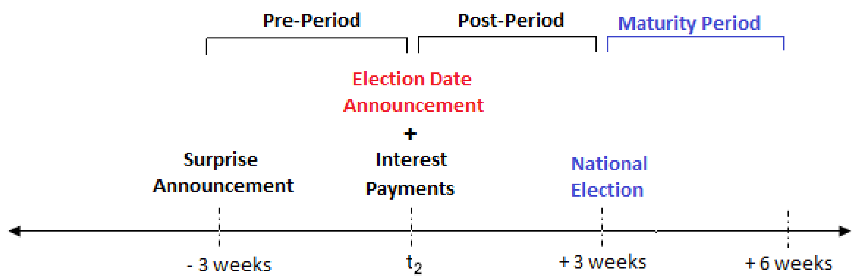
Figure 11: Treatment and Counterfactual Groups to Identify Strategic Motives



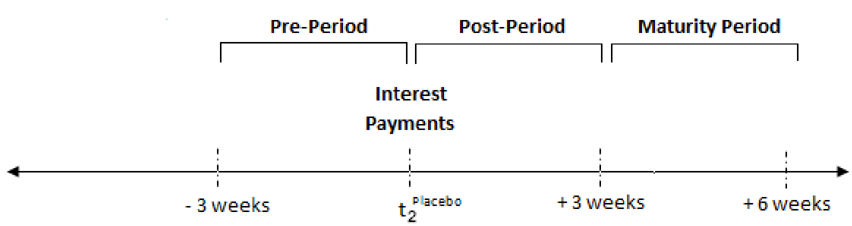
Note: The main event is the surprise announcement at t_1. Treated deposits mature between three and six weeks after the event. We analyze withdrawal behavior of deposits three weeks before and after t_1. Counterfactual deposits mature between three and six weeks after $t_1^{Placebo}$ (in quiet times). We compare their withdrawal behavior three weeks before and after $t_1^{Placebo}$.

Figure 12: Treatment, Control and Counterfactual Groups to Identify Fundamental Motives

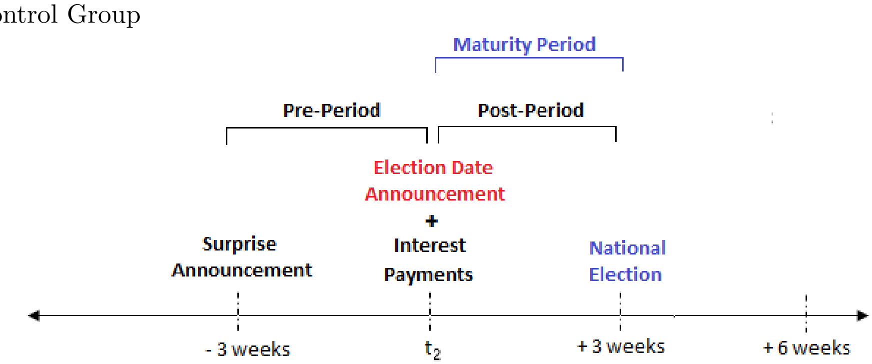
Panel A: Treated Group



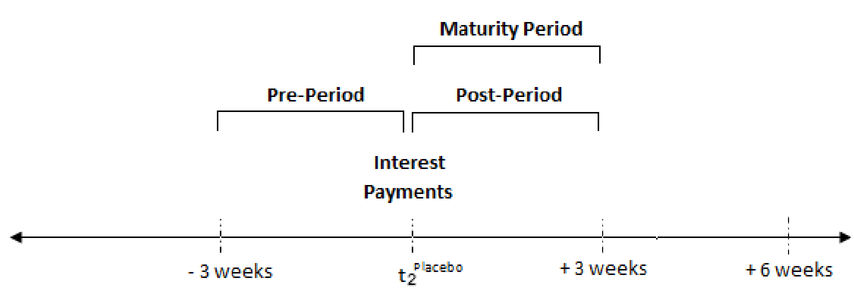
Panel B: Counterfactual Treated Group



Panel C: Control Group

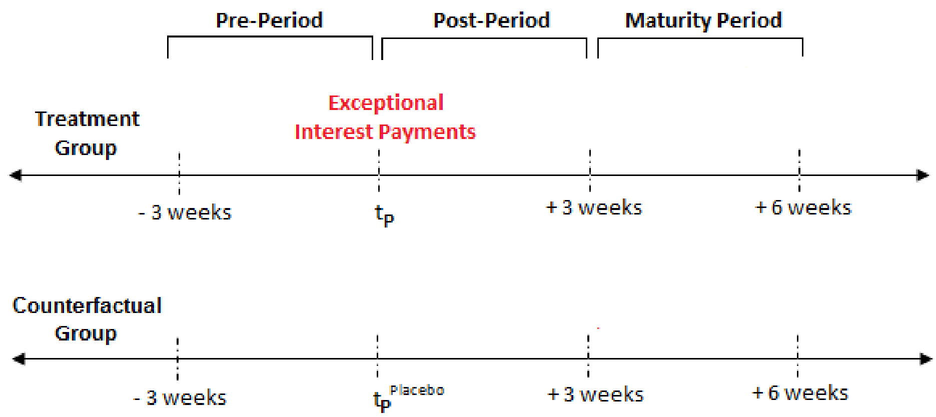


Panel D: Counterfactual Control Group



Note: The main event is the election date announcement at t_2. For the counterfactual groups we consider $t_2^{Placebo}$. We compare deposit withdrawals three weeks before and after the events. There four groups of depositors depending on their maturity dates: 1) maturing between three and six weeks after t_2, 2) maturing between three and six weeks after $t_2^{Placebo}$, 3) maturing in the three weeks after t_2, and 4) maturing in the three weeks after $t_2^{Placebo}$, .

Figure 13: Treatment and Counterfactual Groups for Cost Elasticity Analysis



Note: The main event is the interest payment at t_P. The periods to compare are three weeks before and after the event. The deposits to compare are those maturing between three and six weeks after the event.

Table 1: Descriptive Statistics

PANEL A: Entire Sample (Jan-Nov 2014)

	Mean (1)	S.D (2)	Min (3)	Median (4)	Max (5)	N (6)
Depositor Characteristics						
Age (years)	65	15	18	66	100	>300,000
Female	0.45	0.5	0	0	1	>300,000
Income (€)	25,363	20,880	1,103	21,137	197,609	>40,000
Education (years)	12	3	0	12	20	>200,000
Other Products (mortgage, credit card, loan)	0.3	0.46	0	0	1	>300,000
Years Holding Time Deposits	2.3	2.7	0.06	1	56	>300,000
Bank Employee	0.04	0.2	0	0	1	>300,000
Athens	0.34	0.47	0	0	1	>300,000
Account Characteristics						
Interest Rate (%)	1.94	0.95	0.01	2.2	8.19	>300,000
Balance (€)	57,281	65,490	687	36,000	500,000	>300,000
Currency Euros	0.77	0.42	0	1	1	>300,000
Maturity (days)	164	119	21	130	365	>300,000
Previous Renewals	6.5	10.6	1	3	1513	>300,000

PANEL B: Withdrawn Before Maturity

	Mean (1)	S.D. (2)	Min (3)	Median (4)	Max (5)
Quiet-Times (before t_0)					
Daily % Runners	0.04	0.01	0.01	0.03	0.06
Days to maturity	136	104	6	114	364
Maturity (days)	257	117	21	360	365
Balance (€)	41,188	49,364	2,828	23,500	500,000
Interest Rate (%)	1.86	0.85	0.01	2.1	4
Currency Euros	0.88	0.32	0	1	1
Age (years)	64	16	18	64	100
Female	0.47	0.5	0	0	1
Education (years)	12	3.23	0	12	1 20
Income (€)	24,450	18,678	1,900	20,433	149,569
Bank Employee	0.03	0.18	0	0	1
Years Holding Time Deposits	2.2	2.5	0.08	2.7	47
Previous Renewals	3.5	4.7	1	2	97
Other Products (mortgage, credit card, loan)	0.34	0.47	0	0	1
Forgone Interest Payment	308	493	0	175	8,180
Uncertainty (after t_0)					
Daily % Runners	0.12	0.07	0.02	0.10	0.28
Days to maturity	129	96	6	105	364
Maturity (days)	240	109	21	183	360
Balance (€)	58,583	63,591	687	37,000	500,000
Interest Rate (%)	1.67	0.49	0.01	1.75	3.25
Currency Euros	0.93	0.26	0	1	1
Age (years)	63	15	20	63	100
Female	0.45	0.5	0	0	1
Education (years)	13	3.17	0	12	1 20
Income (€)	25,697	19,304	1,900	21,748	193,491
Bank Employee	0.07	0.26	0	0	1
Years Holding Time Deposits	2.8	3.5	0.08	1.8	56
Previous Renewals	4.9	6.5	1	3	82
Other Products (mortgage, credit card, loan)	0.39	0.49	0	0	1
Forgone Interest Payment	385	531	0	211	8,225

Note: Panel A presents summary statistics for all time deposits between January and November 2014. We need to mask total observations to keep the identity of The Bank confidential. Panel B reports summary statistics for time deposits withdrawn before reaching maturity, both in quiet (before December 8, 2014) and uncertain (after December 8, 2014) times.

Table 2: Identifying Strategic Motives

PANEL A: Percentage of Time Deposits Withdrawn Before Maturity

	Uncertainty Group (maturity in period with uncertainty)	Counterfactual Group (maturity in quiet times)
Withdrawn Before t_1 (or $t_1^{Placebo}$)	0.40 %	0.40 %
Withdrawn After t_1 (or $t_1^{Placebo}$)	0.94 %	0.66 %
Observations (N)	>8,000	>8,000

PANEL B: Difference-in-Differences Estimation for Strategic Motives

Withdrawn Before Maturity (0/1)	(1)	(2)
DiD	0.0027*	0.0027*
	(0.0015)	(0.0015)
Uncertainty	0.000	0.000
	(0.001)	(0.001)
Post	0.0026***	0.0027***
	(0.0009)	(0.0009)
Account Chacteristics	No	Yes
Depositor Chacteristics	No	Yes
Observations	>30,000	>30,000

Note: Panel A reports the percentage of time deposits withdrawn before maturity. The first column considers time deposits with maturity dates after t_2 but before t_E (our *uncertainty* group). The second column refers to time deposits with maturity dates in the quiet period, before $t_2^{Placebo}$ but after $t_E^{Placebo}$ (our *counterfactual* group). The first row reports percentage of time deposits withdrawn before maturity during the three weeks prior to t_1 and $t_1^{Placebo}$ for exposed and counterfactual groups, respectively. The second row reports percentage of time deposits withdrawn before maturity during the three-weeks following t_1 and $t_1^{Placebo}$ for exposed and counterfactual groups, respectively. Panel B reports results from estimating Equation (1). *Uncertainty* refers to deposits maturing after t_2, but before elections at t_E. *Post* refers to a three-week window following t_1 for exposed time deposits and $t_1^{Placebo}$ for counterfactual deposits maturing in quiet times. *DiD* refers to the interaction between *Uncertainty* and *Post*. Column (2) in Panel B includes depositor characteristics (gender, age, bank employee, other products, previous relationship with the bank) and time deposit characteristics (deposit amount, maturity, interest rate, currency). Robust standard errors are in parentheses (*** p<0.01, ** p<0.05, * p<0.1). We need to mask observations in Panels A and B to keep the identity of The Bank confidential.

Table 3: Identifying Fundamental Motives

PANEL A: Fraction of Early Withdrawals

	Uncertainty Period (maturities in period with uncertainty)		Counterfactual Period (matuirties in quiet times)	
	Control Group (No Change Fundamentals)	Exposed Group (Change Fundamentals)	Counterfactual Group (No Change Fundamentals)	Counterfactual Exposed Group (No Change Fundamentals)
Before t_1 (or $t_1^{Placebo}$)	0.40 %	0.49 %	0.40 %	0.41 %
Between t_1 and t_2 (or $t_1^{Placebo}$ and $t_2^{Placebo}$)	1.00 %	1.07 %	0.66 %	0.64 %
Between t_1 and t_2 (or $t_1^{Placebo}$ and $t_2^{Placebo}$)	0.39 %	2.78 %	0.37 %	1.40 %
Observations (N)	>8,000	>8,000	>8,000	>8,000

PANEL B: Interest Payments

	Uncertainty Period (maturities in period with uncertainty)		Counterfactual Period (maturities in quiet times)	
	Control Group (No Change Fundamentals)	Exposed Group (Change Fundamentals)	Counterfactual Group (No Change Fundamentals)	Counterfactual Exposed Group (No Change Fundamentals)
Interest Payment	€526 (680)	€478 (602)	€509 (707)	€475 (603)

Table 4: Difference-in-Differences-in-Differences Estimation for Fundamental Motives

Early withdrawal (0/1)	(1)	(2)
DDD	0.0127***	0.0127***
	(0.0030)	(0.0030)
Uncertainty	0.0030**	0.0028**
	(0.00122)	(0.00126)
Exposed	-0.0016	-0.0016
	(0.0010)	(0.0011)
Post	-0.0028***	-0.0028***
	(0.0009)	(0.0009)
Uncertainty × Post	-0.0033**	-0.0033**
	(0.0015)	(0.0015)
Exposed × Uncertainty	0.0023	0.0025
	(0.0019)	(0.0019)
Post × Exposed	0.0104***	0.0104***
	(0.0017)	(0.0017)
Account Chacteristics	No	Yes
Depositor Chacteristics	No	Yes
Observations	>50,000	>50,000

Note: *Uncertainty* refers to deposit maturing in the uncertainty period when fundamentals started to deteriorate. *Exposed* refers to deposits maturing after t_2 and exposed to a deterioration of fundamentals due to policy uncertainty. *Post* refers to the period after t_2. Column (2) includes depositor characteristics (gender, age, bank employee, other products, previous relationship with the bank) and account characteristics (deposit amount, maturity, rate, currency). Robust standard errors are in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 5: Estimating the Elasticity of Depositors to Interest Payments

PANEL A: Fraction of Early Withdrawals

	Treatment Group (interest payments)	Counterfactual Group (no interest payments)
Before Interest Payment	0.54 %	0.57 %
After Interest Payment	1.26 %	0.40 %
Observations (N)	>8,000	>8,000

PANEL B: Difference-in-Differences Estimation

Early withdrawal (0/1)	(1)	(2)
Interest Pay	-0.00024	-0.00016
	(0.001)	(0.001)
Post	-0.0016	-0.0016
	(0.001)	(0.001)
DiD	0.0088***	0.0088***
	(0.002)	(0.002)
Account Chacteristics	No	Yes
Depositor Chacteristics	No	Yes
Observations	>30,000	>30,000

Note: Column (2) in PANEL B includes depositor characteristics (gender, age, bank employee, other products, previous relationship with the bank) and account characteristics (deposit amount, maturity, rate, currency). Robust standard errors are in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

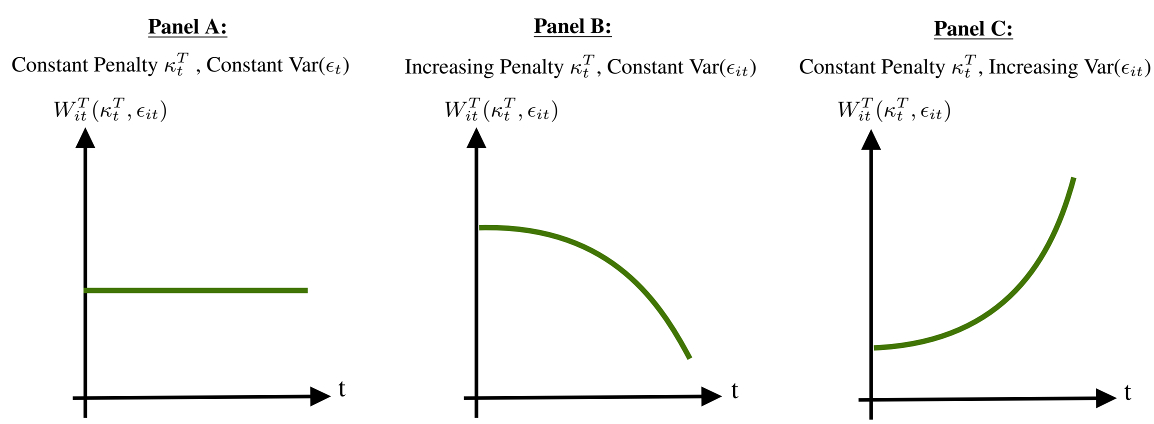
Appendix A Non-Monotonic Payoffs of Early Withdrawals

In the main text (Section 2), for simplicity, we assumed that depositor's expected payoffs of early withdrawal are constant over time (case illustrated in Panel A of Figure A.1). That is, $\frac{\partial W_{it}(\kappa_t^T, \epsilon_{it})}{\partial t} = 0$. In this section we consider the case in which depositors' expected payoffs of early withdrawal can be non-monotonic. We consider this case, because non-monotonic payoffs of early withdrawals can generate non-monotonic probabilities of withdrawal over time – which is what we observe in our setting. The reason to keep the simpler case in the text is that the economic intuition between the case discussed here and the simple one is identical.

In order to generate non-monotonicity, we combine two assumptions: time-varying monetary cost (κ_t^T) and time-varying variance of idiosyncratic shock (ϵ_{it}). We assume that the monetary penalty for early withdrawal increases as we get closer to maturity. That is, $\frac{\partial \kappa_t^T}{\partial (T-t)} < 0$. This assumption matches standard contracts for time deposits across countries. It is also consistent with cases in which there is no monetary penalty, but the depositor will lose all accrued interests in the event of early withdrawal. In this case, payoffs from early withdrawal are decreasing as we get closer to maturity, as illustrated in Panel B of Figure A.1.

We also assume that the the variance of the (unobserved) idiosyncratic shock increases as we get closer to maturity. That is, $\frac{\partial Var(\epsilon_{it})}{\partial (T-t)} < 0$. This assumption can be interpreted as liquidity shocks becoming more unpredictable as we get further away from origination. A person originating a time deposit is betting on not needing the money until maturity. The further into the future, the higher the variance on the person's liquidity needs. In this case, payoffs from early withdrawal are increasing as we get closer to maturity. That is, it is more likely that the depositor will get a larger liquidity shock such the she will need to withdraw the time deposit early, as illustrated in Panel C of Figure A.1.

Figure A.1: Expected Payoffs of Early Withdrawals



Combining time-varying monetary penalties and time-varying liquidity shock variances allows us to simply generate withdrawal probabilities that are an inverted U-shaped. As discussed in Section 3.2.2, this matches the pattern we observe in the data. For completeness, consider Figure A.2 which extends the discussion on withdrawal probabilities in Section 2 with such non-monotonic withdrawal payoffs. The intuition for inverted U-shaped withdrawal probabilities is straight forward. Closer to origination, probability of withdrawal is low because it is unlikely depositor is hit with liquidity shock. As we move further form origination, liquidity shocks have a greater variance, and probability of getting a large enough shock goes up. Therefore, withdrawal probability increases. As we get closer to maturity, depositors are getting greater liquidity shocks, but they also have to pay a significant higher monetary penalty. So many of them decide to wait and withdrawal probability falls.

Figure A.3 shows how the change in long-term fundamentals explained in Section 2.2 will map to the non-monotonic payoff of early withdrawal case. We are able to separate between total, direct and indirect effects in the same way we did in the previous section. Key difference is that now we allow depositors to face a time-varying trade-off between the cost of early withdrawal and the expected value of deposit at maturity.

Figure A.2: Fraction of Withdrawals (Quiet Times, Non-Monotonic Payoffs)

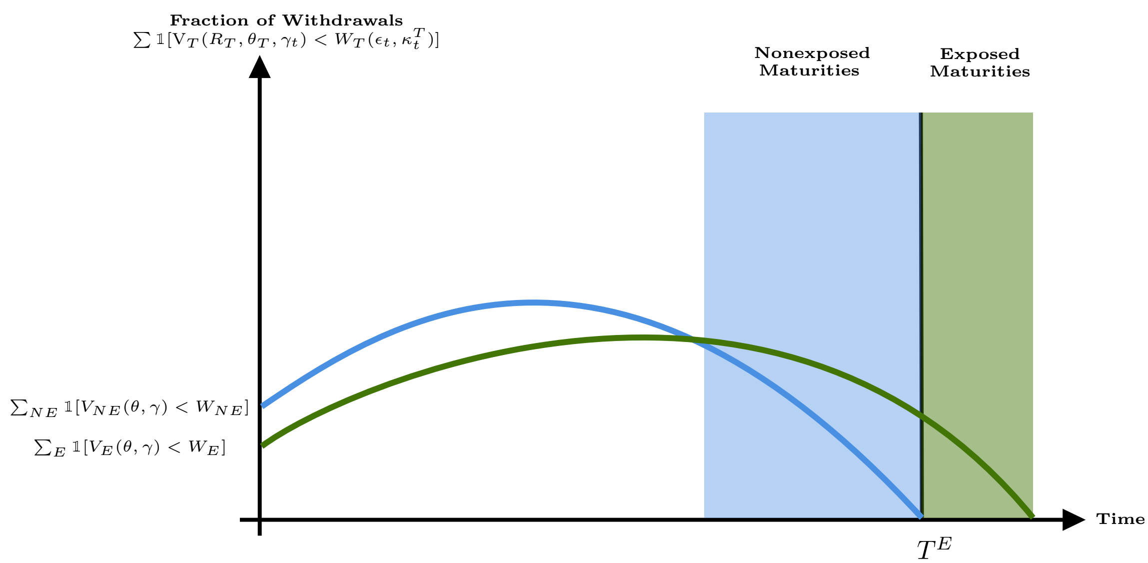
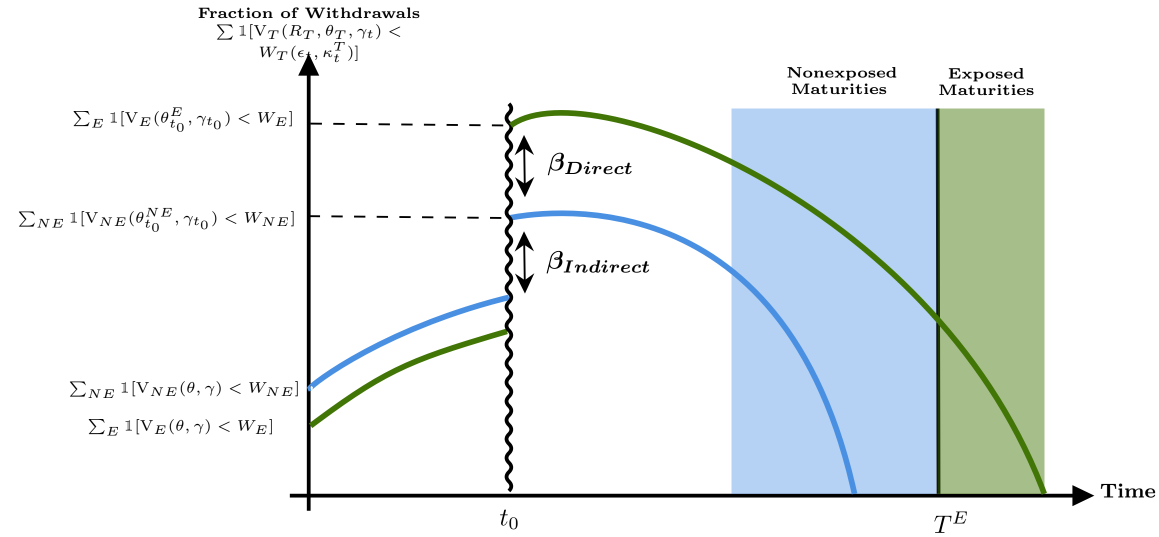


Figure A.3: Changes in Long-term Fundamentals (Non-Monotonic Payoffs)



Appendix B No Changes in Idiosyncratic Risk

Identification of our estimates for strategic motives requires that there are no changes in idiosyncratic withdrawals during the weeks following the surprise announcement on December 8, 2014.

One potential concern is unemployment. If major layoffs took place immediately after the announcement, deposit withdrawals might be driven by liquidity motives differing from those in quiet times. Unemployment rates remain stable during December 2014 and January 2015, and had similar magnitudes to the same months the previous year.[24] Moreover, we find no correlation between changes in regional unemployment figures and changes in deposit withdrawals during this period.

Another concern, given the age of a large fraction of our depositors, is that after the announcement there was a change in payment of pensions. We have found no evidence of pension amounts changing during our period or delays/haircuts taking place after the announcement. There were also no changes in number of patient visits and hospitalizations during our sample period.

Moreover, we have checked the interest rates offered by our bank's competitors before and after the announcement, and they are all similar to those we observed in quiet times. Therefore, there seem to be no changes in competition in the time-deposit market during our period. Even in areas where competition across banks was stronger, it is irrelevant for our exercise as along as competing banks did not offer a return higher than 17%, which is the

[24] See Eurostat Database for detailed figures at the NUTS 2 level, available at `https://ec.europa.eu/eurostat/data/database`

average forgone return for early withdrawals of time deposits in the Bank.

Appendix C No Changes in Bank Fundamentals

Identification of our estimates for strategic motives requires that there are no changes in bank fundamentals during the weeks following the surprise announcement on December 8, 2014.

C.1 Liquidity Measures

The bank tracks short-term liquidity through an index, the Liquidity Assets Ratio (LAR), defined as:

$$Liquidity\,Assets\,Ratio\ =\ \frac{Liquid\,Assets\ of\ up\ to\ 30\ days\ maturity}{Short\ term\ borrowing} \tag{B1}$$

where *Liquid Assets* include cash, interbank placements with maturity up to 30 days, compulsory reserve requirements to Bank of Greece, unencumbered high quality liquid assets, excess collateral pledged to ECB, inflows from installment loans within 30 days and other assets with maturity up to 30 days; and *Short Term Borrowing* considers interbank deposits with maturity up to one year, time deposits with maturity up to one year, wholesale funding with maturity up to one year, and 80% of saving and current accounts.

The LAR index needs to be higher than 20% for the bank to be considered liquid. We have confirmed with The Bank that the ratio was above the minimum threshold during the period for which we perform our strategic uncertainty analysis. At that time, time deposits accounted for more than 15% of The Bank's total liquidity.

The Bank also monitored another liquidity index, the Maturity Mismatch Ratio (MMR), given by:

$$Maturity\,Mismatch\,Ratio\ =\ \frac{Assets-\ \ Liabilities\ of\ up\ to\ 30\ days\ maturity}{Short\ term\ borrowing} \tag{B2}$$

This index needs to be higher than -20%. It was the case that during our strategic uncertainty period the index was significantly above this threshold.

Both indexes deteriorated soon after the January elections, and this trend intensified in early 2015.

C.2 Funding Costs

Despite the deposit outflow after the surprise announcement, The Bank did not face any funding problems. The Bank was able to borrow from the ECB at similar rates in the weeks following the announcement (but before the election). Moreover, there were no changes on the interest rates on both time and demand deposits during this period. Finally, there was a slight decline on the value of the bank's collateral during this period. However, this fall did not pose a threat to the banks solvency.

C.3 Loan Repayment

We also check that there were no changes in repayment behavior of The Bank's customers in the six weeks after the surprise announcement in December 2014. To do so, we have information on the entire August 2014 loan portfolio. We observe payment delinquencies for all corporate and household loans. Every month between August 2014 and February 2015, over 80% of all personal loans and mortgages had no delays in their monthly payments. The fraction of corporate loans during these months also remained stable and high.

Appendix D Heterogeneity Across Deposit Withdrawals

Table D.1: Heterogeneity Analysis for Strategic Subsamples

PANEL A: Depositor and Account Characteristics

Early withdrawal (0/1)	Female	Male	Balance <35,000	Balance >35,000	3-month TDs	6-months TDs	1-year TDs	Currency Euros	Foreign Currency
DiD	-0.0000	0.0051**	-0.0000	0.0053***	-0.0017	0.0086***	-0.0010	0.0034**	-0.0037
	(0.0022)	(0.0020)	(0.0022)	(0.0019)	(0.0026)	(0.0025)	(0.0025)	(0.0016)	(0.0035)
Uncertainty	0.002	-0.001	0.001	-0.001	0.002	0.001	-0.002	0.000	0.002
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.003)
Post	0.0036***	0.0019	0.0014	0.0037***	0.0005	0.0012	0.0062***	0.0028***	0.0008
	(0.0013)	(0.0012)	(0.0015)	(0.0011)	(0.0015)	(0.0013)	(0.0019)	(0.0010)	(0.0024)
Depositor Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Account Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>15,000	>15,000	>15,000	>15,000	>10,000	>10,000	>10,000	>35,000	>5,000
Baseline Prob. of Running	0.36	0.44	0.59	0.24	0.38	0.36	0.47	0.41	0.31
Baseline Cost of Running (% TD)	1.32	1.31	1.17	1.44	0.44	1.00	2.45	1.40	0.57

PANEL B: Depositor-Bank Relationship

Early withdrawal (0/1)	No Other Products	Other Products	Less than 2 years	More than 2 years	3 Renewals or Less	More than 3 Renewals
DiD	0.0016	0.0059*	0.0046**	0.0002	0.0044**	0.0008
	(0.0016)	(0.0034)	(0.0021)	(0.0020)	(0.0022)	(0.0019)
Uncertainty	0.000	0.001	0.000	0.001	0.000	0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Post	0.0023**	0.0037*	0.0011	0.0047***	0.0011	0.0044***
	(0.0010)	(0.0020)	(0.0013)	(0.0013)	(0.0013)	(0.0012)
Depositor Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Account Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>20,000	>10,000	>15,000	>15,000	>15,000	>15,000
Baseline Prob. of Running	0.19	0.95	0.53	0.23	0.54	0.24
Baseline Cost of Running (% TD)	1.32	1.30	1.17	1.51	1.39	1.23

Note: Robust standard errors are in parentheses for both Panels A and B (with *** p<0.01, ** p<0.05, * p<0.1).

Table D.2: Heterogeneity Analysis for Fundamentals Subsamples (Depositor and Account Characteristics)

Early withdrawal (0/1)	Female	Male	Balance <35,000	Balance >35,000	3-month TDs	6-months TDs	1-year TDs	Currency Euros	Foreign Currency
DDD	0.0136***	0.0119***	0.0106**	0.0148***	0.0179***	0.0260***	-0.0033	0.0129***	0.0106
	(0.0043)	(0.0042)	(0.0044)	(0.0042)	(0.0058)	(0.0051)	(0.0049)	(0.0033)	(0.0065)
Uncertainty	0.001	0.004**	0.001	0.005**	0.001	0.009***	-0.004*	0.003**	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Exposed	-0.002	-0.001	0.001	-0.004***	-0.000	0.004**	-0.008***	-0.002*	0.002
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.003)
Post	-0.004***	-0.002	-0.003*	-0.003**	-0.002	-0.001	-0.005***	-0.003***	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
Uncertainty × Post	-0.0017	-0.0046**	-0.0021	-0.0043**	0.0002	-0.0091***	0.0007	-0.00368**	0.000552
	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0024)	(0.0026)	(0.0026)	(0.0016)	(0.0030)
Uncertainty × Exposed	0.0033	0.0018	0.0014	0.0034	0.0094***	-0.0090***	0.0085***	0.0032	-0.0030
	(0.0027)	(0.0026)	(0.0028)	(0.0025)	(0.0036)	(0.0033)	(0.0029)	(0.0020)	(0.0037)
Exposed × Post	0.0107***	0.0101***	0.0091***	0.0116***	0.0025	0.0036	0.0212***	0.0112***	0.0035
	(0.0023)	(0.0023)	(0.0027)	(0.0020)	(0.0025)	(0.0029)	(0.0030)	(0.0018)	(0.0045)
Depositor Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Account Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>20,000	>30,000	>25,000	>25,000	>15,000	>15,000	>15,000	>45,000	>5,000
Baseline Prob. of Running	0.71	0.62	0.72	0.61	0.43	0.48	1.08	0.69	0.39
Baseline Cost of Running (% TD)	1.32	1.31	1.17	1.44	0.44	1.00	2.45	1.40	0.58

Note: Robust standard errors are in parentheses for both Panels A and B (with *** $p<0.01$, ** $p<0.05$, * $p<0.1$).

Table D.3: Heterogeneity Analysis for Fundamentals Subsamples (Depositor-Bank Relationship)

Early withdrawal (0/1)	No Other Products	Other Products	Less than 2 years	More than 2 years	3 Renewals or Less	More than 3 Renewals
DDD	0.0068**	0.0283***	0.0197***	0.0044	0.0161***	0.0093**
	(0.0032)	(0.0070)	(0.0045)	(0.0038)	(0.0046)	(0.0039)
Uncertainty	0.001	0.008***	0.005***	0.000	0.004**	0.001
	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Exposed	-0.002	-0.002	0.002	-0.006***	0.001	-0.005***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Post	-0.002**	-0.004**	-0.002	-0.004***	-0.001	-0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Uncertainty × Post	-0.0025	-0.0053	-0.0052**	-0.0009	-0.0056**	-0.0008
	(0.0016)	(0.0035)	(0.0021)	(0.0021)	(0.0022)	(0.0020)
Uncertainty × Exposed	0.0036*	-0.0004	0.0008	0.0049**	0.0011	0.0041*
	(0.0020)	(0.0042)	(0.0028)	(0.0023)	(0.0029)	(0.0024)
Post × Exposed	0.0093***	0.0134***	0.0090***	0.0122***	0.0097***	0.0111***
	(0.0019)	(0.0035)	(0.0024)	(0.0022)	(0.0025)	(0.0021)
Depositor Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Account Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>40,000	>10,000	>30,000	>20,000	>20,000	>30,000
Baseline Prob. of Running	0.59	0.87	0.64	0.70	0.65	0.68
Baseline Cost of Running (% TD)	1.32	1.30	1.17	1.52	1.39	1.23

Note: Robust standard errors are in parentheses for both Panels A and B (with *** p<0.01, ** p<0.05, * p<0.1).

Table D.4: Heterogeneity Analysis for Idiosyncratic Subsamples

PANEL A: Depositor and Account Characteristics

Early withdrawal (0/1)	Female	Male	Balance <35,000	Balance >35,000	3-month TDs	6-months TDs	1-year TDs	Currency Euros	Foreign Currency
Interest Pay	0.000	-0.000	-0.001	0.000	0.000	0.004*	-0.004*	0.000	-0.000
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.004)
Post	-0.002	-0.001	-0.005**	0.001	-0.003	-0.001	-0.001	-0.001	-0.006*
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.003)
DiD	0.0082***	0.0093***	0.0105***	0.0073***	0.0026	0.0035	0.0166***	0.0091***	0.0066
	(0.0024)	(0.0024)	(0.0030)	(0.0019)	(0.0028)	(0.0030)	(0.0031)	(0.0019)	(0.0047)
Depositor Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Account Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>15,000	>15,000	>15,000	>15,000	>8,000	>10,000	>12,000	>27,000	>3,000
Baseline Prob. of Running	0.56	0.58	1.00	0.18	0.55	0.45	0.71	0.55	0.69
Baseline Cost of Running (% TD)	1.32	1.29	1.18	1.42	0.42	1.02	2.15	1.39	0.59

PANEL B: Depositor-Bank Relationship

Early withdrawal (0/1)	No Other Products	Other Products	Less than 2 years	More than 2 years	3 Renewals or Less	More than 3 Renewals
Interest Pay	0.001	-0.002	0.001	-0.002	0.001	-0.002
	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Post	-0.0003	-0.0051**	-0.0028*	0.0000	-0.0025	-0.0005
	(0.00115)	(0.00241)	(0.0016)	(0.0013)	(0.0016)	(0.0013)
DiD	0.0067***	0.0144***	0.0092***	0.0083***	0.0103***	0.0070***
	(0.0019)	(0.0038)	(0.0026)	(0.0021)	(0.0027)	(0.0021)
Depositor Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Account Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>25,000	>5,000	>20,000	>20,000	>15,000	>15,000
Baseline Prob. of Running	0.42	0.94	0.78	0.28	0.75	0.34
Baseline Cost of Running (% TD)	1.29	1.35	1.25	1.39	1.42	1.17

Note: Robust standard errors are in parentheses for both Panels A and B (with *** $p<0.01$, ** $p<0.05$, * $p<0.1$).

Table D.5: Heterogeneity Analysis for City of Athens

Runner (0/1)	(Strategic) City of Athens	(Strategic) Not Athens	(Idiosyncratic) City of Athens	(Idiosyncratic) Not Athens	(Fundamentals) City of Athens	(Fundamentals) Not Athens
Uncertainty (or Interest Pay)	0.003	-0.001	0.004*	-0.001	-0.001	0.004**
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Post	0.005***	0.002*	0.001	-0.003**	-0.004*	-0.001
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Uncertainty × Post	-0.0014	0.0048***	0.0060*	0.0101***	0.0022	0.0035
(DD)	(0.0027)	(0.0017)	(0.0032)	(0.0021)	(0.0034)	(0.0023)
Exposed					-0.0029	-0.0029***
					(0.0019)	(0.0010)
Uncertainty × Exposed					-0.0035	-0.0030*
					(0.0027)	(0.0018)
Exposed × Post					0.0104***	0.0105***
					(0.0033)	(0.0019)
DDD					0.0175***	0.0107***
					(0.0056)	(0.0036)
Depositor characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Account characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>10,000	>20,000	>10,000	>20,000	>15,000	>30,000
Baseline Prob. of Running	0.38	0.40	0.29	0.70	0.66	0.67
Baseline Cost of Running (% TD)	1.22	1.37	1.30	1.32	1.35	1.31

Note: Robust standard errors are in parentheses for both Panels A and B (with *** p<0.01, ** p<0.05, * p<0.1).

Table D.6: Heterogeneity Analysis for Small and Large Branches

Early Withdrawal (0/1)	(Strategic) Small Branches	(Strategic) Large Branches	(Idiosyncratic) Small Branches	(Idiosyncratic) Large Branches	(Fundamentals) Small Branches	(Fundamentals) Large Branches
Uncertainty (or Interest Pay)	0.003	-0.000	-0.002	0.000	-0.000	0.003**
	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)
Post	-0.001	-0.002	0.001	0.003***	-0.001	-0.002
	(0.002)	(0.001)	(0.003)	(0.001)	(0.002)	(0.001)
Uncertainty × Post	-0.0021	0.0037**	0.0091***	0.0060*	0.0031	0.0022
(DD)	(0.0036)	(0.0016)	(0.0046)	(0.0019)	(0.0043)	(0.0021)
Exposed					-0.0020	-0.0030***
					(0.0022)	(0.0010)
Uncertainty × Exposed					-0.0017	-0.0036**
					(0.0033)	(0.0017)
Exposed × Post					0.0071*	0.0112***
					(0.0039)	(0.0018)
DDD					0.0137**	0.0125***
					(0.0070)	(0.0034)
Depositor characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Account characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>7,000	>23,000	>7,000	>23,000	>10,000	>40,000
Baseline Prob. of Running	0.49	0.38	0.70	0.53	0.66	0.67
Baseline Cost of Running (% TD)	1.35	1.31	1.34	1.30	1.35	1.31

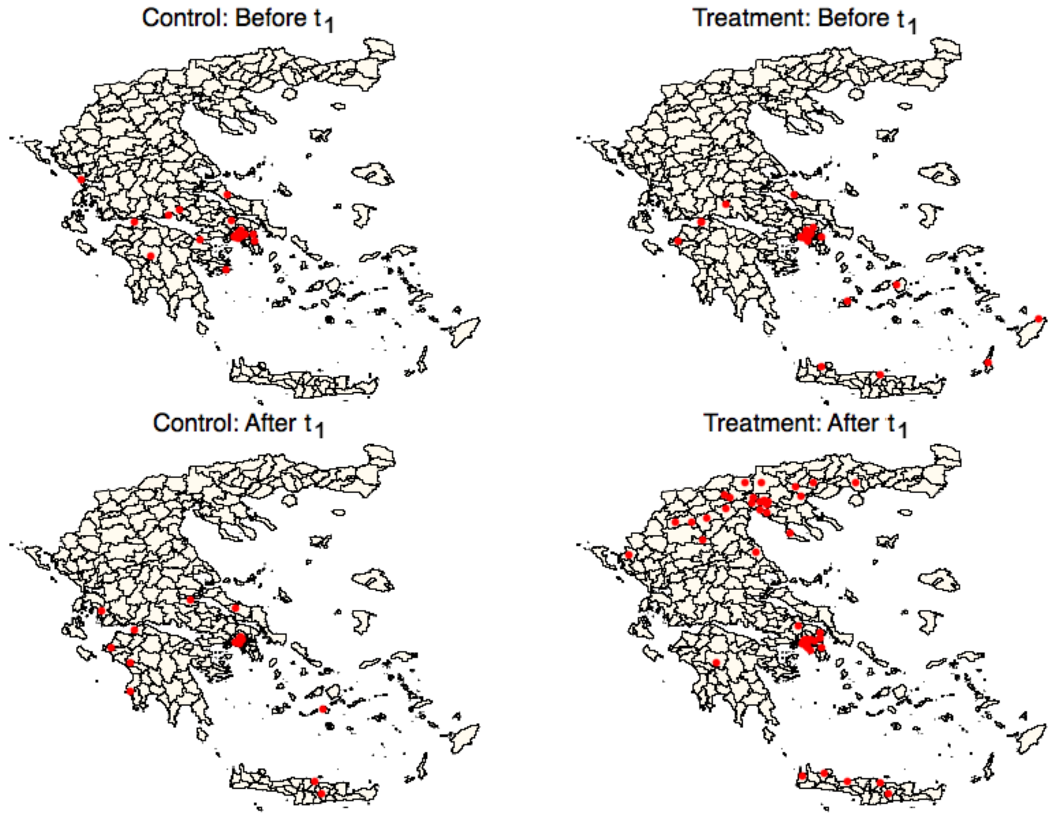
Note: Branch size is defined as those below and above the median in their number of time deposit accounts. Small branches are those with 200 or less daily TD accounts on average, and large branches are those with more than 200 daily TD accounts on average. Robust standard errors are in parentheses for both Panels A and B (with *** $p<0.01$, ** $p<0.05$, * $p<0.1$).

Table D.7: Heterogeneity Analysis on Political Views

Early withdrawal (0/1)	(Strategic) Against Grexit (<50%)	(Strategic) Pro-Grexit (>50%)	(Idiosyncratic) Against Grexit (<50%)	(Idiosyncratic) Pro-Grexit (>50%)	(Fundamentals) Against Grexit (<50%)	(Fundamentals) Pro-Grexit (>50%)
Uncertainty (or Interest Pay)	0.002	-0.000	-0.001	0.000	0.002	0.003*
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Post	0.002*	0.003**	-0.004**	-0.000	0.000	-0.003**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Uncertainty × Post	0.0019	0.0032*	0.0094***	0.0086***	0.0028	0.0022
(DD)	(0.0024)	(0.0018)	(0.0029)	(0.0022)	(0.0032)	(0.0023)
Exposed					-0.0028**	-0.0028**
					(0.0014)	(0.0012)
Uncertainty × Exposed					-0.0041*	-0.0028
					(0.0023)	(0.0019)
Exposed × Post					0.0090***	0.0113***
					(0.0026)	(0.0021)
DDD					0.0167***	0.0103***
					(0.0051)	(0.0038)
Depositor characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Account characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Observations	>10,000	>20,000	>10,000	>20,000	>15,000	>35,000
Baseline Prob. of Running	0.32	0.45	0.75	0.46	0.55	0.73
Baseline Cost of Running (% TD)	1.34	1.31	1.32	1.30	1.34	1.30

Note: Robust standard errors are in parentheses for both Panels A and B (with *** p<0.01, ** p<0.05, * p<0.1).

Figure A.4: Spatial Autocorrelation in Deposit Withdrawals across Branches

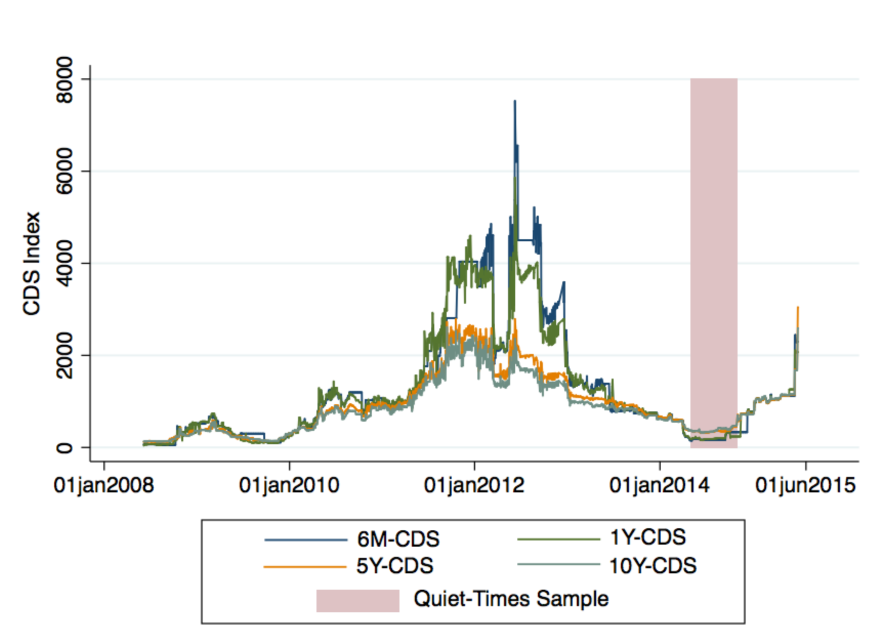


Note: The red dots correspond to branches with deposit withdrawals exhibiting positive spatial autocorrelation with nearby branches, as measured by local Moran's I_i. Spatial autocorrelation measures the correlation of a variable with itself through space. In this case, withdrawal behavior in one branch relative to nearby branches. Positive spatial autocorrelation occurs when similar values occur near one another. The two maps to the left correspond to the control period with no news shock. The two maps to the right belong to the treatment period with the news shock at t_0. The two top maps represent the period before the announcement at t_0, while the two maps at the bottom correspond to the period after the surprise news at t_0.

Appendix E Greek CDS Index and Sovereign Bonds Spreads

Figure E.1: Greek CDS Index and 10-Year Bond

Panel A: Greek CDS for Different Maturities (2010-2015)



Panel B: Greek Bond Spread with respect to German Bond (2010-2015)

Note: Panel A plots the Credit Default Swap Index for Greece, normalized to 100 for June 2008. The shaded area represents the sample period between March and November 2014. Panel B shows the 10-year Greek bond spread relative to the German 10-year bond.

Appendix F Extrapolation to Other Uncertainty Episodes

F.1 Extrapolation to all Bank and all Greek deposits

We evaluate whether our estimates can explain the overall decline of deposits at The Bank and at the Greek banking sector during the time period. The combined increase in CDS prices between t_0 and t_1 (6-weeks) was 219%. Our estimates predict that during the same period there should be: 1) 1.68% of depositors withdrawing because of idiosyncratic reasons (0.04% daily $\times$ 42 days); 2) 1.14% of depositors withdrawing because of strategic motives (baseline of 1.68% withdrawals $\times$ 68% estimate); 3) 3.23% of depositors withdrawing because of fundamental motives (baseline of 1.68% withdrawals $\times$ 192% estimate); and 4) 1.68% of depositors withdrawing because of interest payments on January 1st (using the elasticity, a lower cost of 0.83% leads to a 100% higher probability of withdrawal w.r.t the baseline of 1.68%).

Our estimates predict that an increase in CDS of 219% resulting in both strategic and fundamental uncertainty will lead 7.73% of depositors to withdraw their time-deposits. in the data, we observe that total time-deposits at The Bank dropped by 8%, and total time-deposits in the Greek banking sector declined by 10%. Thus, the magnitude of our estimates of deposit-withdrawal sensitivities aligns well with the magnitude of the aggregate decline in deposits in Greece during the same time period.

F.2 Other Episode Where Country Fundamentals Changed

In this subsection we calibrate our estimates to changes in CDS prices taking place after events that indicated the (possible) exit of Italy from the Eurozone ('Italexit', 'Italeave', or—domestically—'Euroscita') in 2018. During this period there was an increase in aggregate policy uncertainty after an unexpected coalition to form government between two anti-Europe parties (populist Five Star Movement, the right-wing League). Prior to the March 2018 elections, both parties had antagonized each other and expressed no intention of cooperating when in government. Coalition negotiations between both parties became public in May, when a draft for a coalition agreement was leaked in the media.This draft reclaimed radical changes to the Stability and Growth Pact, along with €250 billion from the ECB. It also supported "the introduction of specific technical procedures for single states to leave the Eurozone and regain monetary sovereignty." These news increased policy uncertainty in the country.

When comparing the Italian episode to our analysis of the Greek elections, we can distinguish between two key events. The fist event took place on May 15, 2018, when the draft for a coalition agreement was leaked. The second event is the formation of a new government on May 29, 2018. The first event can be compared to our shock at t_0, since it created policy uncertainty for depositors with long-run maturity expiration, but not for short-run maturity deposits (since policies could not be implemented until after the appoint ment of government). Depositors with shorter maturity expiration only faced a change in their expectations on how other depositors will behave. The second event is comparable to our shock at t_1, when a new government is appointed and all depositors are exposed to policy uncertainty.

Over this 2-week period the CDS price on Italian sovereign bonds increased by 177% during this period of policy uncertainty. During that quarter, almost 4% of time deposits hold by households with maturities shorter than two years were withdrawn.[25] As in Greece, there were no bankruns, only a progressive leakage of depositors out of the system during that period. For an equivalent increase in CDS prices, our estimates predict that, in the month following the election, 5.31% of total time deposits with maturities shorter than one year will be withdrawn for an equivalent CDS change.

F.3 Other Episodes Where Bank Fundamentals Changed

We end by evaluating how our estimates predict deposit withdrawals in recent episodes of bank runs.

F.3.1 Northern Rock

The first is the bank run on Northern Rock in 2007. On September 14, 2007, Northern Rock sought and received a liquidity support facility from the Bank of England. The motive for such an emergency measure was the run on deposits of Northern Rock that took place Friday 14 and Monday 17 September, 2007. It all started in August 9, 2007, when interbank and other financial markets froze. Because of Northern Rock's funding model (requiring mortgage securitization), markets anticipated that there was a probability that the bank will run into trouble because of its next securitization being scheduled for September 2007. During August 10 and mid-September Northern Rock and the British government and regulators tried to find a solution to the liquidity crisis. The main three options under discussion were: 1) Northern Rock finding a solution to its liquidity crisis on its own by means of short-term money markets and securitization; 2) Northern Rock being taken over by another major retail bank; and 3) Northern Rock receiving a support liquidity facility from the Bank of England and guaranteed by the Government. [26]

After Northern Rock unexpectedly asked for liquidity to the Bank of England, its 5-year CDS price increased 180%. Northern Rock lost £10 billion of its £30 billion savings book (33% loss), with £4.4 billion in deposits withdrawn on September 14 (21% of total deposit

[25] See Bank of Italy's sectoral breakdown of MFI deposits as reported by the ECB

[26] For details, see: https://publications.parliament.uk/pa/cm200708/cmselect/cmtreasy/56/5607.htm

amount).[27] Our model predicts that such an increase in the CDS will result in 11% of time depositors leaving the bank.[28]

F.3.2 Washington Mutual

We also consider deposit withdrawals during the bank-runs on Washington Mutual (WaMu). WaMu's first bank run took place on July 12, 2008, centered in Southern California after the federal government seized IndyMac following a $1.3 billion bank run. The second run started on September 11, 2008, when Moody's rated WaMu's financial strength at D+ and downgraded the company's debt rating to junk status. These news and Lehman Brothers' bankruptcy on September 15, 2008, sparked another bank run.

On September 26, 2008,Washington Mutual filed for bankruptcy. In the month prior to the first bank run, the 5-year CDS of WaMu increased by almost 100%. In September 16, 2008 (last day WaMu was traded on CDS markets), the CDS premium increased by more than 100%. Our estimates predict that such increases in CDS will result in 6% withdrawals of total deposits. During these episodes, WaMu depositors withdrew $16.7 billion out of their savings and checking accounts over the next 10 days after the bankruptcy announcement. These withdrawals accounted for 9% of WaMu's total deposits.

[27] See, e.g., Financial Times "Northern Rock fall sees outflow of savings," https://www.ft.com/content/2e3bc984-9a07-11dc-ad70-0000779fd2ac

[28] One key difference between Greek and British deposits is the level of insurance. While Greek retail deposits are insured up to €100,000, the UK government only guarantees 100% of the first £2,000 and 90% of the next £33,000. That is, in the UK only £31,700 are insured per deposit.