Financial Data Transparency, International Institutions, and Sovereign Borrowing Costs

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Abstract

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What explains variation in sovereign borrowing costs, and what role does information about the state of a country's financial sector play in the determination of those costs? Investors charge more interest when there are higher default risks. When estimating default risks, investors consider more than explicit public debt levels and include the risk that the financial sector poses to sovereigns in their calculations. Investors are more confident of their assessments when regulators release credible data on the shape and health of their financial sectors. Investors reward more transparent governments with lower sovereign borrowing costs. At the same time, we predict that the effectiveness of transparency declines as public debt increases. Testing this argument requires a measure of transparency, so we create a new Financial Data Transparency (FDT) Index. The Index measures governments' willingness to release credible financial system data. Using the FDT and a sample of high-income OECD countries, we find that such transparency reduces sovereign borrowing costs. The effects are conditional on the level of public indebtedness. Transparent countries with low debt have lower and less volatile borrowing costs.

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1 Introduction

In September 2016, rumors hit the press that Deustche Bank, the largest bank in Germany, was facing a possible 14 billion dollar fine from the US Department of Justice as a settlement to a case involving sales of mortgage-backed securities. A central concern raised in the media coverage was whether the bank could pay such a fine–it had set aside less than half the rumored fine amount to cover litigation costs.[1] In the wake of these media reports, the price of Deutsche Bank stock dropped precipitously. Investors not only hammered the bank's stock, they also became nervous about the default risk of the German government, with the market's estimate of the five-year probability of sovereign default doubling from about eight per cent at the beginning of the month to 16 per cent at the end of the month.[2] The expectation was that the bank with a balance sheet equal to 58 per cent of Germany's GDP was too big to fail, and the German government would be on the hook if Deutsche Bank were to collapse, increasing its default risk.

This story illustrates several factors that we address in this paper. There is a clear nexus between the viability of major private financial institutions and the sustainability of a sovereign's debt burden where these institutions are located. This affects market expectations about sovereign debt. Rather than focus on specific events, such as one-time fines, this paper considers how sovereign investors use the overall level of information available about potential risks from the financial sector.

We build on recent work in the political science and economics literatures that explores the determinants of sovereign borrowing costs. This work has emphasized the importance of "economic fundamentals", such as the debt to GDP ratio (Ardagna et al., 2007; Baldacci and Kumar, 2010) and liquidity risks. Bernoth et al. (2012) argue that risk premiums increase with fiscal imbalances and depend negatively on financial market size. Beirne and Fratzscher (2013) find that a deterioration of fundamentals during the euro crisis, along with contagion of those fundamentals, is the main explanation for the increase in sovereign bond spreads not only in Europe, but also globally, in the wake of the crisis. Within political science, scholars of comparative and international political economy also have identified a variety of ways in which politics influences sovereign debt markets. Partially building on North and Weingast (1989), Shultz and Weingast (2003) claim that there is a "democratic advantage", where democracies have lower bond spreads than autocracies as they have stronger political incentives to repay. This work has spurred a sub-literature on how political regime type affects the political consequences of defaulting and politicians' willingness to repay (e.g. Beaulieu et al., 2012; DiGiuseppe and Shea, 2015; Saiegh, 2005). More recently authors have highlighted the political incentives that democratic politicians may have not to

[1] *Business Insider Deutschland*, 16 September 2016.

[2] Holger Zschaepitz, "Doom loop: Deutsche Bank has become a threat for Germany's credit stability. Default probability has shoot up on Deutsche woes". 30 September 2016 https://twitter.com/Schuldensuehner.

repay (e.g. DiGiuseppe and Shea, 2015; Walter, 2013). Still others focus on the importance of elections (e.g. Spanakos and Renno, 2009), constitutional checks and merchant power (Stasavage, 2007), and reputation Tomz (2007). Another set of political scientists emphasize the role of signals and information. Gray (2013) focuses on the international organizations that developing countries join as signals to investors about their "quality", with countries that join more stable organizations receiving better terms from international investors. Brooks et al. (2015) similarly argue that investors who focus on emerging market sovereign debt put countries in "peer" groups–based on geography, credit ratings, and level of development–as heuristic shortcuts.

We follow this emphasis on information provision in the existing political economy literature of sovereign borrowing costs to ask the following questions: how do investors know what a government is doing, and in particular how forthright is the government about the risks threatening its fiscal position? The existing literature on "fiscal transparency" focuses on what information governments provide publicly about their explicit debts. Indeed, "fiscal transparency" is a popular topic with international organizations, non-government organizations, and academics. The International Monetary Fund (IMF) has actively pushed governments to publish budget information through its Fiscal Transparency Code and its (voluntary) Fiscal Transparency Evaluations.[3] In terms of measurement of the concept, the International Budget Partnership publishes biannual transparency reports for several countries, and it provides training for civil society groups on how to use information from governments to make those governments more accountable. Greater fiscal transparency, in turn, affects what governments do with their fiscal policies–higher transparency has been found to lead to lower borrowing costs (Glennerster and Shin, 2008) and less "creative accounting" that could obscure public expenditures (Alt et al., 2014). Wehner and de Renzio (2013) consider the political determinants of fiscal transparency and conclude that free and fair elections promote more transparent governance.

This work considers governmental reporting of *public financial data*; that is, data on the government's own accounts. But government supervisors also examine the accounts of private sector actors, and banks in particular. As the global financial and euro area crises have reminded us, risks on financial institutions' balance sheets frequently create significant risks for public budgets. Banking crises depress growth and so tax revenue. Restructuring failed banks can involve significant public funds (Laeven and Valencia, 2012). Given this, Irwin (2015) argues that releasing *information on financial system risks* should be considered an important component of fiscal transparency. The amount of information financial supervisory agencies provide publicly constitutes an important component of financial supervisory transparency and therefore information about the ability of the public to pay back creditors.[4]

[3]The Fund revised its Code in 2014 and is in the process of revising its manual that provides additional details; see http://www.imf.org/external/np/fad/trans/. Accessed January 2015.

[4]Following the broader transparency work, a sub-literature claims that supervisory transparency is desirable for other

Yet on the academic side there have been few examinations of supervisory transparency or its impact on fiscal policy and sovereign borrowing costs. One reason for this gap may be because of data problems–we currently lack a robust and cross-nationally comparable way to measure financial regulatory transparency that could be used to test how it affects stability.

The political science and economics literatures on sovereign debt prices have tended to treat economically developed and developing countries differently (Abbas et al., 2014; Bernoth et al., 2012; Bellas et al., 2010; Brooks et al., 2015). Much of the political science research has been on developing countries. Important reasons for this are discussed in (Brooks et al., 2015, 589). Investors tend to focus more on macroeconomic factors for developed countries–rather than factors such as heuristics, which they show play a larger role in investor decisions for developing countries. Developed countries have larger and more complex financial systems than less developed ones. As the 2008 and subsequent crises remind us, these systems can pose significant fiscal risks, which can be difficult to gather information on and to evaluate due to their complexity. More attention is needed to understand how investors evaluate financial risks to sovereigns in developed countries with complex financial markets.

We fill these gaps in the literature by first using a Dynamic Hierarchical Bayesian Item Response Theory approach to develop a new Financial Data Transparency Index. The Index measures these countries' reporting of financial system information to the World Bank's Global Financial Development Database (GFDD) (World Bank, 2015). The Index is a unique indicator of countries' willingness to credibly reveal information about the structure of their financial system and their regulatory quality, as the data has to pass World Bank and International Monetary Fund quality checks. If a country reports data on its financial system through international organizations that subsequently make the data freely available, it is easier for international investors to scrutinize the safety and soundness of the banking system.

We use this index to consider whether financial reporting transparency is related to changes in sovereign borrowing costs in developed economies with large and complex financial systems. Our expectation, derived from a new formal model, is that actors in sovereign debt markets pay attention to the relative size and stability of the banking sector. They anticipate that large and unstable financial sectors could lead to large and sudden increases in the government's debt burden. We expect that states with higher FDTfin scores will have lower and less volatile borrowing costs as investors penalize countries where they are not able to assess risks from the financial sector.

In our empirical examination, we find that transparency tends to reduce sovereign borrowing costs conditional on a country's public indebtedness. Governments with low debt levels benefit from higher

reasons as well–it has been lauded as enhancing market stability (Arnone et al., 2007) and democratic legitimacy (Gandrud and Hallerberg, 2015).

transparency. We also find that countries with high transparency at lower debt levels also have lower bond spread volatility.

2 Setting

2.1 Developed country setting

As suggested in the introduction, there are reasons why analyses of sovereign debt spreads usually have data from either developed, or developing, countries. For the purposes of this paper, we focus on developed countries. An extension to developing countries would need some additional modifications that would make it a different paper. Emerging markets face a fundamentally different borrowing environment than developed countries for the following reasons. Eichengreen et al. (2007) explain, first, the former set of countries suffer from what the literature colloquially calls "original sin". This means that they are not able to borrow in their own currency. The practical implication for our study is that currency fluctuations have a direct effect on debt sustainability. A currency depreciation, which reduces the purchasing power of domestic output relative to foreign claims, makes it harder to service the public debt while an appreciation has the reverse effect. There are also indirect effects. A country hit by a terms-of-trade shock would ease fiscal and monetary policies if its debt were in its own currency. A country with original sin, however, may have to tighten its macro-economic policies. Developed countries that can borrow in their own currencies do not face these constraints. Second, such countries also face "debt intolerance". As Reinhart et al. (2003) argue, investors stop lending to emerging markets at lower levels of debt to GDP than they do to developed countries. This suggests that there is a lower debt cap, so that such countries do not appear in the data set at levels we characterize as "high" later in the paper. Moreover, if there is systematic debt intolerance, whether because of actual previous external defaults or because of a general wariness of emerging markets, the relative sensitivities of spreads to changes in debt are systematically different.

2.2 Risk information

When making investment decisions, investors need to know something about a country's fiscal health in order to assess the risk that they will not be paid back. Consequently, in order to understand one important avenue through which public institutions shape investment decisions, one needs to examine where such information comes from and what type of information market actors care about most. The first step would be to look directly at policy choices and what effect these have on the government's fiscal position. Very high debt levels could make it more difficult for a government to repay in the future.

Budget deficit levels provide an indicator of the rate of change of debt. Ireland, for example, had a low debt level of below 30 percent of GDP in 2007, but it had very large budget deficits, including over 30 percent alone in 2010, which pushed up the debt level considerably. In her study of sovereign debt costs, Mosley (2000) argues that market actors pay attention to budget deficits and also to the current interest rate in the belief that borrowing under high interest rates is not sustainable. She finds that other types of economic indicators do not affect interest rates that sovereigns pay.[5] Similarly, Baldacci and Kumar (2010) find that sovereign debt spreads remain low at low levels of debts and deficits, but as they approach levels markets find worrying they jump up.

While Mosley and Baldacci and Kumar considered direct measures of public debt sustainability, we hypothesize that markets evaluate other risks to sovereigns' debt positions in addition to these variables. Specifically, we argue that investors pay attention to risks from the private financial sector. Our hypothesis is grounded in a reading of all Standard & Poors' (S & P) credit reports that the agency issued when it either upgraded or downgraded one of the countries in our data set in the time period covered by our data sample. Out of 92 possible cases, about half explicitly discuss the health of the financial sector and its implications for sovereign debt. There is an interesting divide between the type of report, however, with about two thirds of downgrades (25 of 41) discussing the private financial sector while only about one third of upgrades (18 of 49) do so. This provides support for the contention that investors–and especially a credit agency that an investor might refer to for information and analysis–explicitly factor the health of the financial sector into their calculations of sovereign creditworthiness.[6] This discussion begs the follow question–where do investors get their information about these risks?

The information that governments themselves report about their financial sectors is an important source for both rating agencies and investors because the government is usually liable if the sector has a crisis.[7] If the financial sector gets in trouble, the government may be the only actor that can assist–bail out–banks and other private financial institutions Moreover, governments may implicitly or explicitly guarantee (or even own) financial institutions such as mortgage lenders, postal savings banks, and development banks. These liabilities may not appear on government accounts until after guarantees are called, yet they represent potentially significant and very large obligations that could threaten sovereign

[5]Her dependent variable is the interest rate on longer-term, domestic currency denominated government bonds. This variable complicates identification as it could also include exchange rate risk.

[6]Relatedly, there are also worries about the connection between private sector financial sector debt and the public sector. As S & P writes concerning South Korea in October 1997, "Most worrying, however, given the rising level of moral hazard throughout the economy, is the diminished ability of investors to distinguish between the credit risks of Korea's public and private sectors, to the detriment of both". There are, in practice, 90 clear downgrades or upgrades because two cases are really "convergent" between the local and non-local currencies used in the rating. Data used in Cordes (2014). We thank Til Cordes for making his data set available to us.

[7]This assertion is partially based on an interview conducted with a sovereign bond investor at a major United States-based hedge fund, who emphasized the importance of assessing financial sector risks using publicly provided data. Without such credible data, he noted that it was much more difficult and time consuming to evaluate default risks. As such, he believed that a given country's borrowing costs partially reflected the level of credible data available about its banking industry.

creditworthiness. This means that investors find information about the health of the financial sector relevant when thinking about the solvency of the public sector. Information that governments disclose through international financial institutions is useful for investors.

While the S & P reports are clear about the importance of the financial sector, one can also ask whether credit agencies care about the overall level of transparency as well. Indeed, there is anecdotal evidence that they use precisely the type of data that the IMF reports and that we use in the construction of our index below. During the East Asian crisis, Standard and Poor's expressed concern about the lack of transparency in Indonesia but praised "improvements in prudential regulations, transparency and disclosure" in Malaysia.[8] For Guatemala in 2001, Standard & Poor's complained that "The extent of financial-sector fragility is hard to estimate given off-balance-sheet operations and the size of offshore banking (estimated to approximate the size of the regulated system)".[9] In a Standard & Poor's note on Ireland in 2011, the agency indicated that it would resolve its "CreditWatch" on the Irish sovereign only after it had received more information that would "identify domestic banks' additional capital needs."[10] Note, of course, that agencies would only comment on transparency when it was absent.

2.3 When financial regulatory transparency matters

There are good reasons to believe that the effect of financial transparency on sovereign borrowing costs may be conditional on another variable; specifically, creditors may be more concerned with financial regulatory transparency depending on a government's overall fiscal condition. Mosley (2000) argues that, because gathering and using information is costly, creditors strategically gather information to maximize the net marginal benefit for their investment decisions. As such, investors gather more information when the default risk is highest (Mosley, 2000, 743). She finds that investors pay closer attention to inflation, deficits, and overall debt levels when default risks are high. Brooks et al. (2015), Gray (2009), and Gray and Hicks (2014) argue that investors use relatively "unknown" countries' peer groups–e.g. fellow international organization members, countries with similar levels of economic development–as an indicator of their ability and willingness to repay. Each of these pieces assumes a conditional relationship. Investors care about a given indicator only when something else is the case–high default risks or a general lack of information.

Complementing previous work aiming to understand where investors get and use information, in this paper we focus on the government's debt level. Contrary to Mosley's general argument (2000), the formal model we develop below leads us to believe that investors actually use information about financial supervisory transparency more at lower levels of debt, in ways that change their interest rate choices.

[8] Standard & Poor's 1998_04_17 Malaysia
[9] 2001_10_18 Guatemala
[10] 2011_02_02_Ireland

If, while scrutinizing countries, investors find that it is difficult to assess fiscal risks from the banking system due to regulatory opacity, they may demand a higher risk premium.

2.4 Why transparency through international institutions matters

Before developing our formal model for understanding the details of strategic interactions between governments and investors, it is important to elaborate on why we focus on information about domestic financial systems provided through international institutions. The major international financial institutions, such as the World Bank, International Monetary Fund, and the Bank of International Settlements, frequently gather data from national supervisors about their financial systems and publish this data at regular–usually yearly–intervals. In addition to collecting the data, they have also promoted supervisory transparency. The Basel Committee for Banking Supervision added supervisory transparency to its Core Principles for Effective Banking Supervision in 2006. Following the East Asian crisis of the late 1990s, the IMF included transparency in its Code of Good Practices on Transparency in Monetary and Financial Policies that it issued in 1999.[11] The IMF has a Financial Sector Assessment Program where it conducts voluntary reviews of the stability of financial sectors and the development of those sectors, with "transparency" one consideration. While it is up to the country in question to approve publication of the review, most of them are available online, and they usually note the extent to which a given country observes the Fund's standards and codes.[12]

In order for supervisory data to be useful to investors–who face significant information gathering constraints in a world with numerous sovereign debt investment opportunities (Mosley, 2000, 742-743)–, it needs to be accessible, comparable, and credible. Releasing data to international organizations helps achieve these goals. By aggregating and publishing national supervisory data, international institutions make it much more accessible to investors. For example, all of the underlying data used in the FDT Index was downloaded from the World Bank in one spreadsheet. In contrast, Gandrud and Hallerberg (2015) found that it is often very difficult to gather data directly from national supervisors and use it to make meaningful comparisons. This is due not only to a lack of electronic availability, but also inconsistent file formats, definitions, and periodicity. The credibility of figures released solely by national supervisors may also vary. International institutions request data that is comparable across countries and release it in consistent formats. They also conduct quality checks on the data. These checks are done by international institution staff who are independent of national supervisors, governments, and banks.[13] They have little or no incentive to have the data present an unduly positive picture of a country's banking sector. By submitting data for review by international institutions, national supervisors are committing to release

[11] See http://www.imf.org/external/np/mae/mft/Code/index.htm. Accessed September 2014.
[12] See http://www.imf.org/external/np/fsap/fssa.aspx. Accessed January 2015.
[13] From an email exchange with IMF staff.

more credible supervisory data.[14] All of these characteristics make supervisory data provided through the international financial institutions particularly useful for international investors' decision-making.

3 Model: choosing transparency

In this section we develop a signaling model to understand how investors and governments interact, how these interactions affect governments' decisions to reveal information about their financial systems through international institutions, and what effects these decisions have on sovereign bond interest rates.

Players, preferences, and payoffs The game consists of two players: an international sovereign bond investor I and a government G. The investor I expects a return r_D from payments g_k made by the government based on the terms of bonds that the government issues to finance its debt, D. The investor is concerned about non-repayment under the bonds' terms. She assumes that payments in the future (time $t+1$) are a monotonic function f of the government's debt level D_t and their ability to repay in the next period A_t, e.g. ability to raise taxes and/or cut spending to meet scheduled payments. So, $g_k = f(A_t,\ D_t)$. To simplify our exploration of the role that information about the financial sector may play in investors' decisions, we assume that A_t is constant and known to all players. As such, we do not explicitly consider it below. Natural extensions of the model would allow it to vary and/or be private information.

The investor has a reservation return r_R. Below this level, the investor will not agree to purchase the government's bonds and instead they will invest in another sovereign's debt. The investor would be happy to make a return greater than her reservation return, but this is not possible in the game because if she sets $r_k > r_R$ then other investors will enter and offer r_R. She will be outbid. For simplicity, we assume that the investor prefers to purchase government debt rather than being outbid. She sets the interest rate she will pay for government debt r_k in an attempt to meet r_R depending upon the environment.

The government G wants to pay the lowest interest rate on its debt.

The payoff from government repayment g_k at interest rate choice r_k for the investor is $U^I = g_k - r_R$. The government prefers g_k to be the lowest (L) interest rate, so their payoff is $U^G = r_L - r_k$.

Environment For simplicity, we model four states of the public sector debt burden D. It can be low (L), high (H), very high (V), or very very high (VV).

[14] Private firms do release their own data. However, these data often do not capture the same quantities across countries, and may even be inconsistent within countries, because of varying standards and requirements on reporting depending upon the legal form of the financial institution, whether they are subject to market reporting requirements, and the like.

The government's total debt level D has two components. The first is explicit government liabilities. In practice, this is the government debt burden it reports, or X, where $X \in \{L, H, V, VV\}$. The second component is implicit government liabilities, M where $M \in \{L, H\}$. These do not appear on the government accounts. They may, however, appear as formal government guarantees, or they may not appear at all in any reports, but they exist because one or more financial institution is considered by politicians as "too big to fail" and will receive public money if they get into trouble (see Deo et al., 2015). In principle, M is any possible contingent liability, which would include guarantees to state-owned enterprises, implicit guarantees to public-private partnerships, and future pension obligations (Brooks, 2009). In practice, Bova et al. (2016) find that the largest implicit liabilities that become explicit quickly are those that arise in the financial sector, and here we focus on them.

During a systemic banking crisis, the government is usually the only actor who can step in to end the crisis. If implicit liabilities become explicit liabilities due to government assistance they will greatly increase the government's debt burden. So, the investor will want to include implicit liabilities in any debt sustainability analysis.[15]

The financial sector has a risk profile that we denote with ϕ. If the financial sector is performing well and there is little likelihood of a systemic banking crisis, the risk of implicit liabilities from the financial sector becoming explicit and hurting the public finances is low (ϕ_{L}). If it is not performing well and there is a chance of a systemic banking crisis, the risk to the public finances is high (ϕ_{H}).

In sum, the debt level that the investor wants to calculate at time t to estimate the probability that they will be paid according to the terms of the debt agreement is given by:

$$D_t = X_t + \phi_t M_t \tag{1}$$

Information We assume that the investor and the government know X_t. The explicit liabilities of the government are public information. Only the government, however, has information about the size of M and the state of the financial sector, which determines ϕ. The reason is that it has supervisors who aggregate information from across the sector more or less in real-time. This makes the government the sender in this signaling game. The investor, in turn, is the receiver.

Government transparency choices The government has two choices. It can $HIDE$ the state of the financial sector or it can $REVEAL$ the information through international organizations. In terms of the investor, if the government reveals what it knows, then the investor also knows $\phi_t M_t$. For notational

[15] As a 2015 IMF Working Paper notes, "A rough indicator of the government's exposure is given by the liabilities of the financial sector" (Irwin, 2015, 12). Note as well that there are other implicit liabilities common in the literature, such as those that arise from sub-national governments or state-owned enterprises. This model is generalizable to those cases, although we focus only on the implicit liabilities from the financial sector here.

simplicity we use Γ_t to signify $\phi_t M_t$. It constitutes the "type" that varies in this signaling game.[16] The investor also observes the government's behavior, that is, whether G chooses $REVEAL$ or $HIDE$. Note that because we focus on data provided through international organizations that check its veracity, we assume that the information the government provides when they $REVEAL$ is credible.

Investor choices To reach her reservation return, the investor can choose to finance G in time t at a low interest rate (r_{L}), a high rate (r_{H}), or a very high rate (r_{V}). The interest rates match the investor's understanding of D_t.

Note a key constraint of the model: the investor cannot increase the interest rate indefinitely. At the point that the government is unwilling or unable to pay the interest rate needed to clear the market for its debt it creates an "effective interest rate ceiling". It does this by using one or more of the following measures: (a) non-market interventions that generate domestic private sector demand for its debt, (b) borrow from official creditors abroad (e.g. the IMF), and/or (c) have the domestic central bank print money and buy its debt (Abbas et al., 2014, 6).[17] The government will create an interest rate ceiling when the costs–e.g. loss of policy control, inflation–of doing so are less than the difference between the market clearing price in the absence of the interest rate ceiling and r_V for the volume of debt that it issues. The risks to the investor of charging a lower interest rate than the interest rate ceiling make the expected return less than what the investor prefers. Please see the supplementary files for a detailed discussion.

In order to calculate D_t the investor is concerned with the size of M and the probability that it becomes part of X_{t+1}. As such, she searches for information on Γ_t. If Γ_t is low, D_t corresponds to X_t. If Γ_t is high, she increases her assessment of D_t one level above X_t, so:

$$\begin{array}{ccc} D_{VV} & \text{if} & X_V \wedge \Gamma_H \\ D_V & \text{if} & (X_H \wedge \Gamma_H) \vee (X_V \wedge \Gamma_L) \\ D_H & \text{if} & (X_L \wedge \Gamma_H) \vee (X_H \wedge \Gamma_L) \\ D_L & \text{if} & X_L \wedge \Gamma_L \end{array}. \tag{3}$$

The investor then matches her perceived view of D_t to the minimum interest rate she needs to finance new government debt–r_R. If she thinks that the total government debt D_t is low, she buys government bonds at low interest rates. If D_t is thought to be high she buys bonds only at high interest rates. If D_t

[16] Formally, $\Gamma \in \{L, H\}$ where

$$\begin{array}{ccc} \Gamma_H & \text{if} & \phi_H \wedge M_H \\ \Gamma_L & \text{if} & \phi_L \wedge (M_L \vee M_H) \end{array}. \tag{2}$$

[17] The last measure is only possible for governments not suffering "original sin," which means that they have debts in their own currencies and they can print money to pay those debts. This option is in practice available only to developed countries.

is thought to be very high she buys bonds only at very high rates.

At very high explicit debt levels information about the financial sector does not affect the *observed* interest rate. This is not because investors do not perceive a higher risk that would incline them to set a higher interest rate, but instead because an effective interest rate ceiling is created by the government by taking measures to clear the market at r_V. In such situations, investors ration credit to the government, which the government compensates for by using one or more of the three policies mentioned above. The observable effect of these dynamics is that interest rates are at r_V if $(X_H \wedge \Gamma_H) \vee (X_V \wedge \Gamma_L) \vee (X_V \wedge \Gamma_H)$. In the model transparency information does not impact interest rates when the explicit debt level is very high (X_V). The observed interest rate will be r_V regardless of financial market stress. To further understand the role of transparency we now focus on the interactions between the government and investors when $D_t < D_{VV}$.

The investor's purchases depend only on her perceptions of the true value of D_t. Importantly, she is indifferent across the three possible outcomes because they match her reservation return. She would of course prefer a higher return, but we assume there will be another investor who can step in and take the reservation return, in which case she gets nothing.[18]

For calculating the investor's and government's payoffs below, we assign the interest rates numeric values: 1 for the lowest interest rate–the government's preferred rate–, 2 for high, and 3 for very high rates. The cost of creating an interest rate ceiling when $X_V \wedge \Gamma_H$ is assigned the value 0.5.[19]

Sequence of play The game has the following sequence of play:

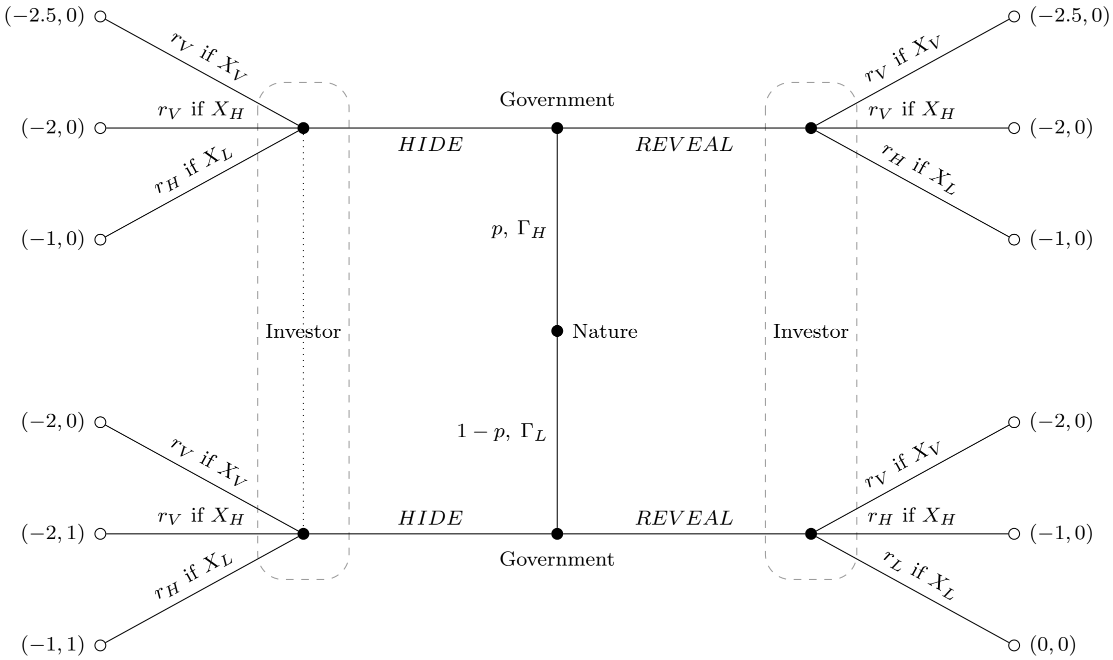
1. $t-1$: the period before, for which all information is known to all players in the following period.
2. t_a: the current period where the government chooses whether to $HIDE$ or $REVEAL$ financial sector information through international organizations.
3. t_b: the current period where the investor chooses the interest rate based on information available about Γ_t. D, X, and Γ do not change between t_a and t_b.
4. $t+1$: the next period where M_t is converted into X_{t+1} with probability ϕ_t causing the government to make payments g_k.

Note that time affects the dynamics of the debt–the assumption is that X cannot increase from L to H and so on between two periods absent a troubled financial system, i.e. Γ_H, converting contingent to explicit liabilities at a rapid pace. Debt can go down one step regardless of Γ.

[18] When there is an effective interest rate ceiling, the investor does not invest. She prefers this to a negative return.

[19] Formally, the government's utility when $X_V \wedge \Gamma_H$ is $U^G = r_L - (r_k + c_C)$, where c_C is the cost of the interest rate ceiling.

Figure 1: Reduced-form Game Tree of Financial Transparency and Sovereign Borrowing Costs with No Intrinsic Transparency Choice Costs



Costless transparency choices Figure 1 presents the reduced-form game tree assuming that there are no intrinsic costs to the government for choosing $HIDE$ or $REVEAL$.[20] The root node is where nature sets Γ_t, with the probability of Γ_H equal to p and of Γ_L equal to $1-p$. The government then decides whether to be transparent; that is, it chooses whether to $REVEAL$ the state of its financial sector. As the right-hand side of the figure indicates, if it reveals then the outcomes are straightforward. The cost to funding the debt depends upon the level of the debt D_t, which is increased one level if the financial sector risk Γ_t is high. The government prefers low interest to high interest, and high interest to very high interest. Moreover, because the information is transparent (note there is no dotted line on the right-hand side of Figure 1), I updates the interest rate offered only if the financial conditions change so that Γ_t moves from low to high.

What happens on the $HIDE$ path? This requires one to work backwards based on the payoffs for the government. The game tree illustrates the cases where Γ_t is either low or high, and a government would always reveal if Γ_t is low. The investor, in turn, would realize this. She would not want to be caught offering an interest rate that is below her reservation rate given the presumed level of debt. She would assume that hidden Γ_t means that Γ_t is *high*. This then takes away any advantage of hiding for the government, and it should always be transparent.

[20]See the supplementary files for the R source code used to model this game and find these payoffs.

This further exposes a puzzle: why does any country choose not to reveal their financial supervisory data through international organizations?

Costly transparency choices in a two-stage game So far we have assumed that governments can choose $HIDE$ or $REVEAL$ without reference to their status quo ante transparency level or the intrinsic costs of changing this level. We now relax these assumptions to allow the transparency choice to have costs and benefits based on how it changes from status quo ante transparency. Doing so provides an explanation for why, as we see below, the level of financial supervisory transparency varies considerably across countries.

There may be technical, legal, and/or political costs to releasing information that is hidden. For example, there may be costs associated with meeting international organizations' technical reporting standards. There may be domestic confidentiality laws regarding the release of information about private companies that would require new legislation or even constitutional amendments to change. There could be powerful political constituencies–such as the banking industry–that want to keep this information hidden.

There could also be benefits to becoming less transparent, such as pleasing constituencies that want less disclosure. Perhaps the banking industry or domestic constituencies are wary of international institutions' involvement in domestic economic policy. Finally, there could be benefits to becoming more transparent and costs to becoming more opaque, regardless of how this affects debt costs. These include reputational benefits/costs from adopting/bucking international transparency norms. There could be domestic constituencies that want more openness and so would reward/punish governments that became more/less transparent.

As such, we denote the government's costs/benefits of switching their transparency level as c, where c is from the discrete uniform distribution $\mathcal{U}\{-1,\ 0,\ 1\}$. The government's payoff in stage two of the game is now defined by:

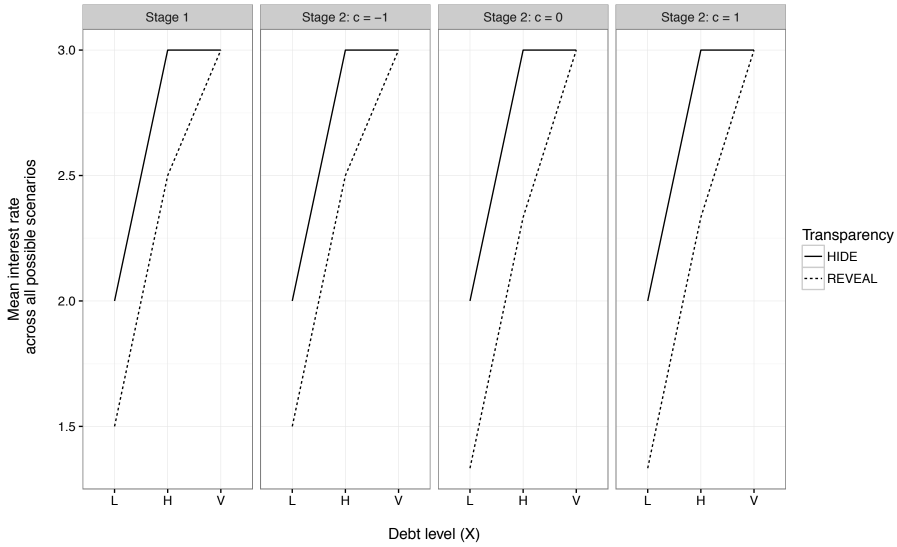
$$U^G = r_L - r_k + c \tag{4}$$

c is known to all players.

Furthermore, we assume a status quo bias: if a government is indifferent between changing or not their level of transparency from the status quo ante based on Equation 4, they will choose not to change.[21] Please see the supplementary files for a discussion of one interesting subset of the game when $c = 1$ because investors, perhaps official overseas lenders such as the IMF, force transparency as a condition of

[21] Note that in the first stage of the game we assume that the transparency level is picked randomly from the discrete uniform distribution $\mathcal{U}\{HIDE,\ REVEAL\}$.

Figure 2: Average Interest Rate Charged Over All Possible Outcomes Given Transparency and Explicit Debt (X) Levels



lending at high and non-declining debt levels.

See the supplementary files for a detailed breakdown of the implications of adding costly transparency changes for all scenarios of the game. Alongside this table is a discussion of how the inclusion of information about whether or not the government switches its transparency level in the investor's set of information affects their interest rate decision.

Observable implication What does our model predict about sovereign borrowing costs? Figure 2 shows the average interest rate charged over all outcomes of the game given different levels of debt, transparency, and transparency switching costs. We see that while governments may, in some situations, most benefit from choosing $HIDE$, they do so while suffering from higher interest rates when at low explicit debt levels. At very high debt levels, there is no effect of opacity on interest rates. This leads to our first hypothesis:

> H_1 : Countries with greater international financial reporting transparency and lower debt levels will have lower sovereign financing costs, while the level of transparency will not affect observed bond prices for high debt countries.

We can extend the model to the relationship between supervisory transparency and bond yield volatility. To do so we make one simple additional assumption. When investors have more information about the financial sector, there are fewer opportunities for "surprises"–events in the banking sector that investors did not anticipate–that would cause them to quickly adjust their risk perceptions and therefore investment decisions. Previous work has even shown that transparency can improve market discipline (for a review see Gandrud and Hallerberg, 2015, 775), reducing the likelihood of negative events that would ultimately impact public finances. As with bond price levels, the effect of transparency on volatility may be conditional. High debt countries could create bond price ceilings. Such ceilings stabilize prices through channels other than foreign private investment that are less subject to financial sector risk perceptions. This leads us to make an additional hypothesis:

> H_2 : Countries with greater international financial reporting transparency and lower debt levels will have less volatile sovereign financing costs, while the level of transparency will not affect observable bond prices for high debt countries.

4 Creating the FDT Index

To test these hypotheses we created a new indicator of supervisory data transparency through international institutions that we call the Financial Data Transparency (FDT) Index. In this section we briefly discuss issues in previous measures of supervisory transparency and the construction of the FDT Index using dynamic Bayesian Hierarchical Item Response Theory, a method that allows us to overcome many of the issues with previous financial transparency indices.

4.1 Previous measures of financial supervisory transparency

Previous assessments of supervisory transparency have tended to be based on self-reported surveys of supervisors' rules and practices. They have largely not examined reporting to international institutions. Financial supervisory transparency indices have typically been constructed by summing responses to survey questions. For example, Liedorp et al. (2013) sent a 15 question survey to 42 banking supervisors, 57 percent of which replied. The survey had questions on a variety of components related to aspects of supervisory transparency including what the authors termed economic, procedural, political, policy, and operational transparency. They then created composite scores by summing responses to the survey questions for each of these five areas, as well as creating a total sum score. Arnone et al. (2007) used a four point scale devised from classified IMF staff assessments of country compliance with IMF codes of good practice. Masciandaro et al. (2008) conducted a survey of supervisory accountability and included some items related to transparency. Seelig and Novoa (2009) also conducted a survey of supervisory practices, including transparency, but, as Liedorp et al. (2013, 316) note, the questions and country details are not publicly available.

Previous measures have other shortcomings beyond the fact that a number of these transparency indices are not themselves transparent and often do not measure reporting to international institutions, in which we are theoretically most interested. First, survey measures are laborious to construct, requiring numerous contacts with supervisors and secondary verification, largely via institutions' websites. Second, they rely on temporally ephemeral information, e.g. institutional websites and staff with institutional knowledge. These two issues are of substantive importance because they prevent both the easy updating of the indices at regular intervals and the extension of the indices back in time. These indices are usually snapshots that cannot readily be turned into up-to-date time-series for time-series-cross-sectional analysis.

Third, these surveys, at least those not conducted by the IMF, have high non-response rates. Non-response information is discarded in the construction of the indices. Fourth, their construction involves summing responses. This assumes that each item is equally important for measuring transparency. Fifth, the indices do not include explicit estimation of the uncertainty that they are estimated with. Sixth, and finally, these approaches either do not incorporate prior information into their estimates or do not do so transparently.

4.2 Included indicators

To create an index that overcomes these issues, we treat financial reporting transparency as an unobserved latent variable that summarizes countries' likelihood of reporting yearly data on items included in the World Bank's Global Financial Development Database.[22] We included countries classified as high income by the World Bank and those on JP Morgan's Emerging Market Bond Index (EMBI). Due to substantive importance, we also included China and India. Please see the supplementary files for a full discussion of the criteria we used to include countries and GFDD indicators. As a result of applying these criteria, the FDT was estimated for 69 countries over 24 years (1990-2013) based on reporting of 13 items through the GFDD. Table 1 shows the list of included items.

4.3 The model

Building on (Stan Development Team, 2014, 49-50) and Hollyer et al. (2014), we let $y_{k,c,t} \in \{0,\ 1\}$ indicate a variable that is 1 when a country c reports GFDD item k in year t. It is 0 otherwise. We then

[22] Čihák et al. (2012) created the first version of the GFDD database by collating information that had been collected over many years by a number of international institutions and corporations. The most recently updated version of the data set is available through http://data.worldbank.org/data-catalog/global-financial-development. We accessed the data in January 2016. Please see the supplementary files for a discussion of how we addressed data that was missing in this version database, as compared to another version of the same data published by the Federal Reserve Bank of St. Louis.

Table 1: Indicators included in the FDT Index from the World Bank's Global Financial Development Database

Series Code	Indicator Name	Source	Periodicity
GFDD.DI.01	Private credit by deposit money banks to GDP (%)	IFS	Annual: 1961-2013
GFDD.DI.03	Nonbank financial institutions' assets to GDP (%)	IFS	Annual: 1961-2013
GFDD.DI.04	Deposit money bank assets to deposit money bank assets and central bank assets (%)	IFS	Annual: 1960-2013
GFDD.DI.05	Liquid liabilities to GDP (%)	IFS	Annual: 1960-2013
GFDD.DI.06	Central bank assets to GDP (%)	IFS	Annual: 1961-2013
GFDD.DI.07	Mutual fund assets to GDP (%)	World Bank	Annual: 1980-2013
GFDD.DI.08	Financial system deposits to GDP (%)	IFS	Annual: 1961-2013
GFDD.DI.11	Insurance company assets to GDP (%)	World Bank	Annual: 1980-2013
GFDD.DI.14	Domestic credit to private sector (% of GDP)	World Bank	Annual: 1980-2013
GFDD.EI.02	Bank lending-deposit spread	IFS	Annual: 1980-2013
GFDD.EI.08	Credit to government and state owned enterprises to GDP (%)	IFS	Annual: 1980-2013
GFDD.OI.02	Bank deposits to GDP (%)	IFS	Annual: 1961-2013
GFDD.SI.04	Bank credit to bank deposits (%)	IFS	Annual: 1960-2013

Series Code is the GFDD variable identifier.

IFS = International Financial Statistics, IMF

estimate the model:

$$\Pr(y_{k,c,t} = 1|\alpha_{c,t}) = \text{logit}^{-1}[\exp(\gamma_k) * (\alpha_{c,t} - \beta_k + \delta)] \tag{5}$$

where:

- $\alpha_{c,t}$ is the estimated propensity for country c at year t to report. This can be thought of as the **transparency (FDT Index) score** for country c at year t,
- γ_k is the **discrimination** parameter for item k,
- β_k is the **difficulty** parameter for item k,
- δ is the **mean transparency**.

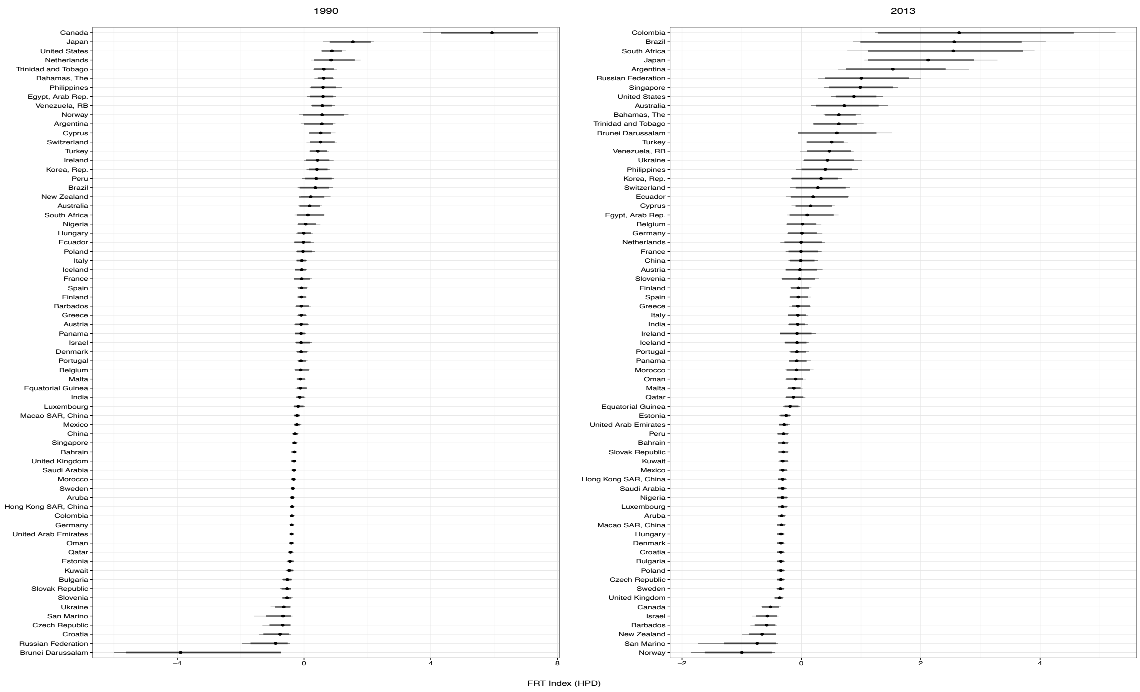
The discrimination parameter (γ_k) indicates how well reporting item k predicts reporting other items.[23] The difficulty parameter (β_k) indicates on average the degree to which countries report indicator k in the GFDD over the entire time span. Higher parameter estimates indicate that the item is more "difficult" to report, i.e. reported less often.[24]

Taking the fraction of items a country reports in a given year as an indicator of transparency would be equivalent to assuming that β_k and γ_k are constant across all variables. However, some items are "harder" to report than others as they reveal information that regulators may find more sensitive (costly) to report. The Bayesian IRT approach allows us to relax the equivalence assumption. We directly estimate the degree to which countries find it difficult to report items and how reporting (or not) one item is related to non-reporting of other items. γ_k is exponentiated to identify the sign in the model as positive. This

[23] It can equivalently be thought of an item specific slope for the logistic regression.

[24] Mean transparency δ can be treated as the location parameter for the transparency scores (Stan Development Team, 2014, 48).

Figure 3: Financial Data Transparency Index in Selected Years



Thin lines represent 95% highest probability density intervals. Thick lines represent 90% intervals. Points represent the median of the posterior distribution.

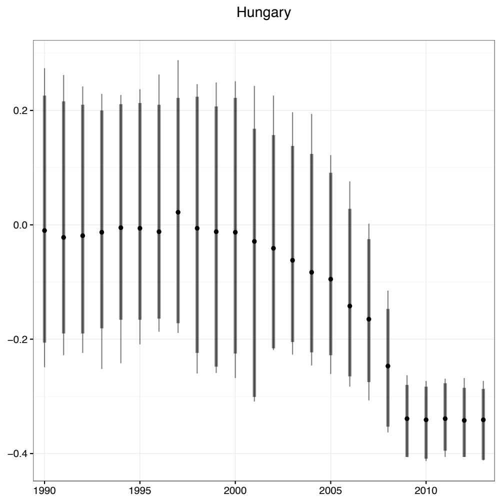
avoids the unlikely possibility that items are more likely to be reported by less transparent countries than more transparent countries.

The transparency values in 1990 are drawn from a normal prior: $\alpha_{c,1990} \sim N(0, 1)$. We then recentered these values by subtracting the mean transparency score and dividing by the standard deviation at each iteration. These measures fixed the scale and location of the Index. We found that we did not need to explicitly fix the Index's direction. Countries we expected to have high financial data transparency, based on previous qualitative research (Gandrud and Hallerberg, 2015), were consistently estimated to have positive FDT values and vice versa. Please see the supplementary files for further details about the model's priors, assessment of convergence, as well as the discrimination and difficulty parameter estimates.

5 Index description and validity

Figure 3 provides snapshots of the Financial Data Transparency Index in 1990 (the first year) and 2013 (the Index's current end year). Higher scores on the FDT Index indicate greater financial reporting transparency. Please see the supplementary files for all scores in all country-years. Additionally, in the supplementary files we further validate the FDT Index and compare it to alternative financial trans-

Figure 4: Financial Data Transparency Index for Hungary



Thin lines represent 95% highest probability density intervals. Thick lines represent 90% intervals. Points represent the median of the posterior distribution.

parency measures to demonstrate the value added by our estimation approach.

The FDT Index passes a face validity test. Jurisdictions that are known for their banking secrecy tend to have lower transparency scores. These countries include San Marino and Luxembourg.[25] At the high-end of the scale we also see countries that have been known for their transparency. Gandrud and Hallerberg (2015) noted a high level of financial regulatory data transparency in the United States relative to many European Union member countries. As we would expect from this work, the United States is regularly placed among the countries with the highest FDT scores. Gandrud and Hallerberg also previously found that the United Kingdom had lower financial data transparency–interestingly in contrast to their generally high fiscal transparency (see Wehner and de Renzio, 2013). Correspondingly, the UK had a median FDT score below 0.

Though some countries–such as the United States on the high-end and a number of the offshore locations on the low-end–have fairly stable FDT scores, many countries' scores do change over time. FDT score changes reflect substantively meaningful policy changes. Hungary is a prime example. Figure 4 shows the trajectory of Hungary's FDT Index scores. In 1990, Hungary had a median FDT score around 0. This score changes over time, making a clear shift to lower transparency in 2009. The 2009 figures would have been reported to international institutions in 2010, the year that Viktor Orbán's Christian Democratic People's Party entered government. This government introduced a number of major economic

[25] In an earlier version of the Index we included 10 jurisdictions that never reported any of the items on the GFDD. These jurisdictions all had the lowest scores. The countries, including Bermuda and the Cayman Islands, are noted for having very secretive banking systems.

and financial policy changes that sometimes directly contradicted Hungary's international economic commitments in a gambit to attract more nationalistic voters.

Other countries increased their transparency during periods when they opened their financial markets. For example, Qatar and the United Arab Emirates improved their transparency from the mid- to late-aughts as they attempted to become international financial centers. A number of former Soviet bloc countries including Estonia, the Czech Republic, Hungary and the Slovak Republic increased their transparency in the early- to mid-1990s, as they transitioned towards market economies. Similarly, many of the EMBI countries, including Argentina, Brazil, and Russia, also increased their transparency from the 1990s.

In other cases, under-reporting is associated with financial distress. For example, France's FDT score noticeably declined during the mid- to late-1990s financial market difficulties following the collapse of France's largest bank–Crédit Lyonnais–due to gross mismanagement. A number of other countries, including Poland, Canada, and Norway reported fewer items and have lower scores beginning around the start of the Global Financial Crisis.

Clearly there are instances where governments see benefits to becoming more or less transparent, and these benefits change over time. Using a measure of transparency estimated in a single year and treating it as representative of longer time spans–as previous research has generally done–is likely to create biased inferences. Using a frequent dynamic indicator like the FDT is preferable.

6 Assessing the relationship between financial supervisory transparency and sovereign borrowing costs

We expect that financial regulatory transparency systematically influences sovereign bond prices. In this section, we use the FDT Index to test the nature of this relationship. Due to data availability, as well as to minimize problems associated with pooling data across different measures of bond prices, we draw on a data set of 31 OECD countries[26] from 1991 to 2011 to look at the movement of bond spreads and bond yield volatility. As discussed in more detail below, looking at this one peer group also allows us to "control" for peer group effects identified in previous research.

The United States is excluded from the models with spreads as the dependent variable. This is because sovereign bond spreads are calculated by comparing yields to US 10 year T-Bills.

We exclude Japan from all models. Japan is a considerable outlier when it comes to the size of

[26]This group was determined by their OECD membership as of 2016. We also examined models using only country-years when countries were OECD members. However, due to list-wise deletion of cases with incomplete data, these sub-samples are in practice similar. As such, the results are largely the same regardless of which definition of OECD membership we use to define the sample. We present results from the former definition here as it includes the most cases.

its public debt.[27] Japan is also an outlier when it comes to one of our key theoretical assumptions: that international investors with exit options and who need to receive signals on implicit liabilities in our model, strongly influence bond prices. A very high proportion of Japanese government debt is and has been owned by domestic investors including households. In 2011, domestic institutions owned an estimated 94 percent of Japanese public debt (authors' calculations based on Abbas et al., 2014, 22). A considerable proportion is now even owned by the Bank of Japan itself, which in 2015 had 30 percent, more than any other investor class.[28] Due to the extremely high domestic demand for Japanese public debt, Japan has operated at a low effective interest rate ceiling for a comparatively long period of time. Its debt prices are thus not particularly responsive to foreign investors' risk perceptions. Clearly a different model from the one we provide here applies to the idiosyncratic Japanese case. Given this, and that it is such an extreme outlier on one of our key variables of interest and so would have considerable leverage on our results, we exclude it.[29]

Please the supplementary files for the list of included country-years in the following regressions.

6.1 Dependent variables

We estimate models using two dependent variables, each of which captures a different dimension of sovereign borrowing costs. Our theoretical model aims to explain the level of sovereign borrowing costs. In the well-developed economics literature, these costs have typically been measured using bond yield spreads relative to US or German 10-year bonds.[30] This measures the bond price *level*. Following this literature, our first dependent variable is the annualized average spread (in percentage points) of the country's 10-year bond yields over US 10-year government bonds for each country-year in the data set. The data for OECD countries is from the Federal Reserve Bank of St. Louis' FRED database.[31] A key advantage of using data solely from this source is its measurement homogeneity which allows us to avoid pooling data from potentially non-comparable bond types.[32]

The second dependent variable in our analysis is bond yield *volatility*. As our measure of volatility, we calculate the coefficient of variation (COV) for FRED's monthly bond yield data in year t for each

[27] Its mean general public debt in the sample as a percentage of GDP is 150, whereas the overall sample mean is 53 percent. Japan's maximum debt level in the sample is 240 percent of GDP.

[28] See https://perma.cc/87P9-4CSG. Accessed June 2016. This has allowed the Japanese government to borrow at consistently low rates even as their debt has increased dramatically (Lam and Tokuoka, 2011).

[29] Ideally we would have directly controlled for the proportion of public debt owned by domestic investors. However, this data is very difficult to find for individual country-years, let alone all years in our sample.

[30] An exception is Bernoth et al. (2012), who use primary spreads; that is, they analyze the yields on bonds denominated either in Euros (D-Marks before 1999) or US dollars.

[31] Available at: https://research.stlouisfed.org/fred2. Accessed April 2016.

[32] All of the country series in the FRED data base are explicitly capturing government bond yields for bonds with 10-year maturities. In other sources of government bond yield data, such as Bloomberg Terminal, Datastream, and J.P. Morgan's EMBI Global Bond Index, it is often unclear as to what the maturity of the "long-term" bonds is. Of these series we found that FRED had the longest time period coverage, especially for countries with large and highly developed financial markets, where investors would likely be more concerned with financial supervisory transparency.

country c in our data set.[33]

6.2 Independent variables

Our core explanatory variable is the FDT Index measuring financial reporting transparency.[34] We interact this with the level of general government debt as a percentage of GDP.[35] For this variable, we draw on the IMF's Historical Public Debt Database[36] and fill in missing values when possible with information from the IMF's World Economic Outlook database.[37]

In addition, we include other variables as controls from the literature that are meant to pick up the "economic fundamentals" of a given country. First, we include the inflation rate, with higher inflation rates presumably pushing up yields, which are listed in nominal terms. Specifically, we use the annual percentage change in consumer prices from the World Bank's Development Indicators (WDI).[38] Second, we include annual country-level GDP growth, also from the WDI.[39] More quickly growing economies may be better able to service their debt. Third, we include per capita GDP (in thousands of US dollars) to control for general level of economic development. Per capita GDP is also from the WDI.[40] Fourth, we include the average GDP growth rate of OECD countries as a measure of the overall state of major industrialized economies. Fifth, we include the annualized average of the yield on short-term (three month) US Treasury bills–the benchmark short-term sovereign lending rate in the global economy. Finally, we include the annualized average Chicago Board Options Exchange Volatility Index (VIX). Frequently referred to as the "fear index", the VIX is a measure of implied volatility, or the uncertainty and risk that investors see in the future short-term movements of the US stock market (specifically the S & P 500). We include it here as a broad measure of investors' short-term concerns about instability and uncertainty in global financial markets. Data on US short-term interest rates and the VIX are drawn from the FRED database. The OECD growth data are calculated from country-specific growth data from the WDI.

Most of the previous right-hand side variables measure aspects of a country's ability to repay creditors. Political factors have been shown to affect governments' willingness to repay and so should also affect investors' decision-making (e.g. DiGiuseppe and Shea, 2015; Shultz and Weingast, 2003; Jensen, 2006;

[33] The coefficient of variation (COV) here is defined as $\frac{\text{standard deviation of monthly bond yields}_{c,t}}{\text{mean monthly bond yields}_{c,t}} * 100$.

[34] We focus on the median of the posterior distribution.

[35] As noted by an IMF official, "for debt sustainability purposes, general government gross debt is the relevant variable". See http://ftalphaville.ft.com/2016/06/03/2164319/the-imf-and-the-greek-governments-financial-assets-part-2/. Accessed June 2016.

[36] From Abbas et al. (2010). For more information see: https://www.imf.org/external/pubs/cat/longres.cfm?sk=24332.0 and https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx.

[37] Data was downloaded from https://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx. Accessed April 2016.

[38] The indicator ID is: FP.CPI.TOTL.ZG. Accessed April 2016.

[39] The indicator ID is: NY.GDP.MKTP.KD.ZG. Accessed April 2016.

[40] The indicator ID is: NY.GDP.PCAP.KD. Accessed April 2016.

Walter, 2013). While we focus on the OECD, where all countries are democratic to some extent, we include a measure of democracy level using mean Unified Democracy Scores (UDS) from Pemstein et al. (2010). These scores are created using a Bayesian latent variable analysis of 10 democracy indices. The index was updated in 2014. We also include variables indicating whether or not it is an executive election year and indicating whether the executive has a left-leaning ideology. Data on the former is taken from Gandrud (2015). The latter is drawn from the Database of Political Institutions (Cruz et al., 2015).

Following Brooks et al. (2015) who examined emerging markets, we examine how peer effects may influence sovereign bond pricing even within the OECD peer group. Please see the discussion below for an examination of the appropriateness of spatial weights in this sample. Ultimately, we focus on an effective 'negative spatial weight' in that countries entering IMF programs effectively leave the OECD peer group in terms of their bond yields.

6.3 Models and results

We employ a single-equation error correction model (ECM) for our analysis. The ECM specification is appropriate in cases where there are both long-term equilibrium relationships between X and Y and short-run fluctuations as a result of period-to-period changes in the explanatory variables (see De Boef and Keele, 2008; Box-Steffensmeier et al., 2014; Soroka et al., 2014). ECMs are useful for estimating both relationships and are applicable to both integrated and stationary time series.[41]

The estimated specification is:

$$\Delta Y_t = \alpha + \alpha_1 Y_{t-1} + \boldsymbol{\beta_0} \Delta \mathbf{X_t} + \boldsymbol{\beta_1} \mathbf{X}_{t-1} + \beta \epsilon_t. \tag{6}$$

where $\mathbf{X}$ is a vector of covariates. $\boldsymbol{\beta_0}$ and $\boldsymbol{\beta_1}$ are vectors of associated coefficients for the year-on-year change and lag versions of these covariates, respectively. In this specification, changes in Y are a function of contemporaneous changes in X, as well as the one period lagged values of both X and Y. If the ECM is appropriate, then $-1 < \alpha_1 < 0$ and α_1 is statistically significant.

Our theoretical model suggests that the effect of transparency on bond prices is conditional on the public debt level. Following Warner (2016) we use a "general" ECM specification to estimate these

[41] Dickey-Fuller tests indicate that non-stationarity is not an issue in our data set for any of the dependent variables. Results available on request.

interactive effects:

$$\begin{aligned}\Delta Y_t = \alpha + \alpha_1 Y_{t-1} + \beta_0 \Delta x_t + \beta_1 x_{t-1} + \\ \beta_2 \Delta z_t + \beta_3 z_{t-1} + \\ \beta_4 \Delta x_t \Delta z_t + \beta_5 x_{t-1} z_{t-1} + \\ \beta_6 \Delta x_t z_{t-1} + \beta_7 x_{t-1} \Delta z_t + \\ \boldsymbol{\beta_8} \Delta \boldsymbol{\Psi}_t + \boldsymbol{\beta_9} \boldsymbol{\Psi}_{t-1} + \beta \epsilon_t.\end{aligned} \tag{7}$$

where x is transparency, z is the public debt, and Ψ is a vector of additional covariates.

Parameter estimates from these models are shown in Table 2. The first and second columns of Table 2 show estimates from models that have changes in bond spreads as the dependent variable. The third and fourth columns show results from models where the dependent variable is changes in the coefficient of variation of bond yields. Coefficients for the lagged dependent variables across all of these models are significant, negative, and in the range indicating that the ECM specification is appropriate. In addition, several of the country-specific variables, such as GDP growth are significant and signed as expected in these models, further indicating appropriateness.

Bond spread models We can see in the first model of Table 2 that there is no significant, unconditional relationship between the level of financial supervisory transparency and bond spreads. In model 2, however, we find evidence of conditional relationships between financial reporting transparency and bond spreads.[42] This relationship is illustrated graphically in figures 5 and 6. The left-panel of Figure 5 shows the marginal effect of FDT at a range of debt levels. Higher lagged levels of FDT reduce changes in bond spreads, but only when debt is lower (debt/GDP below approximately 60 percent). At high debt levels, as predicted by our formal model, a higher level of transparency has no significant marginal effect on changes in bond spreads.

A marginal effect plot for the FDT and debt levels provides us with only a partial window onto our findings, as they effectively assume no change in FDT or debt levels despite the inclusion of these factors in the full interactive ECM specification. To get a sense of the instantaneous and long-term effect of FDT on bond spreads we followed Warner (2016) and King et al. (2000) by simulating quantities of interest for various fitted scenarios. Medians of the simulated quantity of interest distributions are shown in Figure 6. The left-panel shows median expected bond spreads for countries with relatively low and high debt (30 and 100 percent of GDP respectively). We see that predicted bond spreads are about

[42] The full set of interaction terms is statistically significant at the one percent level from a Wald test.

0.75 points lower once the simulated relationship stabilizes for countries with transparency in the 90th FDT percentile compared to those in the 10th percentile. High and low transparency countries have no difference in spreads in the high debt scenario. The right-panel of Figure 6 shows results from the same scenarios that additionally experience a drop in transparency of -1 (close to the sample maximum). Such a drop effectively removes the spread difference between the low and high debt scenarios. The reduction in the difference is caused by increasing spreads in the low debt scenarios, while spreads remain largely unchanged in the high debt scenarios, despite the transparency shock.

These results suggest that increased supervisory transparency is beneficial for countries seeking to access international capital markets, but only under certain conditions. Greater financial supervisory transparency reduces borrowing costs for countries with a lower existing level of public debt. In contrast, for countries that have high existing debt-to-GDP ratios, higher levels of transparency has no significant effect on borrowing costs.

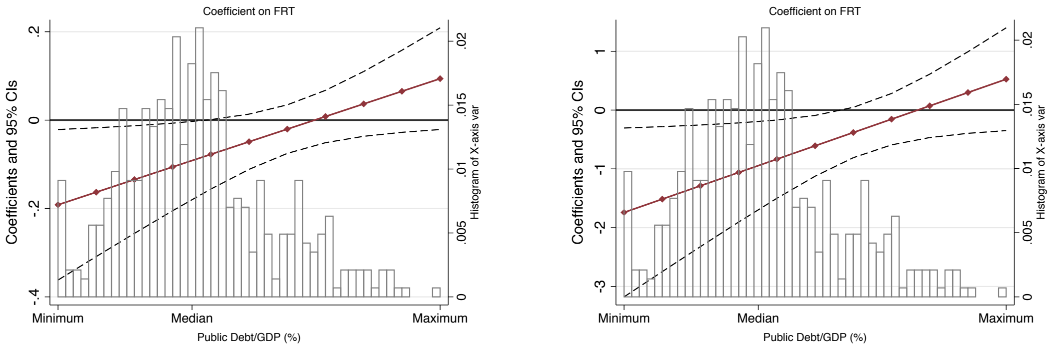
Bond yield volatility Models 3 and 4 of Table 2 present results employing changes in bond yield volatility as the dependent variable. Model 3 shows that the level of FDT is negatively associated with bond yield volatility at the 10 percent level. In Model 4, we incorporate the interactions between both levels and changes in FDT and levels and changes in public debt/GDP, respectively. Once again, we find strong evidence of an effect conditional on the public debt level.[43] The right-panel of Figure 5 illustrates this conditional marginal effect. We see that–as in the bond spread models–higher levels of FDT are associated with reduced sovereign bond volatility, but not at very high levels of public indebtedness. Results of simulated spread volatility over a range of FDT and debt values can be found in Figure 7. The findings are broadly similar to those in Figure 6.

[43] The full set of interaction terms is statistically significant using a Wald test at all accepted significance levels.

Figure 5: Marginal Effect of FDT (Level) at Different Values of Public debt/GDP (Level)

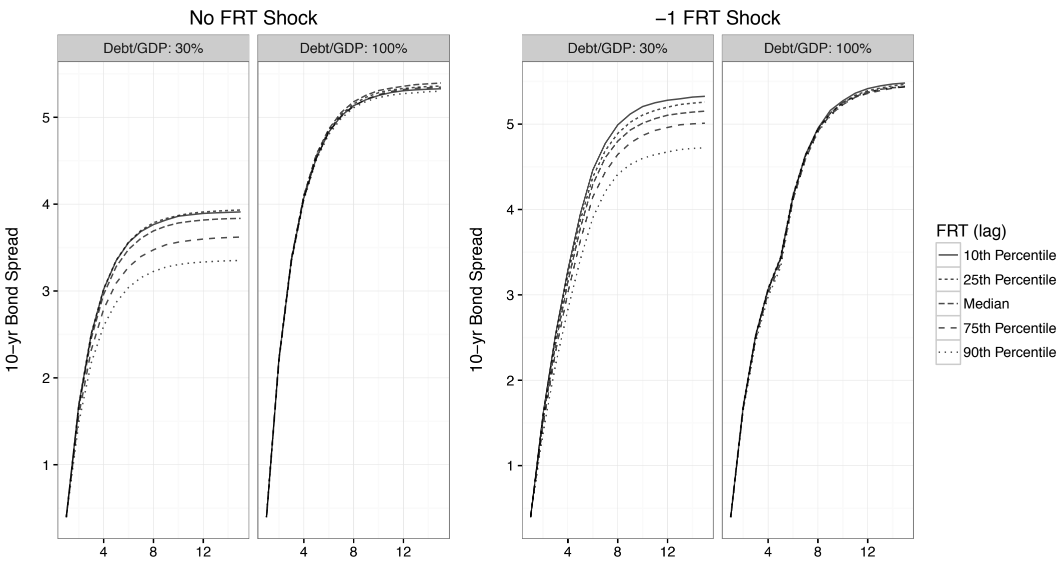
(a) DV: Change in Spreads

(b) DV: Change in Volatility



Estimated from models 2 and 4, respectively, shown in Table 2.

Figure 6: Median Simulated 10-year Bond Spreads for Various Levels of FDT and Debt



X-axes show simulation time. Medians from 5,000 simulations based on estimates from Model 2 in Table 2. All other covariates fitted at 0.

Table 2: Sovereign Bond Prices and the Financial Data Transparency Index (FDT)

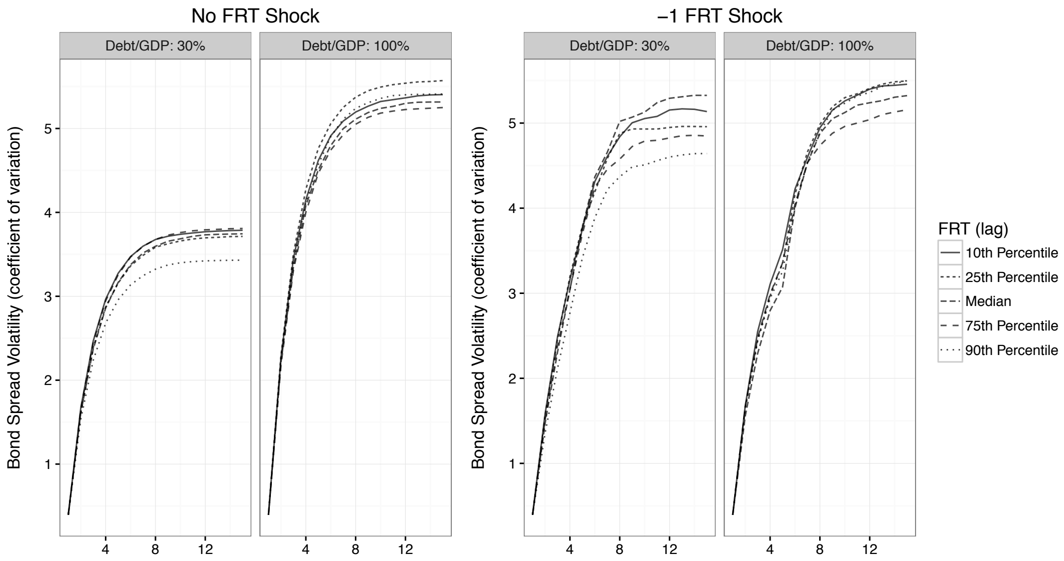
	Δ Long-term (10-year) bond spread (US 10-year bond, %)	Δ Long-term (10-year) bond spread (US 10-year bond, %)	Δ Coefficient of variation, LT bond yields (annual, based on monthly data)	Δ Coefficient of variation, LT bond yields (annual, based on monthly data)
Bond Spread$_{t-1}$	-0.36***	-0.37***		
	(0.05)	(0.05)		
LT rate COV$_{t-1}$			-0.74***	-0.75***
			(0.05)	(0.06)
FRT$_{t-1}$	-0.05	-0.24**	-0.67*	-2.72***
	(0.05)	(0.10)	(0.34)	(0.82)
Δ FRT	0.28***	-0.08	0.48	-2.95
	(0.09)	(1.00)	(1.21)	(4.21)
Public debt/GDP (%)$_{t-1}$	0.01*	0.01*	0.06**	0.05**
	(0.00)	(0.00)	(0.02)	(0.02)
Δ Public debt/GDP	0.03*	0.03**	0.16***	0.16***
	(0.02)	(0.02)	(0.06)	(0.05)
Inflation (%) $_{t-1}$	0.04	0.04	0.04	0.04
	(0.05)	(0.05)	(0.16)	(0.17)
Δ Inflation (%)	0.15***	0.15***	-0.05	-0.05
	(0.05)	(0.05)	(0.14)	(0.14)
GDP Growth$_{t-1}$	-0.15**	-0.15**	0.04	-0.00
	(0.06)	(0.06)	(0.18)	(0.20)
Δ GDP Growth	-0.14***	-0.14***	-0.12	-0.16
	(0.05)	(0.05)	(0.16)	(0.17)
Per Capita GDP$_{t-1}$	-0.01	-0.01	-0.10	-0.11
	(0.01)	(0.01)	(0.06)	(0.07)
Δ Per Capita GDP	0.23***	0.24***	0.28	0.39
	(0.06)	(0.06)	(0.28)	(0.32)
OECD average GDP growth$_{t-1}$	0.05	0.05	-0.07	-0.02
	(0.05)	(0.05)	(0.20)	(0.21)
Δ OECD average GDP growth	0.01	0.01	0.43**	0.45**
	(0.05)	(0.05)	(0.20)	(0.20)
US 3-month interest rate (%)$_{t-1}$	-0.08**	-0.07**	-0.84***	-0.84***
	(0.03)	(0.03)	(0.17)	(0.17)
Δ US 3-month interest rate (%)	-0.24***	-0.24***	-0.44**	-0.42**
	(0.04)	(0.04)	(0.19)	(0.19)
VIX index$_{t-1}$	-0.02***	-0.02***	0.03	0.04
	(0.01)	(0.01)	(0.04)	(0.04)
Δ VIX index	-0.01	-0.01	0.22***	0.22***
	(0.01)	(0.01)	(0.06)	(0.06)
Democracy (UDS)$_{t-1}$	-0.32**	-0.33**	1.00	0.88
	(0.16)	(0.16)	(1.23)	(1.21)
Δ Democracy (UDS)	-0.52**	-0.51**	-0.03	-0.06
	(0.21)	(0.21)	(0.87)	(0.86)
IMF Program Start$_{t-1}$	3.06*	3.05*	-2.18	-2.10
	(1.53)	(1.53)	(2.33)	(2.32)
FRT$_{t-1}$ * Public debt/GDP (%)$_{t-1}$		0.00**		0.02**
		(0.02)		(0.07)
Δ FRT * Δ Public debt/GDP		0.03		0.30***
		(0.00)		(0.01)
Δ FRT * Public debt/GDP (%)$_{t-1}$		0.01		0.05
		(0.00)		(0.02)
FRT$_{t-1}$ * Δ Public debt/GDP		-0.00		0.05**
		(0.03)		(0.08)
Constant	1.10	1.14	6.51	6.88*
	(0.71)	(0.73)	(3.97)	(4.02)
Countries	29	29	30	30
Observations	499	499	529	529
Adjusted R-squared	0.43	0.43	0.39	0.39

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All regressions include country fixed effects and robust standard errors.

Japan outlier excluded.

Figure 7: Median Simulated 10-year Bond Spread Volatility for Various Levels of FDT and Debt



X-axes show simulation time. Medians from 5,000 simulations based on estimates from Model 4 in Table 2. All other covariates fitted at 0.

6.4 Additional political variables and further robustness checks

We conducted a number of robustness checks by examining models with additional political, institutional, and spatial variables. We also examined how the FDT performed relative to other measures of public and fiscal data transparency.

Political/institutional variables Table 2 also shows results from models that include variables for level of democracy. As suggested by previous research (Shultz and Weingast, 2003; Jensen, 2006) we found that more democratic countries and becoming more democratic reduced sovereign borrowing costs. These countries may be viewed as more willing to payback creditors and, as such, are given lower interest rates.

In further models we did not find evidence that having an executive election or a left-learning executive affected either sovereign borrowing costs (see the supplementary files).[44] The inclusion of these variables also did not change our core findings about financial supervisory transparency.

Peer effects, IMF programs, and the European sovereign debt crisis Previous work on the determinants of sovereign borrowing costs has examined how peer effects may impact prices (see recently

[44]Note that while these results are presented in two tables, the findings are substantively similar when run in combined model estimations. Additionally, we ran models that did not include the change in the political variables. This also produced null results for these factors.

Gray and Hicks, 2014; Brooks et al., 2015). Using a sample of developing economies, Brooks et al. (2015) operationalize these effects with spatial weights that represent an average of the outcome variable weighted by being a member of the same geographic region or investor classification. We examined the possibility of applying this approach in our OECD sample by creating regional peer weights using World Bank geographic regions as in Brooks et al. (2015).[45]

Before including these spatial weights in the regression models, we first followed (Darmofal, 2015, 43) by determining if there was evidence of spatial autocorrelation in our sample. There are at least two reasons that our sample may exhibit less regional autocorrelation than has been found in emerging market samples. First, Brooks et al. (2015, 589) note that investors typically pay closer attention to individual country's macroeconomic outcomes, rather than peer behavior, when making their investment decisions in developed countries. Developed countries are not subject to the "original sin" perceived by investors to taint emerging markets' debt. Consequently, they are able to borrow in their own currencies and often at longer maturities than emerging market borrowers (see Eichengreen et al., 2005). Second, the OECD is a peer group. As such, we do not expect regional peer effects to vary meaningfully within a sample of OECD countries. A further practical issue to consider when creating regional peer spatial weights for the OECD sample is that the OECD is predominantly composed of European countries. So, most other regions have only a handful of members. The North American region, for example, only contains Canada and the United States. As such it is difficult to create substantively meaningful regional spatial effects in the OECD sample.

To test the possibility that the OECD sample lacks regional spatial autocorrelation we use Moran's I statistic of spatial autocorrelation for each year-effect with the regional spatial weights and our two dependent variables. The results are shown in the supplementary files. Overall, we do not find evidence of sub-OECD geographic spatial autocorrelation in our OECD sample in almost all years for both dependent variables. Instead, spreads in the OECD tend to move together (see the supplementary files). This is consistent with the possibility that the whole OECD is treated as a peer group. Given these findings, it is substantively inappropriate to include regional spatial weighted dependent variables in the estimation models.

Interestingly, examining descriptive bond spread changes (see the supplementary files) illustrates that spatial autocorrelation among the OECD declines noticeably after 2008, in the wake of the Global Financial Crisis and the Eurozone crisis. Iceland in 2008, and then later Greece, Ireland, and Portugal saw their bond spreads increase dramatically in 2013. All of these countries experienced sovereign debt

[45]We used these classifications as the basis of monadic spatial weights calculated as in Neumayer and Plumper (2010). Countries k could have a relationship with a country i at time t through $\frac{\sum_k w_{kit} y_{kt}}{n_k - 1}$, where w is one if i and k are in the same peer group–geographic region–, zero otherwise. n_{k-1} is the total number of countries in the peer group apart from country i. Modified from (Neumayer and Plumper, 2010, 591) for dichotomous spatial relationships.

crises leading to the acceptance of IMF programs. Perhaps entering an IMF program, and the tumultuous events that directly precede such programs, effectively removes a country from the OECD peer group for some period of time. To empirically address this, we included in our ECM models a dummy variable for the year that each of these countries started their IMF programs.[46] We can see in Table 2 that the IMF program start dummy is significant, positive, and large. Countries that enter IMF programs see dramatic jumps in their bond spreads as we would expect. Including this variable did not change our main findings.

General government transparency and bond prices We reran the models with Hollyer et al.'s (2014) general transparency index. They call this the HRV index. While estimated using generally similar techniques, the FDT and HRV indices are substantively different. The FDT measures international financial regulatory transparency specifically, while the HRV looks at more general government reporting to the World Bank's Development Indicators. Only three variables in the FDT are from the WDI: Domestic credit to the private sector (% GDP), Liquid liabilities to GDP (%), and Bank lending-deposit spread. However, it could be that general government transparency measured in the HRV is a reasonable proxy for financial sector transparency and/or investors consider general public transparency when considering lending to sovereigns.

The FDT and HRV indices are weakly positively correlated.[47] Countries that are more transparent with their general government data have a weak tendency to also be transparent with their financial system data. However, there is considerable variance in the relationship between the two measures (see the supplementary files).

We re-examined the key models with the HRV Index in place of the FDT to assess whether the latter is simply functioning as a proxy for general government transparency. We found no evidence of a relationship between the HRV Index and sovereign debt prices. The results are in the supplementary files. We further attempted to separate the contribution of these two indices by regressing the FDT onto the HRV and then using the residuals in a new model estimating spreads. This also produced null results.

In sum, it appears that it is financial supervisory transparency, rather than general public data openness, that investors consider when investing in sovereign bond.

Fiscal transparency and bond prices A clear extension of our work would be to examine the effects of fiscal transparency–what governments report about their balance sheets directly–on bond prices. As

[46] Alternatively, we could have created an IMF program spatial weight. However, this is not practical. The number of countries in our sample with IMF programs is small.

[47] The correlation coefficient is 0.13 and significant at all standard levels.

mentioned earlier, there is a sizable literature on the causes and effects of fiscal transparency. Glennerster and Shin (2008) in particular found that, between 1999 and 2002, financing became cheaper for countries that released their IMF Section IV reports and met other international data dissemination standards. These data releases included information about fiscal policies. Hameed (2005) contends that more transparent countries have higher sovereign debt ratings and higher primary balances. The empirical evidence, however, is only bi-variate.

A lack of good data is a major obstacle for testing the effect of fiscal transparency on borrowing costs and especially comparing this to financial reporting transparency's effect. Previous work into the direct effect of fiscal transparency on other outcomes–e.g. Wehner and de Renzio (2013)–has used either the Open Budget Survey's Open Budget Index (OBI),[48] a data set originally created by Alt and Lassen (2006b,a) and updated by Lassen (2010), or some combination of the two (e.g. Alt et al., 2014). All of these approaches are very limiting. The OBI Index is currently only available in four waves between 2006 and 2012. The vast majority of included countries are low income. As such, its coverage is not comparable to our sample.[49] Due to the OBI's limited coverage, previous research has been constrained to look at very short time spans. Wehner and de Renzio (2013), for example, only include data from 2008 in their parametric models. Alt and Lassen's measure and their method of aggregating it with the OBI creates a time-invariant indicator. In a number of papers, Alt, Lassen, and Wehner (2006b; 2014) are only able to include indicators of fiscal transparency in fixed effects regressions with cross-country time-series data by interacting them with other political variables that are time-variant. Due to a lack of adequate data, we are unable to run comparable regression models with fiscal transparency on the right-hand side.

In the small subset of our sample where data is available for both financial supervisory and fiscal transparency as measured by the OBI[50] there is a weak positive correlation between the two, though this is not statistically significant at the 10 percent level.[51] Consistently strong performers on the OBI, as almost all developed countries are, have mixed financial supervisory scores. For example, the United States and the United Kingdom are consistently top ranked countries on the OBI. On the FDT, however, the United States consistently scores highly and the United Kingdom is a low scorer. This fits our theoretical model's assumptions where the explicit debt level is known to investors, but information about the financial sector could either be hidden or revealed.

Conversely, the HRV and OBI are strongly positively correlated with one another.[52] This indicates

[48]The OBI can be downloaded from: http://survey.internationalbudget.org/#download. Accessed January 2015.

[49]For example, the 2012 OBI wave, the largest so far, does not include Australia, Austria, Belgium, Canada, Denmark, Iceland, Israel, Japan, Luxembourg, or the Netherlands among their high income countries.

[50]There are 134 shared observations across 38 countries.

[51]The correlation coefficient is 0.12, $p = 0.14$

[52]In our sample, the correlation coefficient is 0.5 and statistically significant at all conventional levels.

that the processes causing fiscal and general public sector transparency may be similar, but that financial regulatory transparency is distinct.

Conclusion

The recent global and Eurozone financial crises have dramatically highlighted the immense and sudden costs that governments can incur when responding to financial stability problems originating in the private sector (see Laeven and Valencia, 2012). Indeed, recent events have made abundantly clear the intimate link between sovereign debt sustainability and the stability of the domestic banking and financial sector–both directly in terms of government assistance to the financial sector and indirectly in terms of creating severe economic shocks that lead to falling tax revenues and prompt fiscal stimulus packages (Reinhart and Rogoff, 2009, 164). Therefore, market actors are wise to consider the potential risks posed by banking and financial sector instability to sovereign debt sustainability.

In this paper, we have explained an important way that market actors consider these potential risks as they make decisions about investing in sovereign debt. As the existing literatures make clear, market actors care about the financial health of the government. Our evidence–using a new and unique measure of credible financial reporting transparency–indicates that they define financial health broadly to include both explicit sovereign liabilities and implicit government liabilities to the private financial sector. Moreover, investors are sensitive to whether the government reveals the state of the financial sector conditional on the public debt context. At lower levels of public debt, governments that reveal information to investors benefit from lower interest and more stable rates.

While the conventional wisdom is that global capital flows restrict national governments' macroeconomic policy autonomy, our findings suggest that increased financial supervisory transparency–by reducing sovereign bond spreads and volatility when governments keep debt to manageable levels–may, to a degree, relax this constraint. Furthermore, our results indicate that transparency and financial supervision play a greater role in shaping sovereign bond spreads than previously suggested by the existing economics literature.

In addition, our paper highlights the important roles of information and international financial institutions in global finance. Our findings suggest that credible information–transmitted to international investors via national supervisors through the international financial institutions–can influence strategic interaction between sovereign borrowers and private creditors in global financial markets. Thus, as past work on "catalytic financing" has found with IMF lending (e.g. Bordo et al., 2004; Shin and Morris, 2006), international organizations can play a crucial role in maintaining financial stability by helping to mitigate information asymmetries between lenders and borrowers. As we demonstrate, however, this role for the IMF and World Bank may not only be about lending. Particularly for developed economies, these institutions' role in gathering and disseminating credible, comparable data is equally–if not more–important.

Our data and empirical findings about the role of financial reporting transparency also point toward several new research possibilities. One key avenue of future research is to explore the factors influencing politicians' costs of being transparent about the state of their domestic financial sector. We have shown that the public can benefit from reduced sovereign borrowing costs if their government chooses to be transparent. Given this, why do many politicians nonetheless perceive that revealing this data is more costly than choosing not to disclose such information? In our model, thus far, we have made the expedient assumption that costs–e.g. legal, political, administrative costs–are drawn from a discrete uniform distribution. Future work might relax this assumption, in order to understand how these costs actually vary across countries and how they might be changed - not only by the collection and dissemination of financial data, but also by the diffusion of transparency best practices through international financial institutions' efforts. Does the indebtedness of similar countries mean that financial reporting transparency in a given country plays a greater role? One can imagine that having more information from the Portuguese financial sector would be of interest to investors if the Spanish financial sector got into trouble, as it did in 2011. The FDT, in conjunction with extensions of our existing model, would allow scholars to explore such issues in the future.

Another avenue of potential research concerns the application of the formal model to other policy areas. The model's framework considers any possible implicit liabilities that could have a step-change effect on debts, not just financial liabilities. One can therefore imagine other types of liabilities that would be of interest, such as pension obligations. For example, Brooks (2009) argues that Latin American governments with large implicit pension liabilities were hesitant to privatize their systems because they were worried about how sovereign debt markets would react when they learned about the scale of the obligations. Note that this corresponds to a case, in our model, where transparency is low and the actual implicit liabilities are high. Our research would suggest that greater transparency would most significant affect those countries with low debt levels. Normally, pension obligations increase gradually over relatively long periods of time, which in modeling terms means that there is a steady and relatively small, but fairly certain, realization of liabilities. Our current model, in contrast, assumes a sudden jump in implicit to explicit liabilities during a crisis. Nonetheless, pension privatization would indeed potentially both reveal, and actualize, the true liability much more quickly. Fully addressing these differences across types of implicit liabilities would require further development of our model, but there are good reasons to believe that the general framework could be fruitfully applied to wider range of cases where the government faces risks from implicit guarantees and market actors worry about the likelihood that such guarantees will become explicit in the future.

Finally, while we intentionally limited the current study to developed countries, future work might extend the analysis to emerging market countries. As we have discussed extensively above, developing countries face a variety of constraints–such as debt intolerance and original sin–that developed countries do not. Nonetheless, our theory and framework could also shed light on the relationship between sovereign debt and transparency in the developing country context. Our expectation is that the differences between OECD and developing countries would suggest a lower debt price ceiling and more sensitivity to the effects of such implicit liabilities in the latter set of countries. Exploring this possibility, as well as the degree to which market actors may demand that emerging markets report different types of information about the financial sector, is another key avenue of future research.

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Supplementary Files

Force $REVEAL$ at high debt levels

One potentially interesting subset of the game is a special case where interest rates are at their highest level–e.g. very high over two stages–and explicit debt is not decreasing. In these cases, governments may be required to make reforms in order to be able to borrow at all. Investors, especially those that lend to governments at the interest rate ceiling like the International Monetary Fund, would likely want the government to choose a $REVEAL$ policy in order to gauge risks over the longer-term. As such we could add an assumption that governments are forced to $REVEAL$ when offered very high rates and their debt (X) is not decreasing. Otherwise investors would not offer to buy the government's debt at all. We can see in Table A-1 that this assumption is equivalent to assuming that governments receive $c = 1$ from switching to a $REVEAL$ in these situations.

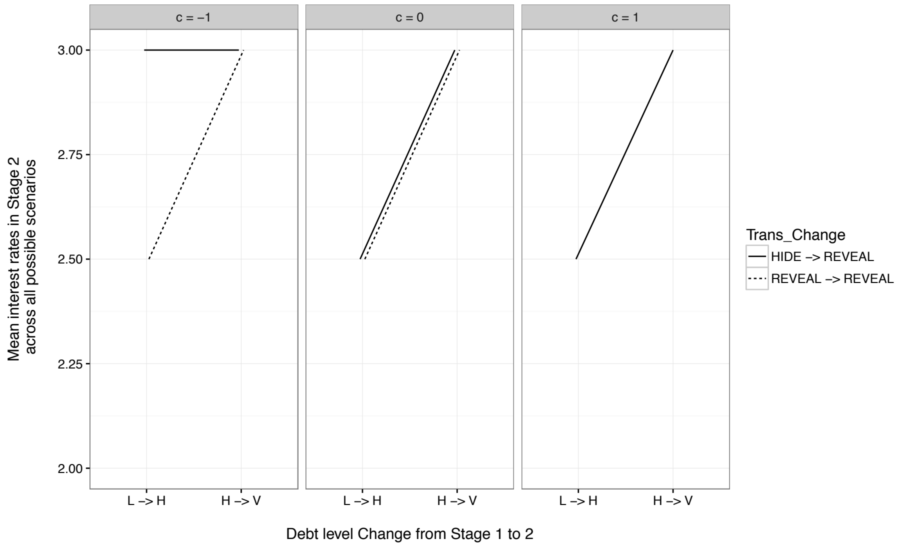
Examining the game over two stages when $c = 1$ exposes a counter-intuitive hypothesis about interest rate costs when governments increase transparency. Figure A-1 shows that under a specific scenario countries with increasing debt and increasing transparency can have higher interest rates. In all other cases of increasing debt, the interest rates are the same regardless of the change (or not) in transparency choice. The reason for this has to do with the situations under which governments with increasing debt would become more transparent. These are countries that have a cost to changing their level of transparency and would prefer to continue hiding but are forced to open as their financial market conditions and debt worsen and thus their interest rates worsen.

If this effect does exist, we anticipate that it will be small on average as it is caused by a specific scenario. In addition to this outcome applying to a specific debt scenario, governments may be able to rely on creditors who do not force transparency and other policies, such as by increasing domestic demand for its debt and having the central bank hold debt. So we do not expect forced openings even in all situations with very high and increasing debt, especially in economically developed countries with more tools to rein in very high interest rates. Future work could examine these types of scenarios in detail.

Note on Table A-1

P^G indicates the preferred transparency level for the government in the second stage of the game. Likewise, the utilities U and whether or not transparency would be Forced refer to the second stage of the game in scenarios discussed in the previous section.

Figure A-1: Average Interest Rate Charged in Stage 2 Over all Possible Outcomes Given Transparency Changes and Increasing Explicit Debt (X) Levels



Note: overlapping lines were dodged to enable visibility.

What an investor learns from the government changing their level of transparency

If the government has $c = -1$, then they never benefit from switching their transparency level from the status quo ante. So observing that a government with $c = -1$ continues to $HIDE$ or $REVEAL$ is not informative about Γ. They will stay with the status quo transparency level regardless, except if they are forced to $REVEAL$.

When $c = 0$ then governments always prefer REVEAL, as we saw earlier, except when the status quo ante is $HIDE$ and they are indifferent between $HIDE/REVEAL$. In these cases status quo bias inclines them to continue hiding (unless they are forced to $REVEAL$). Such indifference occurs when debt is very high regardless of Γ or when X is low or high and Γ is high. As such, when $c = 0$ observing that the government chose $HIDE$ is equivalent to observing Γ_H.

When there is an intrinsic benefit to changing the level of transparency ($c = 1$), the status quo ante is $REVEAL$ and $X_H \wedge \Gamma_H$ or $X_V \wedge (\Gamma_L \vee \Gamma_H)$, then the government would initially prefer to switch their transparency level to $HIDE$. Doing so for X_H indicates to the investor that Γ is high, as if Γ_L they would have been indifferent between $REVEAL$ and $HIDE$ and so would have chosen $REVEAL$. In all of these situations, the investor would force $REVEAL$. When X is low and the status quo ante is $REVEAL$ if Γ_L then the government will be indifferent so will choose $REVEAL$. While if Γ_H they will choose $HIDE$, so the choice of $HIDE$ is equivalent in terms of the information it provides to the investor to revealing Γ_H.

Table A-1: Extensive Form Government Payoffs for All Valid Scenarios in 2 Stage Transparency Games

ID	X_1	X_2	Γ_1	Γ_2	$Transp._1$	$Transp._2$	r_1	r_2	$U^G_{c=0}$	$U^G_{c=-1}$	$U^G_{c=1}$	$P^G_{c=0}$	$P^G_{c=-1}$	$P^G_{c=1}$	Forced?
1	L	L	L	L	HIDE	HIDE	2.0	2.0	-1.0	-1.0	-1.0		P		
1	L	L	L	L	HIDE	REVEAL	2.0	1.0	0.0	-1.0	1.0	P		P	
2	L	L	L	L	REVEAL	HIDE	1.0	2.0	-1.0	-2.0	0.0				
2	L	L	L	L	REVEAL	REVEAL	1.0	1.0	0.0	0.0	0.0	P	P	P	
3	H	L	L	L	HIDE	HIDE	3.0	2.0	-1.0	-1.0	-1.0		P		
3	H	L	L	L	HIDE	REVEAL	3.0	1.0	0.0	-1.0	1.0	P		P	
4	H	L	L	L	REVEAL	HIDE	2.0	2.0	-1.0	-2.0	0.0				
4	H	L	L	L	REVEAL	REVEAL	2.0	1.0	0.0	0.0	0.0	P	P	P	
5	H	H	L	L	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0		P		
5	H	H	L	L	HIDE	REVEAL	3.0	2.0	-1.0	-2.0	0.0	P		P	
6	H	H	L	L	REVEAL	HIDE	2.0	3.0	-2.0	-3.0	-1.0				
6	H	H	L	L	REVEAL	REVEAL	2.0	2.0	-1.0	-1.0	-1.0	P	P	P	
7	V	H	L	L	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0		P		
7	V	H	L	L	HIDE	REVEAL	3.0	2.0	-1.0	-2.0	0.0	P		P	
8	V	H	L	L	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0				
8	V	H	L	L	REVEAL	REVEAL	3.0	2.0	-1.0	-1.0	-1.0	P	P	P	
9	V	V	L	L	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0	P	P		
9	V	V	L	L	HIDE	REVEAL	3.0	3.0	-2.0	-3.0	-1.0			P	F
10	V	V	L	L	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0			P	
10	V	V	L	L	REVEAL	REVEAL	3.0	3.0	-2.0	-2.0	-2.0	P	P		
11	L	L	H	H	HIDE	HIDE	2.0	2.0	-1.0	-1.0	-1.0	P	P		
11	L	L	H	H	HIDE	REVEAL	2.0	2.0	-1.0	-2.0	0.0			P	
12	L	L	H	H	REVEAL	HIDE	2.0	2.0	-1.0	-2.0	0.0			P	
12	L	L	H	H	REVEAL	REVEAL	2.0	2.0	-1.0	-1.0	-1.0	P	P		
13	L	H	H	H	HIDE	HIDE	2.0	3.0	-2.0	-2.0	-2.0	P	P		
13	L	H	H	H	HIDE	REVEAL	2.0	3.0	-2.0	-3.0	-1.0			P	F
14	L	H	H	H	REVEAL	HIDE	2.0	3.0	-2.0	-3.0	-1.0			P	
14	L	H	H	H	REVEAL	REVEAL	2.0	3.0	-2.0	-2.0	-2.0	P	P		
15	H	L	H	H	HIDE	HIDE	3.0	2.0	-1.0	-1.0	-1.0	P	P		
15	H	L	H	H	HIDE	REVEAL	3.0	2.0	-1.0	-2.0	0.0			P	
16	H	L	H	H	REVEAL	HIDE	3.0	2.0	-1.0	-2.0	0.0			P	
16	H	L	H	H	REVEAL	REVEAL	3.0	2.0	-1.0	-1.0	-1.0	P	P		
17	H	H	H	H	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0	P	P		
17	H	H	H	H	HIDE	REVEAL	3.0	3.0	-2.0	-3.0	-1.0			P	F
18	H	H	H	H	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0			P	
18	H	H	H	H	REVEAL	REVEAL	3.0	3.0	-2.0	-2.0	-2.0	P	P		
19	H	V	H	H	HIDE	HIDE	3.0	3.0	-2.5	-2.5	-2.5	P	P		
19	H	V	H	H	HIDE	REVEAL	3.0	3.0	-2.5	-3.5	-1.5			P	F
20	H	V	H	H	REVEAL	HIDE	3.0	3.0	-2.5	-3.5	-1.5			P	
20	H	V	H	H	REVEAL	REVEAL	3.0	3.0	-2.5	-2.5	-2.5	P	P		
21	V	H	H	H	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0	P	P		

21	V	H	H	H	HIDE	REVEAL	3.0	3.0	-2.0	-3.0	-1.0			P	
22	V	H	H	H	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0			P	
22	V	H	H	H	REVEAL	REVEAL	3.0	3.0	-2.0	-2.0	-2.0	P	P		
23	V	V	H	H	HIDE	HIDE	3.0	3.0	-2.5	-2.5	-2.5	P	P		
23	V	V	H	H	HIDE	REVEAL	3.0	3.0	-2.5	-3.5	-1.5			P	F
24	V	V	H	H	REVEAL	HIDE	3.0	3.0	-2.5	-3.5	-1.5			P	
24	V	V	H	H	REVEAL	REVEAL	3.0	3.0	-2.5	-2.5	-2.5	P	P		
25	L	L	L	H	HIDE	HIDE	2.0	2.0	-1.0	-1.0	-1.0	P	P		
25	L	L	L	H	HIDE	REVEAL	2.0	2.0	-1.0	-2.0	0.0			P	
26	L	L	L	H	REVEAL	HIDE	1.0	2.0	-1.0	-2.0	0.0			P	
26	L	L	L	H	REVEAL	REVEAL	1.0	2.0	-1.0	-1.0	-1.0	P	P		
27	H	L	L	H	HIDE	HIDE	3.0	2.0	-1.0	-1.0	-1.0	P	P		
27	H	L	L	H	HIDE	REVEAL	3.0	2.0	-1.0	-2.0	0.0			P	
28	H	L	L	H	REVEAL	HIDE	2.0	2.0	-1.0	-2.0	0.0			P	
28	H	L	L	H	REVEAL	REVEAL	2.0	2.0	-1.0	-1.0	-1.0	P	P		
29	H	H	L	H	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0	P	P		
29	H	H	L	H	HIDE	REVEAL	3.0	3.0	-2.0	-3.0	-1.0			P	F
30	H	H	L	H	REVEAL	HIDE	2.0	3.0	-2.0	-3.0	-1.0			P	
30	H	H	L	H	REVEAL	REVEAL	2.0	3.0	-2.0	-2.0	-2.0	P	P		
31	V	H	L	H	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0	P	P		
31	V	H	L	H	HIDE	REVEAL	3.0	3.0	-2.0	-3.0	-1.0			P	
32	V	H	L	H	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0			P	
32	V	H	L	H	REVEAL	REVEAL	3.0	3.0	-2.0	-2.0	-2.0	P	P		
33	V	V	L	H	HIDE	HIDE	3.0	3.0	-2.5	-2.5	-2.5	P	P		
33	V	V	L	H	HIDE	REVEAL	3.0	3.0	-2.5	-3.5	-1.5			P	F
34	V	V	L	H	REVEAL	HIDE	3.0	3.0	-2.5	-3.5	-1.5			P	
34	V	V	L	H	REVEAL	REVEAL	3.0	3.0	-2.5	-2.5	-2.5	P	P		
35	L	L	H	L	HIDE	HIDE	2.0	2.0	-1.0	-1.0	-1.0		P		
35	L	L	H	L	HIDE	REVEAL	2.0	1.0	0.0	-1.0	1.0	P		P	
36	L	L	H	L	REVEAL	HIDE	2.0	2.0	-1.0	-2.0	0.0				
36	L	L	H	L	REVEAL	REVEAL	2.0	1.0	0.0	0.0	0.0	P	P	P	
37	L	H	H	L	HIDE	HIDE	2.0	3.0	-2.0	-2.0	-2.0		P		
37	L	H	H	L	HIDE	REVEAL	2.0	2.0	-1.0	-2.0	0.0	P		P	
38	L	H	H	L	REVEAL	HIDE	2.0	3.0	-2.0	-3.0	-1.0				
38	L	H	H	L	REVEAL	REVEAL	2.0	2.0	-1.0	-1.0	-1.0	P	P	P	
39	H	L	H	L	HIDE	HIDE	3.0	2.0	-1.0	-1.0	-1.0		P		
39	H	L	H	L	HIDE	REVEAL	3.0	1.0	0.0	-1.0	1.0	P		P	
40	H	L	H	L	REVEAL	HIDE	3.0	2.0	-1.0	-2.0	0.0				
40	H	L	H	L	REVEAL	REVEAL	3.0	1.0	0.0	0.0	0.0	P	P	P	
41	H	H	H	L	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0		P		
41	H	H	H	L	HIDE	REVEAL	3.0	2.0	-1.0	-2.0	0.0	P		P	
42	H	H	H	L	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0				
42	H	H	H	L	REVEAL	REVEAL	3.0	2.0	-1.0	-1.0	-1.0	P	P	P	
43	H	V	H	L	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0	P	P		
43	H	V	H	L	HIDE	REVEAL	3.0	3.0	-2.0	-3.0	-1.0			P	F

44	H	V	H	L	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0			P	
44	H	V	H	L	REVEAL	REVEAL	3.0	3.0	-2.0	-2.0	-2.0	P	P		
45	V	H	H	L	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0		P		
45	V	H	H	L	HIDE	REVEAL	3.0	2.0	-1.0	-2.0	0.0	P		P	
46	V	H	H	L	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0				
46	V	H	H	L	REVEAL	REVEAL	3.0	2.0	-1.0	-1.0	-1.0	P	P	P	
47	V	V	H	L	HIDE	HIDE	3.0	3.0	-2.0	-2.0	-2.0	P	P		
47	V	V	H	L	HIDE	REVEAL	3.0	3.0	-2.0	-3.0	-1.0			P	F
48	V	V	H	L	REVEAL	HIDE	3.0	3.0	-2.0	-3.0	-1.0			P	
48	V	V	H	L	REVEAL	REVEAL	3.0	3.0	-2.0	-2.0	-2.0	P	P		

R source code for costless transparency decisions in one stage

The following code was used to model the payoffs displayed in Figure 1.

```
# Create scenarios -----------------

payoff <- data.frame(

    x = rep(1:3, 2), # 1 = L, 2 = H, 3 = V

    gamma = c(rep(0, 3), rep(1, 3)) # 0 = L, 1 = H

)


# REVEAL

payoff$trans <- 0


# HIDE

payoff2 <- payoff

payoff2$trans <- 1


payoff <- rbind(payoff, payoff2)


# Find real debt level D

payoff$D_actual <- payoff$x + payoff$gamma

payoff$D_actual[payoff$D_actual > 3] <- 3


# Find investors belief about D under an assumption that they don’t want to be

# ’caught out’

payoff$D_I_belief <- NA

for (i in 1:nrow(payoff)) {

    if (payoff[i, ’trans’] == 0) payoff[i, ’D_I_belief’] <- payoff[i, ’D_actual’]

    else payoff[i, ’D_I_belief’] <- payoff[i, ’x’] + 1

}


payoff$D_I_belief[payoff$D_I_belief > 3] <- 3


# Interest rate based on Investor’s beliefs

payoff$r <- payoff$D_I_belief
```

```
# Government's utility
payoff$u_g <- 1 - payoff$r
payoff$u_i <- payoff$r - payoff$D_actual
```

Transparency game with costly transparency changes over two stages

The following R source code was used to find the results in Table A-1.

```
# Create scenarios ------------------
# Constant \Gamma at a low level
scen1 <- data.frame(
    x1 = rep('L', 12),
    x2 = c(rep('L', 4), rep('H', 4), rep('V', 4)),
    gamma1 = rep('L', 12),
    gamma2 = rep('L', 12),
    trans1 = rep(c('HIDE', 'HIDE', 'REVEAL', 'REVEAL'), 3),
    trans2 = rep(c('HIDE', 'REVEAL', 'HIDE', 'REVEAL'), 3)
)
scen1$r1 <- NA
scen1$r2 <- NA

scen1_h <- scen1
scen1_h$x1 <- 'H'

scen1_v <- scen1
scen1_v$x1 <- 'V'

scen1 <- rbind(scen1, scen1_h, scen1_v)

# Constant \Gamma at a high level
scen2 <- scen1
scen2$gamma1 <- 'H'
scen2$gamma2 <- 'H'
```

```
# Increasing \Gamma -----
scen3 <- scen1
scen3$gamma2 <- 'H'

# Decreasing \Gamma -----
scen4 <- scen1
scen4$gamma1 <- 'H'

scen <- rbind(scen1, scen2, scen3, scen4)

# Keep only valid scenarios, where change in debt is caused by change in
## \Gamma or \Gamma high -----
for (i in 1:4) scen[, i] <- as.character(scen[, i])

# Keep only valid scenarios, where change in debt is one step
# Debt can only go up when \Gamma is high
scen <- scen %>% filter(x1 == x2 |
                    (x1 == 'L' & x2 == 'H' & gamma1 == 'H' & gamma2 == 'H') |
                    (x1 == 'L' & x2 == 'H' & gamma1 == 'H' & gamma2 == 'L') |
                    (x1 == 'H' & x2 == 'V' & gamma1 == 'H' & gamma2 == 'H') |
                    (x1 == 'H' & x2 == 'V' & gamma1 == 'H' & gamma2 == 'L') |
                    (x1 == 'V' & x2 == 'H') |
                    (x1 == 'H' & x2 == 'L')
)

# Find interest rate choice ----------------------------------------------------
for (i in 1:nrow(scen)) {
    for (u in 1:2) {
        # Low explicit debt
        if (scen[i, paste0('x', u)] == 'L' &
            scen[i, paste0('gamma', u)] == 'L' &
            scen[i, paste0('trans', u)] == 'HIDE') {
            scen[i, paste0('r', u)] <- 2
        }
```

```
if (scen[i, paste0('x', u)] == 'L' &
    scen[i, paste0('gamma', u)] == 'L' &
    scen[i, paste0('trans', u)] == 'REVEAL') {
    scen[i, paste0('r', u)] <- 1
}

if (scen[i, paste0('x', u)] == 'L' &
    scen[i, paste0('gamma', u)] == 'H' &
    scen[i, paste0('trans', u)] == 'HIDE') {
    scen[i, paste0('r', u)] <- 2
}
if (scen[i, paste0('x', u)] == 'L' &
    scen[i, paste0('gamma', u)] == 'H' &
    scen[i, paste0('trans', u)] == 'REVEAL') {
    scen[i, paste0('r', u)] <- 2
}
# High explicit debt
if (scen[i, paste0('x', u)] == 'H' &
    scen[i, paste0('gamma', u)] == 'L' &
    scen[i, paste0('trans', u)] == 'HIDE') {
    scen[i, paste0('r', u)] <- 3
}
if (scen[i, paste0('x', u)] == 'H' &
    scen[i, paste0('gamma', u)] == 'L' &
    scen[i, paste0('trans', u)] == 'REVEAL') {
    scen[i, paste0('r', u)] <- 2
}

if (scen[i, paste0('x', u)] == 'H' &
    scen[i, paste0('gamma', u)] == 'H' &
    scen[i, paste0('trans', u)] == 'HIDE') {
    scen[i, paste0('r', u)] <- 3
}
if (scen[i, paste0('x', u)] == 'H' &
```

```
            scen[i, paste0('gamma', u)] == 'H' &
            scen[i, paste0('trans', u)] == 'REVEAL') {
            scen[i, paste0('r', u)] <- 3
        }
        # Very high explicit debt
        if (scen[i, paste0('x', u)] == 'V') {
            scen[i, paste0('r', u)] <- 3
        }
    }
}

# Find changes from stages 1 to 2 ---------
scen$delta_r = scen$r2 - scen$r1

# Gov. Utilities: Costless transparency change scenario (Stage 1) --------------
scen$u1 = 1 - scen$r1

# Gov. interest rate ceiling cost of 0.5 for x = V and gamma = H (Stage 1) -----
for (i in 1:nrow(scen)) {
    if (scen[i, 'x1'] == 'V' & scen[i, 'gamma1'] == 'H') {
        scen[i, 'u1'] <- scen[i, 'u1'] - 0.5
    }
}

# Gov. Utilities: Constant change cost = -1 (Stage 1)  ------
scen$u1_costly <- scen$u1
for (i in 1:nrow(scen)) scen[i, 'u1_costly'] <- scen[i, 'u1'] + -1

# Gov. Utilities: Constant change benefit = +1 (Stage 1) ---
for (i in 1:nrow(scen)) scen[i, 'u1_benefit'] <- scen[i, 'u1'] + 1

# Gov. Utilities: Costless scenario (Stage 2) ----------------------------------
scen$u2 = 1 - scen$r2
```

```
# Gov. interest rate ceiling cost of 0.5 for x = V and gamma = H (Stage 2) -----
for (i in 1:nrow(scen)) {
    if (scen[i, 'x2'] == 'V' & scen[i, 'gamma2'] == 'H') {
        scen[i, 'u2'] <- scen[i, 'u2'] - 0.5
    }
}

# Gov. Utilities: Constant change cost = -1 (Stage 2)  ------------------------
scen$u2_costly <- scen$u2
for (i in 1:nrow(scen)) {
    if (scen[i, 'trans1'] != scen[i, 'trans2']) {
        scen[i, 'u2_costly'] <- scen[i, 'u2'] + -1
    }
}

# Gov. Utilities: Constant change benefit = +1 (Stage 2) -----------------------
scen$u2_benefit <- scen$u2
for (i in 1:nrow(scen)) {
    if (scen[i, 'trans1'] != scen[i, 'trans2']) {
        scen[i, 'u2_benefit'] <- scen[i, 'u2'] + 1
    }
}

# Find preferred strategies -----------------------
scen$scenario_id_2 <- with(scen, paste(x1, x2, gamma1, gamma2, trans1,
                                       sep = '_'))

preferred <- function(x, t1, t2) {
    x <- x == max(x)
    # Minimal switching cost, i.e. status quo bias under conditions of indifference
    if (!missing(t2) & length(x[x == TRUE]) > 1) {
        x[t1 != t2] <- FALSE
    }
    x <- as.character(x)
```

```
    x[x == 'TRUE'] <- 'P'
    x[x == 'FALSE'] <- ''
    return(x)
}

# Stage 2 preferred transparency
scen <- scen %>% group_by(scenario_id_2) %>%
    mutate(preferred2_costless = preferred(u2, trans1, trans2),
           preferred2_costly = preferred(u2_costly, trans1, trans2),
           preferred2_benefit = preferred(u2_benefit, trans1, trans2)
           )

# Forced REVEAL under very high interest rates ------------
scen$forced <- ''
scen$forced[scen$trans1 == 'HIDE' & scen$trans2 == 'REVEAL' &
                scen$r2 == 3 & !(scen$x1 == 'V' & scen$x2 == 'H') &
                !(scen$x1 == 'H' & scen$x2 == 'L')
            ] <- 'F'
```

FDT inclusion criteria

We build on Hollyer et al.'s (2014) criteria for inclusion of items and country-years. First, we only include indicators that are reported by at least one country for each year in the period 1990-2011. This gave us the greatest coverage of indicators that are comparable across countries. Second, we exclude all indicators that were explicitly gathered for only a subset of countries. As such we avoid including data where the primary source is the Bank for International Settlements. Third, we do not include any indicator that is from a non-governmental source. This included indicators from World Bank sponsored surveys, such as the Global Financial Inclusion Survey and the Enterprise Survey. In addition we excluded data from Swiss Re's Sigma Reports, Standard & Poor's, Bankscope, and Bloomberg. Fourth, we do not include variables that are linear combinations of other variables. Fifth, we do not include variables that are simply references to the same quantity in different units or whose reporting is perfectly linearly correlated.

Sixth, we aim to focus on countries that have banking systems at a minimal level of development where they would actually have quantities on the included indicators. As such we include countries and jurisdictions that the World Bank classifies as "high income".[53] There are 10 mostly non-national-level jurisdictions[54] that are classified as high income, but which are not recorded as reporting any items in the GFDD. We excluded these jurisdictions from the data set.[55] We also include developing countries that are in JP Morgan's Emerging Market Bond Index (EMBI),[56] as well as China and India.[57]

Discrepancies between World Bank and FRED versions

We aimed to ensure that missing-ness in the GFDD data set was due to decisions made by national governments, rather than data handling issues at the international institutions that publish the data. In the course of these investigations we found that the version of the GFDD published by the World Bank in 2015 was incomplete.

The Federal Reserve Bank of St. Louis maintains the Federal Reserve Economic Data (FRED) database.[58] This database includes a mirror of much of the GFDD data set. FRED uses the same variable ID numbers as the GFDD and credits the GFDD as its source. However, item reporting coverage differs between the two data sets. This is illustrated in Figure A-2 which shows the proportion of items reported in the two versions of the data set where they do not match.[59] If the FRED and World Bank data sets matched exactly in terms of the items reported per country-year then the points would be on the 45 degree line.

In general, FRED has more data, though the World Bank has more data for a few countries such as Australia ("AU"). The biggest difference between the two data sets is for San Marino ("SM"). From 2005 to 2009, San Marino is recorded as having reported about 30 percent of items in the FRED version of the GFDD. In the World Bank version, San Marino reported almost none. Under-reporting in the World Bank version notably also occurs for the United Kingdom ("GB"), New Zealand ("NZ"), Estonia ("EE"), Switzerland ("CH"), and Luxembourg ("LU"), among others.

As the FRED data claims to be a copy of the World Bank's GFDD, we assume that discrepancies between the two data sets are caused by data handling problems at either institution, rather than a decision made by a national government to report or withhold data. As such we treat an item as

[53] We include both OECD and non-OECD high income countries.

[54] Andora, Bermuda, Cayman Islands, Curacao, Faeroe Islands, French Polynesia, Isle of Man, Liechtenstein, Monaco, New Caledonia

[55] Note that in earlier versions they were included. Their inclusion largely only changes the range of FDT scores estimated rather than the relative placement of each country for each year.

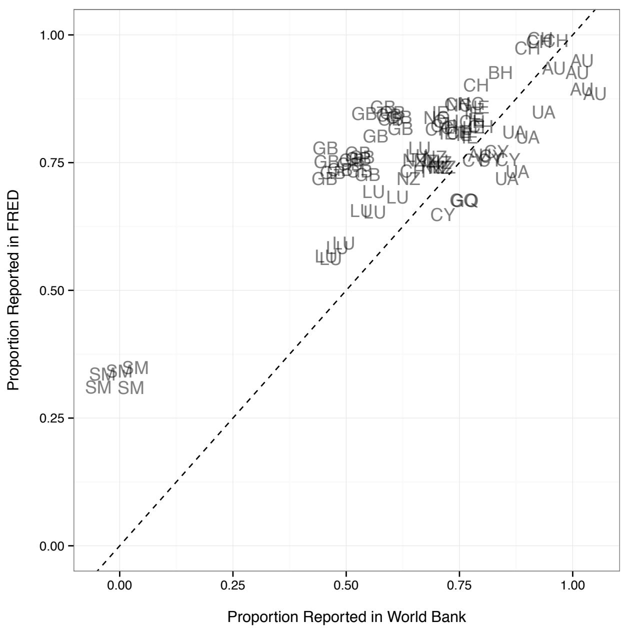
[56] See: https://www.jpmorgan.com/pages/jpmorgan/investbk/solutions/research/indices/product. Accessed May 2015. The countries included in the EMBI as of this writing are: Argentina, Brazil, Colombia, Ecuador, Egypt, Mexico, Morocco, Nigeria, Panama, Peru, Philippines, Poland, Russian Federation, South Africa, Turkey, Ukraine, and Venezuela.

[57] Note that we originally estimated the index with only high income countries. Estimated scores largely matched those when the index was run with the full sample.

[58] Available at: http://research.stlouisfed.org/fred2/. Accessed February 2016.

[59] The FRED database does not include two variables from the GFDD that we looked at. These are Domestic credit to private sector (%) and Liquid liabilities in millions of USD. We only compare items for which any data is available in the two versions.

Figure A-2: Comparison of GFDD Data Reported in the World Bank and FRED's Versions



Labels are ISO two-letter country codes.
The labels are jittered to make the plot more legible.
The dashed line indicates where the two versions of the data would match.
Note: only country-years where the FRED and World Bank versions of the GFDD differ are plotted.

reported for a country-year if it is published in *either* the FRED or World Bank versions of the GFDD.

Further details on FDT estimation model priors and convergence criteria

For each transparency parameter estimated after 1990 we used a system of random-walk priors such that $\alpha_{c,t} \sim N(\alpha_{c,t-1},\ \sigma_{\alpha c}) \forall t > 1$, where σ_c acts as a country-specific smoothing parameter. Each σ_c is estimated with a weakly informative half-Cauchy prior $\sigma_{\alpha c} \sim Cauchy(0,\ 0.05)$. This is in contrast to Hollyer et al. (2014) who use a Gamma prior distribution. Half-Cauchy priors have been shown to be more appropriate with hierarchical data (see Gelman, 2007; Polson and Scott, 2012). Finally, we used similar, though slightly less restrictive priors–$Cauchy(0,\ 0.25)$–[60]when estimating the discrimination and difficulty parameters. The mean transparency δ was given a half-Cauchy–$Cauchy(0,\ 0.05)$–prior.

Previous projects using Bayesian IRT for estimating transparency have used a Markov Chain Monte Carlo algorithm with Just Another Gibbs Sampler (JAGS) for model estimation. In contrast, we used the No-U-Turn Sampler (NUTS), an extension of the Hamiltonian Monte Carlo algorithm. NUTS is more efficient than other methods with models estimated from highly correlated data, as our, and IRT models

[60]We used a more restrictive prior for the transparency parameter in order to rein in the bounds of the Index.

in general are (Hoffman and Gelman, 2014). We implemented the model with Stan (Stan Development Team, 2015).[61] An additional small, though non-trivial, benefit of using Stan is that its more thoroughly vectorised code is considerably more compact and easy to interpret than the JAGS equivalent.[62] We ran the model for 4 chains of 120,000 iterations (half of which were burn-in) and used the Gelman-Rubin Diagnostic (Gelman and Rubin, 1992) to assess convergence with the 1.1 threshold (Gelman et al., 2014, 287).

Value added: comparison to a naive frequency method

A less computationally intensive method for developing an annual financial regulatory transparency index would be to examine item reporting frequencies with sum-scores–i.e. summing the number of items reported per country-year–or some normalizing transformation of this, such as the proportion of items a country reported in a year.[63] These approaches, as with the aggregate scores from the Liedorp et al. (2013) transparency survey, implicitly assume that reporting any one item is equivalent to reporting any other. This may not be the case. Reporting one item may be 'more difficult' than reporting another as it may be more politically sensitive or be on a quantity that is hard for regulators to observe without being intrusive. Using Bayesian IRT allows us to adjust for the fact that some items may be easier to report than others.

A basic test for examining if a frequency method would be just as appropriate and, because it is dramatically less computationally intensive, preferable to Bayesian IRT for constructing a transparency measure is to see if there is a linear association between the Bayesian IRT scores and frequency scores. Figure A-3 compares the proportion of items used (a frequency measure) in the FDT Index a country reported in a given year to that country-year's FDT score.[64] Rather than having a linear relationship, we can see that the FDT Index is less sensitive to indicator reporting than the frequency measure for countries that report fewer items. The FDT does not over-estimate the effect of reporting only the easy items the way that the frequency measure does. It is more sensitive when countries report many items. There is a wide range of FDT scores for countries that report more items as it can distinguish between the harder and easier items to report.

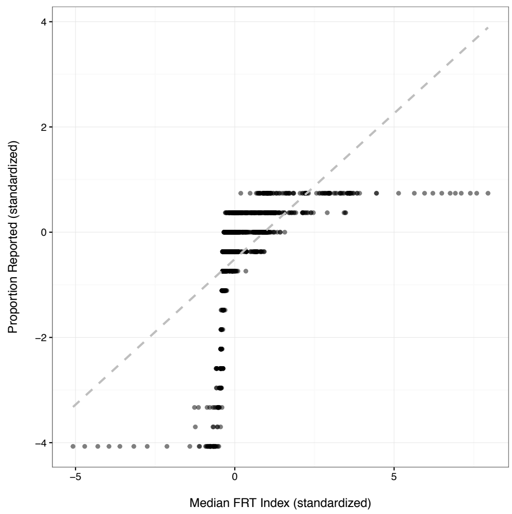
[61] The Stan model can be found at in the Appendix

[62] The Stan version of the model is approximately 67 lines of code whereas equivalent JAGS model is over 150.

[63] See figures A-12, A-13, A-14, and A-15 in the Appendix for the proportions of items reported for each country in our sample.

[64] Both are standardized by subtracting their mean and dividing by their standard deviation.

Figure A-3: Comparing Frequency Reported vs. FDT Index



Both the Proportion Reported transparency indicator and the FDT Index scores are standardized by subtracting their medians and dividing by their standard deviations.

Value added: comparison to Liedorp et al. (2013) frequency survey

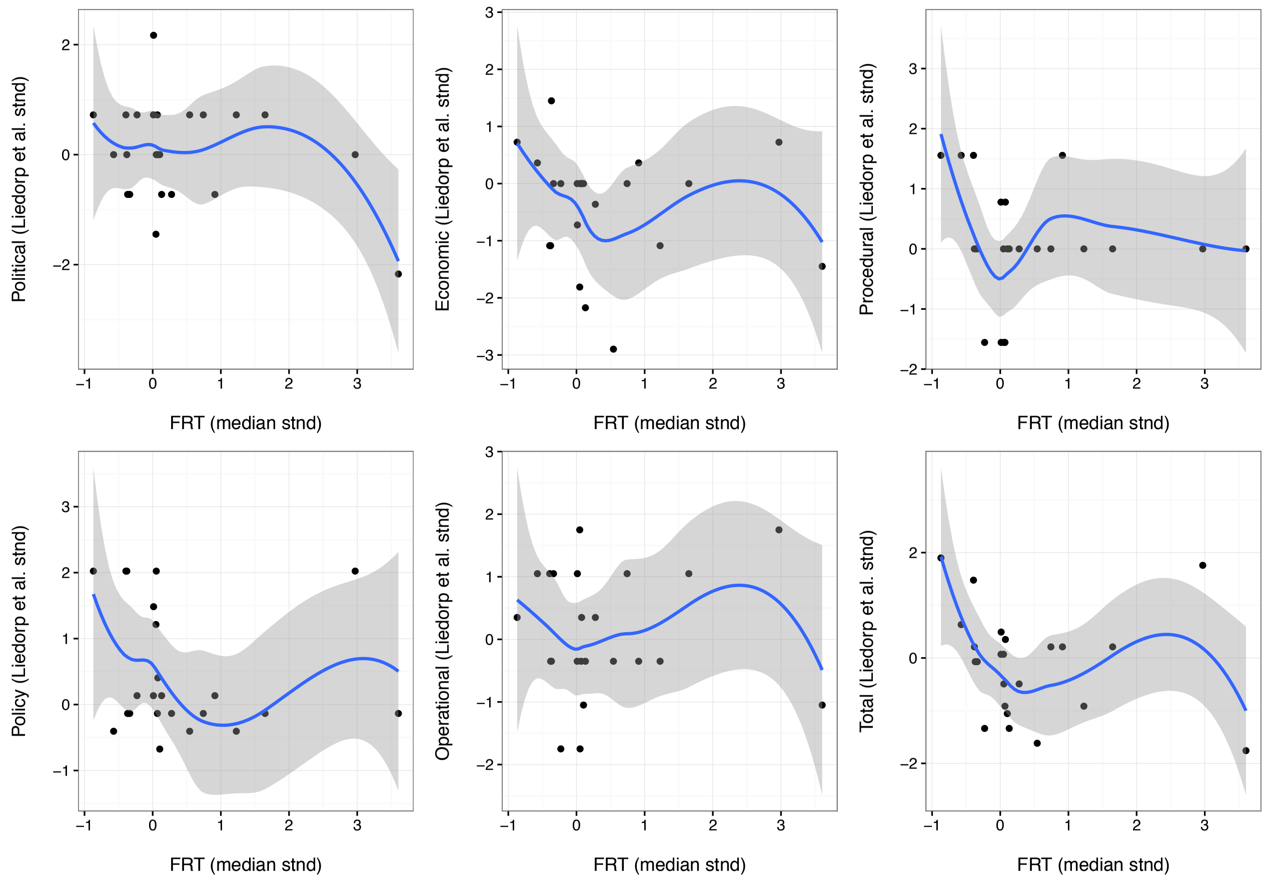
Before directly comparing the FDT Index to Liedorp et al.'s frequency-survey measure, it is important to consider the substantive and practical differences between the two indices. The indices, by design, are estimates of different aspects of transparency. A considerable portion of Liedorp et al.'s index is devoted to capturing formal and procedural components of supervision, including if the supervisor has a stated "supervisory strategy", does it have clear objectives, and are there formal arrangements for independence from politicians. The survey it is based on has a number of questions about what they term "economic" transparency that are broadly similar to what the FDT captures, namely making off-site inspection reports publicly available. Though again, this is not exactly the same as the FDT Index, which captures how transparent supervisors are with financial supervisory data to a specific audience: international institutions and investors.

Nonetheless, it is interesting to see how closely, if at all, the two measures are related. Figure A-4 compares the FDT Index to the components of the Liedorp et al. (2013) index as well as the total score for country-years where both indices have information available. We mean-standardized the measures as above. The top-right panel shows the relationship between Liedorp et al.'s economic transparency measure–the closest to our international data transparency index. There is very little, if any, relationship between the two measures. There is also a negative relationship between Liedorp et al.'s total score (bottom-right panel).

Interestingly, some countries with very high Liedorp et al. scores–namely Norway (the highest scorer) and the United Kingdom–have low data transparency scores in 2010. Norway's data transparency as measured by the FDT was indeed very high during most of the early 2000s. It actually reported all 14 items between 2000 and 2006. However, in 2007 through 2009 it reported only about a third of the items. In 2010–the year of Liedorp et al.'s survey–Norway only reported two items.[65] The United Kingdom consistently only reported about 75 percent of the items.

[65] Mutual fund assets to GDP (%) and Insurance company assets to GDP (%)

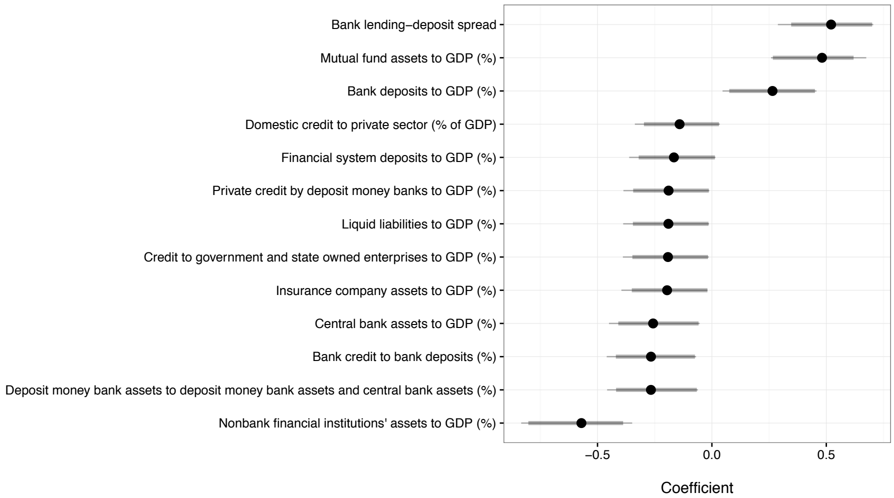
Figure A-4: Comparison of the FDT Index to Liedorp et al. (2013)



Note: both measures were standardized by subtracting their medians and dividing by standard deviations.

Item difficulty parameter estimates

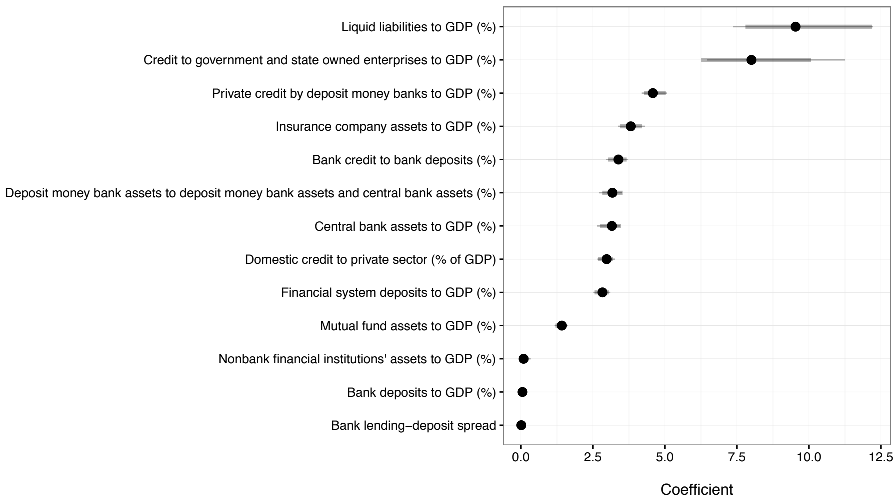
Figure A-5: Estimated Item Difficulty Parameters



Thin lines represent 95% highest probability density intervals. Thick lines represent 90% intervals. Points represent the median of the posterior distribution.

Item discrimination parameter estimates

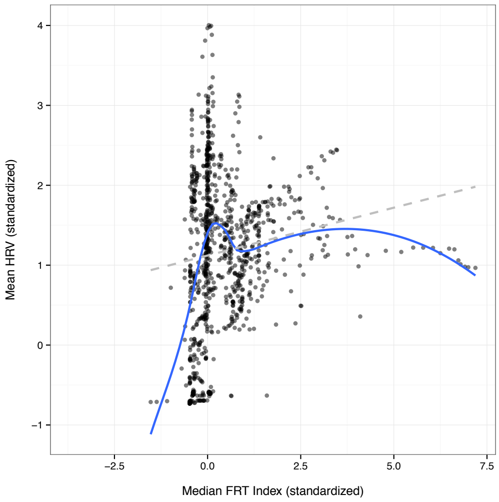
Figure A-6: Estimated Item Discrimination Parameters



Thin lines represent 95% highest probability density intervals. Thick lines represent 90% intervals. Points represent the median of the posterior distribution.

Visual comparison of the FDT and Hollyer, Rosendorff and Vreeland's (2014) Transparency Index

Figure A-7: Comparison of the FDT Index to the HRV Transparency Index



Both the HRV and FDT scores are standardized by subtracting their medians and dividing by their standard deviations.

The FDT's Stan estimation model

```
data {
    int<lower=1> C;                 // number of countries
    int<lower=1> T;                 // number of years
    int<lower=1> K;                 // number of items
    int<lower=1> N;                 // number of observations
    int<lower=1> cc[N];             // country for observation n
    int<lower=1> tt[N];             // time for observation n
    int<lower=1,upper=K> kk[N];     // item for observation n
    int<lower=0,upper=1> y[N];      // response for observation n
}

parameters {
    real delta;                        // mean transparency
    vector[C] alpha1;                  // initial alpha for t = 1 before recentering
    matrix[C,T] alpha;                 // transparency for c,t - mean
```

```
    vector[K] beta;                  // difficulty of item k
    vector<lower=0>[K] gamma;        // discrimination of k

    //// all scale parameters have an implicit half Cauchy prior ////
    real<lower=0> sigma_alpha[C];    // scale of abilities, per country
    real<lower=0> sigma_beta;        // scale of difficulties
    real<lower=0> sigma_gamma;       // scale of log discrimination
}

transformed parameters {
    vector[C] recentered_alpha1;
    real mean_alpha1;
    real<lower= 0> sd_alpha1;

    mean_alpha1 <- mean(alpha1);
    sd_alpha1 <- sd(alpha1);
    for (c in 1:C)
        recentered_alpha1[c] <- (alpha1[c] - mean_alpha1 ) / sd_alpha1;
}


model {
    alpha1 ~ normal(0,1);

    for (c in 1:C) {
        alpha[c,1] ~ normal(recentered_alpha1[c],0.001); // overcome Stan issue
        for (t in 2:T)
            alpha[c,t] ~ normal(alpha[c,t-1], sigma_alpha[c]);
    }

    beta ~ normal(0,sigma_beta);
    gamma ~ normal(0,sigma_gamma);
    delta ~ cauchy(0,0.05);
```

```
    sigma_alpha ~ cauchy(0,0.05);
    sigma_beta ~ cauchy(0,0.25);
    sigma_gamma ~ cauchy(0,0.25);

        for (n in 1:N)
            y[n] ~ bernoulli_logit(
           exp(gamma[kk[n]])
            * (alpha[cc[n],tt[n]] - beta[kk[n]] + delta) );
}
```

Figure A-8: Individual Countries' FDT Scores Over Time (1)

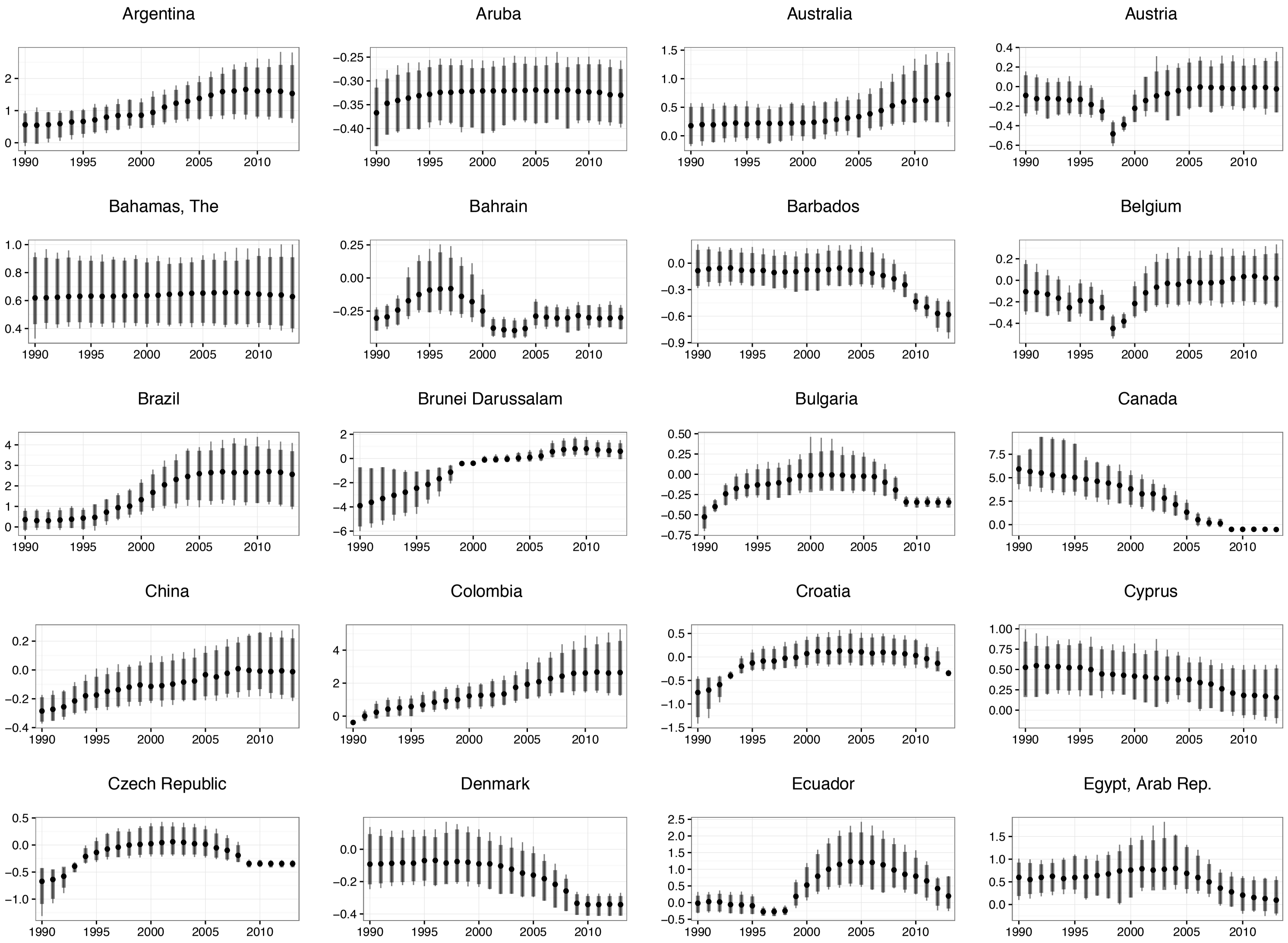


Figure A-9: Individual Countries' FDT Scores Over Time (2)

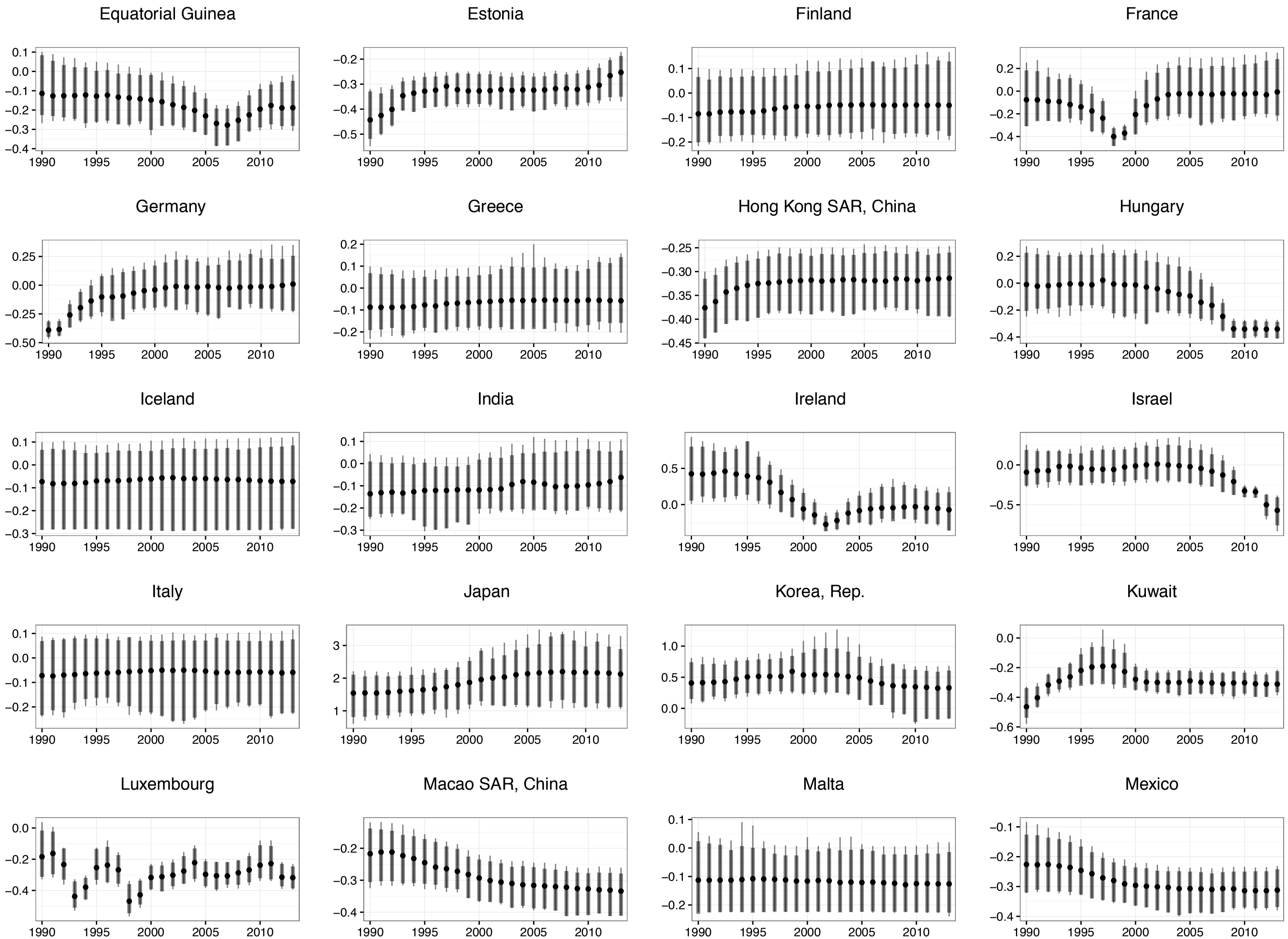


Figure A-10: Individual Countries' FDT Scores Over Time (3)

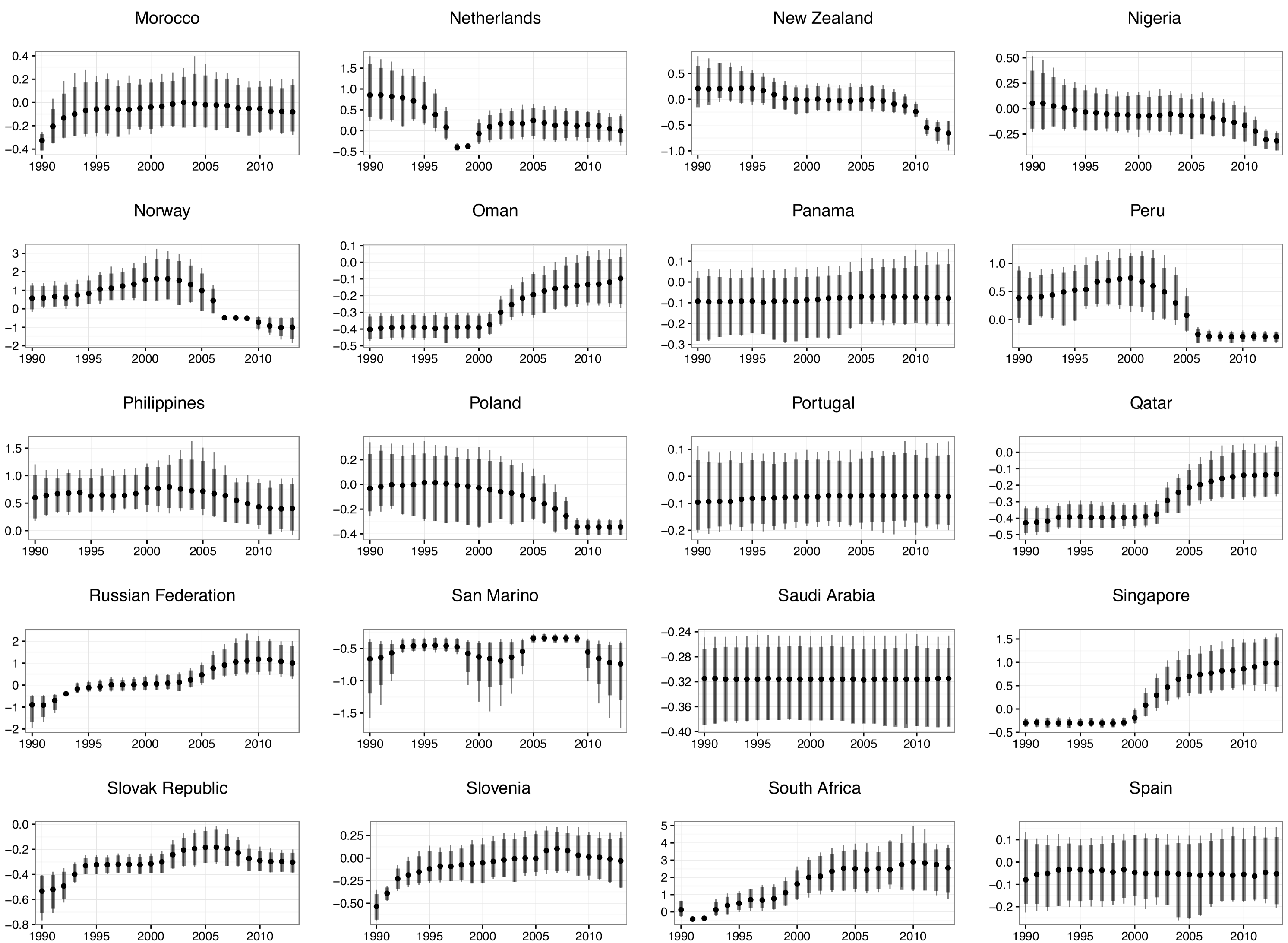


Figure A-11: Individual Countries' FDT Scores Over Time (4)

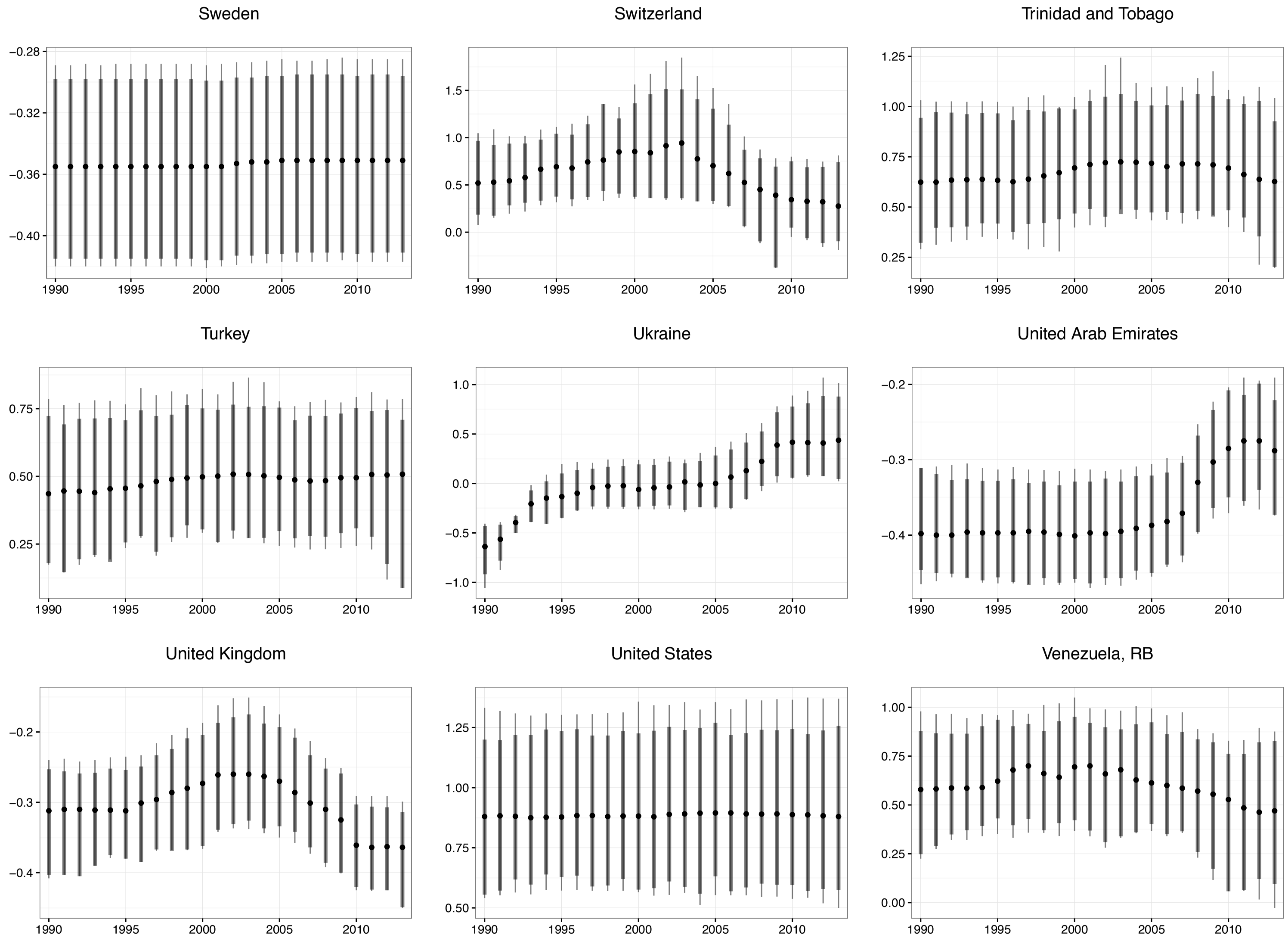


Figure A-12: Individual Countries' Proportions of Items Reported Over Time (1)

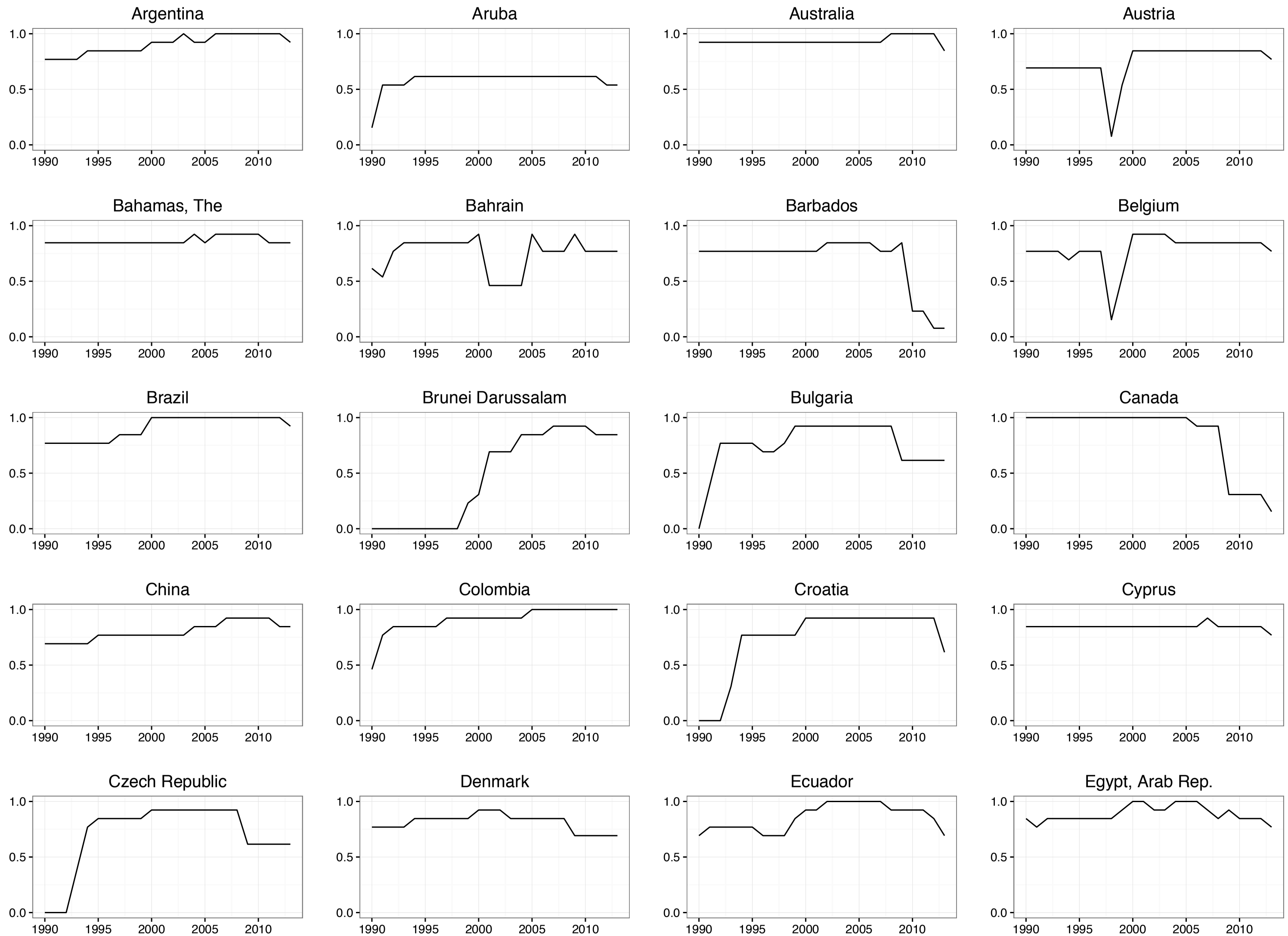


Figure A-13: Individual Countries' Proportions of Items Reported Over Time (2)

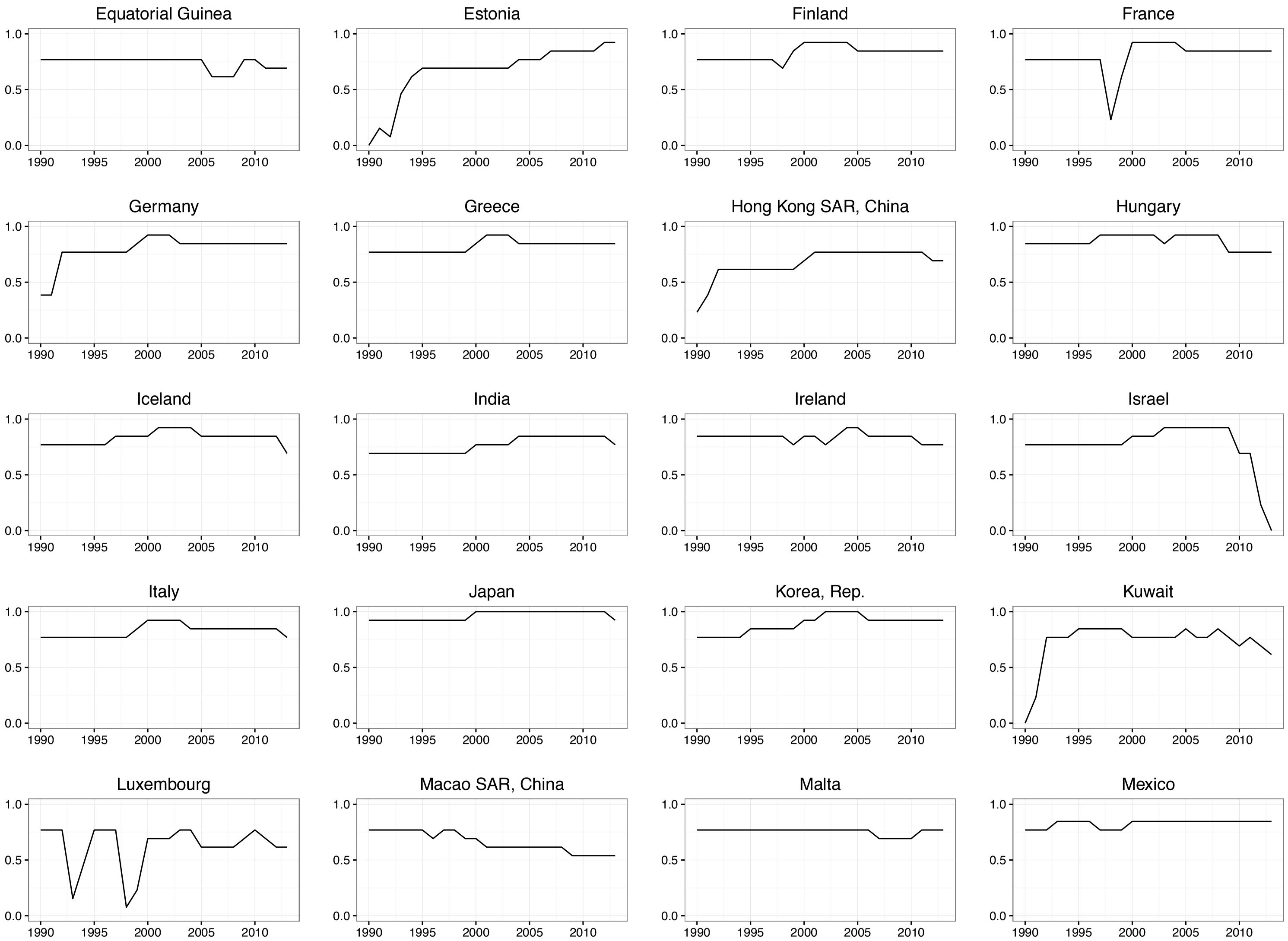


Figure A-14: Individual Countries' Proportions of Items Reported Over Time (3)

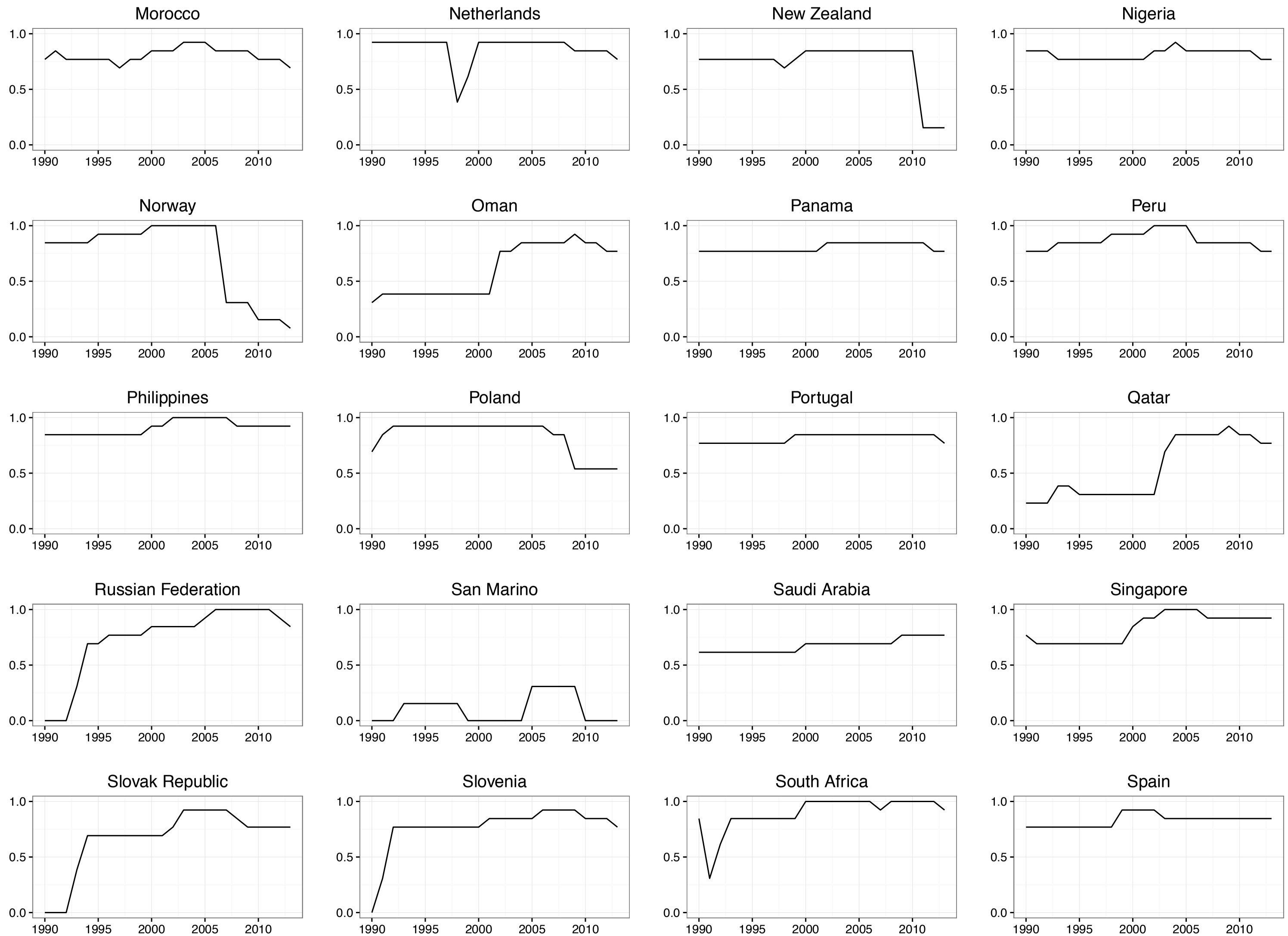
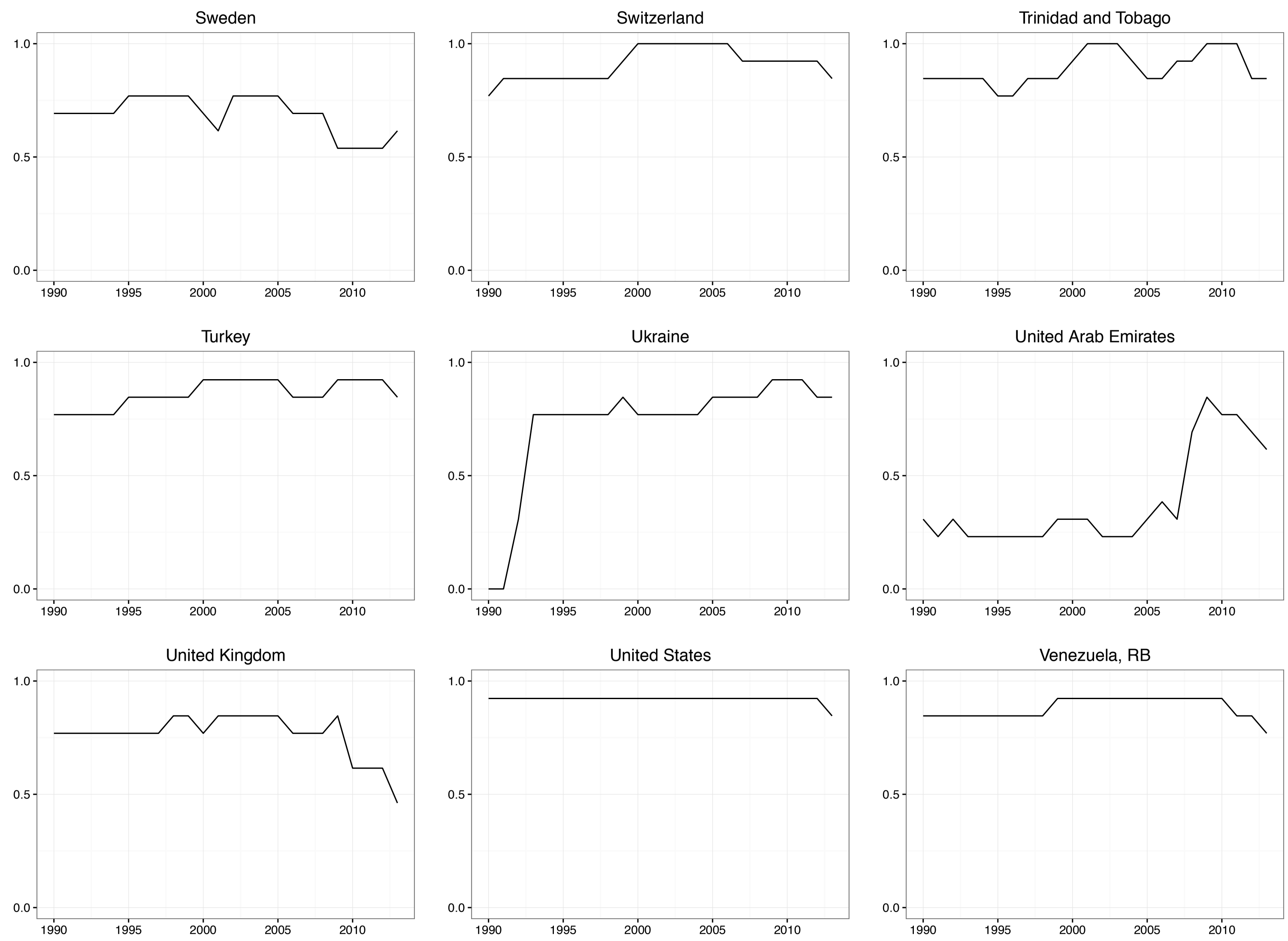


Figure A-15: Individual Countries' Proportions of Items Reported Over Time (4)



Regression model country sample

Note that the United States is excluded from models with bond spreads as the dependent variable and Japan is excluded from all models. Please see the main text for details.

Table A-2: Country sample for OECD countries (as of 2016) for which there is complete data

Country	First Year	Last Year
Australia	1991	2011
Austria	1991	2011
Belgium	1991	2011
Canada	1991	2011
Czech Republic	2001	2011
Denmark	1991	2011
Finland	1992	2011
France	1991	2011
Germany	1993	2011
Greece	1998	2011
Hungary	2000	2011
Iceland	1993	2011
Ireland	1991	2011
Israel	1998	2011
Italy	1992	2011
Japan	1991	2011
Korea, Republic of	2001	2011
Luxembourg	1994	2006
Mexico	2003	2006
Netherlands	1991	2011
New Zealand	1991	2011
Norway	1991	2011
Poland	2002	2011
Portugal	1994	2011
Slovakia	2001	2011
Slovenia	2003	2011
Spain	1991	2011
Sweden	1991	2011
Switzerland	1991	2011
United Kingdom	1991	2011
United States	1991	2011

Table A-3: Re-examining Sovereign Bond Prices Including Executive Election Year & Executive Economic Ideology

	Δ Long-term (10-year) bond spread (US 10-year bond, %)	Δ Long-term (10-year) bond spread (US 10-year bond, %)	Δ Coefficient of variation, LT bond yields (annual, based on monthly data)	Δ Coefficient of variation, LT bond yields (annual, based on monthly data)
Bond Spread$_{t-1}$	-0.33***	-0.33***		
	(0.06)	(0.06)		
LT rate COV$_{t-1}$			-0.74***	-0.73***
			(0.06)	(0.05)
FRT$_{t-1}$	-0.04	-0.22*	-0.70*	-3.87***
	(0.06)	(0.12)	(0.35)	(0.88)
Δ FRT	0.35**	0.30	0.27	-1.98
	(0.14)	(1.14)	(1.13)	(6.06)
Public debt/GDP (%)$_{t-1}$	0.01**	0.01*	0.05**	0.06***
	(0.01)	(0.01)	(0.02)	(0.02)
Δ Public debt/GDP	0.04*	0.04**	0.15***	0.18***
	(0.02)	(0.02)	(0.05)	(0.05)
Inflation (%) $_{t-1}$	0.07	0.07	0.00	-0.08
	(0.04)	(0.04)	(0.17)	(0.16)
Δ Inflation (%)	0.17***	0.17***	-0.09	-0.08
	(0.04)	(0.04)	(0.14)	(0.14)
GDP Growth$_{t-1}$	-0.18**	-0.19**	0.07	0.06
	(0.08)	(0.08)	(0.17)	(0.20)
Δ GDP Growth	-0.16**	-0.16**	-0.11	-0.12
	(0.07)	(0.07)	(0.15)	(0.18)
Per Capita GDP$_{t-1}$	0.00	0.00	-0.10	-0.06
	(0.01)	(0.01)	(0.06)	(0.04)
Δ Per Capita GDP	0.27***	0.28***	0.27	0.41
	(0.07)	(0.07)	(0.28)	(0.36)
OECD average GDP growth$_{t-1}$	0.08	0.09	-0.09	0.16
	(0.08)	(0.08)	(0.19)	(0.17)
Δ OECD average GDP growth	0.00	0.00	0.43**	0.38**
	(0.06)	(0.06)	(0.20)	(0.18)
US 3-month interest rate (%)$_{t-1}$	-0.07**	-0.07**	-0.84***	-0.74***
	(0.03)	(0.03)	(0.18)	(0.16)
Δ US 3-month interest rate (%)	-0.20***	-0.20***	-0.45**	-0.76***
	(0.03)	(0.03)	(0.20)	(0.18)
VIX index$_{t-1}$	-0.02	-0.02	0.03	
	(0.01)	(0.01)	(0.04)	
Δ VIX index	-0.00	-0.01	0.22***	
	(0.01)	(0.01)	(0.05)	
Exec. Election$_{t-1}$	0.01	0.02	-0.25	-0.19
	(0.07)	(0.07)	(0.42)	(0.44)
Left Executive$_{t-1}$	0.04	0.02	-0.42	-0.60
	(0.07)	(0.07)	(0.45)	(0.52)
FRT$_{t-1}$ * Public debt/GDP (%)$_{t-1}$		0.00*		0.03***
		(0.02)		(0.10)
Δ FRT * Δ Public debt/GDP		0.05*		0.33***
		(0.00)		(0.01)
FRT$_{t-1}$ * Δ Public debt/GDP		-0.00		0.03*
		(0.02)		(0.10)
Δ FRT * Public debt/GDP (%)$_{t-1}$		0.00		0.03
		(0.00)		(0.02)
Constant	-0.31	-0.28	8.74**	6.38**
	(0.94)	(0.94)	(3.44)	(2.82)
Countries	29	29	30	30
Observations	499	499	529	529
Adjusted R-squared	0.37	0.37	0.39	0.38

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All regressions include country fixed effects and robust standard errors.

Japan outlier excluded.

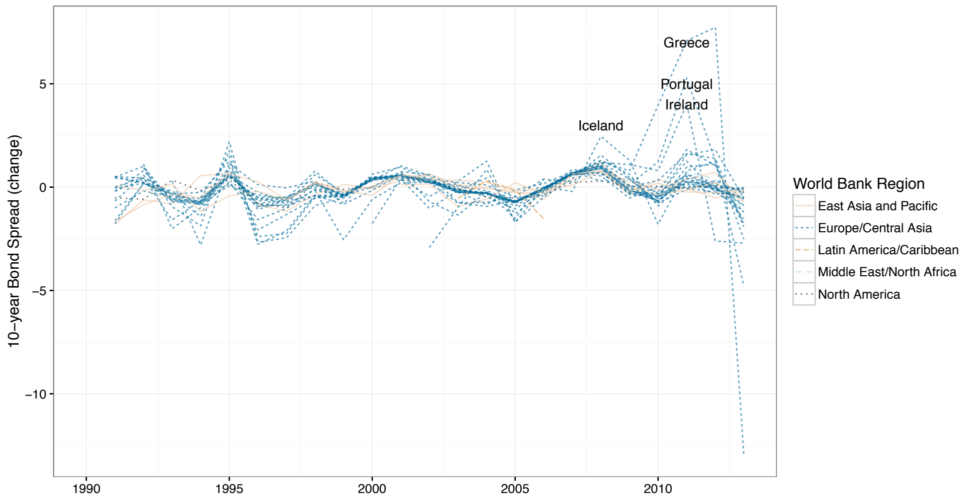
Table A-4: Moran's I Test Statistic of Spatial Autocorrelation, Δ Long-term (10-year) bond spread (US 10-year bond, %)

Year	Observed Moran's I	P-Value
1991	-0.01	0.638
1992	0.46	6.66e-07
1993	-0.05	0.965
1994	-0.04	0.887
1995	-0.00	0.562
1996	0.05	0.24
1997	-0.07	0.83
1998	-0.09	0.634
1999	0.06	0.0307
2000	-0.01	0.559
2001	0.03	0.289
2002	-0.01	0.587
2003	-0.10	0.308
2004	-0.06	0.678
2005	0.32	8.26e-09
2006	0.08	0.0327
2007	-0.00	0.523
2008	-0.03	0.847
2009	-0.03	0.924
2010	-0.05	0.82
2011	0.03	0.237
2012	-0.04	0.94
2013	-0.02	0.617

Table A-5: Moran's I Test Statistic of Spatial Autocorrelation, Δ Coefficient of variation, LT bond yields (annual, based on monthly data)

Year	Observed Moran's I	P-Value
1991	-0.15	0.53
1992	0.19	0.0708
1993	0.16	0.114
1994	-0.03	0.894
1995	-0.26	0.0598
1996	-0.17	0.286
1997	0.17	0.0672
1998	-0.20	0.179
1999	0.05	0.363
2000	0.20	0.0324
2001	0.04	0.397
2002	-0.15	0.192
2003	0.03	0.294
2004	-0.16	0.0372
2005	0.25	0.00202
2006	-0.02	0.873
2007	0.09	0.123
2008	-0.09	0.602
2009	-0.06	0.815
2010	-0.01	0.831
2011	-0.02	0.881
2012	0.12	0.0986
2013	0.19	0.0148

Figure A-16: Change in Long-Term Bond Spreads Grouped by World Bank Geographic Region (OECD Sample)



Countries highlighted with unusually large spread increases in a given year.

Table A-6: Re-examining Sovereign Bond Prices using the Hollyer et al. (2014) Transparency Index (HRV)

	Δ Long-term (10-year) bond spread (US 10-year bond, %)	Δ Long-term (10-year) bond spread (US 10-year bond, %)	Δ Coefficient of variation, LT bond yields (annual, based on monthly data)	Δ Coefficient of variation, LT bond yields (annual, based on monthly data)	Δ Long-term (10-year) bond spread (US 10-year bond, %)
Bond Spread_{t-1}	-0.40***	-0.40***			-0.40***
	(0.04)	(0.04)			(0.04)
LT rate COV_{t-1}			-0.84***	-0.84***	
			(0.06)	(0.06)	
HRV_{t-1}	-0.02	-0.04	-0.12	-0.21	
	(0.02)	(0.05)	(0.15)	(0.34)	
Δ HRV	-0.04	0.00	0.23	0.49	
	(0.08)	(0.07)	(0.66)	(1.33)	
Public debt/GDP $(\%)_{t-1}$	0.01*	0.01	0.03	0.02	0.01*
	(0.00)	(0.01)	(0.02)	(0.02)	(0.00)
Δ Public debt/GDP	0.05***	0.05	0.15**	0.11	0.05***
	(0.01)	(0.04)	(0.06)	(0.12)	(0.02)
Inflation (%) $_{t-1}$	0.14***	0.14***	-0.22	-0.23	0.14***
	(0.04)	(0.04)	(0.17)	(0.17)	(0.04)
Δ Inflation (%)	0.21***	0.21***	-0.09	-0.10	0.22***
	(0.05)	(0.05)	(0.13)	(0.14)	(0.05)
GDP Growth_{t-1}	-0.06	-0.06	-0.30	-0.30	-0.06
	(0.05)	(0.05)	(0.20)	(0.22)	(0.05)
Δ GDP Growth	-0.07	-0.07	-0.23	-0.23	-0.06
	(0.05)	(0.06)	(0.22)	(0.24)	(0.06)
Per Capita GDP_{t-1}	0.00	0.00	-0.15**	-0.14**	0.00
	(0.01)	(0.01)	(0.06)	(0.06)	(0.01)
Δ Per Capita GDP	0.18*	0.18*	0.35	0.40	0.17
	(0.09)	(0.10)	(0.50)	(0.55)	(0.10)
OECD average GDP growth_{t-1}	-0.02	-0.01	-0.16	-0.20	-0.01
	(0.06)	(0.06)	(0.30)	(0.29)	(0.06)
Δ OECD average GDP growth	-0.04	-0.03	0.42	0.38	-0.03
	(0.05)	(0.05)	(0.25)	(0.22)	(0.05)
US 3-month interest rate $(\%)_{t-1}$	-0.03	-0.04	-0.37**	-0.35**	-0.04
	(0.04)	(0.04)	(0.17)	(0.17)	(0.04)
Δ US 3-month interest rate (%)	-0.19***	-0.20***	-0.05	-0.03	-0.20***
	(0.04)	(0.04)	(0.20)	(0.19)	(0.04)
VIX index_{t-1}	-0.02*	-0.02*	0.06	0.07*	-0.02*
	(0.01)	(0.01)	(0.04)	(0.04)	(0.01)
Δ VIX index	-0.01	-0.01	0.24***	0.24***	-0.02
	(0.01)	(0.01)	(0.04)	(0.03)	(0.01)
Democracy $(\text{UDS})_{t-1}$	-0.05	-0.04	0.36	0.47	-0.03
	(0.16)	(0.17)	(1.02)	(1.04)	(0.17)
Δ Democracy (UDS)	-0.33*	-0.33	-0.09	-0.02	-0.32
	(0.19)	(0.21)	(0.74)	(0.80)	(0.20)
HRV_{t-1} * Public debt/GDP $(\%)_{t-1}$		0.00		0.00	
		(0.00)		(0.02)	
Δ HRV * Δ Public debt/GDP		-0.01		0.05	
		(0.00)		(0.00)	
HRV_{t-1} * Δ Public debt/GDP		0.00		0.01	
		(0.02)		(0.10)	
Δ HRV * Public debt/GDP $(\%)_{t-1}$		-0.00		-0.00	
		(0.01)		(0.02)	
FRT Residuals_{t-1}					-0.04
					(0.05)
Δ FRT Residuals					-0.01
					(0.08)
FRT Residuals_{t-1} * Public debt/GDP $(\%)_{t-1}$					0.00
					(0.00)
Δ FRT Residuals * Δ Public debt/GDP					-0.01
					(0.00)
FRT_{t-1} * Δ Public debt/GDP					0.00
					(0.02)
Constant	-0.06	0.01	11.44***	11.06***	-0.10
	(0.83)	(0.90)	(3.68)	(3.67)	(0.84)
Countries	23	23	24	24	23
Observations	395	395	421	421	395
Adjusted R-squared	0.45	0.44	0.49	0.49	0.45

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

All regressions include country fixed effects and robust standard errors. Japan outlier excluded. The IMF Program Start variable was also omitted because of collinearity. The results are substantively similar when we exclude the UDS democracy level.