The Default of Special District Financing: Evidence from California

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Abstract

In response to a series of legislative measures curbing property tax revenues, special taxation districts emerged as a mechanism of financing public infrastructure by local governments in many U.S. states. Community facilities districts (CFDs) in California are but one example. These districts are financed by issuing a special type of land-secured municipal bonds known as CFD or Mello-Roos bonds, and levying special taxes to service the debt. Using a unique comprehensive data set on California CFD bond issues since the moment of their inception until 2006, we study the default experience of these largely nonrated bonds. Contrary to the general belief that the "dirt" CFD bonds are very risky, we find that their lifetime performance is at least as good as that of Standard and Poor's B to BBB rated municipal bonds. Using duration analysis, we explore the dependence of the likelihood of CFD default on issue characteristics and macroeconomic and industry factors. We find that the state of local economy and construction industry are strong predictors of CFD default. The default is positively linked to the risk premium of the CFD bonds measured as the spread between their interest rate and the AAA rated general obligation municipal bonds yield index. We also find aging effects and relate them to stages of CFD development.

Keywords: Mello-Roos, CFD, municipal bonds, default, duration analysis

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1 Introduction

Traditionally, local governments in the U.S. have relied on property taxes as a major source of financing public projects. However, during the past three to four decades the taxation power of local governments throughout the nation has been significantly limited by the states (Sokolow 1998). For example, Proposition 13 approved through a referendum in California in 1978 instituted a 1% cap on property tax rates and rolled back property values for tax purposes to their 1975-76 levels. Furthermore, Proposition 13 limited annual increases in property tax bills to 2% and allowed reassessment only when property ownership changed. Similar property tax-curbing measures have since been passed in most other states.¹

Proposition 13 in California and similar acts and subsequent amendments in other states led to a drastic reduction in property tax revenues² and stimulated the emergence of *special district financing* as an alternative financing method (Orrick and Datch 2008). In California, special district financing originated with the passage of the Mello-Roos Community Facilities Act in 1982. The Act allowed for the funding of a wide variety of improvements and services by enabling local agencies with taxing authority, with voter approval, to form a *community facilities district* (CFD), issue bonds and levy a special tax on the owners of the land securing the bonds. Similar special district financing techniques have developed under different names in other states (Orrick and Datch 2008).

The CFD (Mello-Roos) municipal bond market has since become of growing importance. According to the California Debt and Investment Advisory Commission (CDIAC), the total principal amount of CFD bonds issued in 2006 was \$2.2 billion, constituting about 3.8% of the entire public debt issuance in California that year (\$58.4 billion).³ However, relatively little is known about the riskiness of these bonds. Although municipal debt is generally considered as bearing low risk compared to corporate debt (for example, Nanda and Singh 2004 cite a number of studies that report average default rates of 2% or less for the entire municipal bond market), for a long time there has been a perception that the (nonrated and uninsured) Mello-Roos bonds bear a much higher than average risk. The CDIAC reported in the November 1997 issue of its monthly newsletter *Debt Line* that "for the period 1982-1997 the average rate of default for Mello-Roos bonds was probably around 5%." About a decade later, in summer 2008, in its CFD Yearly Fiscal

¹Prominent examples include Proposition 2-1/2 in Massachusetts (1980), Measure 5 in Oregon (1990), Amendment 10 in Florida (1992). For a detailed discussion and analysis see Sokolow (1998) and references therein.

²See Horler (1987) for a summary of the fiscal impact of Proposition 13.

³CDIAC Annual Report (2006), available at http://www.treasurer.ca.gov/cdiac.

Status Reports the CDIAC reported, on average, about 10 defaults per fiscal year (FY) from FY 1993-94 until FY 2007-08, with a peak in FY 1997-98 (29 defaults) corresponding to default rate as high as 7.1%.⁴ The CDIAC study demonstrates that the overall perception of nonrated Mello-Roos bonds being high risk still prevails, even though starting in FY 2002-03 the reported default occurrences declined steadily, with only few defaults each year.

In the present paper we use a unique data set combining publicly available and proprietary data to analyze empirically the default of California CFD bonds over the period since their inception⁵ until 2006.⁶ Our study has three major contributions. First, to the best of our knowledge, this is the first comprehensive study of credit risk associated with largely nonrated special district financing municipal bonds. Second, our default (and, more generally, retirement) data are obtained from independent sources, and are more complete than those reported by the CDIAC. Specifically, we collected the history of retirement for all CFD bonds over the entire period whereas the CDIAC has retirement data only starting 1997. Also, unlike the CDIAC, we define default as a terminal state, thereby avoiding multiple counting. We show that the CDIAC substantially overestimates the risk of default associated with CFD bonds. We find that of all CFD issues, less than 2% defaulted during 1983-2006, and the cumulative lifetime risk of default for *nonrated* CFD bonds during this period was at the level of Standard and Poor's (S&P's) B to BBB rated municipal bonds.

Third, we use duration analysis to explore the relationship between the likelihood of default and individual bond-level data, as well as industry and macroeconomic factors. We find that the risk of default is related to specific phases in real estate development. Defaults are also positively linked to the market risk premium on the CFD bonds (the spread between the bond's interest rate and the 20-year AAA rated general obligation municipal bonds yield index) measured at the time when the bonds were issued. Moreover,

⁴These numbers are based on self-reported special tax payment delinquencies by the agencies, and, according to the CDIAC, "to the extent local agencies under-report or fail to report their defaults ... the Commission's data will reflect the under-count." Reports are available at http://www.treasurer.ca.gov/cdiac.

⁵The very first CFD bond issuance took place in 1983, followed by one more issue in 1984; however, massive issuance did not start until 1985. In our data, we do not include the first two issues due to unavailability of other pertinent information (such as the principal amount and interest rate). Neither of those two issues defaulted, and hence, given the size of our data set, their exclusion should not materially affect our results.

⁶Since 2006, the real estate market decline and subprime mortgage crisis dramatically changed the environment for municipal debt. In 2008, the number of CFD issues dropped by more than half as compared to the peak year of 2006. As of writing this article (early 2014), four new defaults occurred after 2006, and an increased number of draws on reserves has been registered.

the risk of default tends to be significantly higher when the state of the local construction industry and the overall local economic conditions are relatively poor. We further perform the analysis of predicted changes in the hazard rate to assess the relative importance of each factor in explaining the variation in defaults. Based on the observed variation, local economic conditions and the state of the local construction industry are the strongest predictors of the variation in the probability of default.

Our findings provide new information about the risk associated with CFD-funded municipal debt in California, as an example of special district financing debt and hence, should be useful to both investors and issuers of such debt. The results motivate studies of the impact of defaults on homeowners and post-default community development. Moreover, our study relates the risk of CFD debt to the characteristics of local economy and the underlying construction industry.

The remainder of the paper is organized as follows. In Section 2, we describe the process of formation and operation of a CFD and provide a brief overview of related literature. Data are described in Section 3. In Section 4, we provide summary statistics for the relevant variables and present a descriptive analysis of CFD default. We further assess the overall riskiness of CFD bonds by comparing their performance to the U.S. rated municipal market. The conditional duration analysis of CFD defaults is presented in Section 5. Section 6 concludes.

2 Background and related literature

2.1 Mello-Roos Community Facilities Act in California

In June 1978, California voters enacted Proposition 13 that reduced local property tax revenues by more than 50% by introducing a 1% cap on property tax rates and rolling back property values for tax purposes to their 1975-76 level. Reassessment was allowed generally only when property changed ownership and annual increases in property tax bills were capped at 2%. Increasing state taxes were required to receive 2/3 legislature approval and the taxing authority of local governments became more restricted. These factors made raising taxes more difficult and limited the ability of local governments to fund public infrastructure. There was a need for a new funding mechanism that provided greater flexibility and addressed the growing demand for financing public improvements.

Proposition 13 served as the catalyst for the introduction of such alternative. The necessary flexibility was provided by the passage of the Mello-Roos Community Facilities Act in California in 1982 (The Act), which offered an alternative vehicle for financing

capital improvements. The Act allowed the funding of the construction or acquisition of real or tangible property with a useful life of five years or more, such as streets, sewers, etc. It also allowed schools, police and fire services, as well as other services to be financed to accommodate the growing needs of developing areas.

Under the Mello-Roos Act, local government agencies with taxing authority may, with voter approval, form a community facilities district (CFD), issue debt and levy a special tax. The local jurisdiction's legislative body forms a CFD with boundaries to include property that will derive benefit from the improvements that are proposed to be financed. In most cases, the improvements will be financed by the issuance of bonds. The bonds are then repaid by a special tax levied annually and collected on the annual property tax bill for each parcel within the CFD. In order to levy special tax, the Constitution of the State of California requires a 2/3 voter approval to authorize the CFD, the bonded indebtedness and the annual special tax levy. If there are less than 12 registered voters living in the CFD, a landowner vote is held, allowing each property owner one vote for each acre of land owned. The special tax then becomes a continuing lien against the property and may be levied for up to 40 years to repay the bonds issued. Some CFDs do not issue bonds but use the special tax instead to directly fund services on a pay-as-you-go basis.

Table 1 contains information on the number of CFD bonds by purpose issued during the period from 1985 through 2006. In total, 1,686 CFDs have been issued. Most of them have been used to finance K-12 school districts (29%) and multiple capital improvements and public works (56.82%). The latter category includes building and maintaining community facilities, such as pools and fitness centers. Other relatively sizable categories include funding street construction and flood control.

Mello-Roos bonds are secured by special tax revenues on the property for which such bonds are being issued. The amount of special taxes that is collected each year is generally defined as the amount sufficient to pay the administrative expenses for the CFD, the regularly scheduled debt service payments for that year (including principal and interest payments), any amount required to replenish any reserve fund established in connection with the bonds, any reasonably anticipated delinquent special taxes for the previous fiscal year, and any remarketing costs and credit enhancement and liquidity fees. Thus, special taxes are levied in an amount that is sufficient to pay administrative expenses and provide special tax revenues in an amount equal to 110% of maximum annual debt service on the outstanding bonds. This 110% coverage serves as a cushion against unexpected failure to collect all taxes due to make the debt service payments on the bonds.⁷

⁷Although the maximum special tax generates sufficient revenue to meet or exceed debt service payment, some CFDs may choose to have special tax escalators in order to have an increased capacity to

Purpose of CFD issue	Number	Percent
Airport	1	0.06
Bridges and highways	10	0.59
College, university facility	1	0.06
Commercial development	1	0.06
Flood control, storm drainage	50	2.97
K-12 school facility	499	29.6
Multiple capital improvements, public works	958	56.82
Other capital improvements, public work	4	0.24
Other purpose	1	0.06
Other, multiple educational uses	16	0.95
Parking	9	0.53
Parks, open space	6	0.36
Project, interim financing	4	0.24
Public building	19	1.13
Recreation and sports facilities	2	0.12
Redevelopment, multiple purposes	8	0.47
Street construction and improvements	58	3.44
Wastewater collection, treatment	14	0.83
Water supply, storage, distribution	25	1.48
Total	1,686	100

Table 1: CFD bond issues by purpose, 1985-2006.

In some cases, after the bonds are issued, there are instances of default occurrence. Default occurs when there is a missed payment of principal or interest on any bond that is due or payable. If the taxes owed are paid subsequent to that default date, along with all penalty and interest, there can be sufficient revenue to reinstitute the punctual payment of debt service on the bonds and cure the default.⁸ However, if that is not the case, the district remains in default until foreclosure action is taken against the delinquent property and such property is sold at a judicial foreclosure sale or until a workout has been reached that brings current all special taxes owed.

2.2 Previous studies of default

The major goal of the present study is to examine the determinants of default for the CFD market. Empirical studies of default go back at least to the work of Hickman (1958), Beaver (1966), and Altman (1968) on bankruptcy prediction. Structural models of default are based on the underlying stochastic value crossing an exogenous or endogenous boundary (see, e.g., Black and Scholes 1973, Merton 1974, Black and Cox 1976, or, more recently, Çetin et al. 2004), whereas reduced form models use the hazard rate approach to model default as an instantaneous jump (e.g., Jarrow and Turnbull 1995, Duffie and Singleton 1999).⁹

Most of the empirical work on default has focused on analyzing the default of publicly traded corporate bonds (see, e.g., Altman 1989, Huffman and Ward 1996) that belong to one of the credit rating categories assigned by the rating agencies – Moody's, S&P and Fitch.¹⁰

cover potential delinquencies. Moreover, upon the issuance of the Mello-Roos bonds, a debt service reserve fund (DSRF) is created to provide additional protection in the event of delinquency.

⁸Thus curing a CFD bond default is very different from curing a corporate bond default. If there are delinquencies associated with CFD bonds, all that is needed to make the bonds current and cure the default is to make the missed payments. There is no acceleration clause for the entire amount of debt. With corporate bonds, on the other hand, very often if one payment is missed, the entire amount of debt can become due and payable, which can make the curing of the default more challenging.

⁹Altman and Saunders (1997) summarize the research published over the previous few decades on statistical models of debt default and loss. Gordy (2000) and Crouhy et al. (2000) discuss the advances in modeling credit risk and present a comparison of the variety of parametric models. These models are primarily based on credit migration analysis, i.e. the likelihood of transitioning from one credit quality (rating) state to another, including default, within a given time period. A separate stream of literature focuses on pricing corporate bonds that are at risk of default (see, e.g., Xie et al. 2008, Schaefer and Strebulaev 2008 and references therein). Cohen (1989), Fons (1987), Yawitz (1977), Yawitz et al. (1985), Cirillo and Jessop (1993) discuss default and its determinants.

¹⁰Further studies have examined the default occurrence among private placements of bonds or insurance companies' investments (e.g., Carey 1998). Altman and Suggitt (2000) studied the default rate in the corporate bank loan market.

The pricing and default of municipal bonds have been extensively studied in relation to the so-called "muni puzzle" – the observation that tax-exempt municipal bonds have higher yields than predicted by theory, which cannot be explained by higher default rates (e.g., Miller 1977, Chalmers 1998, Wang et al. 2008). Denison (2001) and Nanda and Singh (2004) discuss the insurance of municipal bonds as an alternative risk pricing mechanism. Wu (1991) discusses the role of investors' risk aversion in default risk estimation for municipal bonds. When considering the incidence of default, Cohen (1989) shows that municipal bond default rates are related to the business cycles. McInish (1980) and Leonard (1983) study the relationship between term-to-maturity and default risk premia for municipal bonds.

Most related to our analysis are the studies that have looked for an explanation of the fluctuations in default rates of corporate bonds. Fons (1987, 1991), Helwege and Kleiman (1996), Jonsson and Fridson (1996), Jonsson et al. (1998), among others, developed statistical models which identified that default was influenced by three major factors: credit quality, the state of the economy, and the age of the bonds under investigation. We expect CFD bonds to exhibit characteristics somewhat similar to high-yield corporate bonds (Altman and Kishore 1995) and hence, be influenced by the same factors, although there are some specificities as discussed below. In terms of methodology, we use the hazard rate approach to model default as a function of various factors (see, for example, Jarrow and Turnbull 1995, Duffie and Singleton 1999). Both the methodology and variables used in our analysis are described in Section 5.

3 Data

Our initial data set consists of three major parts obtained from several independent sources. The first part is the data on issuance and individual characteristics of CFD bonds. These data are publicly available on the CDIAC website as part of a searchable database on public debt issuance in California. To focus on CFD bonds, we used the inclusion of abbreviation "CFD" in the issuer name as a search criterion. For each CFD issue, we recorded CDIACID (a unique numerical identifier of the issue by the CDIAC), issue date, county, principal amount, interest rate,¹¹ and whether the issue was rated by

¹¹The interest rate we use is the total cost of debt calculated upon issuance using either NIC (Net Interest Cost) or TIC (True Interest Cost) methodology. According to the *Glossary of Municipal Securities Terms* (http://www.msrb.org/msrb1/glossary/default.asp), the difference between the results of two methodologies is small.

at least one of the three rating agencies (Fitch, Moody's, S&P).¹² The data include all CFD issues from January 1, 1985 until December 31, 2006.

The second part of the data is the data on retirement of CFD bonds. At the end of its lifetime a CFD bond issue can mature, be redeemed, or default. For each issue that was retired between 1985 and 2006, we recorded the retirement date and type. Part of these data, from 1993 onward, was provided by the CDIAC through personal communication. The retirement data from 1985 until 1993 were acquired by Fieldman, Rolapp & Associates, Inc. from Bloomberg and Thomson Municipal Market Monitor.

Finally, the third part of the data are economic and construction industry indicators at the national and California county level for the period from 1985 until 2006. These include the national CPI and county-level unemployment rate (obtained from the Bureau of Labor Statistics), population and per capita income by county (obtained from the Bureau of Economic Analysis), 20-year AAA rated GO municipal bonds yield index (obtained from Thomson Municipal Market Monitor), and total (residential and nonresidential) new building valuation by county (acquired by Fieldman, Rolapp & Associates, Inc. from the Construction Industry Research Board, a California-based nonprofit research firm).

The total number of CFD issues in our sample is 1,686. A more detailed description of the data is available in B.

4 Descriptive analysis of default

4.1 Overview

For the purposes of the analysis, we use a standard definition of default. Specifically, we have considered default to be an event in which there was a missed payment of interest and/or principal to bond holders. For each issue, default was counted only once, at the first time of occurrence.¹³

Of the total number of 1,686 CFD issues from 1985 through 2006, 532 were either called or matured, leaving 1,154 CFD issues outstanding for that period. Of those 1,154 issues outstanding, 27 defaulted by our terminal date, December 31, 2006. Therefore, total defaults were 1.60% of all issues, and 2.29% of the CFD issues not refunded or matured.

¹²Additional variables pertaining to each issue included issuer name, type of debt, source of payment, purpose, interest type, whether the issue was to refund another issue, and the actual rating by each agency (if assigned). We do not use this information in the estimation.

¹³The CDIAC based their default rate analysis on counting each reported delinquency in principal and/or interest payments as a separate default event (sometimes several times per year). This led to the overestimation of risk associated with CFD bonds.



Figure 1: CFD (Mello-Roos) bonds outstanding and defaulted, 1985-2006. The grey bars (left scale) show the number of outstanding bond issues. The black bars (right scale) show the number of defaulted issues as a percentage of outstanding issues.

Almost all defaults occurred during the 1990s with peaks in 1994 and 1997, when the default rate, defined as the number of defaulted issues as percentage of outstanding issues, approached 1.57% and 1.64%, respectively (Figure 1).

4.2 Cumulative default rates

One of the goals of the present study is to assess the default risk associated with CFD bonds. This goal can be achieved by comparing the lifetime performance of Mello-Roos bonds to that of the U.S. rated municipal market. There have been a number of studies of various segments of the latter in the industry.¹⁴ A study that seems somewhat comparable to ours in terms of the time span and the types of bonds is Woodell et al. (2004).¹⁵

Woodell et al. (2004) employ the static pool methodology to analyze the rating transitions and default history of the rated U.S municipal debt during 1986-2003. To maximize comparability with their study, we use the same methodology and consider

¹⁴See, e.g., Municipal Default Risk (Fitch IBCA, 1999); Municipal Default Risk Revisited (Fitch Ratings, 2003); Moody's U.S. Municipal Bond Rating Scale (Moody's Investors Service, 2002).

¹⁵Woodell et al. (2004) examine credit types such as general obligation (GO), lease/appropriation/moral obligation, special tax (sales, gas, etc.), special district, water and sewer revenue, public power, airports, ports, toll roads and bridges, parking, various types of bond pools, transit, public and private higher education, auxiliary higher education debt, independent schools, hospitals (stand alone and systems), continuing care, and physicians' practices. In the present study, the CFD credit types are similar and are summarized in Table 1 in B.

	Cumulative default rate			
Year	All CFD bonds	Nonrated CFD bonds		
1986-1990	0	0		
1991 - 1993	0.2	0.22		
1994	1.37	1.56		
1995	1.5	1.71		
1996	2.06	2.33		
1997	4.05	4.6		
1998	4.17	4.75		
1999	4.79	5.43		
2000-2001	5.38	6.14		
2002-2003	5.72	6.56		

Table 2: Cumulative default rates (%) in 1986-2003 for all CFD bonds and nonrated CFD bonds, calculated using the static pool methodology (Woodell et al. 2004).

individual issuances rather than dollar amounts of issued debt. Computational details are provided in A.

Using the static pool methodology, we calculated cumulative default rates for the entire sample of CFD bonds (covering years 1985-2006) and restricted sample of *nonrated* CFD bonds. Out of the 1,686 issues in the sample, 1,429 are nonrated. None of the rated issues defaulted; therefore, the cumulative default rates are higher in the nonrated sample. The results (shown in Table 2) indicate that the cumulative default rates for the CFD issues range from zero in 1986-1990 to about 5.7-6.6% in 2003. For comparison, the corresponding rates for the S&P's B rated municipal bonds reported by Woodell et al. (2004) are 2.14% in 1986, 7.47% in 1991, and 9.65% in 2003. For the BBB rated municipal debt, the numbers are 0%, 0.24%, and 0.4%, respectively. Thus, the performance of nonrated CFD bonds is comparable to that of the S&P's BBB rated bonds during the early years, and it is substantially better than the performance of the B-rated bonds throughout the considered period.

Because over a sufficiently long period of time the CFD bonds are riskier than BBB rated municipal bonds, one would expect that the yields on CFD bonds are higher. We confirmed this by comparing the 30-year yield on a sample of nonrated CFD bonds issued in 1998-2004 to the 30-year yield on BBB rated municipal bonds.

5 Duration analysis of default

5.1 Methodology

To study the impact of various factors on the probability of default we use duration analysis. Specifically, we model the time-to-default by defining a hazard rate,

$$\theta(\tau, X) = \frac{f(\tau, X)}{1 - F(\tau, X)} = \frac{f(\tau, X)}{S(\tau, X)},$$
(1)

where τ and X denote time and bond-specific characteristics, respectively, $F(\tau, X) = \Pr(\mathcal{T} \leq \tau | X)$ is a cumulative distribution function that returns the probability of default occurring no later than moment τ , $f(\tau, X) = \partial F(\tau, X) / \partial \tau$ is the probability density function, and $S(\tau, X)$ is the survivor function. Although the hazard rate cannot be interpreted as probability, it is related to the likelihood of default at instant τ conditional on no default up until that moment.

Although survival occurs in continuous time, in our data the event of default is recorded in intervals. We use yearly data, where the status (default vs. no default) is recorded as of the end of each year. For some bonds, spell lengths may be as short as 2-3 years, and hence, continuous analysis is hardly applicable. Therefore, we employ the discrete hazard rate (Jenkins 2005), defined as:

$$h_t(X) \equiv h(a_t, X) = \Pr(a_{t-1} < \mathcal{T} \le a_t | \mathcal{T} > a_{t-1}, X).$$

$$\tag{2}$$

Here $h_t(X)$ captures the discrete nature of the data and is equal to the probability of default occurring some time during period $(a_{t-1}, a_t]$, conditional on no default up to moment a_{t-1} and given bond characteristics.

Considering the proportional hazard models with $\theta(\tau, X) = \theta_0(\tau) \exp(X\beta)$, the discretetime model is the complementary log-log model (Jenkins 2005, Wooldridge 2002). Then, the discrete hazard rate for bond *i* in time interval $(a_{t-1}, a_t]$ is given by

$$h_t(X_{it}) = 1 - \exp[-\exp(X_{it}\beta + \lambda_t)].$$
(3)

In the equation above, the covariates, X_{it} , may take on different values over time, and λ_t is a function of time-to-default t summarizing the baseline hazard during period t. Because the time-to-default is measured from the sale date, λ_t is a function of the age of the bond in years.

We transformed the data into an unbalanced panel, with the spatial dimension rep-

resented by CFD bond issues and the time dimension represented by years from 1985 to 2006. Each bond issuance appears in the data in the year when it was issued and disappears in the year of retirement. Estimation is performed by maximum likelihood. Specifically, we observe each bond from the sale date until it defaults, matures, is redeemed, or until the end of year 2006, whichever comes first. At the end of year T_i , when bond *i* is observed for the last time, the spell is either complete (the default occurs) or is right censored. The likelihood contribution for a completed spell is

$$L_{i} = h_{T_{i}}(X_{iT_{i}}) \prod_{t=1}^{T_{i}-1} (1 - h_{t}(X_{it})),$$
(4)

and the likelihood contribution for a censored spell is

$$L_i = \prod_{t=1}^{T_i} (1 - h_t(X_{it})).$$
(5)

The vector of parameters, β , is estimated by maximizing the following likelihood function:

$$L = \prod_{i=1}^{N} \left[h_{T_i}(X_{iT_i}) \prod_{t=1}^{T_i - 1} (1 - h_t(X_{it})) \right]^{c_i} \left[\prod_{t=1}^{T_i} (1 - h_t(X_{it})) \right]^{1 - c_i}, \tag{6}$$

where c_i is an indicator that equals one if bond *i* defaults and is zero otherwise.

It may also be useful to consider a more general model that incorporates unobserved heterogeneity (or frailty) in the model. In such case, we can write the discrete hazard rate as

$$h_t(X_{it}) = 1 - \exp[-\exp(X_{it}\beta + \lambda_t + \log v_i)], \tag{7}$$

where v_i captures unobserved bond-specific characteristics. When performing estimation, we assume that v_i has a log normal distribution with mean zero. The likelihood function (6) is then multiplied by a normal probability density function, and the contribution of the unobserved heterogeneity is "integrated out" numerically.

In our analysis, the vector of time-varying factors, X_{it} includes variables that have been identified as important determinants of default in previous studies. These are discussed in detail below.

5.2 Determinants of default

5.2.1 Age of the bond

The "aging" effect, as described in many studies (e.g., Altman 1993, Jonsson and Fridson 1996), reflects the time that elapses between a bond's issuance and its default and is an important factor in explaining the likelihood of default occurrence of high yield corporate bonds (Altman and Nammacher 1985), as well as low-rated bonds (Altman and Kishore 1995).

In the case of CFD bonds, variation in default patterns by age is related to the different stages of a typical CFD development. Real estate development is usually comprised of two phases: land development and building construction. During the land development phase, the site is acquired and graded, infrastructure is installed, and all other activities pertaining to the conversion of raw land into improved building lots are conducted. During the second phase, residential, commercial and industrial structures are constructed for sale to end users. Often these two phases are not carried out by the same real estate developers. It is very common for a group of developers to improve raw land and then sell it to merchant builders who, under the best case scenario, contract with clients to construct residential units, or simply build such units on their own, taking the risk that there will be buyers for their product upon completion.

Historically, most Mello-Roos bonds have been issued during the first phase of raw land when there is high concentration of property in the hands of only one or few developers. This is the stage with highest credit risk, since then those property owners are responsible for all or the majority of the special taxes levied on the property in order to pay the debt service on the bonds. Under such circumstances, if these majority property owners are delinquent in their special tax payments, the reserve fund on the bonds can be depleted and a bond default may occur. A developer may be delinquent on its special tax payments for a number of reasons, the most likely ones being that contrary to expectations, demand for its product does not materialize, or that the project ultimately does not generate the expected revenues, or costs more than anticipated.

Another wave of defaults may occur during the second phase. Within five to six years after issuance, development plans are usually completed, models are well underway, and the product is being absorbed. It is then though that a sudden significant change in any of the economic drivers of real estate development, such as prices, employment and demand, may have a detrimental impact on the project and ultimately lead to the default of the bond issue.

Figure 2 illustrates that indeed, the default patterns in our data are consistent with



Figure 2: The distribution of CFD bond defaults by age.

different phases in real estate development. The first peak of defaults is around the third year of the bonds' "life," during the land development stage. Two other peaks in Figure 2 occur around the sixth and ninth year after issuance. This is the time when the project absorption is usually well underway, houses are being sold and escrows closed, and it is only an economic downturn or a significant change in the real estate market environment that may result in the developers' inability to continue paying special taxes and lead to default.

Given these characteristics of the development process, we generate age dummies that reflect the described development stages. Specifically, we create a dummy variable equal to one if the age of a bond is between three and five years, and a dummy variable equal to one if the age is between six and ten years. Each variable represents the years during a particular development phase when the risk of default appears to be higher.

5.2.2 Credit quality

Due to the specific nature of CFD bonds, and in the absence of recognizable ratings, the municipal market has established a special set of criteria to help assess the credit quality of each nonrated CFD bond issue. These include, among others, the value-tolien, status of development, and diversification of ownership at the time of bond issuance. Unfortunately, complete historical data on these criteria cannot be obtained. Similarly, it is difficult to obtain information on the average yields of CFD bonds. Therefore, as a measure of credit quality we use the difference between the interest rate and the 20-year AAA rated GO municipal bond yield index recorded at the time of bond issuance (instead

	Mean	St. Dev.	Percentile		# Obs.
			5th	95th	
Risk premium, %	0.99	0.89	-0.23	2.23	1627
Unemployment rate, $\%$	7.47	3.95	3.2	15.6	562
Real TBV per capita, \$1,000/person	1.33	1.44	0.52	3.06	562
Real principal, \$1,000,000	9.33	11.13	1.03	29.9	1686

Table 3: Descriptive statistics for variables. For risk premium and real principal, the number of observations is the number of issues with the available data. For the unemployment rate and real TBV per capita, the number of observations is the number of years times the number of counties.

of using the yields spread as, e.g., Chen et al. 1986, Bernanke and Blinder 1992, Ewing 2001, for reasons of data unavailability). This measure is constant over time and reflects the overall riskiness of the bond as assessed at the time of issuance.¹⁶

Moreover, the probability of default is expected to be higher when the size of the debt is relatively large. Because the information about debt-to-value ratio is not available, we use the real total principal amount of the CFD issue to account for the absolute size of the project. This measure, although imperfect, may help to capture the variation in defaults by debt size.

Summary statistics for the measures of credit quality are reported in Table 3.

5.2.3 Economic and industry factors

Macroeconomic variables, such as inflation and real economic activity, have been identified as important explanators of the performance of stocks and bonds (see, e.g., Ewing 2003, Xie et al. 2008). In the present study, we account for inflation by transforming all our explanatory variables into real terms.

The performance of the local real estate market is expected to have a significant impact on the performance of CFD bonds. Strong economy and rapid development, measured by high building permit issuance and low unemployment, are typically associated with strong issuance of land secured bonds and lower default risk. Therefore, to account for variation in the overall and industry-specific economic conditions, we use the unemployment rate and the total new building valuation per capita (in real terms) at the county level.¹⁷

¹⁶For alternative measures of credit quality, we tried using the 10-year U.S. Treasury notes' yield and the Federal Funds rate as the "risk-free" basis for the risk premium, and the results are qualitatively the same. We argue that the AAA rated GO municipal bonds are the most appropriate basis for comparison.

 $^{^{17}}$ See, e.g., Yinger (2002) for a discussion of the relationship between housing values and local government taxation.

Summary statistics for these factors are reported in Table 3.

5.3 Results

Estimation results from complementary log-log regressions are reported in Table 4. Because the interest rate and principal amount are missing for some bonds, the sample used in the regression analysis is slightly smaller than the original sample (1627 CFD bonds in total, including 1390 that are not rated). All bonds that have eventually defaulted, however, have complete data and are included in the regressions.

When considering all Mello-Roos bonds (column 1 in Table 4), estimated age effects follow the predicted pattern. As expected, the risk of default is significantly higher in the third, fourth and fifth year after issuance than during the initial two years. Moreover, the likelihood of default increases further during the sixth through tenth year after issuance. Based on the outcome of the likelihood-ratio test, the null hypothesis that the two age effects are equal is rejected at the 10% significance level ($\chi_1^2 = 2.98$, p = 0.084). Both age ranges correspond to the periods when property owners are more likely to become delinquent in their special tax payments and there is a higher chance that the bond issue will default. If the bond does not default up until the end of the tenth year, its risk of default drops in subsequent years.

Local economic and industry conditions – total building valuation and unemployment – have expected effects. The likelihood of default is lower in the years and states where the total building valuation per capita is high, implying that issuances are less likely to default when the market conditions are favorable. Specifically, a \$10 increase in the real per capita total building valuation is associated with a 2% decrease in the hazard rate. On the other hand, the hazard rate is predicted to be about 29% higher if the unemployment rate increases by one percentage point.¹⁸

Holding macroeconomic factors fixed, the likelihood of default is positively related to the size of risk premium. The effect is highly significant and large in magnitude. A 0.1 percentage point increase in the risk premium is associated with an 8% increase in the hazard rate. Similarly, the issuances that are used to finance large projects have a slightly higher risk of default, although the effect is not statistically significant.

Column (2) of Table 4 displays estimation results for nonrated Mello-Roos bonds. The estimates are very similar to those obtained on the full sample. For each variable,

¹⁸We use $\exp(\beta_k) - 1$ to calculate these effects. The estimated effects refer to percentage changes in the hazard rate. For example, if the initial hazard rate is 1%, a one percentage point increase in the unemployment rate would change the hazard rate to 1.29%.

	All CFD bonds (1)	Nonrated CFD bonds (2)
Three to five years after issuance	1.539**	1.340**
Six to ten years after issuance	(0.629) 2.377^{***}	(0.599) 2.204^{***}
Risk premium	(0.714) 0.786^{***}	(0.589) 0.744^{***}
Unemployment rate	(0.171) 0.258^{***}	(0.168) 0.276^{***}
Real TBV per capita	(0.063) -2.026***	(0.058) -1.938***
Real principal amount	(0.629) 0.020	(0.625) 0.024*
Constant	(0.014) -8.661***	(0.014) -8.540***
	(1.820)	(1.101)
Observations	9641	7994
Number of bonds	1627	1390

Table 4: Complementary Log-Log Estimates of Default

Standard errors in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Regressions allow for unobserved heterogeneity (frailty).

the direction of the effect is unchanged. For most variables, the size of the effect is also unaffected. The magnitude of the coefficient on risk premium is only slightly smaller for nonrated bonds, suggesting that even in the absence of ratings the Mello-Roos bonds market adequately evaluates the riskiness of the bonds on the basis of other variables that we do not observe. As discussed in Section 5.2, these likely include the value-to-lien, status of development, and diversification of ownership at the time of bond issuance.

Figure 3 helps gain better understanding of the importance of each factor for CFD defaults. The figure displays the estimated survivor function computed at the sample mean, as well as the 5th and 95th percentiles of the distribution of each variable, while holding all other covariates constant at their sample mean levels.

Consistent with the estimated age effects, the survivor function declines during years 3 through 5, then experiences an even stronger drop in years 6 through 10, and flattens



Figure 3: The estimated survivor function evaluated at the sample mean (\bar{S}) , 5th $(S_{0.05})$, and 95th $(S_{0.95})$ percentiles of the distribution of each variable while holding all other variables constant at their sample mean values.

out afterwards.

Variation in real per capita TBV leads to the most substantial variation in the survival function. Specifically, when the real per capita TBV is at its top 5th percentile value, the probability of the CFD issue not defaulting until the end of year 14 is more than 5 percentage points higher than for the bond issued in a state with the bottom 5th percentile real per capita TBV value. The corresponding difference in the estimated probability of survival is roughly 2.5 percentage points when considering the observed variation in the risk premium and 10% for the unemployment rate. It is less than two percentage points when looking at the real principal amount.

Overall, Figure 3 demonstrates that any practically reasonable changes in economic conditions and risk quality are associated with only moderate changes in the survivor function. This finding is consistent with the low mortality rates reported in Table 2.

6 Conclusions

In this paper we use unique data to analyze empirically the default of CFD bonds over the period since their inception until 2006. We find that the perception of the "dirt" CFD bonds being extremely high risk is inaccurate. At the aggregate level, we show that nonrated CFD bonds demonstrate lifetime default performance at the level of Standard and Poor's B to BBB rated municipal bonds.

We next employ duration analysis to study the factors that contribute to the variation in the risk of default. CFD bonds are secured by land and serviced by special taxes. Thus, inability (or unwillingness) to pay special taxes is the underlying reason for CFD defaults. It hinges on the developer's being able to complete the project as planned and sell it in the market. Therefore, we argue that the incidence of default is related to the phases of a typical development project. The initial phase – the phase of raw land development – is typically characterized by high concentration of ownership, which is associated with an increased credit risk. Another peak in credit risk occurs during the second phase, when residential, commercial or industrial property is constructed for sale to end users, and unforeseen adverse changes in economic conditions, such as negative demand shocks, may increase the risk of default. Indeed, the likelihood of CFD defaults in our sample followed the phases of a typical CFD development, as reflected in the nonlinear age effects.

Similar to the existing default studies for corporate bonds, we find that industry conditions and the state of the economy are strong predictors of CFD default. Specifically, the CFD default is associated positively with local unemployment rate and negatively with the total new building valuation. The risk of default increases by 2% per each \$10 decrease in the real per capita total building valuation in the county. Also, holding other factors constant, a one percentage point increase in the county unemployment rate is associated with a roughly 30% increase in default risk.

We also find that default is positively related to a measure of market risk premium on the CFD bonds – the spread between the bond's interest rate at issuance and the 20-year AAA rated GO municipal bonds yield index. The risk of default is predicted to be about 8% higher for each 0.1 percentage point increase in the risk premium. This finding implies that even in the absence of accurate information on the overall riskiness or ratings for the majority of CFD bonds, the market risk premium captures at least some variation in the underlying credit quality by issue.

Our results allow for quantitative assessment of the impact of reasonable variation in each individual factor on credit risk, and thus are suitable for out-of-sample predictions. For each of the four default factors in our study (risk premium, real principal amount, per capita real total building valuation, and unemployment rate), we measured the variation in default risk in response to a hypothetical variation in one factor between its 5th and 95th percentile values. Based on the observed variation, the most substantial change in the risk of default follows due to changes in the county-level unemployment rate and real per capita total building valuation.

All the CFD defaults in our sample occurred at the stage of highly concentrated ownership. Thus, they are caused by suboptimal investment decisions and incorrect expectations of developers. Starting in 2007, the subprime mortgage crisis and real estate market decline could have led to previously unobserved channels for CFD default at later stages of a CFD development when land ownership is already diverse. Insofar the factors leading to such defaults are reflected in the local economic and industry variables that we use (unemployment rate and total new building valuation), our model can be used to forecast CFD defaults.

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A Static pool methodology

To compute cumulative default rates, we use the static pool methodology. We begin by creating the so-called "static pools." A static pool is constructed at the beginning of each year covered by the data and tracked from that point on. For example, the static pool in year t is comprised of all debt outstanding as of the beginning of that year. Then, the static pool associated with year t + 1 is formed by adding new issuances to the still outstanding debt as of the year t static pool and subtracting those issuances that defaulted or were retired during year t. The important characteristic of the static pools is that the denominator of each static pool (i.e. the issuances included in the pool) remains constant over time.

Cumulative default rates are obtained by accumulating average experiences of all static pools. This is done in three steps. First, marginal default rates conditional on survival are calculated for each static pool and for each possible time horizon. This is done by dividing the number of issuers in the static pool that defaulted during the considered year by the number of issuers that were still outstanding at the beginning of that year. Next, the weighted average of the conditional marginal default rates is computed for each year, where weights are based on the number of issues in each static pool. Finally, cumulative default rates are computed according to the formula:

$$CDR_t = 1 - \prod_{\tau=1}^t (1 - MDR_{\tau}), \quad t = 1, \dots, T,$$
 (8)

where MDR_{τ} is the weighted average of conditional marginal default rates in year τ .

B Data description

Table 5 displays the breakdown of CFD bond issues by the county where the CFD is located.¹⁹ The majority of CFDs are based in the urban areas of Southern California. The counties leading in the numbers of CFDs are Riverside (30.43%), Orange (11.33%), San Diego (8.9%), San Bernandino (8.72%), and Los Angeles (6.29%).

The number and total principal amount (in 1990 dollars) of Mello-Roos bonds issued for the period 1985 through 2006 are shown in Figure 1. The Figure illustrates that the CFD bonds gained some popularity in the late 1980s with a subsequent drop in the number and value of issues in the early 1990s, which coincided with the beginning of

¹⁹The counties that are not in the table had no CFDs located in them in 1985-2006.

County	Number	Percent	County	Number	Percent
Alameda	17	1.01	Placer	70	4.15
Alpine	3	0.18	Riverside	513	30.43
Amador	6	0.36	Sacramento	88	5.22
Calaveras	2	0.12	San Bernardino	147	8.72
Contra Costa	34	2.02	San Diego	150	8.9
El Dorado	9	0.53	San Francisco	9	0.53
Fresno	6	0.36	San Joaquin	85	5.04
Imperial	10	0.59	San Mateo	6	0.36
Kern	13	0.77	Santa Barbara	1	0.06
Kings	2	0.12	Santa Clara	12	0.71
Los Angeles	106	6.29	Santa Cruz	3	0.18
Madera	3	0.18	Solano	28	1.66
Marin	22	1.3	Sonoma	8	0.47
Merced	8	0.47	Stanislaus	31	1.84
Mono	1	0.06	Sutter	2	0.12
Monterey	3	0.18	Ventura	24	1.42
Nevada	4	0.24	Yolo	65	3.86
Orange	191	11.33	Yuba	4	0.24
			Total	$1,\!686$	100

Table 5: CFD bond issues by county, 1985-2006.

recession. However, after 1993 the use of these bonds as a financing mechanism started growing again. The bond issuance averaged about 41 transactions in 1985-1992, 62 in 1993-1999, and 133 in 2000-2006. The dollar per issue yearly average demonstrates a decline over time when measured in real terms.

Figure 5 shows the real average interest rate of CFD bond issues, real 20-year AAA GO bonds yield, and the total new building valuation (residential and nonresidential) in California in real terms. In our estimation (Section 5.3) we use the difference between the CFD bond's interest rate and the AAA GO bonds yield as a measure of a risk premium associated with the possibility of the CFD default.

The California unemployment rate shown in the left panel of Figure 5 is clearly counter-cyclical with respect to the total new building valuation shown in the right panel. These measures reflect the state of the economy and are correlated with the issuance of CFD bonds (Figure 4). The mid to late 1980s were a period in which the economy was strong and characterized by rapid development, especially in electronics and computer industries. The unemployment rate fell from its high of 7.2% in 1985 to 5.1% in 1989. In 1990-91, however, the economic outlook changed significantly. This was the beginning of a deep recession in California, which lasted through the mid 1990s until the recovery



Figure 4: CFD (Mello-Roos) bonds issuance, 1985-2006. The grey bars (left scale) show the real total principal amount of new issues, in 1990 dollars. The black bars (right scale) show the number of new issues.



Figure 5: Left: The average real interest rate of CFD bond issues (solid squares), real 20-year AAA GO bonds yield (solid circles), and the unemployment rate in California (triangles). Right: Total new building valuation (residential and nonresidential) in California, in billions of 1990 dollars.

started in 1996-97.