UNIVERSIDAD COMPLUTENSE DE MADRID

FACULTAD DE CIENCIAS ECONÓMICAS Y EMPRESARIALES
Departamento de Fundamentos del Análisis Económico II (Economía Cuantitativa)

AN ANALYSIS OF THE EUROPEAN COVERED BOND MARKET: A CREDIT RISK APROACH.

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AN ANALYSIS OF THE EUROPEAN COVERED BOND MARKET

A CREDIT RISK APPROACH

(ANÁLISIS DEL MERCADO EUROPEO DE COVERD BONDS BAJO LA PERPECTIVA DEL RIESGO DE CRÉDITO)

RAQUEL BUJALANCE RODRÍGUEZ

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Introducción

"Innovación", "complejidad" y "globalización" podrían ser las palabras más adecuadas para describir la evolución de los mercados financieros en los últimos años. Innovación en los productos ofrecidos por el mercado y en la cobertura de riesgos, complejidad en la creación de nuevos productos y en la dificultad para entender todas las implicaciones subyacentes en dichos productos y, globalización en la interrelación de agentes y mercados muy diferentes, con distintos intereses, no siempre compatibles.

La innovación registrada en productos y mercados ha sido en gran medida respuesta a las necesidades de cobertura y transferencia de riesgos por parte de los agentes. Podemos hablar del riesgo de mercado (principalmente de tipo de interés), riesgo de crédito, riesgo de liquidez y riesgo operacional como los principales riesgos a los que se enfrentan los agentes del mercado financiero.

Sin embargo, productos que originalmente se crearon para satisfacer una demanda de cobertura, han pasado en muchos casos a ser demandados, por motivos especulativos, por inversores deseosos de incrementar el conjunto de potenciales elecciones riesgo-rendimiento, traduciéndose en un crecimiento espectacular de estos mercados. La innovación financiera ha sido muy positiva no sólo en términos de transferencia de riesgos – fundamentalmente el riesgo de crédito-, sino que también ha permitido mayor diversificación de las fuentes de financiación con las que cuentan las entidades financieras y mayor profundización en el proceso de desintermediación financiera, con la creación de nuevos mercados y el progresivo acceso de nuevos agentes a los mismos (por ejemplo el acceso de las pymes a derivados de tipo de interés y de inflación para realizar la cobertura de salarios de los trabajadores).

Cabe destacar, no obstante, que en ocasiones, el incremento de la capilaridad e interrelación de los mercados ha sido fuente de inestabilidad y fragilidad del sistema. Tenemos al respecto muy presente los episodios recientes en el mercado hipotecario de EEUU y su traslación al resto de mercados crediticios internacionales.

El aumento de la complejidad de los productos financieros ha impulsado, tanto a nivel académico como regulatorio y bancario, numerosos estudios acerca de los mecanismos que actúan en la determinación de los precios de los activos, la cuantificación de sus riesgos y la cobertura de los nuevos productos, desde las emisiones menos complejas -los bonos emitidos por entidades privadas- hasta los derivados de crédito sobre carteras (CDOs), donde en muchos casos el activo subyacente es muy opaco.

La última crisis financiera que se ha dado en llamar “crisis de la liquidez”, pone de manifiesto la necesidad de efectuar un análisis más profundo sobre los elementos que deben imperar en una adecuada gestión de los riesgos por parte de las entidades, así como de la estructura y fuentes de financiación del sistema en su conjunto.

Las cédulas hipotecarias (Covered Bonds emitidos en España) se han convertido, en los últimos años, en una de las principales fuentes de financiación de las entidades financieras españolas y europeas a pesar de ser uno de los productos más antiguos del mercado europeo. Su importancia como fuente de financiación se ha visto reflejada no sólo en términos del incremento de los volúmenes emitidos, sino también por la incorporación a este mercado de numerosos países europeos sin tradición previa en este tipo de emisiones. Las Figuras 1-4 muestran el volumen en el mercado (saldo vivo) y el volumen emitido en el mercado Europeo clasificado por tipo de subyacente en la cartera que actúa de garantía (hipotecas, prestamos a entes públicos y otros activos) y por país emisor.

Se puede definir un Covered Bond (CB) como un bono emitido por una entidad financiera y garantizado por un conjunto de hipotecas o préstamos a entidades territoriales. La diferencia entre un bono emitido por una entidad financiera y un CB es que, este último, está garantizado, lo que le convierte en una emisión doblemente garantizada (por el emisor y el conjunto de hipotecas, sobre el que el inversor del CB tiene preferencia, por delante del resto de acreedores en caso de default del emisor). Por lo tanto, la rentabilidad ofrecida sobre el libre de riesgo viene inferida en gran medida, de la calidad crediticia del emisor y de la calidad de la garantía. Para que el inversor en CBs tenga plena seguridad en que puede disponer de la garantía en caso de default del emisor, la mayoría de las legislaciones de los países emisores garantizan la preferencialidad de dichos acreedores a la vez que imponen una serie de reglas a la composición de la cartera de hipotecas para mantener su alto nivel crediticio.

El mercado de CBs se desarrolló en primer lugar en Alemania. En la actualidad los principales emisores de CBs son Alemania, Dinamarca, España y Francia. Aunque las emisiones son bastante homogéneas, existen diferencias en la legislación sobre CBs en cada país. Se puede considerar que hay dos tipos de Covered Bonds: Los tradicionales, en los que se va a centrar este trabajo, que se caracterizan por tener una amplia legislación en el país de emisión, aunque existen pequeñas diferencias entre la legislación entre países, como ejemplo la Tabla 1 recoge las principales diferencias entre las emisiones de Alemania, España y Francia. Y los Structured Covered Bonds que permiten dar las mismas garantías contractuales a las emisiones que no cuentan con una legislación especifica o suficientemente desarrollada, por medio de clausuras especiales, a través de un SPV (*special-purpose vehicle*) que emite las cédulas. También entrarían dentro de este tipo las emisiones de

CBs cuya garantía pertenece a distintas entidades financieras, se denominan Structured CBs ya que utilizan las técnicas de estructuración de activos para replicar el pago de un Covered Bond tradicional. La Tabla 2 muestra las características de dos países emisores de esta clase de activos UK y Austria.
Aunque en los dos últimos años se han realizado algunas emisiones puntuales en EEUU, el Mercado de CBs es un Mercado propiamente europeo, esta ausencia de mercado americano puede ser en parte explicada por la ausencia de una legislación ad hoc para este tipo de emisiones, así como de la existencia de entidades semi-publicas que realizaban un papel similar en el mercado americano (como Fannie Mae y Freddie Mac).

En ocasiones se confunden los Covered Bonds con las titulizaciones (MBS), al ser ambos una fuente de financiación de las entidades de financieras y tener como subyacente la cartera hipotecaria de la entidad financiera, la diferencia principal con las titulizaciones o MBS es que en el caso de los CBs no se realiza un trasvase de riesgo de la cartera hipotecaria al comprador del bono, ya que la cartera sigue en el balance del emisor, mientras que en las titulizaciones se transfiere el riesgo de la cartera subyacente.

A pesar del espectacular desarrollo del mercado de CBs, no ha sido un producto muy estudiado desde el punto de vista académico, quizá debido a su centralización en el mercado europeo. Sin embargo, este mercado posee características claras que hacen interesante profundizar en su estudio. En primer lugar, a pesar de que esperaríamos encontrar que estos activos ofrecieran una rentabilidad de acorde al *rating* asociado, próximo a la renta fija del Estado, y muy por debajo de los bonos emitidos con las mismas características sin garantía, estos activos cotizan en el mercado con un diferencial o *spread* relativamente alto sobre el libre de riesgo; en particular, los CBs españoles cotizan por encima de sus homónimos europeos. Esta puede ser otra de las causas de la expansión del mercado de CBs, no sólo resultan atractivos como fuente de financiación de las entidades financieras sino también lo son para distintos inversores, dado que permiten realizar un "arbitraje de *rating*", ofreciendo una mayor rentabilidad dentro de los límites de *rating* permitidos para sus inversiones.

En segundo lugar, al ser un mercado marcadamente europeo, nos parece interesante el análisis de la dinámica de interrelación de los precios entre los distintos países. En tercer lugar, resulta una cuestión relevante obtener una fórmula de valoración adecuada a sus especiales características. Por último, la interacción de los CBs con otros derivados de crédito de los mismos emisores puede ayudar a comprender mejor la apreciación del riesgo de crédito de los emisores por el mercado y las particularidades de este mercado. Este es uno de los principales focos de interés de los últimos años, como demuestra el acuerdo de Basilea II y actual implantación.

La forma habitual de hacer *pricing* con estos activos por emisores y agencias de crédito se basa en modelos tipo *scoring* que recogen las principales características, tanto cualitativas como cuantitativas, de la garantía, así como las del mercado y del emisor. Al no haber datos de quiebra de este tipo de activos, resulta complejo establecer un modelo adecuado de valoración. Por otra parte, la mayoría de los inversores que intervienen en el mercado no tienen acceso a toda la información sobre la garantía necesaria para realizar un modelo, dentro de este enfoque, pero pueden realizar una valoración alternativa a través de la metodología habitualmente aplicada a los activos con riesgo de crédito como son los bonos o los CDS, asumiendo una tasa de recuperación mayor en los CBs que en los otros activos emitidos por la misma entidad.

En la literatura moderna sobre riesgo de crédito se utilizan principalmente dos tipos de enfoque, que derivan bien en modelos estructurales o en modelos de forma reducida. El enfoque estructural se inició con el trabajo de Merton de 1974, y consideraba que el incumplimiento de una contrapartida se produce cuando el valor de los activos cae por debajo de un umbral o "nivel de deuda". Su implementación requiere conocer el valor de los activos de la empresa y estructura de las deudas, lo que no siempre es observable, especialmente en las compañías no cotizadas. Para resolver este problema, Jarrow and Turnbull infirieron, en 1995, las probabilidades martingala condicionales de la estructura de los *spreads* de crédito, dando lugar a los modelos de forma reducida. Mientras que en los modelos estructurales el fallido sucede cuando el valor de la empresa desciende por debajo de cierto límite, los modelos de forma reducida toman el momento de quiebra como una variable aleatoria exógena y tratan de modelizar o ajustar la probabilidad de fallido. La principal herramienta para modelizarla es un proceso de Poisson con intensidad aleatoria, donde el salto denota el evento de crédito. Además, la tasa de recuperación puede ser aleatoria, y la relación con la *hazard rate o tasa de fallido*, dependerá de la forma que adopten ambos procesos y de la relación de dependencia que se asuma. En esencia, estos últimos permiten utilizar mejor la información observable y disponible en el mercado (*credit spreads* o *ratings*) para inferir la valoración que hace el mercado del proceso de quiebra y, a partir de ella, poner precio a los instrumentos derivados que dependan de la evolución de la calidad del crédito. La ventaja de estos modelos es que son fáciles tanto de implementar como de calibrar y, dadas sus características particulares, parecen la metodología más eficaz para los CBs. Mientras el enfoque estructural se construye alrededor del valor del emisor, el enfoque reducido permite dar el mayor peso del modelo a la función de pérdidas, que recoge tanto la probabilidad de quiebra del emisor como la tasa de recuperación debida a la garantía. Además, en la práctica, no disponemos de información detallada de los activos que conforman la garantía de cada emisión de CBs, de muy difícil acceso por tratarse de características especificas de los préstamos e hipotecas concedidas y por su magnitud, que se multiplica al tener dichas carteras un carácter dinámico en el tiempo.

Así, el primer objetivo del trabajo es analizar las características de este mercado utilizando un enfoque reducido, por las razones expuestas anteriormente. Nos parece adecuado en una primera aproximación realizar el estudio detallado en un único país. Por proximidad y de forma natural elegimos el español. Además, el mercado español de CBs se caracteriza – más incluso que en el resto de Europa – por que estos cotizan con un *diferencial* sobre el activo libre de riesgo por encima de lo que se podría esperar de un bono del máximo nivel crediticio. Por otra parte, independientemente del emisor elegido, estos activos parecen tener una dinámica muy parecida a lo largo del tiempo. El primer capítulo de este análisis se centra en el estudio las características que explican el *diferencial* de CBs español, así como su dinámica temporal.

Por una parte, esperaríamos que este tipo de bonos cotizasen más cerca de los bonos gubernamentales que del resto de los bonos emitidos por las mismas entidades, ya que tienen un nivel de riesgo muy parecido. Así, la primera parte del Capítulo I analiza si las características propias de cada bono (emisor, volumen emitido…) pueden explicar al menos una parte del diferencial observado. La segunda parte analiza las posibles variables que podrían explicar la dinámica de dichos *spreads* a lo largo del tiempo (tipos de interés, sector, ciclo económico…). El objetivo de ambos análisis es el mismo; identificar las variables relevantes que, posteriormente nos permitirán postular un modelo de precios para dichos activos.

Para poder identificar dichas variables tomamos como modelo *benchmark* el modelo reducido de Duffie y Singleton (1999) suponiendo una *hazard* constante. A partir de ahí, utilizaremos el concepto de "hazard implícita", con un significado análogo al de la volatilidad implícita en el modelo de Black-Scholes (1973). Es decir, la "hazard implícita*"* es el valor de la *hazard* que iguala el precio observado al precio obtenido a través del modelo. Tomando estos valores como variable dependiente, estudiamos las principales variables que pueden afectar al nivel y la dinámica del *spread* de estos activos. La significatividad de los resultados nos dará un indicio de cómo deber estructurarse un mejor modelo de *pricing.*

Los resultados obtenidos muestran que las variables macroeconómicas explican una gran parte de la dinámica de estos activos pero, por el contrario, no encontramos que las características propias de dichas emisiones expliquen el diferencial sobre el tipo libre de riesgo al que cotizan.

Una posible explicación a estos resultados podrían deberse a un efecto país. De hecho, las diferencias existentes en la legislación de los países emisores de CBs pueden hacer las emisiones más o menos atractivas para cada inversor y la diferencia en los niveles de los *spread* de las emisiones españolas (más altos que los franceses y alemanes) pueden ser explicados por la falta de confianza que generan en el inversor estas diferencias, a pesar de tratarse de emisiones calificadas por el mismo *rating*. Así, la no-existencia de un administrador independiente en caso de *default* de las emisiones españolas, o las diferentes características del mercado hipotecario español puede ser algunas de las causas de estas diferencias. Sin embargo estas emisiones poseen, por legislación, un grado de sobrecolaterización muy superior al resto de las emisiones. (Tabla 1)

Estas consideraciones nos llevan a realizar el estudio en un marco más amplio. Por ello, en el Capítulo 2, incorporando datos de CBs franceses y alemanes, analizamos las variables que afectan a la evolución de los *spreads* de crédito de dentro del marco europeo. También estudiamos la interrelación que existe entre los *diferenciales* de los tres países a través de la metodología VAR sobre los *spreads* medios de cada país, al que añadimos las variables macroeconómicas equivalentes en el mercado europeo que encontramos relevantes en el Capítulo 1. A partir de los resultados obtenidos en este análisis (y en los resultados obtenidos en el capítulo uno) proponemos y probamos un modelo de valoración para dichos activos.

Dentro de las modelizaciones propuestas habitualmente para la identificación de la función de pérdidas (Loss Given Default) en los modelos reducidos nos centraremos en el modelo de Jarrow (2001). Una adaptación de este modelo para la función de pérdidas parece la modelización más apropiada a la vista de las variables encontradas significativas en el Capítulo 1 y en la primera parte del Capítulo 2, dado que este modelo incorpora dos de las variables encontradas relevantes en nuestro análisis, los tipos de interés y un índice de mercado. Finalmente, la adaptación del modelo de Jarrow (2001) al mercado de CBs se ha realizado añadiendo dos variables más que incorporan el pasado en el mercado alemán y en el mercado local de CBs, donde la selección de dichas variables atiende a un criterio de ajuste a los datos y de predicción.

En este punto, es importante señalar una importante restricción de este tipo de modelos, siempre hay que determinar la función de perdidas a través de la función *hazard rate* y de la *recovery rate*. La recovery rate o tasa de recuperación es la variable clave a la hora de evaluar la perdida asociada al incumplimiento de una contrapartida, y en la literatura académica ha sido objeto de estudio desde distintas perspectivas, modelos actuariales, enfoque estructural, enfoque reducido...Hasta ahora el trabajo se ha centrado en la *hazard rate* de estos activos, fijando *la tasa de recuperación* (Capítulo 1) o utilizando directamente la función de pérdidas (Capítulo 2). Debido a la formulación de los modelos reducidos no es posible estimar ambas funciones a la vez (*hazard rate* y la *recovery rate*), el investigador debe elegir fijar una de ellas o estimarlas conjuntamente en la función de pérdidas.

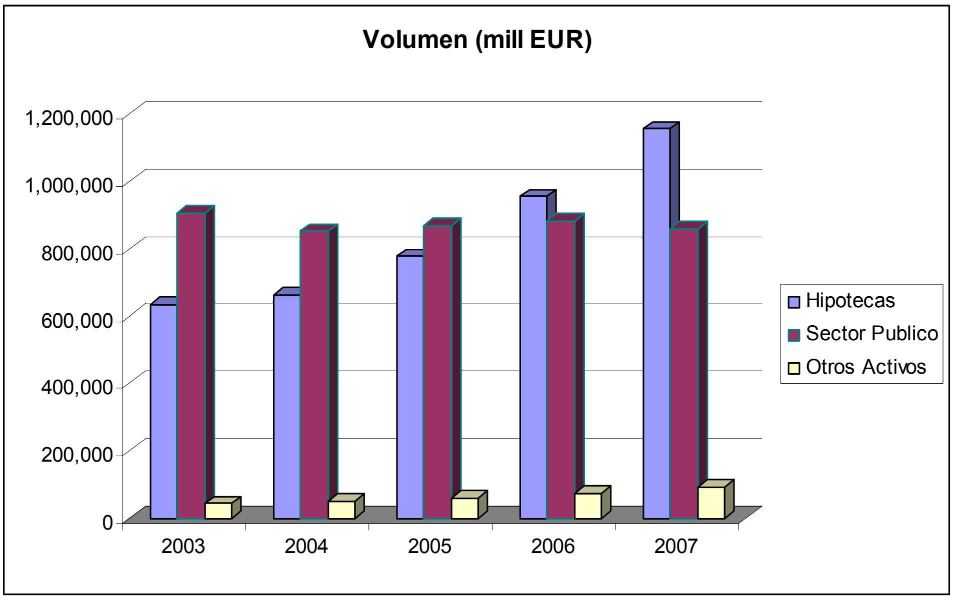
En el Capítulo 3 se aborda este problema estudiando la relación entre los CBs y los bonos con las mismas características emitidos por el mismo emisor. Dada las características de este tipo activo la diferencia entre un bono a vencimiento con cupón fijo y un Covered Bond con las mismas características en caso de quiebra del emisor es la tasa de recuperación que podemos esperar de cada uno, siendo la del CB mucho más alta al tener los inversores derecho preferencial sobre la cartera que actúa de garantía. A partir de Bonos y CBs con las mismas características podemos analizar los determinantes de la tasa de recuperación de cada uno y las interrelaciones que puede haber entre ellas, bajo el supuesto de separabilidad de ambas funciones (*hazard rate* y *recovery rate*) y la identificación de *default* con quiebra del emisor. Para ello, obtenemos primero una función de pérdidas implícita para nuestra base de bonos y CBs, las diferencias entre ambas funciones de pérdidas responderán principalmente a las diferencias en la *tasa de recuperación*. Además al obtener el ratio entre ambas funciones de perdidas, la *hazard rate* debería cancelarse, y solo quedar los determinantes que afectan a cada *tasa de recuperación* de manera distinta.

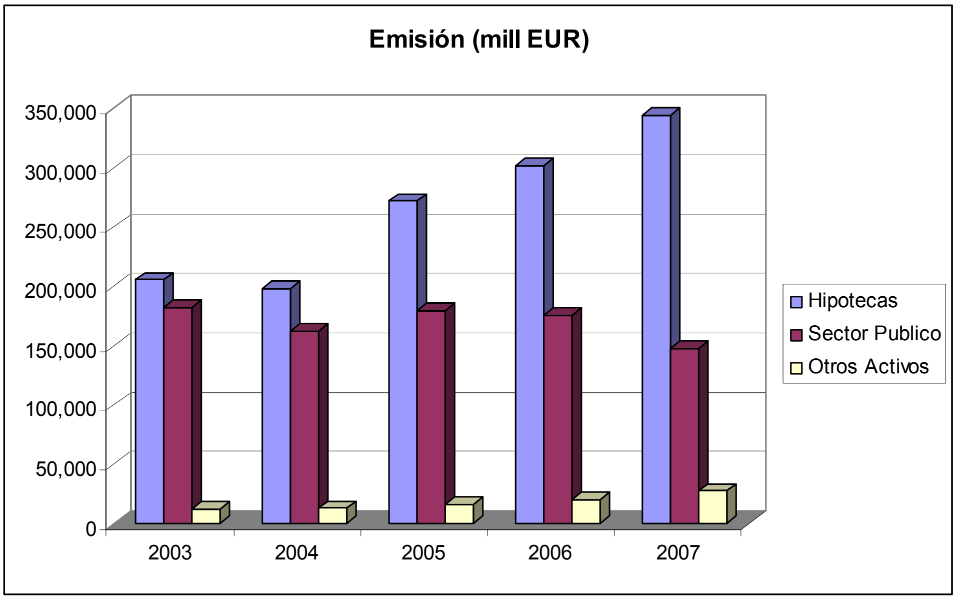
Este estudio de los determinantes de cada *función de recuperación* es interesante por dos motivos, en primer lugar, nos permite estudiar desde una nueva perspectiva la *tasa de recuperación* del sector bancario sin imponer ninguna restricción sobre la función de pérdidas y en este sentido, es conveniente comparar nuestros resultados con los obtenidos por los modelos que imponen alguna restricción, normalmente derivada de los modelos estructurales, dando lugar a los llamados modelos híbridos. (Jarrow , 2001; or Das and Hanouna, 2006).

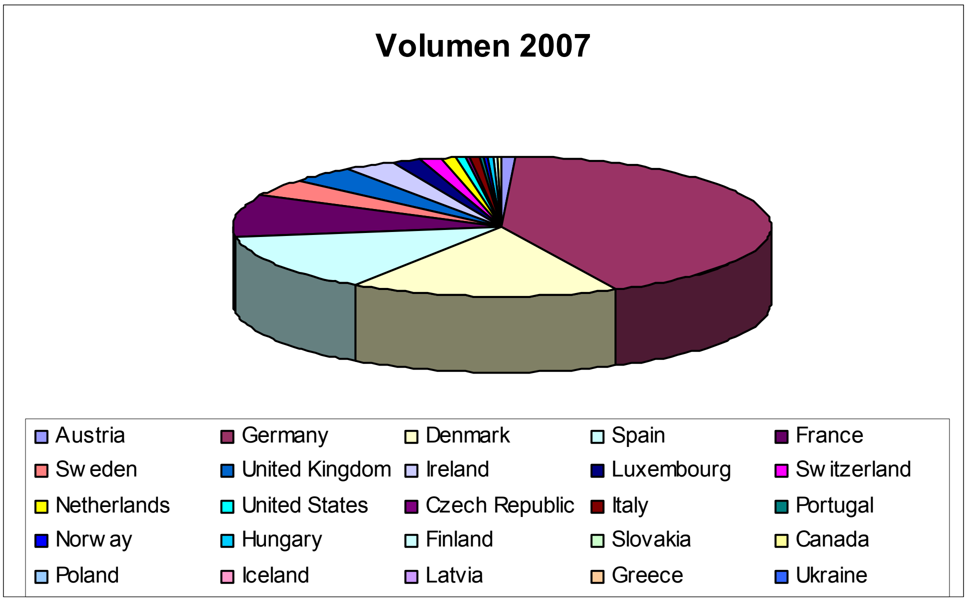
En segundo lugar, nuestro análisis riesgo-neutral supone un buen complemento a los análisis realizados desde el “análisis experto”, análisis habitual de las agencias de rating para este tipo de misiones, en el que se consideran características cualitativas y cuantitativas como cartera garante, marco legal, indiosincracias del mercado local, impuestos, etc., con la problemática de que en el caso de los CBs no existe una base de datos de emisiones que hayan hecho de *default*. Nuestra propuesta se basa en inferir las características de ambas funciones de los *spreads* de mercado, a partir de la relación encontrada entre Bonos y CBs de un mismo emisor, podría extrapolarse la información que existe acerca de *defaults* en carteras de bonos de las que si existen bases de datos.

En resumen, el trabajo analiza las características del mercado de *Covered Bonds* Europeo desde un perspectiva de riesgo de crédito; el primer capítulo se centra en el mercado español de Cédulas Hipotecarias; el segundo capítulo amplia el estudio al mercado Francés y Alemán, que junto al mercado Español representan una parte importante del mercado tradicional de CBS , los resultados obtenidos en estos dos capítulos permiten postular un modelo de *pricing* adecuado para esto activos; por último, el tercer capítulo analiza la relación entre las funciones de pérdidas de Bonos y Covered Bonds emitidos por las mismas entidades, especialmente la relación existente entre las tasas de recuperación de ambos activos.

Figura 1- 4. Volumen y emision de CBs en el mercado Europeo



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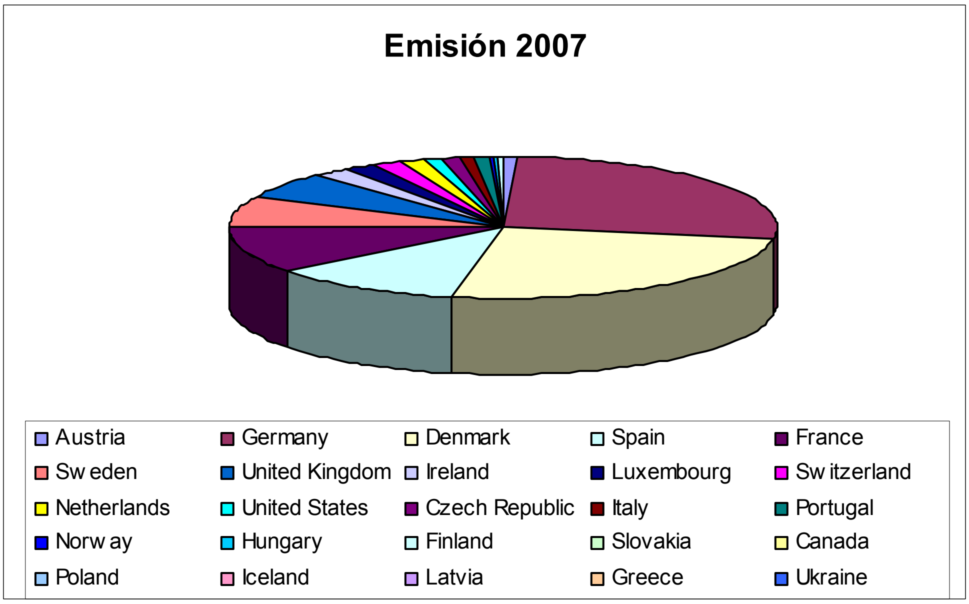
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Tabla 1. Características Covered Bonds Alemanes, Españoles y Franceses			
	CBs alemanes (Pfandbriefe)	**CBs Españoles (Cedulas Hipotecarias y Territoriales)**	**CBs Franceses (Obligations Foncieres)**
Emisores	Bancos alemanes con licencia del BaFin	Bancos y Cajas Españoles	French Sociétés de Crédit Foncier (SCF)
Entidad Supervisora	Bundesanstalt für Finanzdienstleistungsauf sich (BaFin)	Banco de España	Comisión Bancaire (CBs)
Supervisión	El banco emisor propone un auditor independiente al BaFin, que garantiza que la las características de la garantía se mantiene dentro de sus limites	BdE tienen el poder de realizar inspecciones periódicas y la responsabilidad de asegurarse que se cumplen las características de la garantía, asegurando la emisión en caso de incumplimiento de las características	Dentro de cada emisor un controlador especifico ç(dentro de los auditores) monitoriza el cumplimiento de la normativa e informa regularmente al CBs.
Risk-weighting	10%	10%	10%
Tipo de Garantía	Hipotecas y créditos a entidades publicas	Hipotecas y créditos a entidades publicas de "alta calidad crediticia" concedidos por la entidad emisora de CBs	Hipotecas y créditos a entidades publicas "elegibles" concedidos por la entidad emisora de CBs
Localización de la Garantía	UE, USA, Canadá, Japón, suiza y créditos a entidades publicas de países europeos de la OECD (10% limit)	Hipotecas registradas en el registro de la propiedad español. Créditos a entidades publicas de la Unión Europea	UE y antiguas-colonias francesas. Créditos a entidades publicas de Suiza, USA, Canadá y Japón.
Valoración	No puede exceder al valor de mercado. Solo se pueden tener en cuenta las características permanentes. La forma de valoración debe estar aprobada por el BaFin. Prestamos territoriales y créditos a la construcción de viviendas no pueden exceder el 10% de la garantía.		Valoración conservadora (excluyendo elementos especulativos) , basado en las el uso, las características del inmueble y del mercado local. La valoración se realiza por un experto independiente.
Limie LTV	60% hipotecas		60% para hipotecas residenciales y 60%-80% para hipotecas comerciales
Ratios de Covertura	98% mínimo, en la practica una cobertura mayor en las emisiones AAA	Sobre-cobertura, solo se puede emitir por el 90% de las hipotecas y 70% de los prestamos a entidades publicas	Al menos 100%.
Posible sustitución por otra clase de activos	10% de los emitidos. Pueden sustituirse por depósitos del Bundesbank u otras entidades equivalentes, por bonos emitidos por los gobiernos admitidos como garantía y de	No se pueden utilizar otra clase de activos	20% (hasta un 30% con el permiso del regulador)

	algunos emisores de alta calidad crediticia		
Mark to market del collateral	No hay requerimientos formales de re-valoración	No hay requerimientos formales de re-valoración. Los deudores pueden ser obligados a aportar garantías adicionales si el valor del activo decae por debajo del 20%.	Al menos una vez al año.
Acceso a la garantía por otros acreedores (contrapartes de los derivados)	Si, si están incluidos en la garantía	Si	No
Ranking de acreedores	Por delante de otros acreedores sobre el garantía, si el colateral no fuese suficiente para pagar toda la duda, los acreedores podrían acceder al resto de activos del banco (no-preferencial).	Acreedores "supre-preferenciales" sobre toda la cartera de prestamos de la entidad (no solo los activos que componen el garantía).	Por delante de otros acreedores sobre la garantía, si el colateral no fuese suficiente para pagar toda la duda, los acreedores podrían acceder al resto de activos del banco al que pertenece la SCF (no-preferencial).
Quiebra	La quiebra del emisor no conlleva la terminación inmediata de los contratos. El BaFin podría crea un proceso de quiebra separado para los CBs si fuese necesario ya que los activos que forman parte de la garantía se consideran "activos especiales" y no forman parte de los activos exigibles por los acreedores.	LA quiebra de los CBs depende de la insolvencia del emisor , en caso de quiebra del emisor, las emisiones de CBs seguirían vigentes siempre que se mantenga la calidad del la cartera colateral.	La quiebra de la entidad matriz del SCF no puede extenderse al SCF. La quiebra del SCF implicaría la terminación inmediata de los contratos.
Historia de default	Ningún banco hipotecario alemán ha quebrado desde 1900. Anteriormente no ha habido ningún caso de default de CBs (emitidazas desde XX) a pasar de que diversas entidades financieras quebraron en la crisis de 1873-1875.	Hasta 1981, CH solo eran emitidas por el Banco Hipotecario (1869-1981). Sin ningún default en ese periodo ni en emisiones posteriores por otras entidades.	Desde las primeras emisiones en 1852 no ha habido eventos de default.
			Fuente: Morgan Stanley Covered Bond Handbook

Tabla 2. Características de los Structured Covered Bond de Reino Unido y Austria		
	CBs Reino Unido (UK Covered Bonds)	**CBs Austriacos (Austrian Covered Bonds)**
Emisores	Todos los bancos de UK	Bancos Austriacos
Entidad Supervisora	FSA regula la emisión de CBs pero no es responsable de su supervisión	FMA
Supervisión	Se realizan informes periódicos de la calidad de las emisiones. Una entidad independiente comprueba que se cumplen los requisitos necesarios en el "asset coverage test"	Regierungskommissat
Risk-weighting	20%	10%
Tipo de garantía	Bases de la garantía separadas entre activos hipotecarios y créditos a entidades publicas	Hipotecas y Créditos a entidades Publicas, el emisor puede crear bases de las garantías independientes.
Localización del garantía	Principalmente hipotecas locales.	UE y Suiza
Valoración	Cada activo es valorado a precios de mercado cuatrimestralmente, teniendo en cuenta el nivel del Halifax House Price Index.	La valoración de los activos no puede superar el precio de venta de mercado. El método de valoración debe ser aprobado por el regulador.
Limie LTV	Depende del emisor. 60% -75%	60%
Ratios de Cobertura	Depende del emisor. Ratios de sobrecobertura entre el 7% y el 11%	Mínima Sobre-cobertura del 2%
Posible sustitución por otra clase de activos	Depende del emisor HBOS permite sustituir un máximo de 10%, otras entidades no permiten ningún tipo de sustitución.	Se puede sustituir con máximo del 15% del volumen emitido, solo en el caso de que no haya CBs disponibles. La sustitución se puede realizar por cash o depósitos de Bancos Centrales.
Mark to market del collateral	Cada activo es valorado a precios de mercado cuatrimestralmente, teniendo en cuenta el nivel del Halifax House Price Index.	
Acceso a la garantía por otros acreedores	Si, si están incluidos en la garantía	Si

(contrapartes de los derivados)		
Ranking de acreedores	En caso de quiebra los activos son traspasados a un LLP, los inversores en CBs tienen derechos preferenciales sobre los activos.	Loa acreedores tienen derechos "super-preferenciales". En caso de quiebra se crearía un administrador sobre la base garante.
Quiebra	La quiebra del emisor no conlleva la terminación inmediata de los contratos, las emisiones de CBs seguirían vigentes en manos de un administrador mientras exista una adecuación de los cash-flows.	En caso de quiebra del emisor, las emisiones de CBs seguirían vigentes en manos de un administrador hasta vencimiento.
Historia de default	No hay datos históricos de quiebra	Los activos elegidos como garantía no han quebrado desde 1945

Fuente: Morgan Stanley Covered Bond Handbook

1. Spanish Covered Bonds: Investigating The Reasons For A Discount Puzzle Through The Implicit Hazard Rate

Abstract

Covered Bonds (CBs) are bonds issued by financial institutions and collateralized by the issuer's entire pool of mortgage loans or public sector loans. Empirical evidence for the European CBs market shows that they trade at a significant spread over treasuries. Although these instruments are very safe, it is often hard to see why they are priced at such a discount. A number of possible explanations for this phenomenon are analyzed in this work through the "implicit hazard rate." We used Duffie and Singleton (1999)'s reduced-form model to introduce the notion of the implicit hazard rate as the value that matches the observed price with the one from the model ,as far the implicit volatility in the Black-Scholes obteined option pricing formula (1973). We analyzed the characteristics of the resulting implicit hazard rate and discuss which variables may explain the observed prices and their time dynamics.

1.1 Introduction to Covered Bonds

Covered Bonds (CBs) are bonds issued by financial institutions and collateralized by the issuer's entire pool of mortgage loans or public sector loans. The standard product is a long-term bullet amortization and a fixed annual coupon.

Concepts of CBs and mortgage-based securitization are often confused, largely because both instruments rely on the same underlying securities (i.e. mortgages) and provide some kind of asset-based financing. Nevertheless, while in a CBs transaction the issuer retains and assumes the risk of the underlying securities, in a securitization transaction a substantial portion—if not all—of the risks are transferred to the investor.

Consequently, from the investor's point of view, purchasing CBs would expose her to the credit risk of the issuer institution, thereby putting her in the same position as a corporate bond investor, albeit with "super-preferential" rights. Although not exposed to issuer risk, a securitization buyer is exposed to the risks embedded in the underlying portfolio.

This assets first appeared in Prussia more than two hundred years ago, under the name of *Pfandbrief*. Nowadays, Germany is still the biggest market in Europe; in fact, excluding the American pseudo-covered bond, CBs *per se* are not found outside the European market. The legal framework is fragmented across different jurisdictions within Europe. Nowadays, more than nineteen different regimes coexist within the European market. Nevertheless, some legal differences aside, are a reasonably homogenized product with several common features:

They are collateralized by a pool of mortgage loans or public sector loans, often called the base pool. Its collateral has to be greater than or equal to its own value. Usually, a legal threshold is established so that the aggregate nominal value of all issues does not exceed 90% of the base pool. If at some point the volume exceeds the threshold, the issuer must revert the situation by either adding more loans to the base pool or buying back the bonds or both. Supervising authorities control the time-varying composition of the base pool, and verify the fulfillment of either the legal threshold or the over-collateralization requirement. The investors have "super-preferential" rights in the event of issuer bankruptcy, which means that, in the event of bankruptcy, investors are assigned preferential rights on the liquidation proceeds of the entire base pool.

In terms of issuance and outstanding volume Covered Bonds are an important segment on the European capital market. As of year-end 2002, euro 1.51 trillion[1] were outstanding (25.3 billion of which were Spanish CBs), a 17% share of the total bond market. In 2005 issuance came to 1.78 trillion, of which some euro 159.4 billion were Spanish CBs. Although trading in these instruments has increased considerably in recent years, it has yet to match the pace of issuance.

However, despite the growing importance, the space and time devoted to them in the academic press has been minimal and the main sources for specialized information on the market have been the yearly surveys by the European Mortgage Federation, the European Covered Bond Council (created in 2004) and research by the rating agencies particularly Moody's, Fitch and Standard & Poor´s. The intention with this study to help start filling up what we feel is a gap in the existing literature on the subject.

The present paper has a twofold objective. After reviewing the Spanish Covered Bonds Market, it proposes an explanation for the variables affecting credit spread levels and dynamics. Empirical evidence for the European Covered Bond market shows that CBs trade at a significant spread over treasuries (ECB Fact Book). Being very safe instruments, it

[1] One trillion equals 10^9

is often hard to understand why they should be priced at such a discount. Some possible explanations for this phenomenon are presented and discussed in a non-analytical fashion in the following section. Further research focuses on subjecting the hypotheses involved to more stringent tests.

One hypothesis explaining the discount puzzle between CBs and Treasury Bonds is the existence of some level of added, treasury-related credit risk embedded in CBs. This suggestion leads to a discussion of credit risk models under the framework of reduced –form models.

In this context the present paper focuses on the Spanish Covered Bond market, where they are referred to as *Cédulas Hipotecarias* or simply as *Cédulas*. The satisfactory specification of our reduced-form model relies on a correct modelling to hazard rate dynamics, where the hazard rate is the key variable in the CBs valuation model. Finding the characteristics reliable in the Spanish CBs Market is main goal of this work. To do this we propose using a reduced-form model oriented towards clarifying the variables that explain the hazard rate. That done, we may begin to consider using a more sophisticated model in which hazard rate dynamics is modeled according to the explanatory variables we found.

Section 1.2 provides a theoretical analysis of variables that might explain the CBs-Treasury spread. and describes the reduced-form model developed by Duffie and Singleton (1999) This model is estimated assuming a constant hazard rate in Section 1.3, which allows us to introduce the notion of an implicit hazard rate as the value that matches the observed price with the one obtained from the model, analogous to the notion of implicit volatility in the Black-Scholes model for options (1973). Section 1.4 looks in more detail at the resulting implicit hazard rate and discusses which variables might explain them and their time dynamics. Section 1.5 provides our conclusion.

1.2. The Discount Puzzle

Several factors may lie behind bond spreads. Major studies, e.g. Elton et al, (2001), Delianedis and Geske (2001) and Schultz (2001), suggest that credit risk premiums provide a very limited explanation of the size and movement of spreads embedded in corporate bond data. The authors of these studies argue that other sources of risk, such as liquidity risk, idiosyncratic risk, market risk, the effect of taxes, or diversification, need to be taken into account to complete the picture.

Each of these factors clearly needs to be analyzed if we are to find an explanation for the observed behavior of Spanish CBs, which seem to trade consistently at relatively high spreads over the comparable maturity Spanish Treasury bond.

Information on CBs spread curves over time is given in Figures 1 and 2. Figure 1 shows the evolution of their yield rate curves during one year (February 2003- February 2004), the spread is obtained estimating an interest rate term structure from the Treasury Bonds data and replicating the Covered bonds cash-flows assuming no default risk. All yields move in the same direction, the only differences apparently occurring in the levels, which do not themselves seem to be caused by intrinsic characteristics such as maturity, issuer, in first visual inspection by scatter plots..

If we compare the spread curves built from the Treasury bonds (Treasury-spread) or from the IRS curves (IRS-spread), we can find that the IRS-spread over CBs is not too significant, at some points being actually negative. The Treasury-spread therefore, is larger, around 30 basic points on average. The different values for both spreads are as expected, because IRS yield is normally grater than treasury yield. We can find arguments in the academic literature in favor of both approaches for calculating the spread. In recent years the IRS have become the preferred datasource, however given our sample and from a

practitioner's perspective, it seems reasonable to compute the spread against the IRS when the issue is sold on the Euro market, and take the Spanish Treasury as benchmark when traded inside of the domestic market. As we are interested in explaining the idiosyncrasies of the Spanish market, we think that the use of the IRS curve exclusively to build the spread, could mean the losts of some of the characteristics that affect market makers.
Figure 2 shows the spread between *cédulas* and the treasury for each *cédula* considered in our study, (built as the yield differences between de CBs and the riskless replicant bond discount with the term structure estimating from the GPS Indexs), from February 2003 to February 2004. There are noticeable spikes in two points of the sample, which may be due to event-driven jumps or mean reversion behavior. The downward swing in the spreads on both dates coincided with poor economic reports in the euro zone, which pushed the treasuries up, while the *cédulas* remained more or less constant. This kind of behavior is typical in the corporate bond class. The following section describes the main candidate variables for an explanation of the observed spread.

As noted above, CBs rely on an indefinite pool of mortgages acting as collateral should the issuer default. As such, the probability of a CBs defaulting is linked to the probability of the issuer doing so. However, when this does happen, CBs investors gain access to the collateral pool, which by Spanish law is guaranteed to be at least 111% of the outstanding balance of all CBs (i.e. the inverse of the required 90% maximum issuance level).

Even assuming that a default by the issuer is connected to the health of its mortgage portfolio, which might be seriously damaged, the extreme excess of mortgage assets relative to CBs issues (coupled with the fact that loan to value (LTV) ratios of each particular loan are legally under 80% for the eligible pool, and probably lower than 100% for most of the non-eligible mortgage pool) renders Loss Given Default (LGD) insignificant to CBs investors.

If default were followed by the issuer's declaration of bankruptcy, it might be argued that the liquidation of the mortgage pool would probably result in some costs being borne by investors, thereby reducing the amount of effective collateral, particularly in a situation of systemic distress of the financial system with no buyers to be found for the collateral. The investors in Spanish CBs are pretty sure to receive close to 100 % of all monies due to principal and interest. The severity could being determined by a characteristic loss of dynamism of the collateral pool, the early liquidation of the mortgage portfolio in the wake of a credit event, possible exposure to pool asset interest risk, credit and prepayment risk, etc.

Despite high trading levels, CBs are not traded as much as treasuries. Although Covered Bond issuance levels have picked up hugely in Spain in recent years, a major share has been retained by banks as collateral for repo operations, thanks to its AAA status. This fact may well be reducing market liquidity.

Another point to focus on is the possibility of trading flowing from more to less seasoned CBs issues. Under this hypothesis, trading on more seasoned CBs issues would subside rapidly after a new issuance had come to market, which would then capture all trading until the next issuance, and so on. Such behavior has previously been observed with respect to treasuries themselves, the so called on-the run phenomenon (Amihud and Mendelson 1991, Warga 1992).

It is sometimes argued that a diversification premium exists with respect to bonds. Risks on bonds, relative to equities, are harder to diversify, as individual return distributions are more asymmetric; furthermore, a model of default correlation on a portfolio level is still fundamentally lacking. In other words, to some extent we are less able to manage fixed income portfolios than we are equity portfolios.

While this is not the issue at hand, we are comparing two debt instruments and it seems neither trivial nor inapposite to determine whether government bonds already include some diversification effects that CBs do not.

Both instruments apparently provide exposure to the country's entire economic system. CBs depend on the performance of individual homeowners and their salaries, which in turn depend on general economic activity. Nevertheless, mortgage portfolios are not perfectly distributed across geographical areas, either by GDP or population.

As noted above, recent tax legislation amendments have made CBs more attractive to foreign investors since foreign investment in Spain has not been taxed. Our data includes prices before those amendments were enacted, so it might be useful to have post-amendment data in future work.

The housing market in Spain has been booming for some years now. Many authors describe the situation as a speculative bubble, in which investors (i.e. people buying second homes for investment purposes) have been irrationally attracted to this market partly driven by false expectations, partly because other capital markets have been particularly depressed. Banks have been competing furiously in this market, as they cannot afford to miss out on its double-digit growth rates. Competition has caused a depression in mortgage loans interest rates, which has further fuelled the investment boom while making the funding needed to support the investment growth scarcer. While bank balance sheets have not kept up with the pace of this process, funding shortages have been partially solved through CBs issuance and the securitization effect they provide; even so, they have had an impact on theirs prices.

The credit risk factor appears to be the main candidate to explain the observed spread. The next section shows how we used a credit risk model to obtain an implicit hazard rate.

1.3. Reduced-Form Models of Bond Pricing

The modern literature on credit risk generally takes one of two main approaches: structural models and reduced-form models. Structural models began with the seminal work by Merton (1974), which was subsequently expanded and adapted in several ways, the better to match the term structure of empirically observed spreads, e.g. Black and Cox (1976), Geske (1977), Nielsen et al (1993), Leland and Toft (1996), Longstaff and Schwarz (1995). This approach is difficult to implement as it relies on the value of the bond issuer's assets, which is rarely observable, and the subordination structure of the issuer's liabilities, which is complex. In structural models, default occurs when the asset value falls below the value of the liabilities. The key is, therefore, to model the process for the assets correctly.

Reduced-form models—Jarrow and Turnbull (1995)—ignore the mechanism that makes a company default. It is enough to know that the moment such an event takes place is a random variable, subject to stochastic modeling. In what follows we adopt this approach. In this context, modeling hazard rate movement suitably is critical.

Several authors have suggested using a stochastic model for the hazard rate (Schmidt and Stute (2004)). Jarrow, Lando and Turnbull (1997) use affine models where the short rate is included in addition to the hazard rate. Duffie and Singleton (1999) use a two-factor CIR model to drive the default process.

Although many benefits can be gained from such specification, the fact that the model proposed is justified empirically remains to be proved. To determine what are the specifict variables that affect to the spread of CBs, we obtain an implicit hazard rate thougt the Duffie and Singleton (1999) intensity model. The implicit hazard rate contains all the information available concerning the risk factors to which CBs are exposed. Using the hazard rate information, we tried to determine the number, and kind, of factors with a bearing on CBs spread. We also discuss whether *cédulas* are homogenous (i.e. if they can be dealt with jointly), or if the specific characteristics of the *cédulas* need to be brought up in the analysis.

Model Setup

Take τ as the time of default of some company on some bond issued by it, maturing at some time T. Clearly, if $\tau \leq T$, the company defaults on the bond and investors are subject to sustaining some loss, while if $\tau \geq T$ the company has not defaulted by the time the bond matures, and investors receive full payment.

Denote

$$F(T) = \Pr(\tau \leq T), \quad T \geq 0 \quad and \quad S(T) = \Pr(\tau > T), \quad T \geq 0$$

where $F(T)$ represents the probability of default at or before some time T, and $S(T)$ the probability of surviving. $S(T) = 1\text{-}F(T)$. From this cumulative distribution function, one can derive the density function f(t) as follows

$$f(t) = F'(t) = -S'(t) = \lim_{\Delta t \to 0} \frac{F(t+\Delta t) - F(t)}{\Delta t} = \Pr(t \leq \tau \leq t + dt)$$

which may be interpreted as the probability of defaulting at some time t.

Within this framework, the hazard rate $\lambda(t)$*is defined as*

$$\lambda(t) = \frac{F'(t)}{S(t)} = \frac{-S'(t)}{S/t} = \lim_{\Delta t \to 0} \frac{F(t+\Delta t) - F(t)}{\Delta t \cdot (1 - F(t))} = \Pr(t \leq \tau \leq t + dt \mid \tau > t)$$

which refers to the probability of defaulting in some interval $(t, t+dt)$ conditional to have survived at t. Integrating the previous expression in the interval (t, T), the relationship between $S(t)$ and $\lambda(t)$ can be given as

$S(T) = e^{\int_t^T \lambda(u) \cdot du}$ and we may also infer $f(t) = \lambda(t) \cdot e^{-\int_t^T \lambda(u) \cdot du}$

Looking at the expression for *S(T)* we can think of it in terms of the probability of non-arrival of a non-homogenous Poisson process. That is

$S(T) = \Pr(N_T - N_t = 0) = e^{-\int_t^T \lambda(u) \cdot du}$ which enables us to think that

$$F(T) = \Pr(N_T - N_t = 1) = 1 - e^{-\int_t^T \lambda(u) \cdot du}$$

given that a company can default only once, and we have to "cut" the Poisson process when the counter reaches 1. The price at time *t* of a zero-coupon riskless bond maturing at *T* is known to be given by

$$B(t,T) = E^Q \left[\cdot e^{-\int_t^T r(u) du} \mid F_t \right]$$

where *r(t)* is the risk-free short rate, *Q* is the martingale probability, and $\boldsymbol{F_t}$ is the amount of information available for investors at time *t*. In contrast with such a risk-free bond, the value of a risky one would be given by

$$V(t,T) = E^Q \left[S(T) \cdot e^{-\int_t^T r(u) du} \mid F_t \right] + E^Q \left[F(T) \cdot Z_\tau \cdot e^{-\int_t^\tau r(u) du} \mid F_t \right]$$

where the first summand indicates the present value of a unitary payment at *T* weighted by the probability of the bond surviving until such time, and the second expresses the present value of a payment *Z* received at the time of default τ weighted by the probability of default.

Following Duffie and Singleton (1999), we assume that $Z_\tau = \delta_\tau \cdot V(\tau, T)^-$

In other words, contingent upon default, investors receive a random payment Z_τ comprised of some fraction δ_τ of the pre-default value of the bond. Even though δ might depend on τ , or *r*, in what follows we make the simplifying assumption that *r(t)*, τ , and *Z* are all independent quantities.

Thus we have the final model,

$$V(t,T) = E^Q\left[e^{-\int_t^T [r(s)+\lambda(s)]ds} \mid F_t \right] + E^Q\left[\int_t^T \left(\delta_s V(s,T)\cdot\lambda(s)\cdot e^{-\int_t^s [r(u)+\lambda(u)]du} \right) ds \mid F_t \right]$$

which if worked out recursively renders the value of a zero coupon risky bond

$$V(t,T) = E^Q\left[e^{-\int_t^T [r(s)+\lambda(s)(1-\delta(s))]ds} \mid F_t \right]$$

Appling the valuation model we need to infer the unobservable hazard rates embedded in corporate bond prices. Backing out hazard rates from credit spreads involves a simple calibration exercise and as such we can rely on the following non-restrictive assumptions:

The term structure of risk-free discount factors $\left(B(t,T) = e^{-r(t,T)\cdot(T-t)}\right)$ is obtained from the calibration of the IRS curves employed the Nelson-Siegel (1987) methodology, whereby

$$r(t,T) = \left[\beta_0 + (\beta_1 + \beta_2)\frac{\beta_3}{T-t}\left(1 - e^{-\left(\frac{T-t}{\beta_3}\right)}\right) - \beta_2 \cdot e^{-\left(\frac{T-t}{\beta_3}\right)} \right]$$

We impose that $\lambda(t)$ is given by

$$E^{Q}\left(\lambda(s) \mid F_t\right) = \alpha, \qquad \alpha \geq 0, \forall\, s \in [t, T]$$

and we have that

$$S(T) = E^{Q}\left(e^{-\int_t^T \lambda(u)\cdot du} \mid F_t \right) = e^{-\alpha(T-t)}$$

$$f(t) = \frac{-dS(t)}{dt} = \alpha \cdot e^{-\alpha(T-t)}$$

In this setting, the mean under the conditional distribution of $\lambda(t)$ is driven by just one parameter. It corresponds to the density of the exponential distribution. By assuming a constant risk function, the resulting hazard rate (i.e. the instantaneous candicionaly default rate) model becomes independent of time. As noted above, correct specification for the hazard rate is crucial. It is as important in intensity models as the asset value process is in the context of structural models.

However, before beginning to model the hazard rate, we needed a method to obtain the implied hazard rate data first. We selected a simple function that fulfilled the minimum criteria required for risk functions.

$- \lambda(t)$ *is a non negative function*

$$- \int_0^{\infty} \lambda(t)dt = \infty$$

This is a simplistic identification of the hazard rate. Empirical data about default probabilities show a dependency between idiosyncratic and systematic factors and the hazard rate for the US market, but this specification allows to extract a “implicit hazard” for data prices and study the variables that affect it.

Finally, we will also assume that

$$E^{Q}\left(\delta(s) \mid F_t\right) = \beta, \qquad \beta \geq 0, \forall\, s \in [t, T]$$

Therefore, our final calibration model is

$$V(t,T) = \sum_{i=1}^{n} c(t,s_i) \cdot B(t,s_i) \cdot e^{-(1-\delta)\cdot(\alpha\cdot[t,T]} + B(t,T) \cdot e^{-(1-\delta)\cdot(\alpha\cdot[t,T]}$$

where $c(t, s_i)$ are the coupons paid at dates s_i , $i = 1 \ldots n$.

For pricing purposes, everything is known but δ, which will be fixed by the researcher and α, which takes account of the constant hazard rate in the model. This means that, when we perform calibration and use available prices, α may be computed for each price and the resulting value will be the implied hazard rate for that price.

1.4 Hazard rate calibration in the Spanish Market

1.4.1 The Spanish Covered Bonds market. The data

Spanish *Cédulas Hipotecarias* are the CBs issued in Spain with the backing of Spanish mortgages. The first issuance dates back as far as 1861. *Cédulas Territoriales* appeared for the first time in 2003. These are CBs where the base pool is comprised of loans granted to Spanish regions and entities dependent on regional administrations, and where the over-collateralization ratio is more restricted. In what follows, however, we concentrate on the *Cedulas Hipotecarias* rather than the *Cédulas territoriales*, the simple CBs being by far the more important of the two products in terms of market share. Some standard features of theirs are described below:

The mortgage base pool is comprised of loans with initial maturity of 20 to 30 years, most of them paying a floating rate of interest on a Euribor reference. Spanish CBs are regulated by the Spanish Mortgage Act of 1981, which was subsequently developed by a series of Royal Decrees up until 1991. Any credit institution operating under the regulation and supervision of the Bank of Spain may issue CBs. The over-collateralization threshold is set at 90%, which is the maximum amount of bonds an institution can issue against its mortgage portfolio. They may be issued at maturities different from the mortgage base, thereby inducing some interest rate risk that issuers have to manage. Should an issuer go bankrupt, such risk is transferred to the CBs investors, who are left exposed to reinvestment or price risk depending on whether the CBs mature later or earlier than the mortgage pool.

Foreign investment in Spain has not been taxed since 1999. This fact enabled Spanish CBs to compete on an equal terms with other countries' issues, which in turn saw a significant rise in CBs issuance and the appearance of the first Spanish jumbos, unheard of until that time. The new Bankruptcy Law, enacted in 2004, guarantees that interest and principal amortization payments are not interrupted or altered during the issuer liquidation process.

The main attractive for CBs issuers is that they are a relatively cheap source of financing and provide diversified and extended access to capital markets. Moreover, the time and effort required for a CBs issue to be arranged and sold on the market is significantly lower than with other products. On the other hand, the more favorable treatment of mortgages under the Basle II guidelines, including a reduction of risk weight factors for mortgages from 50% to 20%, for the mortgages eligible like collateral, will significantly reduce the appetite for issuing MBS. The main incentive for investors is that while CBs have significantly lower credit risk than the standard senior corporate bond by the same issuer, the yield is almost as high as the latter. Furthermore, market liquidity is usually higher for covered bonds than for the respective corporate bonds. Finally, coming now to the central point of our study, CBs most often receive the highest ratings from rating agencies, which, in terms of creditworthiness, puts them on a par with Government or Treasury bonds, while achieving much higher returns.

Our dataset spans the period 3/02/03-25/02/04, comprising daily observations of spreads under 17 different CBs (AIAF), issued by several Spanish financial institutions from 1999 to 2003. The main features of the CBs under study are summarized in Table 1. All CBs are bullet amortizing, pay a fixed coupon and have a minimum principal outstanding of euro 1000 million. Also available are IRS rates (Reuters) and a Generic Spanish Treasury Index GSP (Bloomberg), both spanning the period considered for the CBs.

1.4.2. Hazard rate calibration

We extract a daily hazard for each CBs by solving the folloging optimization problem:

Choose α_{sk} for any asset (k) and any date (i)

to minimize $[P_k(t_i,T) - VCB_k(t_i,T)]^2$ where

$$VCB_k(t_i,T) = \sum_{j=1}^{n} c(t_i,t_j) B(t_i,s_j) e^{-(1-\beta)\hat{\alpha}_{s,k}[T-t_i]} + B(t_i,T) e^{-(1-\beta)\hat{\alpha}_{s,k}[T-t_i]} \qquad E1$$

There is only one piece of time series data for each *cédula* and time node for which we want to back out the hazard rate information. This means that only this variable can be estimated and the recovery rate is exogenously input in the model, and its value is set to δ= 0.88, following studies from Moody's Investor Services. Although high, this figure seems reasonable in light of the creditworthiness of the issuers. Given the lack of historical default data, recovery rates are extremely difficult to extract within this framework. Therefore rating agencies assign the recovery through an "expert model" that studies the issuer, the collateral and the economic environment.

To study homogeneity of the results we performed two more types of calibration for the same model: First, keeping the time fixed, we obtain a daily hazard common to all the CBs for which we had prices available, i.e.

Choose α_s for any date (i) to minimize $\sum_k [P_k(t_i,T) - VCB_k(t_i,T)]^2$

where

$$VCB(t_i,T) = \sum_{j=1}^{n} c(t_i,s_j) \cdot B(t_i,s_j) \cdot e^{-(1-\beta)\cdot(\hat{\alpha}[s-t]} + B(t_i,T) \cdot e^{-(1-\beta)\cdot(\hat{\alpha}[T-t]} \qquad E1.1$$

Second, keeping the CBs fixed, for each CBs we obtain one hazard rate for the entire observation period, i.e.

Choose α_k for any asset (k) to minimize $\sum_i [P_k(t_i,T) - VCB_k(t_i,T)]^2$

where

$$VCB_k(t_i,T) = \sum_{j=1}^{n} c(t_i,s_j) \cdot B(t_i,s_j) \cdot e^{-(1-\beta)\cdot(\hat{\alpha}_k \cdot [s-t]} + B(t_i,T) \cdot e^{-(1-\beta)\cdot(\hat{\alpha}_k \cdot [T-t]} \qquad E1.2$$

Table 2 summarizes the results obtained with each method. E1, E1.1 and E1.2 obtain almost identical results, especially if we focus on the average hazard rate value, which is around 6 bp.. The mean squared root of the errors is also very similar in the last two methods, time and cross section, and set to approximately 1%. E1 provides the best optimization results, which is not surprising in view of the fact that it is almost like solving multiple systems of equations with only one equation and one unknown each.

Figure 3 presents results from the E1 calibration procedure. CBs hazard rates would seem to follow almost identical paths. The differences in levels do not appear to be explained by the time to maturity. We expect that the greater the time to maturity, the greater the upward shift of the path, however the initial visual inspection does not confirm this guess.

The figures provide a visual inspection of the results obtained. Figure 4 corresponds to the E1.1 model. Results are always positive and always within reasonable bounds. It is also interesting to note that values seem to revolve around the 6 bps mean. Figure 5 corresponds to the E1.2 Model. The graph attempts to capture a possible relationship between a Covered Bond’s mean during the process and its maturity. Such a relationship is by no means clear; on the contrary, CBs means cluster in the 6 bps area independently of time to maturity.

1.4.3. Analysis of Implicit Hazard Rate

The hazard rate data implicitly obtained from CBs yields reflect all the information contained in credit spreads once a proper discount factor has been used. The study of implicit hazard rates is an important tool in advancing a particular specification for the risk function or the recognition that additional risk factors—a liquidity risk factor, for instance—are needed to determine the movement of cédula credit spreads.

In recent years, a number of authors have proposed different specifications for the hazard rate in the context of corporate bond valuation and other credit risky instruments. Jarrow and Turnbull (1995) and (2000), Madan and Unal (1998 and 2000), Duffie and Singleton (1999), Dufee (1999 and Bakshi, Madan and Zhang (2001) are just a few examples of the interest aroused by the subject.

Nevertheless, most of the literature is purely theoretical and practical empirical tests are still lacking. Generally speaking, each case may be thought of as modeling a unique risk-adjusted discount factor. The risk-adjusted zero coupon bond would then be determined as

$$P^*(t,T) = E^Q\left(e^{-\int_t^Y R(u)du} \mid F_t \right)$$

where $R(t) = r(t) + \lambda(t)$ has a different specification depending on the particular setting proposed.

Duffee (1999) employs three stochastic factors: the short rate, a long rate, and some non-observable factors intended to capture that portion of the risk function not correlated with interest rates. Jarrow and Turnbull (2000) show the need for a variable, besides interest rates, that approximates to the economic cycle. They use a stock exchange index even though other macro measures such as real output would be better supported by theory, because data for these variables is usually only available at monthly or even lower frequencies. This makes it unsuitable in practice for valuation purposes, where daily or even intra-daily data is required.

Bakshi, Madan and Zhang (2001) also go for three factors in the estimation of different models, the short rate, a stochastic mean to which the short rate reverts, and a micro factor that reflects issuer characteristics. The models tested differ as to the type of micro factor used. The advantage of this type of modeling is that it nests the specifications of Jarrow and Turnbull (1995), Duffie and Singleton (1997), and Duffee (1999) as special cases. In their article they show how models that incorporate some micro factor, such as average or "book-to-market" ratio, do better in reducing out-of-sample errors. Nevertheless, error reduction gains are marginal with respect to the situation where only interest rates (a two-factor model) are employed. Moreover, the study of residuals in the extended models gives credence to the hypothesis that a fourth factor might be in order.

In short, the main questions to be asked are: what variables should be considered in modeling the loss function? How many of these factors are necessary? Which variables would make good candidates for these possibly unobserved factors?

To answer these questions, we analyzed the implied hazard rate data (IH) from the previous section in two ways. First, we identified the variables (asset/issuer characteristics and macroeconomics variables) that might help explain the data, and subsequently we tried to determine what and how many of those factors were needed.

In order to analyze possible dependency relationships between the hazard rate and the intrinsic variables pertaining to each of the issuers, as well as other macro variables, we performed a regression using panel data techniques. Issue-specific variables were issuance size (V), maturity

(M) and trading activity (F) - Trading activity was calculated as days in which at least one trade took effect over all possible potential trading days in the period covered.-. In addition we included a dummy to discriminate jumbo issues (J) -for the purposes of this study, a jumbo issue was considered when the amount issued was above at least 1500 mm- from smaller ones. The size distinction was drawn because bigger issues tend to attract the largest portion of trading activity on the market

To capture the influence of issuer specific characteristics, another dummy was set for every issuer: Banco Bilbao Vizcaya, Argentaria (BBVA), Caja Madrid(CM), La Caixa(C), CBs Hipotecarias Argentaria (CHA), Ahorro Corporación (AYT), Banesto (B) and Banco Santander Central Hispano (BSCH).

Finally, we used the IBEX as representative of the economic cycle, and a banking index as a representative measure of the evolution of the issuer's industry.

The relationship between the implicit hazard and the zero coupon curve was drawn using three variables: the 3-year GPS rate (GPS3), the difference between the 10-year GPS and the 3-year GPS rates (GPS10_03), and the difference between the 30-year GPS to 10-year GPS spread and the 3-year GPS and 2-year GPS spread (GPSLS). These variables were chosen because they are usually good measures of the level, slope and curvature of the zero coupon curve.

Two different estimation procedures were followed. One aimed at explaining the level, while the other was used in an attempt to explain the dynamics of the implicit hazard rates.

Given that dynamics for different *cédulas* were almost the same, we would expect differences in levels to be explained by issue and issuer specific characteristics, and so we employed these variables in the estimation.

$$
\begin{aligned}
IH_{ti,k} = {} & \gamma_1 \cdot V_k + \gamma_2 \cdot M_{ti,k} + \gamma_3 \cdot F_k + \gamma_4 \cdot J_k + \gamma_5 \cdot BBVA_k + \gamma_6 \cdot CM_k \\
& + \gamma_7 \cdot C_k + \gamma_8 \cdot CHA_k + \gamma_9 \cdot AYT_k + \gamma_{10} \cdot B_k + \gamma_{11} \cdot BSCH_k + \varepsilon_{ti,k}
\end{aligned}
$$

$$
i = days, \quad k = \text{cov}ered\ bonds, \quad n = maturity
$$

The results are shown in Table 3. All issue and issuer specific variables are significant except for size, but have a small explanatory power in terms of explain variance. Trading activity is significant but its sign, being positive, goes against our intuition that more trading activity means less liquidity risk, and therefore a smaller hazard rate.

Maturity appears to be significant and positive, in contrast with the visual inspection when we do not find a specific relationship. The negative relationship between default rate and maturity going in line with the "Maturity Theory" for the high corporate bonds. The issuer dummies are significant and positive which reflect a level of issuer-specific risk in line with credit ratings of the issuers. The jumbo dummy is significant and negative as expected, which together with the non-significance of the size variable could be taken to mean that only size buckets or thresholds are important while amounts within each size bucket are indistinguishable.

Having found the asset characteristics significant contrasts with the homogeneous rating assigned by the rating agencies which would imply one common level of hazard rates for the CBs and as a consequence, the non-significance of the asset characteristics. This result shows that the level of hazards rate must be modelled for each individual asset. Therefore a unique model for all the issues by the same issuer or rating class could be misguided.

All in all, it seems that issue and issuer-specific variables are relevant in explaining the spread between government bonds and *cédulas*. As previously explained, a second estimation was performed in an attempt to determine the dynamics of hazard rates.

$$IH_{ti,k} = \theta_1 \cdot \Delta IBEX_{ti,k} + \theta_2 \cdot \Delta GPS_{ti,k} + \theta_3 \cdot \Delta GPS1003_{ti,k}$$
$$+ \theta_4 \cdot \Delta GPSLS_{ti,k} + \theta_5 \cdot \Delta IBVA_k + \nu_{ti,k}$$
$$i = days, \quad k = \mathrm{cov}ered\ bonds, \quad n = maturity$$

For this purpose the variables (Hazard Rate, IBEX, GPS3, IBA, GPS1003, and GPSLS) are expressed in one-period differences. The results presented in Table 4.1 show the IBEX variable is significant, which somehow confirms the importance of the economic cycle in the determination of the risk function. However, the IBVA (banking index) variable is not. Interest rates are by far the most decisive factor in explaining hazard rate movement. The table 4.2 show the product of the parameters times the standard desviation of the variables relative to the stardadr desviation of the dependente variable. This product could give a indication of the weigh of the variables to explain de implicit hazard dynamics. The results show that the level of the term structure could be the principal variable to explain the dynamics, while the informative capacity of the market index is small.

The sign of the level and slope of the term structure and market index coefficients are positive against the empirical evidence in other markets. Longstaff and Schwartz (1995), Duffe (1998), Collin-Dufresne (2001) and others, found for the US bond market a negative relationship between the level and slope of the term structure and the credit spreads, explained by the fact that a higher spot rate increase the riskneutral drift of the firm value process, which reduces the probability of default, Van Landschoot (2004) found similar relationship in the European bond market. The slope, of the term structure, reflects the agents' expectations of the future short rate, and the relationship with default probability would be almost inverse.

A positive relationship could only be explained in a context where the firms had a big leverage, causing that when the spot rate rises, default probability of firms increases because the debt servicing cost is more expensive. Further research could be perform to test if this relationship holds for any kind of bonds in Spain between 2003 and 2004, to try to explain this positive relationship for the country or asset caracterisics.

The sign of the coefficients related to the market index, associated with the economic cycle, could only be explained by the particular historical data sample regarding the Spanish house market which was a period characterized by an excess supply of CBs in the market.

To verify that this unusual relationship is robust to colinearity problems (althougth the correlation between the variables is not too large) we regress the implicit hazard rate over each variable alone. The results in Table 4.3 are very similar except for the slope of the term structure, wich has negative sign. The change in this sign could be due because in the regression of table 4.1 the coeficiente of the slope could be influence by the curvature variable.

Although R-squared is not too high, the analysis indicates that some portion of the deviation of hazard rates with respect to their mean can be explained by such factors.

Out-sample analysis

Using the final specification for the dynamics of the implicit hazard rates, we tried to predict the implicit hazard rate value one month in advance. This prediction was carried out in two different ways. First, parameters were estimated using data up to the day on which the prediction occurred (dynamic forecast). In a second approach, prediction values were obtained without updating the parameters at each prediction date (static forecast) of the implicit hazard rate conditional to known the rest of dynamics variables.

We use as our benchmark values for the proyected hazard the previous day's hazard data, which is consintent with the initial assumption for the hazard rate). With regard to dynamic projection, the two models considered obtained similar results as measured by RMSE, although the Benchmark model estimated seems to yield slightly better predictions (0.003415 RMSE of the Benchmark model against 0.003457 RMSE of our model). If we take a look at the RMSE on a day-by-day basis, our model is comparatively more accurate than the benchmark 53% of the time. On a CBs basis, our model outperforms the benchmark for only 18% of the issues.

On the other hand, as regards static projection and always in terms of RMSE, our model clearly outperforms the Benchmark (0.003455 RMSE of our model against 0.010628 RMSE of the Benchmark). On a day-by-day basis, the RMSE is lower 80% of the time. Results show our model consistently beats the Benchmark as the projection horizon increases. On a CBs basis, our model leads to better projections for the whole CBs sample[2].

[2] we obtained similar results for monthly and weekly data

1.5 Concluding Remarks

Throughout this paper we achieved relevant conclusions about Spanish Covered Bonds market. Covered bonds are bonds collateralized by the issuer's entire pool of mortgage loans or public sector loans. Despite the European covered bond market's remarkable development in recent years, the academic literature continues to ignore this sort of asset. To our knowledge, nothing has been published on the analysis of these products or about the use of the Duffie and Singleton model to extract the implicit hazard and detect the relevant variables that explain its time behavior.

Given its characteristics, the credit risk embedded in CBs lies somewhere in between the credit risk of issuer's bonds and that of the government's. Although it ought to be more close to the latter, the spread between government and covered bonds is significant, and this fact is what we have attempted to explain through the intrinsic characteristics of this asset.

Credit-risk models appear to be the most natural way of valuing these instruments. In the context of reduced form models, the hazard specification is crucial, which is why we have devoted so much of our study to the problem of identifying the variables that explain hazard behavior.

First, covered bonds can be modeled in the same way as corporate bonds, the sole difference being that, owing to this asset's special characteristics, the researcher needs to fix the recovering rate higher.

Second, at least as regards the Spanish sample data, to use an exponential specification for the extraction of hazard rates would seem to be an adequate procedure. But results obtained from these implicit hazard rate data show that a constant hazard is an overly simplistic characterization of hazard rates as we find that the variables that represent the term structure and the economic cycle can help to explain their dynamics.

The empirical analysis brought to light evidence that issue-specific characteristics such as size, maturity and issuer are significant in explaining hazard rate levels, which contrasts with the homogenous ratings of the sample. With regard to the existence of a liquidity premium, the results we obtained were inconclusive.

While negotiation frequency appears not to be significant, the same cannot be said about issue size. The hazard rate does not, however, depend on the issuer in its time-varying dynamics.

Interest rates and the equity market seem to be major factors in explaining the hazard rate and CBs spread movements. The positive relationship between hazard rates and the level of the term structurea and the market index could only be explained by the specific characteristics of the spanish market, and could form part of future research to verify whether such characterization is exclusive of the CB market or else can be argued for the whole bond market in Spain.

Finally, in terms of prediction, the model improves on the use of the previous period hazard rate: results show our model consistently surpasses the benchmark as the projection horizon increases

So the present paper provides a guide to designing a valuation model for pricing covered bonds. This model should consider a dynamics for the hazard rate, possibly a mean reversion stochastic path, related to interest rate and stock market dynamics. Now we are in a position to build a more sophisticated model in which the hazard rate dynamics is modeled according to the explanatory variables we have found. This task clearly exceeds the scope of the present paper and will be the subject of future research.

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1.7. Appendix

Figure 1: Time evolution of the CBs' IRR

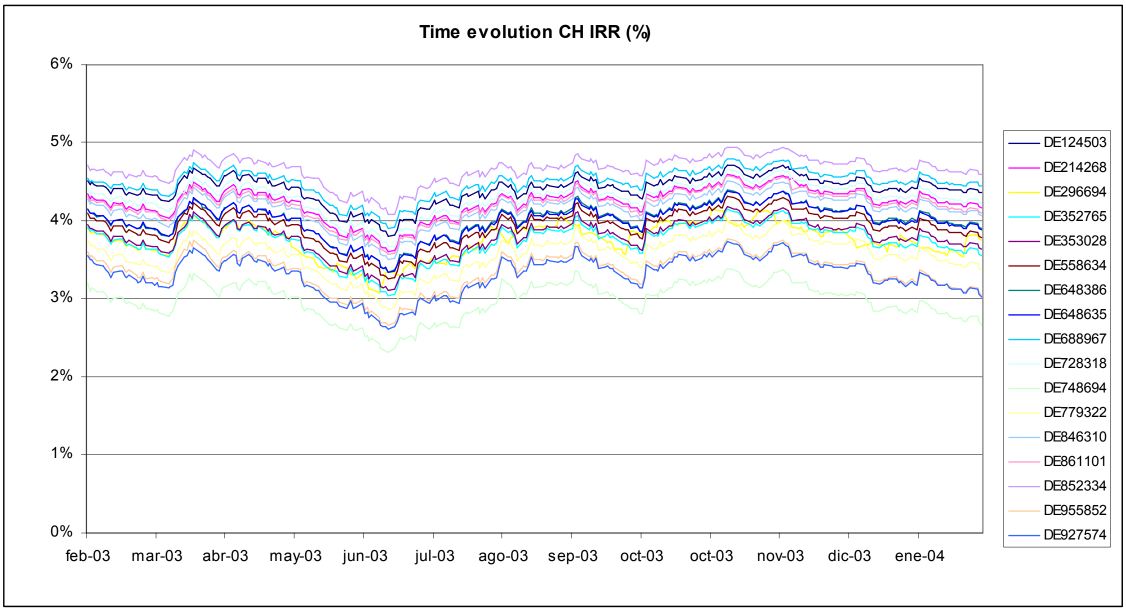

Figure 2: Time evolution of credit spreads between Covered bonds and GPS Index

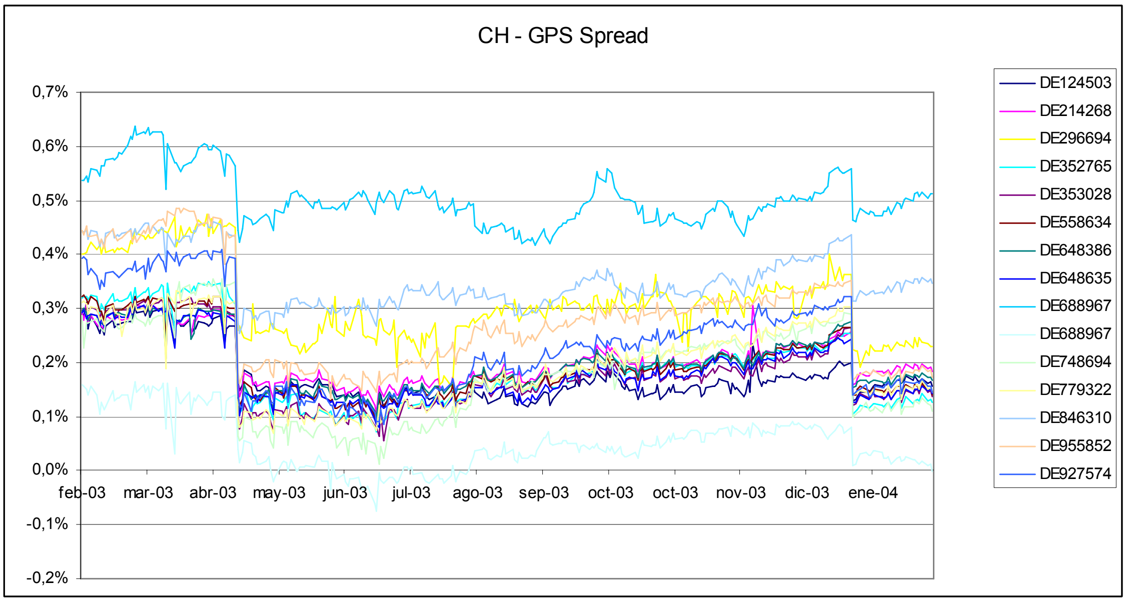

Figure 3: Hazard rate calibration E.1. "Implicit Hazard Rate"

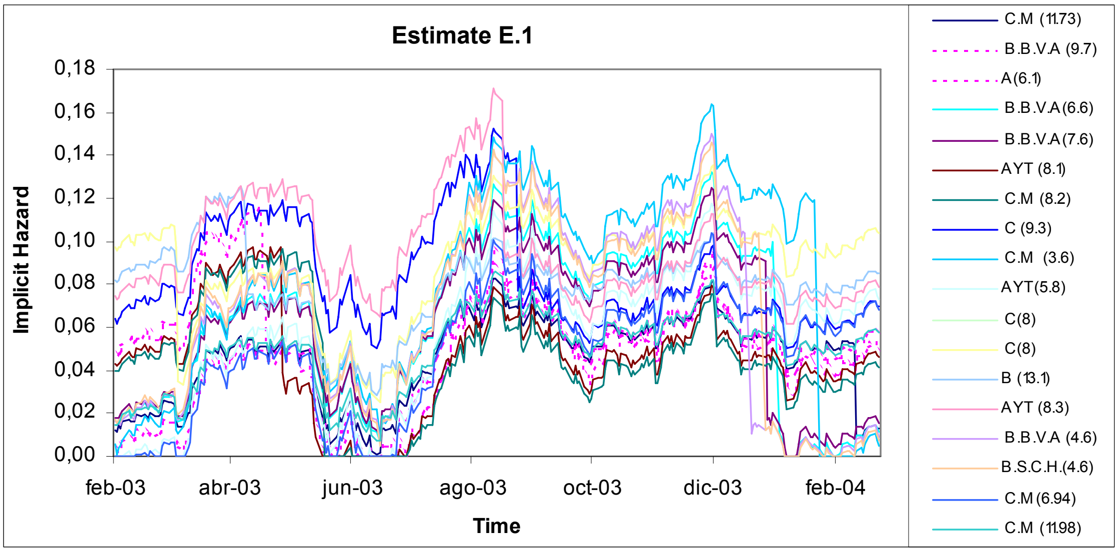

Figure 4: Hazard rate calibration E.1.1 (Time section)

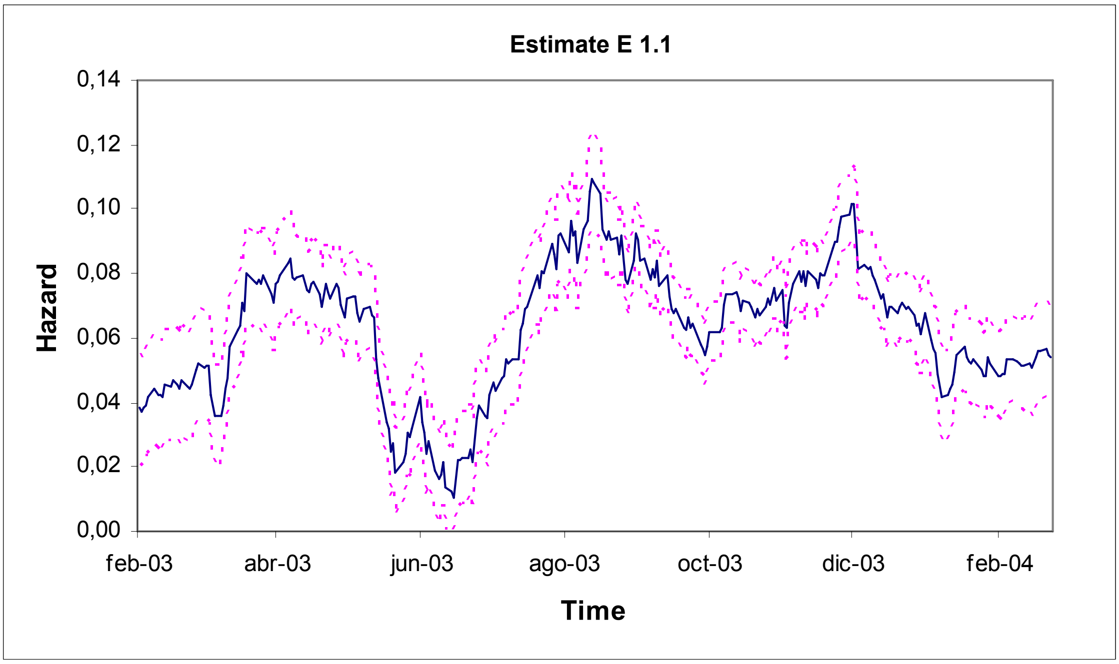

Figure 5: Hazard rate calibration E.1.2 (Cross section)

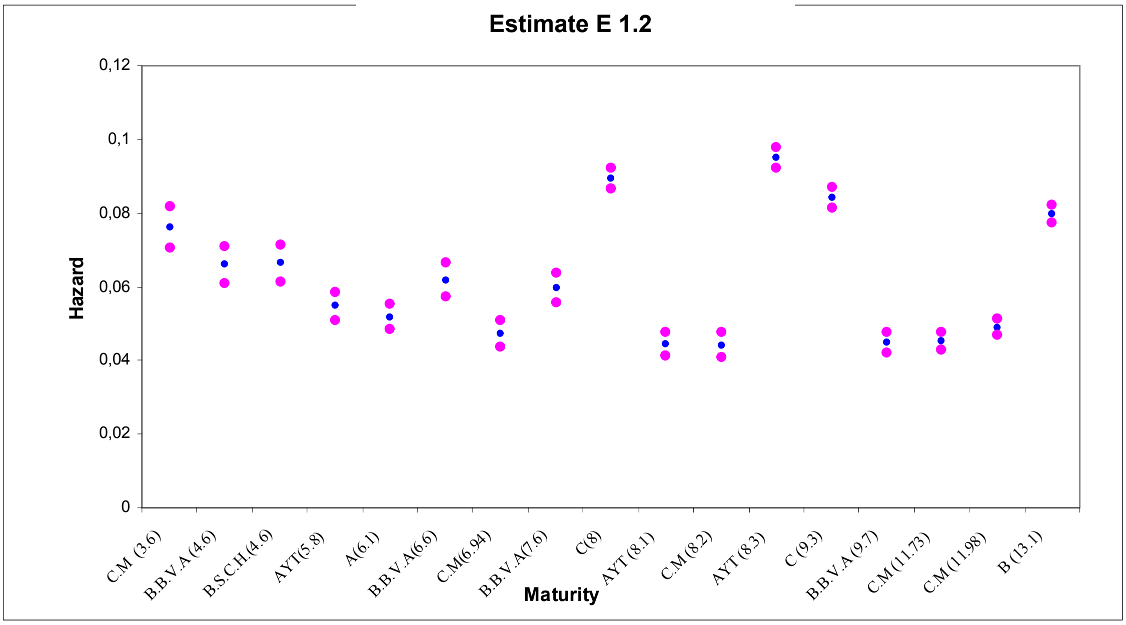

Table 1: SPANISH COVERED BOND

RIC NAME	ISSUER	COUPON	MATURITY	RATING	AGENCY	ISSUE DATE
DE748694	CM	4,25	2006	Aaa	MOO	2001
DE927574	BBVA	4,25	2007	Aaa	MOO	2002
DE955852	BSCH	4	2007	Aaa	MOO	2002
DE779322	BTNAYT	4,5	2008	Aaa	MOO	2001
DE296694	A	4,375	2009	Aaa	MOO	1999
DE352765	BBVA	5,5	2009	Aaa	MOO	1999
DE353028	CM	5,5	2010	Aaa	MOO	1999
DE558634	BBVA	5,75	2010	Aaa	MOO	1999
DE648386	LC	5,25	2011	Aaa	MOO	2001
DE648635	BTNAYT	5,25	2011	Aaa	MOO	2001
DE846310	CM	5,25	2012	Aaa	MOO	2002
DE861101	BTNAYT	5,25	2012	Aaa	MOO	2002
DE214268	C	4,5	2012	Aaa	MOO	2002
DE728318	BBVA	4,25	2013	Aaa	MOO	2002
DE124503	CM	5	2014	Aaa	MOO	2003
DE688967	CM	5,75	2016	Aaa	MOO	2001
DE852334	B	5,75	2017	Aaa	MOO	2002

Table 2: Calibration of "Hazard Rate"			
Model	**E1.1**	**E1.2**	**E1**
λ mean	0.0629	0.0625	0.0632
λ min	0.0107	0.0442	0.0010
λ max	0.1091	0.0950	0.1708
λ median	0.0671	0.0598	0.0671
RMSE	1.0741	1.0828	1.4201e-007

Table 3: Estimation of the Implied Hazard			
Variable	**Coefficient**	**Std.E**	**T-statistic**
Volume	2.14E-12	1.42E-12	1.508802
Time to maturity	–0.0029*	0.0002	-12.1848
Trading frecuency	0.0003*	0.0001	2.9837
JUMBO	–0.0041*	0.0014	-2.7539
BBVA	0.0698*	0.0698	26.0191
CM	0.0721*	0.0024	29.5267
C	0.1016*	0.0029	34.3633
CHA	0.0680*	0.0027	24.7571
AYT	0.0810*	0.0035	22.7637
B	0.1161*	0.0039	29.6309
BSCH	0.0741*	0.0041	18.0787
R^2(A): 0.1342	**Durbin-Watson:** 0.0364	**SER:** 0.0323	**SSR:** 4.9255

* shows significant variables of 5% of significant level

Table 4.1: Estimation 2 of the Implicit Hazard (ΔH)

Variable	Coefficient	Std. E	T-statistic
DIBEX	8.36E-06	1.19E-06	7.029
DGPS03	0.0385	0.0017	21.8660
DGPS1003	0.0192	0.0032	5.9491
DGPSLS	-0.0192	0.0033	-5.7934
IBA	1.34E-05	2.22E-05	0.602
R2(A): 0.1752	**Durbin-Watson:** 2.048	**SER**: 0.0056	**SRR:**0.1477

Table 4.2. % over std (ΔH)

	Coefficient	Std.E	Product	% over std (ΔH)
DH		6.168E-03		
DIBEX	8.390E-06	7.440E+00	6.242E-05	**1.012%**
DGPS03	3.849E-02	5.423E-02	2.087E-03	**33.838%**
DGPS1003	1.930E-02	3.156E-02	6.091E-04	**9.874%**
DGPSLS	-1.930E-02	3.282E-02	-6.333E-04	**-10.267%**

Table 4.3: Individual estimation of Table 4. Implicit Hazard (ΔH)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**
DIBEX	2,03E-05	1,17E-06	1,74E+01
R^2 (A)	5,70E-02	S.D.D.V.	6,17E-03
S.E.R.	5,99E-03	S.S.R.	1,68E-01
Variable	**Coefficient**	**Std, Error**	**t-Statistic**
DGPS03	4,53E-02	1,52E-03	2,97E+01
R^2 (A)	1,56E-01	**S.D.D.V.**	6,17E-03
S.E.R.	5,67E-03	**S.S.R.**	1,51E-01
Variable	**Coefficient**	**Std, Error**	**t-Statistic**
DGPS1003	-1,02E-02	2,85E-03	-3,59E+00
R^2 (A)	6,45E-06	**S.D.D.V.**	6,17E-03
S.E.R.	6,17E-03	**S.S.R.**	1,79E-01
Variable	**Coefficient**	**Std, Error**	**t-Statistic**
DGPSLS	-3,82E-02	2,69E-03	-1,42E+01
R^2 (A)	3,81E-02	**S.D.D.V.**	6,17E-03
S.E.R.	6,05E-03	**S.S.R.**	1,72E-01

Table 5: Forescast

	Average Dinamic Forescast Implicit Hazard	Average Dinamic Forescast Benchmark	Average Estatic Forescast Implicit Hazard	Average Estatic Forescast Benchmark
05-02-04	0,000657	0,000558	0,000657	0,000558
06-02-04	0,004890	0,003956	0,004887	0,004175
09-02-04	0,000260	0,000314	0,000255	0,004411
10-02-04	0,000932	0,000490	0,000960	0,004093
11-02-04	0,001003	0,001252	0,001025	0,003054
12-02-04	0,000792	0,000932	0,000822	0,002243
13-02-04	0,011659	0,011395	0,011657	0,012102
16-02-04	0,000953	0,000824	0,000921	0,012450
17-02-04	0,000763	0,001550	0,000795	0,011722
18-02-04	0,003407	0,003148	0,003378	0,013124
19-02-04	0,000955	0,002426	0,000924	0,014599
20-02-04	0,000558	0,000521	0,000550	0,014640
23-02-04	0,000524	0,000821	0,000497	0,015180
24-02-04	0,000971	0,002081	0,000952	0,013784
25-02-04	0,000964	0,001485	0,000996	0,012921

Table 6: Mean Square Error

	MSE Dinamic Forescast Implicit Hazard	MSE Dinamic Forescast Benchmark	MSE Estatic Forescast Implicit Hazard	MSE Estatic Forescast Benchmark Model
CM 2014	0,010815	0,011018	0,010821	0,029436
C 2012	0,002251	0,002048	0,002248	0,007887
CHA 2009	0,002690	0,002645	0,002685	0,009274
B.B.V.A 2009	0,002559	0,002386	0,002552	0,009333
B.B.V.A 2010	0,002342	0,002100	0,002336	0,008464
C 2011	0,002334	0,002135	0,002327	0,008478
AYT 2011	0,002429	0,002198	0,002422	0,008635
CM 2016	0,001971	0,001820	0,001962	0,007433
CM 2006	0,001679	0,001891	0,001676	0,005236
AYT 2008	0,002510	0,002510	0,002511	0,009617
CM 2012	0,002224	0,002046	0,002218	0,008012
B 2017	0,001961	0,001642	0,001953	0,006368
AYT 2012	0,002217	0,001993	0,002211	0,007567
B.B.V.A 2007	0,002696	0,002672	0,002693	0,008794
B.S.C.H 2007	0,002400	0,002406	0,002398	0,007042
B.B.V.A 2010	0,002429	0,002360	0,002428	0,009205
B.B.V.A 2013	0,002218	0,001909	0,002215	0,007175
ECM	**0,003457**	**0,003415**	**0,003455**	**0,010628**

2. An Analysis of the European Covered Bond Market

Abstract

This paper presents an empirical analysis of the European Covered Bonds Market. Covered Bonds are one of the most prominent components of the European capital market in terms of outstanding balance and issuance. We analyze the dynamic relationships between the covered bond average yield spreads of Germany, France and Spain.

Our results indicate that an adequate valuation model should include variables representing the economic cycle and interest rates alongside the interrelations among countries. These results are arrived at independently of considering the variables as stationary or nonstatinary. We propose and test a reduced-form model for this kind of assets to account for the presence of Credit Risk.

2.1. Introduction

A Covered Bond is a corporate bond issued by a financial institution and collateralized by a pool of loans within the issuing institution's balance sheet, usually comprised of mortgages or loans to the public sector.

Covered Bonds first appeared in Prusia more than two hundred years ago under the name of "Pfandbrief". Since then the market has experienced both great growth and geographical expansion across Europe, where CBs have been established as one of the main sources of financing for banks in the area.

Although very similar in nature, the European CBs market are far from being homogeneous. Different types of CBs coexist, reflecting the varied nature of the legal frameworks underlying CBs across the different national jurisdictions within Europe.

Nevertheless, that collateral has to be greater than or equal to the amount of bonds issued. Usually, a legal threshold is established so that the aggregate nominal value of all CBs issued against the base pool does not exceed 90%. If, at any time, the volume of bonds exceeds the threshold, the issuer must act so that the situation is reverted by adding more loans to the base pool, buying back bonds, or both. Supervision authorities control the composition of the base pool on an ongoing basis, and verify the fulfillment of the threshold or over-collateralisation requirement. CBs investors have "super-preferential" rights in the event of bankruptcy of the issuer. This means that in the event of bankruptcy, investors are assigned preferential rights on the liquidation proceeds of the entire base pool.

CBs are one of the most important components of the European capital market in terms of outstanding balance and issuance volumes (Table 1). Outstanding balance as of the end of 2003 reached Euro 1.82 Trillion[3], 1.62 Trillion in 2004 and 1.78 in 2005 (more than 20% of total European

[3] One trillon is equal to 10^9

bond market). Although less prominently than issuance, trading in these instruments has increased considerably in recent years, with the arrival of new issuer countries such as Italy, The Netherlands, Finland and Lithuania in 2005 (Figures 2 and 3). Despite the rise in the importance of Covered Bonds markets, these assets have not received a similar attention by the specialized financial press or the academic literature, even though covered bonds have recently become an interesting topic of the financial market, with the creation of the European Bond Council.

It is not unusual that the concepts of CBs financing and mortgage based securitization are mixed up. Both instruments rely on the same underlying securities (ie. mortgages) and provide some kind of asset based financing. Nevertheless, while the issuer retains and assumes the risk of the underlying in a CBs transaction, in a securitisation transaction, a substantial -if not all- portion of the risk assets is transferred to the investor.

The main attractive for issuers is that it constitutes a relatively cheap source of financing and provides a diversified and extended access to capital markets. Under the more favourable treatment of elegible mortgages to Covered Bond Pool under the Basel II guidelines, with a reduction of risk weight factors for mortgages from 50% to 20%, the banks have fewer incentives to issuing MBS. For the invertors' point of view, the same issuer CBs have significantly lower credit risk than the standard senior corporate bond by the same issuer, but the yield is almost as high as the latter. Moreover, also market liquidity is usually also higher for covered bonds than for the corresponding corporate bonds.

Therefore, the study of what characteristics are driving CBs market prices is a relevant area of research in the financial literature. This paper performs an empirical analysis with the main objective of selecting an adequate pricing formula that incorporates the variables that significantly explain the observed market prices. Section 2.2 explains the main characteristics of European CB market, in particular the three market have been considered; German, French and Spanish market. Section 2.3 analyzes the dynamics of the CB market in the European Franwork. In section 2.4 we propose the pricing formula as an adaptation to the Jarrow model (2001), which we estimate in section 2.5 under different specifications and back-testing in section 2.6. The last section concludes presents the concluding remarks.

2.2. European Covered Bond Market and Data Description

2.2.1 The German market

Covered Bonds are known in Germany as *Pfandbriefe*. They were first issued more than two hundred years ago and since then there have been many changes in their regulation. 2005 *Pfandbriefe* regulation was established that issuers are no longer required to have specialized bank status in order to issue *Pfandbriefe*. Now, any lender with a special licence is allowed to take part in this market to obtain such license banks have to fullfill some minimum requirements: A core capital of at least 25 mill. €, general banking license, suitable risk management procedures and instruments, business plan as well as necessary organizational structure.

It is worth mentioning that in spite of the recently legal changes introduce some longer standing distinctive features remaind of *Pfandbriefe*. The issuer holds the cover assets on its balance sheet. It is not possible to transfer the cover assets to another legal entity. In the case of insolvency, the cover pool is segregated by law from the general insolvency estate and is reserved for the claims of the *Pfandbriefe holders*.

The cover pool is comprised of mortgage loans, public sector lending and ship financing activities (*HypothekenPfandbriefe, Öffentliche Pfandbriefe* and SchiffsPfandbriefe). Transparency requirements for issuing are regulated in "28 PfandBG". Up to 10% of the nominal volume of the CBs outstanding may consist of money market claims against the European Central Bank, central banks in the European Union or other suitable credit institutions. The geographical scope of eligible mortgage assets is restricted to EU/EEA countries, Switzerland, USA, Canada and Japan. A cover pool monitor (*Treuhäde*r) supervises the cover pool.

The "*4 PfandBG*" stipulates that the total volume of covered bonds outstanding must be covered constantly assets of at least the same amount and with the same interest income. The new *Pfandbrief Act* requires that the issuer has to provide an over collateralisation of at least 2% after stress tests considering to be carried out weekly.

2.2.2. The French market

The name for CBs in France is *Obligations foncières*, which are issued by *sociétés de crédit foncier*, specialized credit institutions with a single purpose; to grant or acquire eligible assets, as defined by law and to finance theses assets by issuing covered bonds, which benefit from a legal privilege. In addition they may also issue other types of debt instruments which do not benefit from this legal privilege. *Sociétés de crédit foncier* operate under the French banking regulator supervision and are subject to special rules in addition to standard banking regulation.

Eligible assets for the cover pool are: loans guaranteed by first-ranking mortgages, loans granted to finance real state development that benefit from the guarantee of a credit institution or an insurance company, claims on public sector entities, and senior tranches of securitisation funds or equivalent entities whose assets are composed of, at least 90%, of these types of loans and claims. The geographical area of eligible mortgage assets is the European Economic Area, the French Republic's Overseas Territories, Switzerland, United States, Canada and Japan.

Holders of CBs have preferred creditor status and the right to be paid prior to other creditors. The liquidation of a *Société de Crédit Foncier* does not accelerate the reimbursement of covered bonds, in fact, the CBs continue to be paid at their contractual due dates prior to all other commitments. The French legislation stipulates that the total value of the assets must be greater than the total amount of liabilities benefiting from the privilege, a condition that makes for a coverage ratio always greater than 100%. The cover pool is monitored by a "Specific Controller" whose mission is to verify that the company complies with the law and regulations.

2.2.3. The Spanish market

Spanish "*Cédulas Hipotecarias*" are the CBs issued in Spain with the backing of Spanish mortgages. The first issuance dates back as far as 1861. In 2003, "*Cédulas Territoriales*" were born. These are CBs were the base pool is comprised of loans granted to Spanish regions and entities dependent on regional administrations, and where the over-collateralisation ration is more restricted. In what follows we will however concentrate not in the "*Cédulas Territoriales*", but only in the simple CBs, by far the more important of the two products in terms of market share. Following are some of the most typical and standard features:

The cover pool is comprised of loans with an initial maturity of 20 to 30 years, most of them paying a floating rate of interest on a Euribor reference. CBs are regulated by the Spanish Mortgage Act of 1981, which was subsequently developed by a series of Royal Decrees up until 1991. Any credit institution operating under the regulation and supervision of the Bank of Spain may issue CBs. The over-collateralisation threshold is set at 90%, which is the maximum amount of CBs an institution can issue against its mortgage portfolio. They may be issued at different maturities than the mortgage base, thereby inducing some interest rate risk which issuers have to manage. If an issuer should go bankrupt such risk is transferred to the CBs investors, which are left exposed to reinvestment or price risk depending on whether the CBs mature later or earlier than the mortgage pool.

Since 1999 foreign investment into Spain is no longer taxed. This fact enabled Spanish CBs to compete on an equal footing against other countries issues, which in turn saw a significant rise in CBs issuance and the appearance of the first Spanish jumbos which had until then been unheard of. 2004 Bankruptcy Law, guarantees that interest and principal amortization payments are not interrupted or altered during the liquidation process of the issuer.

The two principal differences exist between the Spanish legislation and the Germany. First, in Spain all of the mortgages of the balance of the issuer would be acting as collateral in case of default, not only the pool of eligible assets. And second, the legislation does not forces the existence of an independent administration for the pool in case of default until 2008.

Regulatory framework for CB across Europe has evolved significaltly particularly due to the appearance of issuers' countries , but for our study we are interesting in the framework established until 2004.

2.2.4. Data Description

We use daily price observations of 56 CBs from Germany (30 Pfandbriefe), France (9 Obligations Foncières) and Spain (17 Cédulas Hipotecarias) during 1 year (2003-2004). All CBs used have similar characteristics (Tables 2,3, 4 and 5); fixed annual coupon (between 3,5 and 5,5), maturity between 3 and 15 years, and very good rating. We use data from these countries because they are some of the most important components of the European covered market (data from Danish CBs was desirable too, but was impossible to obtain for this work).

As we can see in Figure 3, the average of the yields spreads between CBs and risk-free interest ratesfor different maturities[4] is always positive for the Spanish CBs , and some times for French and German CBs. However for these this kind of assets, which bear minimal credit risk,, we could expect a zero or even a negative spread. This is because the IRS curves reflect counterparty credit risk in the interbank market, and are therefore not risk free entairely.

As with any other asset it is interesting from an academic point of view to findvariables that influence prices. Since Germany is the biggest and oldest market in Europe, we would also expect to find some influence

[4] we explain the construction of the spreads in the next section

from the German market on other European markets. We can see in Figure 3 that the three countries considered could follow a similar pattern albeit with different lags and appears that the German market moves before the other.

This leadership of the German market in the CBs market is opposite to the last tendency in the European Treasury Bonds market, when before 1999 Germany treasury bonds appear to drive the euro government bonds market, but since 2003 the risk and liquidity premia in the government bonds spreads (versus Germany) start to disappear, specially for the triple-A bonds (European Central Bank 2007), Nevertheless, in the corporate bonds market it is not possible to appreciate a German market leadership, the evolution until 2007 showinga generaldecrease in the levels of spreads.

2.3. Empirical Analysis of the Spreads

We built a synthetic CBs index for the three markets fromCBs data. The common representation of the credit spread structure gives a curve for every rating and every maturity. As the level of credit spread differs across rating and maturity usually we would expect that bonds with lower rating to have greater spread. Eventhough this relationship does not hold consistently over time in corporate bonds we would expect that bonds with longer maturities have greater spread than shorter ones, although this relationship does not hold consistently over time either in corporate bonds.

Covered bonds within the sample have a similar rating but they do not show a special relationship between credit spread and maturity (maturities falls between four and ten years). This may be due to data scarcity or due to differences in the liquidity. However in the spreads between the German benchmark curves of covered bonds and IRS curves we can appreciate that, prior to 2005, there are differences between the level of credit spreads for different maturities even though allcurves follow the same dynamics. Since 2005 differences between the curves for 1 year to 10 year to maturity narrow and the curves for different maturities become entangled, in both cases the average curve being to be a good representation of the market, as the maturity apper to have influence only in the levels.

In essence, we are interested on characterizing macroeconomic variables that might affect the three markets, and measuring their effects on each one. For this purpose, the particular characteristics of the issuer would be irrelevant, and sinceassets are enough homogeneous in terms of rating, we could aggregate the information in the panel. The characteristics of the CBs market allowfor building just one index for each market as the average of credit spreads of covered bonds for different maturities. That way, we can explore what variables could explain the dynamics of the CBs market, without missing to much information aboutspecific country behavior.

As usual, we have built the spread as the difference between the yield of the covered bond and the yield obteined from the comparable time to maturity risk-free bond, discounted with the estimating interest rate structure from IRS curves, for any day and for any asset. Then, we have aggregated the information by constructing for each observed day, an average yield spread for each of the three countries.

To proceed with the study of the dynamics of spreads and propose a VAR specification (Engel and Granger, 1987), it is important to detect whether the variables are stationary or not. If the variables have a unit root, we can use the Johansen ´s methodology (1991) to look for cointegration relationships among countries. We apply the Augmented Dickey-Fuller (Dickey and Fuller 1979) unit root test to our series. The lag length is chosen to minimize the residual correlation. Moreover, no trend has been considered necessary. Table 6 presents test statistics and critical values. Results for all countries indicate that spreads index are integrated of order one, I(1).

However, it could be the case that spreads have time-varying movements but they have not the explosive beheviour of a unit-root process. In this case the variables are locally stationary (Dahlhaus 2000, Orbe et all 2004) and the standard VAR methodology applies. Since the usual unit root test are not designed to distinguish between unit-root and locally stacionary proceses, we will use both type of approaches.

If we accept that the spreads contain a unit root, the next step in VAR methodology is to test for the presence of a common stochastic trend. A set of I(1) series are said to be cointegrated if there is a linear combination of these series that is stationary. We use Johansen's methodology to investigate for possible cointegration relationships among the spreads**.** Table 7 reports the results for the Jonhansen likelihood ratio test of cointegration. The null hypothesis of non-cointegration is rejected and the cointegration rank is seen to be equal to one at the 5% significance level. This suggests that there is a single long-term relationship between the average spread of Germany, France and Spain. The cointegration vector it show at the top of Table 8, it have been normalized to have a unit coefficient on on Germany's spread (GE). In the long-term stable relationships, the German average spread is negatively correlated with the French (FR) and the Spanish spread (SP), but the Spanish spread does not seem to be statistically significant.

The Granger representation theorem states that a VAR model on differences of I(1) variables will be misspecified if the variables are cointegrated, unless we include lagged disequilibrium terms, this is known as the error correction model (ECM).

The estimation results for ECM are presented in Table 8. Our estimations indicate that some lags of Germany are statistically significant for all countries. The Adjusted R^2 indicates that this model explains more than 40% of the dynamics of Germany and France and only a 10% of Spain dynamics.

Some authors have indicated the need to lag introducing variables that represent the economic cycle such as interest rates to study the time evolution of bond spreads (Delianedis and Geske 2001). To that end, now we include some exogenous variables in the ECM. We use the Eurostoxx 50 (ESTX) as a representative of the economic cycle in Europe, which has the advantage over other possible proxies in the availablility at daily frecuency of data.

We use the 6 years swap rate (IRS06) , to measure the level of the interest rates term structure, and the difference between the spreads of 10 year to 3 year swap rates (IRS10_03) as a measure of term structure slope.

Table 9.1 summarizes the main results for the ECM, once these exogenous variables have been added, with some changes relative to the previous estimation. For Germany are statistically significant her lags, some of the French and Spanish lags, and the error correction term (Z).

For France are statistically significant the Germany and Spanish lags, the interest rates (level and slope) and the error correction term (Z). And for Spain are statistically significant the lag of Germany, the lag of Spain, the market index and the interest rates (level and slope).

The signs of estimated coefficients of the macroeconomics variables are as expected. The relationship between credit spreds and the level of term estructure is negative. For the market index we obtain equivalent results. In the literature we can find a large amount of evidence about this relationship, lower interest rates are usually associated with a weakening economy, and some autors as Longstaff and Schwartz (1995) and Duffe (1999) explain this negative relationship arguing that an increase in interest rates reduce the probability of default due to an accompanying increase the expected growth rate of the firm's asset value.

The negative sign of estimated parameter associated with the market index for Spain agrees with the interpretation of the economic theory since the index capturing the state of economic cycle. Thus, in a favorable environment we would expect lower default probabilities and vice versa. Kwan (1996) and Collin and Dufrene (2001) show the same relationship obtains in the US market, and Van Landschoot (2004) reports the same for the European bond market.

The negative sign of estimated parameters on the lags of the German credit spread index suggest that the gap between the German spread and the rest of the countries minght decrease when credit conditions worse in the German market.

Adjusted R^2 are 0.63 in the Germany equation, 0.48 in the equation for France and 0.11 in the one for Spain, indicating that this model we can explain a good deal of the dynamic of the variables in differences.

We find remarkable the fact that IRS06, as a proxy of the level of interest rates, is statistically significant for France and Germany, with Eurostoxx 50 being significant for Spain, and specially the statistical significance of past German spreads for all the countries. This migth indicate the direction of causality in the sense of Granger with the German market leading the French and Spanish Covered Bond markets. As expected the German market seems to be the leader, possibly may be due to be the first CB market developed in Europe and the most liquid one. The relevance of the interest rate and stock market variables in our analysis has also been previously documented in empirical studies for the American bond market.

As mentioned, it could be the case that the variables are locally stationary and, in which case, the ECM would not be appropriate. For this reason, we have repeated the analysis using the classical VAR methodology. The Results in Table 9.2 are very similar and lead to the aforementioned conclusions, confirming the evidence of the importance of incorporating the dynamics in the German market, the Eurostoxx 50 index, and the interest rate variables in a valuation model.

2.4 The valuation model

CBs rely on an indefinite pool of mortgages acting as collateral for the benefit of the investor in case the issuer bond defaults. Even though the probability of CBs defaulting is linked to the issuer's own probability of default. CBs, will generally, survive the issuer's default event, as investors gain access to the collateral pool. How the access to the collateral is gained differs among countries according to their particular regulations and legal system.

If default is followed by the issuer declaration of bankruptcy, it could be argue, that the liquidation of the mortgage pool would probably result in some costs to be borne by investors, thereby reducing the amount of effective collateral, especially in a situation of systemic distress of the financial system where there are no buyers for the collateral. The actual recovery obtained in a situation of systematic default would depend in general on the loss of dynamic characteristic of the collateral pool, the early liquidation of the mortgage portfolio, derived of the occurred of a credit event, could be expose to the interest risk, credit and prepayment risk of the pool assets, etc.

In a sense, CBs are corporate bonds and their credit risk is linked to that of the issuer's, we will now introduce this ingredient in our valuation model. The two main approaches in the literature about credit risk are the Structural and the Reduced-form models. Structural models first appeared with the seminal work by Merton (1974), which has been subsequently expanded and adapted in several manners to better match the term structure of spreads observed empirically, [Black and Cox (1976), Geske (1977), Nielsen et al. (1993), Leland and Toft (1996), and Longstaff and Schwarz (1995)]. This approach is difficult to implement, as it relies on the value of assets of the bond issuer, which are infrequently observable, and the subordination structure of its liabilities, which is often complex. In structural models, default occurs when the asset value falls below the value of liabilities. Therefore, the key is the correct modelling of the process for the assets values.

On the other hand, reduced-form models, like Jarrow and Turnbull (1995), ignore the mechanism that makes a company default. It suffices to consider that the time of occurrence of the event of default is a random variable, subject to stochastic modelization. Following this approach our next objective is to adequately model the hazard rate movements.

In recent years, there have been several authors proposing different specifications for the hazard rate in the context of corporate bond valuation and other credit related instruments. [Jarrow and Turnbull (1995) and (2000), Madan and Unal (1998 and 2000), Duffie and Singleton (1999), Dufee (1999), and Bakshi, Madan and Zhang (2001)]

Nevertheless, most of the literature is purely theoretical and there is still a sensible lack of empirical tests. Duffee (1999) employs three stochastic factors: the short interest rate, a long rate, and some non observable factor intending to capture that share of risk not correlated with interest rates. Jarrow and Turnbull (2000) shows the need for a variable that approximates the economic cycle (additional to interest rates). They use a stock exchange index, even though other macro measures such as real output would be better supported by theory. For valuation purposes, daily or even intra daily data are required and therefore these macro measures are not suitable. Janosi, Jarrow and Yildirim (2002) implemented Jarrow-Turbull model incorporating liquidity risk.

Bakshi, Madan and Zhang (2001) consider three factors in the estimation of different models. One is the short rate, the second is a stochastic mean to which the short rate reverts, and the third one is a microeconomic factor that reflects issuer characteristics,of which they tried different variatons of such micro factors. The advantage of this type of modelling is that it nests as special cases the specifications of Jarrow and Turnbull (1995), Duffie and Singleton (1997), and Dufee (1999). They shown how models that incorporate some micro factor such as leverage "book-to-market" ratio reduce out-of-sample errors. Nevertheless, error reductions are marginal with respect to the situation where only interest rates (in a two factor model) are employed. Moreover, the study of residuals in the extended models suggests that a fourth factor might be in order.

We contribute with an adaptation of the Jarrow 2001 model for CBs market using the results in the previous section on spread analysis. We model the hazard rate, or more precisely, the expected loss function as being dependent on interest rates, the stock market, past information of the German market, and past realizations of itself.

Hazard Rate Model

Let τ be the time of default of some corporation bond issued maturing at some time T. Clearly, if $\tau \leq T$ the company defaults on the bond, and investors are subject to sustain some loss, while if $\tau \geq T$ the company has not defaulted by the time the bond matures, and investors receive full payment.

The hazard rate $\lambda(t)$ refers to the probability of defaulting in some interval $(t,t+dt)$ conditional to having survived until t.

$$\lambda(t) = \Pr\left(t \leq \tau \leq t + dt \mid \tau > t\right)$$

The probability of surviving $S(T)$ can be writen then

$$S(T) = e^{\int_t^T \lambda(u)du} \text{ with density function } f(t) = \lambda(t) \cdot e^{-\int_t^T \lambda(u)du}$$

The price at time t of a zero-coupon riskless bond maturing at T is known to be given by

$$B(t,T) = E^Q\left(e^{-\int_t^T r(u)du} \mid F_t\right)$$

where $r(t)$ is the risk-free short rate, Q is the martingale probability, and

F(t) is the amount of information available for investors at time *t.*

In contrast, the value of a risky bond is

$$V(t,T)=E^{Q}\left[S(T)\cdot e^{-\int_{t}^{T}r(u)du}\mid F_{t}\right]+E^{Q}\left[F(T)\cdot Z_{\tau}\cdot e^{-\int_{t}^{\tau}r(u)du}\mid F_{t}\right]$$

where the first summand indicates the present value of a unitary payment at T weighted by the probability that the bond survives until such time, and the second expresses the present value of a payment Z received at the time of default τ, weighted by the probability of default.

Following Duffie and Singleton (1999) we assume that

$$Z_{\tau}=\delta(\tau)\cdot V(\tau,T)^{-}$$

In other words, contingent upon default, investors receive a random payment made up some fraction δ_{τ} of the pre-default value of the bond.

As usual in this kind of models, we simplify by assuming that *r(t)*, τ, and Z are all independent from each other.

Thus we have,

$$V(t,T)=E^{Q}\left[e^{-\int_{t}^{T}[r(s)+\lambda(s)]ds}\mid F_{t}\right]+E^{Q}\left[\int_{t}^{T}\left(\delta(s)V(s,T)\cdot\lambda(s)\cdot e^{-\int_{t}^{s}[r(u)+\lambda(u)]du}\right)ds\mid F_{t}\right]$$

which renders to value of a zero coupon risky bond

$$V(t,T)=E^{Q}\left[e^{-\int_{t}^{T}[r(s)+\lambda(s)(1-\delta(s))]ds}\mid F_{t}\right]$$

Once we have the model for corporate bond prices, we infer the unobservable hazard rates embedded in such prices.

Recovering hazard rates from credit spreads constitutes a simple calibration exercise which we implement the following assumptions:

1. Short interes rate follow an extended Vasicek process:

$$dr_t = a_r(k_t - r_t)dt + \sigma_r dW_t$$

2. The Market Index follows a Geometric Brownian Motion with drift r_t and volatility σ_m, with constant correlation between the spot rate and the Market Index.

$$dM_t = M(t)\left[r_t dt + \sigma_m dZ_t\right] \qquad dZ_t dW_t = \varphi_m dt$$

Jarrow Model Adaptation

Following Lando (1998) and Jarrow and Turnbull (2000), we assume that "the default process follows a Cox process in which *λ(t)* and *δ(t)* are predetermined functions of a vector of observable state variables" like a "multidimensional stochastic process" (Jarrow 2001). In our case, in order to incorporate the findings of the previous section, the vector of state variables includes the spot interest rate, the market index, and the history of the local and German CBs markets spreads.

$$\lambda(t)(1-\delta(t)) = \max\left\{a_0 + a_1 r_t + a_2 Z_t + a_3 spg_{t-1} + a_4 sp_{k,t-1}, 0\right\}$$

As we do not prescribe a separate model for the recovery function, calibration is carried out for the whole expected loss function *λ(t)(1-δ(t)*. We will working without the maximum operator for tractability, and then the value of the default zero-coupon bond can be rewritten as:

$$V(t,T) = E^{Q}\left(e^{-\int_t^T \left[r(u)+\lambda(u)\left(1-\delta(u)\right)\right]du} \mid F_t \right)$$

$$= E^{Q}\left(e^{-\int_t^T \left[r(u)+a_0+a_1 r(u)+a_2 Z(u)+a_3 spg_{t-1}+a_4 sp_{k,t-1}\right]du} \mid F_t \right)$$

$$= e^{-\int_t^T \left[a_0+a_3 spg_{t-1}+a_4 sp_{k,t-1}\right]du} E^{Q}\left(e^{-\int_t^T \left[(1+a_1) r(u)+a_2 Z(u)\right]du} \mid F_t \right)$$

Finally, the valuation formula becomes

$$V(t,T) = b(t,T) e^{-[a_0+a_3 spg(t-1)+a_4 sp_k(t-1)][T-t]}$$

$$\cdot e^{-a_1\mu_r - a_2 Z(t)[T-t]+\frac{1}{2}(2a_1+a_1^2)\sigma_r^2+\frac{1}{6}a_2^2[T-t]^3+(1+a_1)a_2\varphi\eta_{(T,t)}}$$

2.5. Calibration

The purpose of this section is to select the best pricing formula using the different valuation models implicit in the previous section. The first one, which we use as benchmark, is the model proposed by Jarrow 2001 (J01). The second model adds the German CBs spread. In the third model we incorporate the history of the local CBs spread. Finally, the last model contains both the German CBs spread and the history of the local CBs spread variables. Obviously, we will only estimate the last two specifications for the French and Spanish market.

Data

To calibrate the parameters in the valuation model we use the same data as for the spread analysis: daily prices for 32 German CBs, 17 Spanish CBs, and 9 French CBs, observed from February 2003 to January 2004, and swap curves and EUROSTOXX Index prices from February 2002 to January 2004.

Calibration of the model is performed sequencially. First, we obtain daily values of interest rate parameters (a_r, σ_r) using the swap curve with one year rolling window of past data. Second, we obtain market index parameters (σ_m, φ_{rm}) using daily EUROSTOXX index prices and spot rates with a rolling window of one year. Results are shown in Table 10. Third, we estimate the daily cumulative excess return on the market index process $Z(t)$ using the estimated values of σ_m and spot rates.

$$Z(t) = Z(t-1) + \left[\frac{\log \frac{M_t}{M_{t-1}} - \int_{t-1}^{t} r(u)du + \int_{t-1}^{t} \frac{1}{2}\sigma_m^2 du}{\sigma_m} \right]$$

.

Finally, we calibrate the loss function parameters (a_0, a_1 y a_2) in the valuation model.

$$V(t,T) = b(t,T)e^{-[a_0 + a_3 spg(t-1) + a_4 sp_k(t-1)][T-t]}$$
$$\cdot\, e^{-a_1\mu_r - a_2 Z(t)[T-t] + \frac{1}{2}(2a_1 + a_1^2)\sigma_r^2 + \frac{1}{6}a_2^2[T-t]^3 + (1+a_1)a_2\varphi\eta_{(T,t)}}$$

We use the spreads index constructed in section 3 for: France (SPF), Germany (SPG) and Spain (SPS). Although there might be other variables that capture the performance of each market better than average spread, CBs indexes are only available to the German market, while in Spain and France similar data do not exist. To analyze the robustness of results to alternative construccion of spread index variables, we consider two German CBs indexes in addition to our Germany average spread (SPG); the one-to-ten years maturity Pfandbriefe Benchmarks (SPGB) and the one-to-ten years Zero Coupon Pfandbriefe Yields (SPGB), both from the Deutsche Bundesbank, from which we build additional spread variables. The construction of these two new average spreads follows the same procedure as the SPG which is detailed in Section 3.3.

Calibration Results

We calibrate all models by the minimization of the squared errors.

$$\textit{Choose } a_{i,k} \textit{ to} \quad \min \frac{1}{n}\sum [P_k(t_i,T) - VCB_k(t_i,T)]^2 \;\; \textit{for any asset } k$$

where $VCB_k(t_i,T)$ represent the differents valuation models implicit in the previous section. We consider the Jarrow 2001 (J01) model, the J01 model plus the German CBs spread (J01+SPG), the J01 plus the history of the local CBs spread (JO1+SPL), and the J01 plus both the German CBs spread and the history of the local CBs spread (J01+SPG+SPL). Four extra models are estimated using the average spread variables built from the German CBs indexes (J01+SPGB, J01+SPGZ, J01+SPGB+SPL, J01+SPGZ+SPL). Table 11 details the estimating equations corresponding to each of the eight previous models.

Average calibrate parameters by countries are presented in Table 12. The average percentage pricing error is around 1%, but with two different modes, around 0,5% and 3%. Only in very few cases (less than 5%) we find that the calibtated expected loss fuction obtained is negative, and consequently set the hazard rate to equal cero (the maximum operator in the hazard definition applies). To check for the stability of the coefficients we have estimated the model within different time windows and have found very similar parameters.

2.6. Out-of Sample Analysis

To analyze out-of sample behaviour we have used 40 day of simulated values for the dependent variable, using estimated parameters and the new data available each day for the explanatory variables. The results for the back-testing of the model are presented in Table 13. Based on our results, we can separate the covered bonds into two groups attending to the goodness of fit of the proposed models. Only about 60% of our sample of CBs are reasonably fitted ("fitting sample"), with the remaining 40% is subject to significant pricing error ("unfitting sample"), hovering around 3% of the price. Although this figure is somewhat lower for model versions J01+SPG, J01+SPGB and J01+SPGZ, it is in any case too high for valuation purposes.

Average percentage pricing error for the "fitting sample" group is less than 0.05%. Interestingly, for this group the inclusion of a German spread index helps the model leads to a better performance than the J01 model, especially when we use the Benchmark Pfandbriefe Curve to build the credit spread index, and particularly for France and Spain. This evidence is also true for the Local CSCBM but only relative to a subset of the issues within the group. However, for those particular issues where the model overperforms J01, gains seem so significant that it would justify its usage in practical implementations.

To test for the statistical significance of these differences, we apply the Diebold and Mariano Statistic (1995). However, since some parameters need to be estimated and we are comparing nested models in some cases, Ferreira and Stute (2008) procedure is followed to implement the test in a proper way. In this framework we test the null hypothesis of equal loss functions across models using a quadratic loss function[5].

Models are specified with the combination of JJY, SPGB, SPS and SPF variables (Table 16). In most of the cases the null hypothesis of equal

[5] We also tried a penalty function in the loss function to the nested models in the way of the adjusted R^2, but the result was similar.

accuracy of the models is rejected. In the case of French CBM the JJY+SPG model appears to be better. For Spanish CBM, the inclusion of the Spanish spread (JJY+SPGB+SPS model) seems to significantly improve the fit, while for German issues the JJY model seems to be the best model. These results confirm our previous conclusions from section 2.3: i) the German CBM leads the European CBM, and ii) local idiosyncrasies play a relevant role in the Spanish CBs market.

It would also be interesting to understand why a particular covered bond belongs to the “fitting sample” or “unfitting sample” groups. In order to investigate the possible causes, we drew scatter plots that related prediction errors and intrinsic characteristics of the assets: firm issuer, country issuer, issue date, maturity date, outstanding volume and illiquid days. But we were unable to locate a significant specific characteristic (Figure 5).

Finally, we tried to improve the fit in the “unfiting sample” group using two complementary models. The first is the simplest version of our model, where only the interest rate appears as a source of risk. In the second model we add liquidity risk as in Jarrow 2001. Both models perform better than the previous versions on the outfitting sample, but the gain is not significant and the pricing errors continue to be too high.

The extent of what seems to be an abrupt divide among issues within the sample relative to model performance might be an indication of the existence of an unobservable characteristic that has been over looked in the analysis. It would be therefore very advisable to confider this topic for future research on CBs.

2.7. Concluding Remarks

We have analyzed the dynamic relationship between credit spread CBs indexs of German, French and Spanish markets in the context of a multi-variate error-correction model.

Several conclusions could be drawn from our results. First, there is evidence supporting that the lag of the lagged German credit spread index is significant to explain the dynamics in the three countries. Second, interest rates seem to be important to explain the dynamics of the German and French spread, and third the stock exchange index explains the dynamics of the Spanish average spread. These results also indicate specific country effects of theses variables. These conclusions are robust to the specification of the spread.. Therefore, we propose a valuation model that takes these factors into account.

We use an adaptation of Jarrow 2001 model where two additive state variables are included: the credit spread in the German CBs market (German CSCBM) and the credit spread in the local CBs market (Local CSCBM). We have obtained mixed results that allocate particular CBs to one of two different sample groups. While our model seems very adequate for one group, it is not so for the other.

The adaptation of the Jarrow (2001) model, with the inclusion of the German CSCBM, appears to improve the valuation with respect to the initial model over most of the sample in France and Spain. In the Spanish case, the improvement seems to be the result of the addition of the local CSCBM with the German CSCBM. Results for the German data are mixed and, as such, the initial model could be considered an acceptable representation. All these results tend to confirm the leadership of the German CBM in the European CBM. However, the analysis shows that the best results would be obtained by calibrating a separate model for each issue.

In the out-of-sample analysis of our model we learn the importance of bearing in mind the need for including a german credit spread index variable in the pricing model for CBs, and how critical an adequate construction of this variable is. From a practitioner's point of view this implais that much is left to the end user to decide how the model must be set in practice, at least until further research might uncover what latent characteristics in CBs make them particularly suited for each setting.

2.8. References

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2.9. Appendix

Figure 1: Outstanding Volume

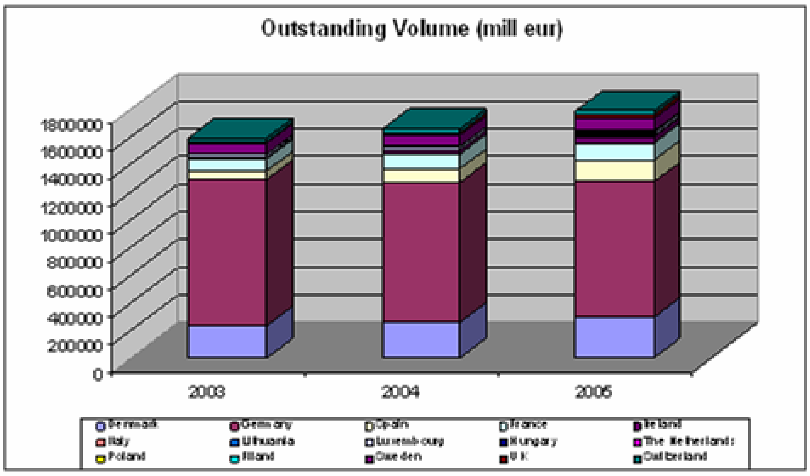

Figure 2: Issue Volume

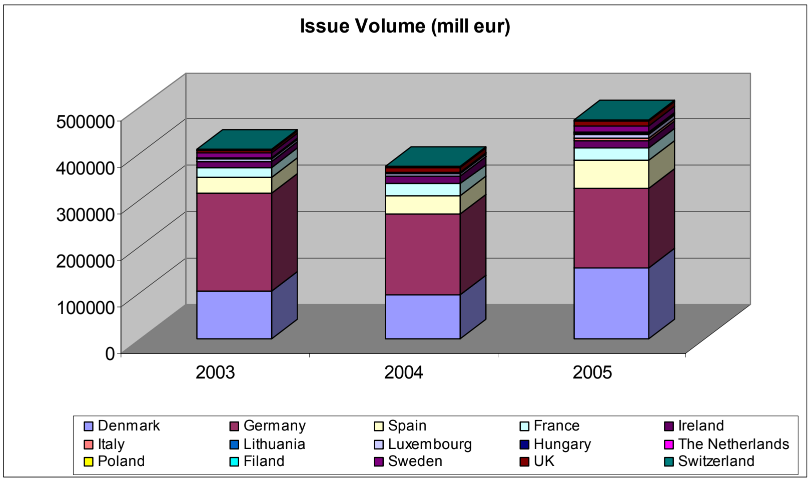

Figure 3: Average Yield Spread for German, France and Spanish Covered Bonds

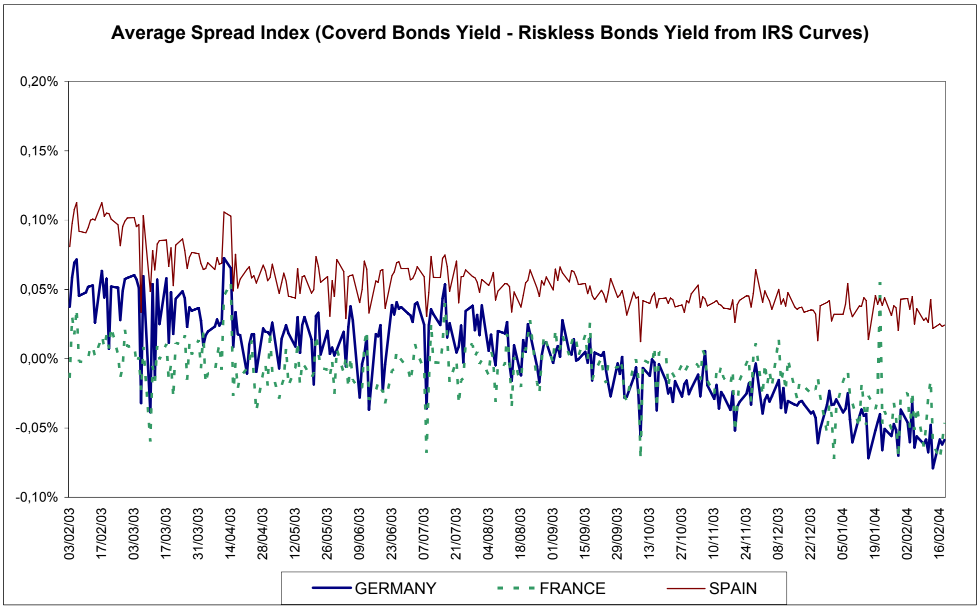

Table 1: Outstanding and Issuace Volume European Covered Bond Market		
	Outstanding Volume (mill eur)	Issuance Volume (mill eur)
2003	**1.587.977**	**408.591**
2004	**1.652.017**	**372.045**
2005	**1.783.752**	**472.006**

Table 2: GERMAN COVERED BOND						
RIC NAME	ISSUER	COUPON	MATURITY	RATING	AGENCY	ISSUE DATE
DE325269	DGHYP	4.5	2005	AAA	S&P	1999
DE242575	EUHYP	4.5	2005	AAA	FIT	1998
DE202783	AHBR	5.25	2006	AAA	S&P	1997
DE251560	HVB	4.75	2006	AAA	FIT	2001
DE242589	EUHYP	4.5	2006	AAA	FIT	1998
DE202939	AHBR	3.5	2006	AAA	S&P	2000
DE202940	AHBR	3.25	2006	AA+	FIT	2003
DE215864	MHB	5	2006	Aaa	MOO	1999
DE315997	AHBR	5.25	2007	AAA	FIT	2000
DE202785	AHBR	5.5	2007	AAA	FIT	1997
DE313174	EUHYP	5.75	2007	AAA	FIT	1997
DE253803	DHYH	5	2007	A	FIT	2001
DE222047	HVB	4.75	2007	AAA	FIT	1998
DE202789	AHBR	5.25	2008	AAA	FIT	1998

Table 3: GERMANY COVERED BOND II						
RIC NAME	**ISSUER**	**COUPON**	**MATURITY**	**RATING**	**AGENCY**	**ISSUE DATE**
DE315914	AHBR	5,25	2008	AAA	FIT	1998
DE215843	MUHY	5	2008	Aaa	MOO	1998
DE232115	DGHYP	4,75	2008	AAA	FIT	1998
DE229430	DEUTPF	4,75	2008	AAA	FIT	1998
DE202931	AHBR	5,75	2008	AA+	FIT	2000
DE325259	DGHYP	4,25	2008	AAA	S&P	1998
DE247479	DEUTPF	5,75	2009	AAA	FIT	1997
DE253770	DHYH	4,25	2010	Aaa	MOO	1999
DE236652	DGHYP	5,5	2010	AAA	FIT	2000
DE251545	HVB	5,75	2010	AAA	FIT	2000
DE247292	EUHYP	5,75	2010	AAA	FIT	2000
DE351054	DEUTPF	5,25	2011	AAA	S&P	2001
DE251580	HVB	5	2011	AAA	FIT	2001
DE215878	MUHY	5	2012	Aaa	MOO	2002
DE748314	DGHYP	4,5	2013	AAA	FIT	2003
DE361188	EUHYP	4,5	2013	AAA	FIT	2003
DE229459	DEUTPF	4,5	2014	AAA	S&P	1998
DE161756	DEUTPF	4,5	2018	AAA	FIT	2003

Table 4: FRANCE COVERED BOND						
RIC NAME	ISSUER	COUPON	MATURITY	RATING	AGENCY	ISSUE DATE
FR0000483729	DEXMA	5,5	2006	AAA	FIT	2000
FR0000487290	DEXMA	4,25	2007	AAA	FIT	2001
FR0000499790	DEXMA	5,375	2007	AAA	FIT	2003
FR0000470049	DEXMA	4,25	2007	AAA	FIT	2002
FR0000497430	DEXMA	5,5	2010	AAA	FIT	1999
FR0000489296	DEXMA	5,5	2012	AAA	FIT	2002
FR0000488132	DEXMA	5,25	2017	Aaa	MOO	2002
FR0000487308	CIFEM	4,75	2008	Aaa	MOO	2001
FR0000470387	CIFEM	4,625	2012	Aaa	MOO	2002

Table 5: SPANISH COVERED BOND						
RIC NAME	**ISSUER**	**COUPON**	**MATURITY**	**RATING**	**AGENCY**	**ISSUE DATE**
DE748694	CM	4,25	2006	Aaa	MOO	2001
DE927574	BBVA	4.25	2007	Aaa	MOO	2002
DE955852	BSCH	4	2007	Aaa	MOO	2002
DE779322	BTNAYT	4.5	2008	Aaa	MOO	2001
DE296694	A	4.375	2009	Aaa	MOO	1999
DE352765	BBVA	5.5	2009	Aaa	MOO	1999
DE353028	CM	5.5	2010	Aaa	MOO	1999
DE558634	BBVA	5.75	2010	Aaa	MOO	1999
DE648386	LC	5.25	2011	Aaa	MOO	2001
DE648635	BTNAYT	5.25	2011	Aaa	MOO	2001
DE846310	CM	5.25	2012	Aaa	MOO	2002
DE861101	BTNAYT	5.25	2012	Aaa	MOO	2002
DE214268	C	4.5	2012	Aaa	MOO	2002
DE728318	BBVA	4.25	2013	Aaa	MOO	2002
DE124503	CM	5	2014	Aaa	MOO	2003
DE688967	CM	5.75	2016	Aaa	MOO	2001
DE852334	B	5.75	2017	Aaa	MOO	2002

Table 6: Unit Root Tests			
	GERMANY	**FRANCE**	**SPAIN**
Augmented Dickey-Fuller			
Level	- 1.59	- 1.98	- 2.10
Differences	- 8.61	- 9.22	- 9.37

Augmented Dickey-Fuller and Phillips-Perron unit root statistics. Critical values for both statistics: -3.45 (1%) -2.87 (5%) -2.57 (10%)

Table 7: Jonhansen Cointegration Test			
	r = 0	**r = 1**	**r = 2**
LR test Stadistic	39.07*	7.78	2.81
5% Critical Value	29.68	15.41	3.76
1% Critical value	35.65	20.04	6.65

Table 8: Error-Correction Model

COINTEGRATION EQUATION			
GE(-1)	**FR(-1)**	**SP(-1)**	**C**
1	**-3.144**	**-0.004**	**-0.045**

ERROR CORRECTION MODEL													
	Z	ΔGE(-1)	ΔGE(-2)	ΔGE(-3)	ΔFR(-1)	ΔFR(-2)	ΔFR(-3)	ΔSP(-1)	ΔSP(-2)	ΔSP(-3)	**R-sq**	**A R-sq**	**Akaike**
ΔGE	**0.108 (2.66)**	**-0.866 (-10.05)**	**-0.561 (-5.61)**	**-0.421 (-4.24)**	0.241* (1.93)	0.188 (1.63)	0.099 (0.98)	-0.091 (-1.32)	0.065 (0.96)	**-0.116 (-1.70)**	0.48	0.45	-5.24
ΔFR	**0.232 (5.52)**	**-0.191 (-2.14)**	**-0.239 (-2.30)**	-0.181* (-1.75)	-0.111 (-0.86)	-0.015 (-0.12)	-0.069 (-0.66)	-0.032 (-0.45)	0.133* (1.89)	**-0.11 (-1.57)**	0.44	0.41	-5.17
ΔSP	-0.045 (-1.21)	**-0.205 (-2.56)**	-0.119 (-1.28)	-0.086 (-0.936)	0.167 (1.44)	0.099 (0.92)	0.149 (1.58)	**-0.131 (-2.04)**	-0.075 (-1.19)	**-0.156 (-2.46)**	0.14	0.10	-3.21

The table gives parametersstimates with t-statistic in braquets. Bold figures indicate the presence of a significant variable at the 5% significant level. And the R^2, the adjusted R^2 and the Akaike information criteria stadistic

Table 9.1: Error Correction Model including exogenous Variables

COINTEGRATION EQUATION

GE(-1)	FR(-1)	SP(-1)	C
1	-3.104	-0.001	-0.045

ERROR CORRECTION MODEL

	Z	ΔGE(-1)	ΔGE(-2)	ΔGE(-3)	ΔFR(-1)	ΔFR(-2)	ΔFR(-3)	ΔSP(-1)	ΔSP(-2)	ΔSP(-3)	ΔESTX	ΔIRS06	ΔIRS10_03
ΔGE	**0.102**	**-0.909**	**-0.607**	**-0.391**	**0.323**	**0.25**	0.14	-0.069	0.055	**-0.118**	0.004	**-0.175**	0.051*
	(3.05)	**(-12,88)**	**(-7.37)**	**(-4.81)**	**(3.17)**	**(2.64)**	(1.70)*	(-1.23)	(0.99)	**(-2.12)**	-(0.21)	**(-9.934)**	(1.82)
ΔFR	**0.231**	**-0.213**	**-0.248**	-1.158	-0.059	0.011	-0.042	-0.014	**0.135**	-0.111	0.035	**-0.106**	**0.081**
	(5.75)	**(-2.51)**	**(-2.51)**	(-1.63)	(-0.48)	(0.10)	(-0.42)	(-0.21)	**(2.03)**	(-1.66)	(1.39)	**(-5.03)**	**(2.43)**
ΔSP	-0.045	**-0.208**	-0.123	-0.092	0.153	0.091	0.144	-0.139	-0.078	**-0.157**	**-0.049**	0.034*	0.016
	(-1.21)	**(-2.60)**	(-1.31)	(-1.01)	(1.32)	(0.85)	(-1.53)	(-2.184)	(-1.24)	**(-2.48)**	**(-2.06)**	(1.71)	(0.51)

	R-sq	A R-sq	Akaike
? GE ΔGE	5	0.63	-5.64
? FR ΔFR	1	0.48	-5.28
? SP ΔSP	6	0.12	-5.38

The table gives parametersstimates with t-statistic in braquets. Bold figures indicate the presence of a significant variable at the 5% significant level. And the R^2, the adjusted R^2 and the Akaike information criteria stadistic

.

Table 9.2: VAR Model with exogenous variables

	K	ΔGE(-1)	ΔGE(-2)	ΔGE(-3)	ΔFR(-1)	Δ FR(-2)	Δ FR(-3)	ΔSP(-1)	Δ SP(-2)	Δ SP(-3)	ΔESTX	ΔIRS06	ΔIRS10-03
ΔGE	-0.001 (-1.675)	**-0.838** (-12.467)	**-0.551** (-6.781)	**-0.344** (-4.254)	0.068 (1.114)	0.059 (0.837)	0.001 (0.014)	-0.070 (-1.231)	0.043 (0.777)	**-0.130** (-2.313)	0.004 (0.193)	**-0.173** (-9.576)	**0.059** (2.033)
ΔFR	-0.001 (-0.851)	-0.0169 (-0.201)	-0.090 (-0.888)	-0.035 (-0.347)	**-0.624** (-8.155)	**-0.433** (-4.905)	**-0.356** (-4.066)	-0.024 (-0.341)	0.108 (1.543)	**-0.147** (-2.084)	0.038 (1.423)	**-0.110** (-4.866)	**0.076** (2.109)
ΔSP	-0.001 (-0.919)	**-0.263** (-3.512)	-0.167 (-1.848)	-0.124 (-1.381)	**0.261** (3.817)	**0.186** (2.358)	**0.206** (2.639)	**-0.134** (-2.098)	-0.072 (-1.160)	**-0.145** (-2.310)	**-0.051** (-2.157)	**0.038** (1.919)	0.027 (0.846)

	R-sq	A R-sq	Akaike
ΔGE	0.649	0.627	-5.609
ΔFR	0.448	0.413	-5.160
ΔSP	0.167	0.115	-5.386

The table gives parametersstimates with t-statistic in braquets. Bold figures indicate the presence of a significant variable at the 5% significant level. And the R^2, the adjusted R^2 and the Akaike information criteria stadistic

Table 10: Spot Rate and Market Index Parameter Estimates				
	Mean	**Std**	**Min**	**Max**
a_r	-0,0502	0,1560	-0,6889	0,0267
σ_r	0,0015	0,0037	1,60E-06	0,0165
σ_{mt}	0,0055	0,0017	0,0022	0,0078
φ_{mt}	0,0155	0,0499	-0,0783	0,1459

Table 11. Expected Loss Models

JJY

$$\lambda_1(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t, 0\}$$

$$V(t,T) = b(t,T) \cdot e^{-a_0[T-t]} \cdot e^{-a_1\mu_r - a_2 Z(t)[T-t] + \frac{1}{2}(2a_1 + a_1^2)\sigma_r^2 + \frac{1}{6}a_2^2[T-t]^3 + (1+a_1)a_2\varphi\eta(t,T)}$$

JJY+SPL*

$$\lambda_2(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_4 spl_{t-1}, 0\}$$

$$V(t,T) = b(t,T) \cdot e^{-(a_0 + a_4 spl_{t-1})[T-t]} \cdot e^{-a_1\mu_r - a_2 Z(t)[T-t] + \frac{1}{2}(2a_1 + a_1^2)\sigma_r^2 + \frac{1}{6}a_2^2[T-t]^3 + (1+a_1)a_2\varphi\eta(t,T)}$$

JJY+SPG

$$\lambda_3(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_3 spg_{t-1}, 0\}$$

$$V(t,T) = b(t,T) \cdot e^{-(a_0 + a_3 spg_{t-1})[T-t]} \cdot e^{-a_1\mu_r - a_2 Z(t)[T-t] + \frac{1}{2}(2a_1 + a_1^2)\sigma_r^2 + \frac{1}{6}a_2^2[T-t]^3 + (1+a_1)a_2\varphi\eta(t,T)}$$

JJY+SPGB

$$\lambda_4(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_3 spgb_{t-1}, 0\}$$

$$V(t,T) = b(t,T) \cdot e^{-(a_0+a_3 spgb_{t-1})[T-t]} \cdot e^{-a_1\mu_r - a_2 Z(t)[T-t] + \frac{1}{2}(2a_1+a_1^2)\sigma_r^2 + \frac{1}{6}a_2^2[T-t]^3 + (1+a_1)a_2\varphi\eta(t,T)}$$

JJY+SPGZ

$$\lambda_5(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_3 spgz_{t-1}, 0\}$$

$$V(t,T) = b(t,T) \cdot e^{-(a_0+a_3 spgz_{t-1})[T-t]} \cdot e^{-a_1\mu_r - a_2 Z(t)[T-t] + \frac{1}{2}(2a_1+a_1^2)\sigma_r^2 + \frac{1}{6}a_2^2[T-t]^3 + (1+a_1)a_2\varphi\eta(t,T)}$$

JJY+SPG+SPL*

$$\lambda_6(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_3 spg_{t-1} + a_4 spl_{t-1}, 0\}$$

$$V(t,T) = b(t,T) \cdot e^{-(a_0+a_3 spg_{t-1}+a_4 spl_{t-1})[T-t]} \cdot e^{-a_1\mu_r - a_2 Z(t)[T-t] + \frac{1}{2}(2a_1+a_1^2)\sigma_r^2 + \frac{1}{6}a_2^2[T-t]^3 + (1+a_1)a_2\varphi\eta(t,T)}$$

JJY+SPGB+SPL*

$$\lambda_7(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_3 spgb_{t-1} + a_4 spl_{t-1}, 0\}$$

$$V(t,T) = b(t,T)\cdot e^{-(a_0+a_3 spgb_{t-1}+a_4 spl_{t-1})[T-t]}\cdot e^{-a_1\mu_r - a_2 Z(t)[T-t]+\frac{1}{2}(2a_1+a_1^2)\sigma_r^2+\frac{1}{6}a_2^2[T-t]^3+(1+a_1)a_2\varphi\eta(t,T)}$$

JJY+SPGZ+SPL*

$$\lambda_8(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_3 spgz_{t-1} + a_4 spl_{t-1}, 0\}$$

$$V(t,T) = b(t,T)\cdot e^{-(a_0+a_3 spgz_{t-1}+a_4 spl_{t-1})[T-t]}\cdot e^{-a_1\mu_r - a_2 Z(t)[T-t]+\frac{1}{2}(2a_1+a_1^2)\sigma_r^2+\frac{1}{6}a_2^2[T-t]^3+(1+a_1)a_2\varphi\eta(t,T)}$$

*SPL=SPE, SPF

Table 12. Average Parameters Estimation					
			GERMANY	**SPAIN**	**FRANCE**
JJY	CTE	A0	0,0027	0,0037	0,0047
	R	A1	0,0431	0,0558	0,0375
	Z	A2	-3,52E-05	2,62E-05	-1,82E-05
JJY+SPL*	CTE	A0	-	0,0026	0,0046
	R	A1	-	0,0546	0,0381
	Z	A2	-	3,89E-05	-1,82E-05
	SPL	A4	-	0,0048	0,0003
JJY+SPG	CTE	A0	0,0021	0,0041	0,0048
	R	A1	0,0557	0,0483	0,0358
	Z	A2	-2,80E-05	2,13E-05	-2,08E-05
	SPG	A3	0,0064	-0,0044	-0,0022
JJY+SPGB	CTE	A0	0,0027	0,0039	0,0047
	R	A1	0,0429	0,0562	0,0371
	Z	A2	-3,58E-05	2,46E-05	-1,82E-05
	SPGB	A3	-0,0007	-0,0018	-0,0001
JJY+SPGZ	CTE	A0	0,0028	0,0041	0,0047
	R	A1	0,0385	0,05272	0,0364
	Z	A2	-3,45E-05	2,57E-05	-1,76E-05
	SPGZ	A3	8,55E-05	-0,0006	0,0002
JJY+SPG+SPL*	CTE	A0	-	0,0030	0,0048
	R	A1	-	0,0429	0,0362
	Z	A2	-	3,45E-05	-2,09E-05
	SPG	A3	-	-0,0051	-0,0023
	SPL	A4	-	0,0052	0,0011
JJY+SPGB+SPL*	CTE	A0	-	0,0027	0,0047
	R	A1	-	0,0561	0,0376
	Z	A2	-	3,72E-05	-1,82E-05
	SPGB	A3	-	-0,0014	-0,0001
	SPL	A4	-	0,0047	0,0004
JJY+SPGZ+SPL*	CTE	A0	-	0,0027	0,0046
	R	A1	-	0,0529	0,0372
	Z	A2	-	3,85E-05	-1,76E-05
	SPGZ	A3	-	-0,0003	0,0002
	SPL	A4	-	0,0048	0,0001
*SPL=SPE to Spain and SPL=SPF to France					

RMSE GERMANY

	CBG1	CBG2	CBG3	CBG4	CBG5	CBG6	CBG7	CBG8	CBG9	CBG10	CBG11	CBG12	CBG13	CBG14	CBG15	CBG16	CBG17
JJY	3,34%	3,74%	0,41%	0,89%	2,83%	0,54%	2,97%	4,65%	0,51%	0,50%	0,43%	4,08%	4,65%	0,52%	0,53%	1,29%	0,71%
JJY+SPG	3,29%	3,85%	0,35%	1,21%	3,06%	0,62%	2,95%	4,75%	0,48%	0,47%	0,42%	4,09%	4,68%	0,50%	0,49%	1,35%	0,80%
JJY+SPGB	3,32%	3,71%	0,44%	0,83%	2,84%	0,51%	2,95%	4,60%	0,54%	0,53%	0,45%	4,06%	4,62%	0,54%	0,56%	1,20%	0,69%
JJY+SPGZ	3,38%	3,75%	0,42%	0,90%	2,83%	0,54%	2,97%	4,65%	0,51%	0,50%	0,43%	4,14%	4,65%	0,51%	0,52%	1,29%	0,67%

	CBG18	CBG19	CBG20	CBG21	CBG22	CBG23	CBG24	CBG25	CBG26	CBG27	CBG28	CBG29	CBG30	CBG31	CBG32
JJY	1,58%	5,17%	4,31%	1,30%	0,90%	3,28%	1,53%	1,70%	0,73%	4,43%	0,39%	0,36%	0,26%	0,34%	0,38%
JJY+SPG	1,18%	5,18%	4,37%	1,61%	1,13%	3,41%	1,59%	1,82%	0,51%	4,38%	0,45%	0,34%	0,28%	0,32%	0,32%
JJY+SPGB	1,65%	5,15%	4,27%	1,28%	0,83%	3,33%	1,44%	1,60%	0,84%	4,41%	0,39%	0,38%	0,28%	0,36%	0,41%
JJY+SPGZ	1,63%	5,18%	4,31%	1,27%	0,85%	3,28%	1,46%	1,59%	0,79%	4,40%	0,39%	0,37%	0,27%	0,34%	0,38%

RMSE FRANCE

	CBF1	CBF2	CBF3	CBF4	CBF5	CBF6	CBF7	CBF8	CBF9
JJY	1,30%	0,29%	3,04%	3,61%	3,04%	3,65%	0,41%	2,82%	4,64%
JJY+SPF	1,33%	0,34%	3,14%	3,52%	3,13%	3,69%	0,44%	2,86%	4,66%
JJY+SPG	1,33%	0,34%	3,14%	3,52%	3,13%	3,69%	0,44%	2,86%	4,66%
JJY+SPGB	1,30%	0,27%	2,98%	3,60%	2,97%	3,64%	0,39%	2,80%	4,63%
JJY+SPGZ	1,30%	0,29%	3,07%	3,66%	3,00%	3,64%	0,38%	2,82%	4,63%
JJY+SPG+SPF	1,36%	0,41%	3,22%	3,47%	3,16%	3,72%	0,46%	2,92%	4,68%
JJY+SPGB+SPF	1,33%	0,31%	3,07%	3,51%	3,05%	3,68%	0,42%	2,84%	4,64%
JJY+SPGZ+SPF	1,33%	0,33%	3,13%	3,54%	3,06%	3,68%	0,41%	2,85%	4,65%

Table 13: RMSE

RMSE SPAIN																	
	CBS1	**CBS2**	**CBS3**	**CBS4**	**CBS5**	**CBS6**	**CBS7**	**CBS8**	**CBS9**	**CBS10**	**CBS11**	**CBS12**	**CBS13**	**CBS14**	**CBS15**	**CBS16**	**CBS17**
JJY	**2,06%**	**0,10%**	2,65%	4,75%	5,03%	2,96%	3,14%	1,59%	2,96%	0,19%	0,68%	2,58%	1,57%	3,48%	3,66%	0,20%	0,16%
JJY+SPE	2,08%	0,11%	1,79%	4,82%	5,10%	2,25%	2,65%	2,14%	2,88%	0,19%	0,49%	1,71%	2,10%	3,26%	3,59%	0,15%	0,16%
JJY+SPG	2,12%	0,12%	2,68%	4,86%	5,14%	2,95%	3,08%	1,81%	3,08%	0,18%	0,79%	2,57%	1,78%	3,55%	3,74%	0,16%	0,19%
JJY+SPGB	2,06%	0,11%	2,71%	4,70%	4,98%	3,04%	3,11%	1,55%	2,93%	0,20%	0,63%	2,65%	1,54%	3,46%	3,61%	0,23%	0,15%
JJY+SPGZ	2,06%	0,11%	2,65%	4,73%	5,00%	3,00%	3,19%	1,55%	2,96%	0,17%	0,67%	2,62%	1,50%	3,48%	3,66%	0,27%	0,16%
JJY+SPG+SPE	2,14%	0,16%	1,74%	4,96%	5,22%	2,23%	2,59%	2,38%	3,02%	0,18%	0,51%	1,69%	2,31%	3,35%	3,69%	0,15%	0,19%
JJY+SPGB+SPE	2,08%	0,10%	1,81%	4,77%	5,05%	2,28%	2,59%	2,13%	2,84%	0,22%	0,52%	1,73%	2,08%	3,23%	3,52%	0,18%	0,15%
JJY+SPGZ+SPE	2,07%	0,11%	1,79%	4,80%	5,06%	2,27%	2,71%	2,10%	2,88%	0,18%	0,49%	1,73%	2,02%	3,26%	3,59%	0,16%	0,16%

Table 14: Average parameters c

RT	$\lambda_8(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t, 0\}$ $V(t,T) = b(t,T)e^{-a_0[T-t]}e^{+\frac{1}{2}(2a_1+a_1^2)\sigma_r^2}$
JJY+SPGB+LQ	$\lambda_9(t)(1-\delta(t)) = \max\{a_0 + a_1 r_t + a_2 Z_t + a_3 spgb_{,t-1}\}$ $V(t,T) = e^{\gamma(t,T)}e^{-[a_0+a_3 spgb(t-1)][T-t]}e^{-\mu_r - a_1\mu_r + \frac{1}{2}\sigma_r^2 + \frac{1}{2}(2a_1+a_1^2)\sigma_r^2 + \frac{1}{4}a_2^2[T-t]^2 + (1+a_1)a_2\varphi\sigma_r\sigma_m}$ $\gamma(t,T) = \gamma_0 + \gamma_1 r(t) + \gamma_2 Z(t)$

			GERMANY	SPAIN	FRANCE
RT	CTE	A0	0.0037	0.0021	0.0051
	R	A1	0.0107	0.1063	0.0223
JJY+SPGB+LQ	CTE	A0	-0.0530	-0.0620	-0.0350
	R	A1	-0.0323	-0.0326	-0.0638
	Z	A2	3.97e-004	8.53e-005	3.4597e-004
	SPGB	A3	0.0025	0.0016	0.0024
	LQ	γ_0	-0.2983	-0.4731	-0.1921
		γ_1	0.1468	0.4159	-0.0899
		γ_2	0.0021	9.4890e-004	0.0018

Table 15. Prediction

RMSE GREMANY																	
	CBA1	**CBA2**	**CBA3**	**CBA4**	**CBA5**	**CBA6**	**CBA7**	**CBA8**	**CBA9**	**CBA10**	**CBA11**	**CBA12**	**CBA13**	**CBA14**	**CBA15**	**CBA16**	**CBA17**
RT	2,98%	2,62%	1,53%	1,04%	1,75%	1,95%	2,95%	3,36%	1,44%	1,50%	1,73%	3,74%	3,98%	1,44%	1,48%	2,66%	2,89%
JJY+SPGB+LQ	2,85%	3,48%	0,27%	1,81%	3,78%	0,85%	1,35%	4,14%	0,47%	0,45%	0,34%	0,80%	3,71%	0,49%	0,51%	0,98%	0,35%
	CBA18	**CBA19**	**CBA20**	**CBA21**	**CBA22**	**CBA23**	**CBA24**	**CBA25**	**CBA26**	**CBA27**	**CBA28**	**CBA29**	**CBA30**	**CBA31**	**CBA32**		
RT	2,99%	4,55%	3,44%	1,34%	1,01%	2,17%	2,96%	2,85%	3,47%	4,65%	1,57%	1,19%	1,37%	1,48%	1,30%		
JJY+SPGB+LQ	1,19%	3,49%	3,68%	2,01%	1,26%	2,87%	1,22%	0,50%	0,95%	2,71%	0,43%	0,60%	0,47%	0,58%	0,54%		
RMSE FRANCE																	
	CBF1	**CBF2**	**CBF3**	**CBF4**	**CBF5**	**CBF6**	**CBF7**	**CBF8**	**CBF9**								
RT	1,15%	1,22%	1,81%	3,16%	1,98%	2,51%	0,97%	1,90%	3,32%								
JJY+SPGB+LQ	1,38%	0,35%	2,82%	1,03%	2,04%	2,95%	0,31%	2,50%	4,04%								
RMSE SPAIN																	
	CBE1	**CBE2**	**CBE3**	**CBE4**	**CBE5**	**CBE6**	**CBE7**	**CBE8**	**CBE9**	**CBE10**	**CBE11**	**CBE12**	**CBE13**	**CBE14**	**CBE15**	**CBE16**	**CBE17**
Rt	1,98%	1,77%	0,64%	2,82%	2,92%	0,90%	0,54%	0,98%	1,88%	1,81%	1,89%	1,02%	0,73%	2,35%	2,47%	0,10%	0,13%
JJY+SPGB+LQ	1,44%	0,11%	2,14%	3,53%	3,38%	2,20%	2,20%	0,70%	2,66%	0,08%	0,82%	0,93%	0,56%	2,60%	3,04%	0,22%	0,21%

Figure 5: Scatters Plots

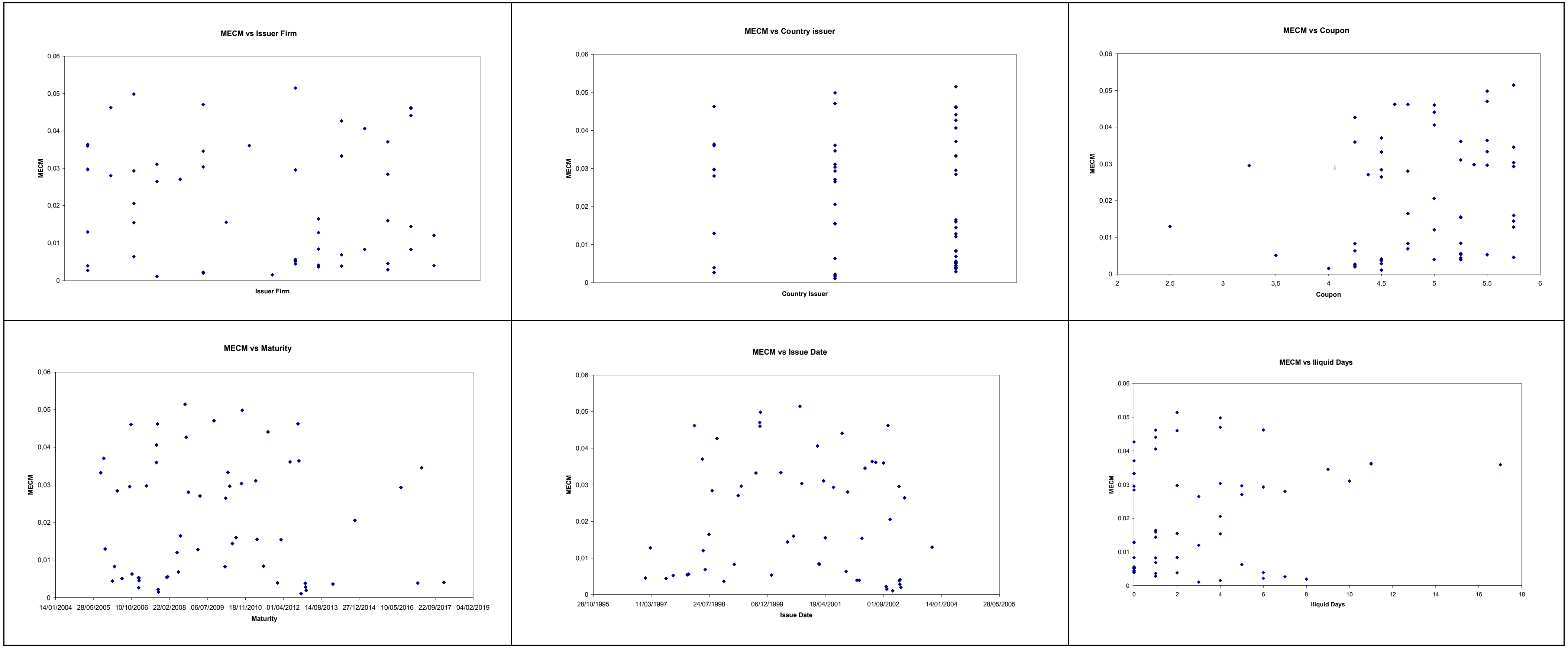

Table 16. Diebold y Mariano Stadistic (1995)

RMSE ALEMANIA																	
	CBA1	**CBA2**	**CBA3**	**CBA4**	**CBA5**	**CBA6**	**CBA7**	**CBA8**	**CBA9**	**CBA10**	**CBA11**	**CBA12**	**CBA13**	**CBA14**	**CBA15**	**CBA16**	**CBA17**
JJY VS JJY+SPGB	33,06	4,69	4,43	12,69	11,33	3,04	29,12	6,56	3,15	3,18	3,04	21,47	30,73	3,37	4,39	4,30	**1,61**
	CBA18	**CBA19**	**CBA20**	**CBA21**	**CBA22**	**CBA23**	**CBA24**	**CBA25**	**CBA26**	**CBA27**	**CBA28**	**CBA29**	**CBA30**	**CBA31**	**CBA32**		
JJY VS JJY+SPGB	10,46	28,09	9,75	13,54	6,87	11,45	8,60	10,25	4,04	20,85	6,72	3,42	3,93	3,48	5,26		

FRANCIA									
	CBF1	**CBF2**	**CBF3**	**CBF4**	**CBF5**	**CBF6**	**CBF7**	**CBF8**	**CBF9**
JJY VS JJY+SPGB	**-0,21**	-2,36	-3,68	-3,52	-3,81	-2,31	-2,63	-2,07	-2,88
JJY VS JJY+SPF	1,99	3,45	5,72	-6,06	5,49	3,20	3,33	3,05	4,11
JJY VS JJY+SPGZ+SPF	**1,93**	**0,85**	**0,91**	-7,17	**0,20**	2,41	**1,92**	**1,61**	**0,79**
JJY+SPG VS JJY+SPF	**1,89**	4,02	7,42	-4,93	7,44	3,72	3,45	3,74	5,17
JJY+SPG VS JJY+SPG+SPF	**1,93**	2,82	5,63	-6,10	5,38	3,18	3,24	3,00	4,11
JJY+SPF VS JJY+SPG+SPF	**-0,55**	-2,82	-3,80	-3,68	-3,91	-2,47	- 2,76	-2,26	-2,95

RMSE ESPAÑA																	
	CBE1	**CBE2**	**CBE3**	**CBE4**	**CBE5**	**CBE6**	**CBE7**	**CBE8**	**CBE9**	**CBE10**	**CBE11**	**CBE12**	**CBE13**	**CBE14**	**CBE15**	**CBE16**	**CBE17**
JJY VS JJY+SPGB	**-0,73**	**0,77**	3,87	-3,30	-3,67	3,74	-3,72	-3,30	-2,46	**1,04**	- 3,81	3,36	-3,33	-3,66	-3,67	3,33	**-1,45**
JJY VS JJY+SPE	**1,60**	**0,71**	-9,20	6,35	6,29	-9,82	-8,17	6,25	-3,54	3,17	-2,48	-13,30	5,82	-9,09	-8,88	-3,19	**-1,37**
JJY VS JJY+SPGB+SPE	**1,25**	**0,18**	-8,90	**1,29**	**1,12**	-8,72	-9,94	6,01	-3,58	2,29	**-1,75**	-12,60	5,64	-11,30	-11,10	-2,68	**-1,35**
JJY+SPGB VS JJY+SPE	**1,50**	**-0,18**	-9,95	6,66	6,68	-11,05	-9,02	6,57	-3,49	3,97	**-1,21**	-14,17	6,12	-9,68	-9,42	-4,11	**-0,74**
JJY+SPGB VS JJY+SPG+SPE	**1,50**	**-0,18**	-9,95	6,66	6,68	-11,05	-9,02	6,57	-3,49	3,97	**-1,21**	-14,17	6,12	-9,68	-9,42	-4,11	**-0,74**
JJY+SPE VS JJY+SPGB+SPE	**- 0,97**	**-1,41**	3,45	-4,29	-4,48	3,36	-3,79	- 4,44	-2,67	1,97	**1,05**	2,53	-4,58	-4,94	-5,03	2,33	**-1,17**

*Bold statistics represents that we can not reject the null hypothesis of equal errors series at 5% level

3. Determinants of Recovery Rate in the Financial Sector

Abstract

Understanding the determinants of recovery rates has been one of the most important objectives of academic research in the field of credit risk in recent years. This paper analyzes the determinants of recovery rates in European financial sector bonds using a reduced-form model with no a priori modelling of the loss function.

We obtain an implicit loss function from Covered Bonds (CBs) and Bonds (Bs) issued by financial institutions. CBs and Bs share the same issuer and, since in both cases the hazard rate is driven by the probability of bankruptcy of the issuer, we assume that they should have the same hazard rate function. Therefore, we can study whether certain determinants such as interest rates, the business cycle and inflation affect the ratio between loss functions for CBs and B, and measure the implications for both recovery rates.

3.1 Introduction

Understanding the determinants of recovery rates has been one of the most important objectives of academic research in the field of credit risk in recent years. Traditionally, research into credit risk has focused on default probabilities assuming that recovery is constant, but the empirical evidence suggests that the recovery rate is volatile and inversely correlated with economic cycles and default probabilities.

Some examples of the large body of recent literature about recovery rates that study the determinants of recovery rate and its dependence on systematic factors are Bakshi et al (2006), Jarrow and Zeng (2005), Altman et al. (1996, 2001, 2004, 2005), Hu and Perraudin (2002), Acharya et al. (2003), Schürmann (2004), Frye (2000), Carey (2004), Hamilton et al. (2001), Gupton et al (2000), etc.

One of the main approaches in the literature on credit risk is to use reduced-form models, beginning with the work of Jarrow and Turbull (1995), Lando (1998) and Duffie and Singleton (1999). Under this approach it is not possible to estimate the recovery rate and the hazard rate function separately. Therefore, within such a framework, the analysis requires that the researcher fix one variable in order to study the other or to study the loss function, which is a combination of the two. One of the aims of this paper is to analyze the determinants of the recovery rate in the European financial sector using a reduced-form model without fixing the hazard rate a priori.

In the literature of reduced-form models three different models of recovery are considered: recovery of face value, recovery of market value and recovery of treasury value. The first measures the recovery payment as a fraction of face value, the second as a fraction of pre default market value of debt and the last as a fraction of the value at the time of default of a treasury bond with the same maturity.

The differences between these assumptions imply alternative characterisations of the economic mechanism by which recovery payments are settled in the market and, as has been said, differences in the scale by which those payments are measured. This change of scale per se is irrelevant for mathematical purposes and should not give rise to any pricing deviations between models which differ only on this point. Discussion of recovery mechanisms in those terms is spurious and motivated mainly by the fact that in most practical settings the recovery payment is assumed to be constant, or at most time dependent, but always non random. This assumption allows us to obtain implicit default probabilities but disregard the recovery risk component.

Extracting meaningful recovery rates from market price data is difficult within the reduced-form context, and some authors try to overcome this problem by introducing complementary specifications in the model to obtain an “identification condition”. Bakshi et al (2006) incorporate an economic equilibrium model for the recovery rate, Unal, Madan and Guntay (2001) obtain a measure of recovery rates on senior debt relative to junior debt. Jarrow (2001), Guo, Jarrow and Zeng (2005), Karoui (2005) and Das and Hanouna (2006) rely on a structural framework for the recovery rate, in what constitutes a hybrid approach between structural and reduced-form models.

However, the most prominent and prolifically used approach to date in recovery rate analysis is to use historical data on recovery rates. In this branch of literature, empirical indicators have been found to explain the high volatility of recovery rates in recent years. There are studies that try to explain recovery rates by using endogenous variables related to bond issuers; others consider the dependence of recovery rates on the level of defaults among issuers that are somehow correlated, while still others consider economy-wide macroeconomic variables. Finally, the most recent studies consider a general mix of all possible variables that have been successful in explaining recoveries. For instance, Altman et al. (2005) find that the recovery rate is very variable and that there is a negative relationship between default probabilities and recovery rates. The same negative correlation is found in Hu and Perraudin (2002). Acharya et al. (2003) focus on the importance of industry effects. Schürmann (2004) finds that some of the factors which should play a role in any recovery rate model are the characteristics of collateral, industry and timing of the business cycle. Frye (2000) shows that in recession periods, recoveries are much lower than in expansions. Carey (2004) finds that the nature of a firm's debt is correlated with the level of the recovery rate. Other important studies are Hamilton et al. (2001), Gupton et al (2000), Van de Castle and Keisman (1999).

This study makes use of some of the above approaches and applies them to our particular setting. First, given that we use a loss function proportion between Bonds and Covered Bonds, that issuer characteristics should be almost irrelevant with respect to CBs, and that collateral characteristics should be even less relevant to Bonds in turn, we have refrained from using issuer and collateral variables and employ only macroeconomic variables as determinants of the recovery rate (interest rates, business cycle, inflation, volatility, etc.). Second, since there are no historical data on recovery for Covered Bonds (as none has defaulted yet), and given the special characteristics of the collateral of CBs, it is not advisable to transfer knowledge from the bond market, so we rely on market value data. This study provides a different approach and a new contribution to the relevant literature since it helps to provide an understanding of the determinants of the recovery of Covered Bonds relative to that of others bond issues by the same issuer.

Following Duffie and Singleton (1999), we obtain an implicit loss function (ILF) using data on Covered Bonds and Bonds issued by financial institutions. They share the same issuer and should, therefore, have the same hazard rate function since in both cases the hazard rate is driven by the probability of bankruptcy of the issuer. Hence, differences in the loss function should reflect underlying differences in the recovery rates of each instrument. Covered Bond investors benefit from a pool of eligible Covered Bond collateral as preferential security and usually enjoy a certain degree of over-collateralisation (OC) and a special legal framework. Thus, they expect a very high recovery rate, whereas ordinary Bond investors enjoy comparably less rights and thus might expect a lower recovery rate.

Obtaining the ratio between loss functions for Covered Bonds and Bonds (Implicit Loss function, ILFR) the hazard rate function cancels out, and only the determinants that affect to the recoveries function remain. Although we cannot study the determinants that affect each recovery function separately, we are able to study how some common determinants such as interest rates, the business cycle and inflation affect the recovery rates of both Covered Bonds and Bonds in a qualitative manner (quantitatively the effects should be studied individually for Bonds and Covered Bonds, which we are not able to do). Finally, we can compare this effect with the effect that the same variables have on the loss function.

The rest of the paper is structured as follows. Section 2 provides the general framework and presents the data. Section 3 analyses the implicit loss function for Bonds and Covered Bonds, and the analysis of the implicit recovery rate ratio between Bonds and Covered Bonds is covered in Section 4. Section 5 concludes.

3.2. General Framework and Data.

In general, the price at time t of a zero-coupon riskless bond maturing at T is known to be given by

$$B(t,T) = E^{Q}\left[e^{-\int_{t}^{\tau} r(u)du} \mid F_t \right]$$

where *r(t)* is the risk-free short rate, *Q* is the martingale probability, and *F(t)* is the amount of information available to investors at time *t*.
By contrast, the value of a risky bond is given by

$$V(t,T) = E^{Q}\left[S(T) \cdot e^{-\int_{t}^{T} r(u)du} \mid F_t \right] + E^{Q}\left[F(T) \cdot Z_{\tau} \cdot e^{-\int_{t}^{\tau} r(u)du} \mid F_t \right]$$

where *S(t)* is the survival probability, *F(t)* represents the probability of default on or before a time *t*, *Z(t)* is the recovery function and τ is the time of default . The first summand indicates the present value of a unitary payment at *T* weighted by the probability that the bond will survive until that time, and the second expresses the present value of a payment Z received at the time of default τ weighted by the probability of default.

For the sake of simplicity we follow Duffie and Singleton (1999) in assuming a market value recovery (the recovery is a fraction of the market value before default), and assuming that *r(t)*, *τ*, and *Z* are all independent quantities, then

$$Z_{\tau} = \delta_{\tau} V(\tau,T)^{-}$$

In other words, contingent upon default, investors receive a random payment comprised of a fraction of the pre-default value of the bond. Subtituting in the risky zero coupon bond value equation we have

$$V(t,T) = E^Q\left(e^{-\int_t^T [r(u)+\lambda(u)(1-\delta(u))]du} \mid F_t \right)$$

And the price of a risk-adjusted zero coupon bond would then be

$$P^*(t,T) = E^Q\left(e^{-\int_t^T R(u)du} \mid F_t \right)$$

where

$R(t) = r(t) + \lambda(t)(1-\delta(t)) = r(t) + ILF(t)$

has a different specification depending on the particular setting. In this case we extract the implicit loss function by the calibration of an LF constant every day for each issuer.

The data

Bonds and Covered Bonds

We use daily closing price observations of Bonds[6] (22 issues) and Covered Bonds (59 issues) from six different issuers: Deutsche Postbank (DP), Bayerische Hypho und Vereinsbank (BHV), Munchener Hypothekenbank (MH), Caja Madrid (CM), Caja Catalunya (CC) and Caja Galicia (CG). The data span is two years, from May 2005 to May 2007.

All Bonds and Covered Bonds have similar characteristics (Tables 1 and 2): a fixed annual coupon (between 3.1 and 5.5), time to maturity between 4 and 11 years and very good rating. We use data from these countries because they are among the most important in the European market covered. The main issuers in the Covered Bonds market are Germany, Denmark, Spain and France, and the initial idea was to work with issuers

[6] The sources for the different data are Reuters, Bloomberg and Ecowin.

from all these countries to study country effects, but it was not easy to find pairs of Bonds and Covered Bonds with the compatibility characteristics required for this analysis, so we finally settled for working only with issuers from Germany and Spain.

Interest rates

The daily European swap curves (IRS), between 1 and 30 years, are employed to obtain the term structure of risk-free discount factors B(t,T), following the Nelson-Siegel (1987) methodology.

Explanatory Variables

The macroeconomic variables used for the analysis are the stock market (represented by the Eurostoxx50 Index (ESX50), which is known to be a good representative of the business cycle in the European Union), the HIPC-linked inflation Index (HIPCLI) (to capture inflation expectations in EU), two interest rate variables, the six year IRS (LTSIR) to represent the level of the term structure, and the difference between the 10 year and 1 year IRS curves for the slope (STSIR). Finally, the VDAX index expresses the implied volatility of the anticipated DAX on the derivatives market. These variables have the advantage of being available daily as the closing prices for the same sample of Bonds and Covered Bonds. The whole sample runs daily from May 2005 to May 2007.

3.3. Implicit Loss Function Analysis

First, consider the prices of the assets available for each day and each issuer using the pricing formula:

$$V_k^B(t,T) = \sum_{i=1}^{n} c_{j,k}^B(t,s_i)B(t,s_i)e^{-ILF_k^B} + B(t,T)Ne^{-ILF_k^B}$$

$$V_k^{CB}(t,T) = \sum_{i=1}^{n} c_{j,k}^{CB}(t,s_i)B(t,s_i)e^{-ILF_k^{CB}} + B(t,T)Ne^{-ILF_k^{CB}}$$

We calibrate the implicit loss function for Bonds and Covered Bonds by minimizing the root-mean-squared percentage pricing errors.

$$\textit{Choose } ILF_k^{B,CB} \textit{ to } \quad \min\left[P_k(t_i,T) - V^{B,CB}{}_k(t_i,T)\right]^2 \textit{ for any asset } k \textit{ and any day}$$

Table 4 reports a summary of the ILF estimates for Bonds and Covered Bonds. Mean ILF estimates range from 0.0028 to 0.034 for Bonds and from 0.0071 to 0.0014 for Covered Bonds. Median and mean values are very close in all cases. The average Bond ILF is consistently higher than that of Covered Bonds, except for the case of Caja Madrid where the difference is quite small.

Second, we analyze the macro-determinants of the loss function for Bonds and Covered Bonds and then compare with the results when the same analysis is made for the loss function ratio. We perform twelve different estimations, one for each firm and type of instrument, where the estimated ILF acts as the dependent variable and our five macro-variables (ESTX, HIPCLI, LTSIR, STSIR, VDAX) are introduced as explanatory variables. We employ the seemingly unrelated regression equations (SURE) methodology following Zellner (1962), which allows us to account for heteroskedasticity and contemporaneous correlation across equations.

$$\Delta ILF_i^k = \beta_{i,1}^k + \beta_{i,2}^k \Delta HIPCLI + \beta_{i,3}^k \Delta ESTX + \beta_{i,4}^k \Delta LTSIR + \beta_{i,5}^k \Delta STSIR + \beta_{i,6}^k \Delta VDAX + \varepsilon_i^k$$

$i = \{DP, BHV, MH, CM, CC, CG\} \quad k = \{B, CB\}$

Table 5 shows the estimation results for Bonds. As described, only the HIPC-linked inflation index and the level of the term structure of interest rates are significant for most firms. The STSIR is significant only for Caja Madrid. The positive sign of HIPC-linked inflation and the negative sign of the ΔLTSIR are as expected. To check this effect from the HIPC and measure the net effect of this variable when inflation is removed, we substitute the HIPC variable for the residual of an OLS regression between ΔLTSIR y HIPC. The results are similar.

Table 6 summarizes the estimation results for Covered Bonds. As for Bonds, the variations in the HIPC-Linked Inflation Index and the variations in the level of the term structure of interest rates (ΔLTSIR) are significant for all issuers, with the same signs. The difference lies in the effect of the Eurostoxx index, which here becomes significant for four issuers (BHV, MH, CC and CG), and the slope of the term structure of interest rates, which appears to be significant for Spanish issuers, with the expected signs. The Adjusted-R2 reflects a quite good fit of the model to the variation of the loss function.

Next, we test for equality of the influence of the variables in the different issuers, with the results shown in Tables 7 and 8. We use the Wald Test to check for the equality of coefficients. In the case of Bonds, it is only for the HIPCLI variable, and only for German issuers, that we cannot reject the null hypothesis of equality of coefficients. The results for Covered Bonds show that we cannot reject the null hypothesis for the HIPCLI, ESTX and STSIR variables as they affect Spanish issuers, and the LTSIRS across all issuers. These results could reflect first that the Bonds market is more issuer specific than the Covered Bond market, and second that there might be a country effect for Covered Bonds.

The results are also indicative of the importance that the term structure (LTSIR) and the HIPC-Linked Index (HIPCLI) have in the pricing valuation of any instrument. The HIPC-Linked Index captures the inflation expectations in the economy, and it seems to be an essential variable for modelling variations in the loss function of European Financial Sector Bonds. It is difficult to find other papers that consider inflation as a determinant of the loss function for bonds. Das and Hanouna (2007) did not find the inflation rate (as a measure of changes in the consumer price index) to be significant in explaining implicit recovery rates (implied from CDS spreads of US firms). On the other hand they found the implicit volatility of the S&P 500 to be an essential variable for the US market. This prompts a further analysis of a broader spectrum of issuers in Europe to test the effects of the inflacitn rate in European Bond Recovery.

The differences between the determinants of the ILF in the Bond and Covered Bond markets must be related to differences in the recovery structure for both types of instrument. Given the assumption of equal default probabilities, such differences should be attributed to the way in which those macro-variables impact fundamentally different recovery structures.

From the above findings we can postulate that the ESTX index and the slope of interest rates are determinants of the recovery rate of Covered Bonds but not of Bonds. Remember that recovery in the case of Bonds depends on the value of the firm after default, whereas recovery for Covered Bonds depends on the value, at default time, of the collateral pool of mortgages. The Eurostoxx and the slope of the interest rate reflect the expectations of the business cycle, and the collateral mortgage pool of the covered bonds could be more sensitive to changes in this variable than to the value of the firm.

The level of interest rates appears to explain the ILF for Bonds and Covered Bond in the same way, and thus we cannot determine whether they have an effect on recovery rates. On the other hand, the HIPC-linked index seems to affect the ILF of Bonds and Covered Bonds differently, and thus it could be a particular determinant of the recovery rate for both. To study how much of this dependence remains when we eliminate the effect of default probabilities from the loss function, in the next section we work with the ratio of ILFs for Bonds and Covered Bonds.

3.4. Implicit Loss Function Ratio Analysis

We construct our implicit loss function ratio (ILFR) as the ratio between the ILF for Covered Bonds and Bonds calibrated in the last section. We expect this ratio to represent the implicit Loss Given Default (LGD) rate ratio between Covered Bonds and Bonds, since the default probability factor should cancel out.

$$ILFR_t^k = \frac{ILF_t^{k,CB}}{ILF_t^{k,B}} = \frac{\lambda_t^k(1-\delta_t^{k,CB})}{\lambda_t^k(1-\delta_t^{k,B})} = \frac{(1-\delta_t^{k,CB})}{(1-\delta_t^{k,B})}$$

Two main assumptions must be considered for the above equation to hold. First, we assume default to be synonymous with bankruptcy of the issuer. This might be a strong assumption, as according to recent literature a default event might arise due to any of several causes including downgrading, restructuring, etc. Despite representing a relatively simplistic view of default, this assumption helps us understand the different phenomena underlying the determination of hazard and recovery rates. In addition, it is difficult to imagine how a financial institution under the supervision of the regulator could be allowed to default on its obligations and nevertheless skip bankruptcy.

The second assumption is that the two functions that comprise the loss LGF (hazard and recovery rate) can indeed be separate functions. This is a common discussion in research jinto intensity models. While it is true that the two functions are heavily integrated and share several common factors, we expect there to be other variables that affect them in a different ways.

Under these assumptions, given that the default probability factor should cancel out, we would expect the ILF ratio to represent the implicit Loss Given Default (LGD) rate ratio between Covered Bonds and Bonds. We anticipate the ILFR to lie between zero and one, as the LGD (recovery rate) for Covered Bonds is lower (higher) than for Bonds. For the same reason we also expect the ILFR to be strictly less than one. Descriptive statistics in

Table 9 show ILFRs higher than one for some days of our estimation period, but median values (means are more influenced by the days when the ratio is higher than one) are always below one and in most cases far below.

We apply the same macro-analysis as in the last section to the ILFR data, carrying out six regressions with the variation in the ILFR as the dependent variable and HIPCLI, ESTX, LTSIR, STSIR, VDAX as explanatory variables. On the basis of our findings in the last section, we expect HIPCLI, ESTX and STSIR all to have explanatory power.

$$\Delta ILFR_i = \varphi_{i,1} + \varphi_{i,2}\Delta HIPCLI + \varphi_{i,3}\Delta ESTX + \varphi_{i,4}\Delta LTSIR + \varphi_{i,5}\Delta STSIR + \varphi_{i,6}\Delta VDAX + \varepsilon_i$$

$$i = \{DP, BHV, MH, CM, CC, CG\}$$

Table 10 presents the estimation results. Contrary to our guess, macroeconomic variables do not seem to have any significant explanatory power on ILFRs except for Caja Galicia and Caja Catalunya. This could indicate that the relationship between the variables is non-linear (although the inclusion of the powers and cross products of the variables gives similar results) or that it is hard to identify the factors that affect the ratio. However, our results show that the LTSIR variable is one of the few explanatory variables remaining in the regressions. In fact the LTSIR parameter for Caja Madrid could be the parameter that causes the ILFR sometimes to exceed one for this particular issuer. The differences between the results for CC and CG and the rest of issuers may be based on a size effect in recoveries that would explain the differences in terms of volume outstanding in fixed income between the two groups, with volumes for the latter group being so much bigger.

Assuming that our model is not misspecified, if the variation of the ILFR is close to zero that would mean that the conditional expectation of ILFR is constant. A constant ILFR appears as a reasonable hypothesis that leads to the possibility of finding the recovery rate for Covered Bonds indirectly from the recovery rate of Bonds.

If there is a link between the two recovery rates, it is very important for practical reasons, especially in the context of the absence of historical data on Covered Bond recoveries and since the study of the performance of the collateral is highly limited to the investor. Rating agencies enjoy better access to such collateral information, and have improved their methods for understanding the risk component underlying recoveries. Nevertheless, neither the philosophy of the scope of the rating analysis carried out by the rating agencies nor the frequency basis on which the information is communicated affords the kind of analysis that practitioners demand.

In order to study whether we could characterize the ILFR as a constant or as time dependent, we implement a statistical test to observe whether the ratio is significantly different from the median or significantly different from a time-moving function. We use one of the family of Kolmogorov- Smirnov tests, implemented by Ferreira and Gil (2004), which allows us to test for equality between two regression functions with a different set of alternatives.

$$H_o : E[LFCB] - E[p \cdot LFB] = m(t) \quad with\ m(t) = 0$$
$$H_1 : E[LFCB] - E[p \cdot LFB] = m(t) \quad with\ m(t) \neq 0$$

Where p is a constant and $m(t)$ is a continuous function that captures the time-varying structure due to the presence of other factors.

Under the null hypothesis

$$z = \frac{1}{\sqrt{\hat{a}}} \max |Sn(t)| \Rightarrow_d \max_{0<v<1} |B(v)|$$

Under the null hypothesis the difference between the unconditional expectations value of the implicit loss functions for CB (LFCB) and a proportion of the unconditional expectations value of the implicit loss functions for CB (LFB) is zero, and therefore the ratio should equal the constant *p*.

Under the alternative we have that the difference is equal to a function of time, and thus the ratio can be decomposed into a constant p plus a changing time function m(t)

Table 11 depicts the value of the *Z* statistic for all firms and critical values for the three values of the constant p: the ratio mean, the ratio median and the unit value. We reject the null hypothesis of a constant ratio for all issuers except CG, for which we cannot reject the null hypothesis when p is assumed to be the mean or the median. This means that we need to identify the variables that affect the ratio in order to express the recovery rate of Covered Bonds as the recovery rate of different but otherwise equivalent Bonds issued by the same issuer. However, we were only able to obtain this information by comparing the results in the macro analisis for the implicit loss functions of the two assets.

3.5. Concluding Remarks

In this work we follow Duffie and Singleton (1999) to obtain an implicit loss function (ILF) for Covered Bonds and Bonds issued by financial institutions in the European Market and study their macroeconomic determinants. We compare the results obtained for the two assets, to find whether they reflect underlying differences in the recovery rate of each instrument. As a complementary analysis we construct an implicit loss function ratio to study the proportion between the two recovery rates and to analyze the possibility of expressing the recovery rate of Covered Bonds as a function of the recovery rate of Bonds from the same issuer.

Our results are very important in several ways. First, we find some evidence in favour of the importance of the level of the interest rate term structure and the HIPC-Linked Inflation Index (HIPCLI) in the recovery rate of European Financial Sector Bonds and Covered Bonds. There are several papers that show the influence of interest rates as a determinant of recovery rates, but to the best of our knowledge this is the first time that evidence in favour of the role of inflation in recovery rates has been found.

Second, we also find that the variation in Eurostoxx has a significative linear effect on the Covered Bond loss function. However, we do not find any similar effect on Bonds, which is consistent with the results found in Altman (2001). All together this means that the Eurostoxx should have some linear effect on the recovery rate of Covered Bonds, and therefore this effect should somehow translate to the ratio between recoveries, expressed as the ratio between the LGDs. However, if this effect remains, the results do not support a linear effect.

Third, the regression analysis results show that the macro variables chosen have a non linear effect on the ratio, and therefore the only way to study the differences between the two recovery rates must be to conduct a separate analysis for each.

Finally, although the sample is assumed to be representative of the market, it is not large enough to make an inference between the ratio of recovery rates for Bonds and CB from the same issuer. That said, results are as would be expected for this asset class. In both cases, the recovery rate depends on the assets on the issuer's balance sheet. The difference in recovery rates can be reasonably explained in terms of the existence of a super-preferential creditor clause enjoyed by CB investors, and also because the collateral pool on CBs does not have to be settled immediately after the issuer has declared bankruptcy. The existence of a relationship between the two recovery rates found seems reasonable.

Our risk neutral assessment of recovery rates in Covered Bonds could be a complement to the usual fundamental and risk management-oriented analysis of rating agencies, which place significant emphasis on structural aspects of instruments such as collateral pool information, legal framework, domestic market idiosyncrasies, tax and liquidity effects, etc.. Here we give an arguably good approximation of recovery rates of Covered Bonds when this relevant information is lacking.

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3.7. Appendix

Table 1: Bond Characteristics

BOND	Issuer	Coupon	Issue	Maturity	Rating	Agency	Amt. Outstanding
DE007789017	DEUTSCHE POSTBANK	6,88	23/07/1997	23/07/2007	AA	FIT	154.937.070
DE251444	BAYERISCHE HYPO UND VEREINSBANK	4,75	27/01/1999	27/01/2009	NR	MOO	200.000.000
DE010048524	BAYERISCHE HYPO UND VEREINSBANK	5,63	08/09/1999	08/09/2009	A-	FIT	200.000.000
DE210366	BAYERISCHE HYPO UND VEREINSBANK	5,5	01/10/1962	01/10/2007	A	FIT	20.451.675
DEBLB003	BAYERISCHE HYPO UND VEREINSBANK	3,64	04/08/2005	23/12/2014	WR	MOO	10.000.000
DE214632	BAYERISCHE HYPO UND VEREINSBANK	4,75	28/08/1998	28/08/2008	AAA	FIT	153.387.564
DE214645	BAYERISCHE HYPO UND VEREINSBANK	4,00	08/12/1998	08/01/2008	AAA	FIT	153.387.564
DE214656	BAYERISCHE HYPO UND VEREINSBANK	4,25	25/03/1999	25/04/2008	AAA	FIT	200.000.000
DE214667	BAYERISCHE HYPO UND VEREINSBANK	5,00	03/08/1999	03/08/2009	AAA	FIT	200.000.000
DEBLB2XL	BAYERISCHE HYPO UND VEREINSBANK	3,25	26/04/2006	26/04/2011	Aaa	MOO	20.000.000
DE101585	MUNCHENER HYPOTHEKENBANK	5,00	10/01/2001	10/01/2011	Aa3	MOO	50.000.000
DE215856	MUNCHENER HYPOTHEKENBANK	4,75	26/01/1999	26/01/2009	NR	MOO	150.000.000
DE101586	MUNCHENER HYPOTHEKENBANK	5,75	17/01/2001	17/01/2011	Aa3	MOO	50.000.000
DE101592	MUNCHENER HYPOTHEKENBANK	5,00	10/08/2001	10/08/2011	Aa3	MOO	50.000.000
ES31495006	CAJA MADRID	5,00	26/12/1997	29/12/2007	AA-	FIT	
ES31495008	CAJA MADRID	4,00	06/10/1998	06/10/2008	AA-	FIT	
ES31495015	CAJA MADRID	3,1	07/04/2004	31/03/2009	Aa1	MOO	
ES31495018	CAJA MADRID	3,5	10/08/2004	10/08/2009	AA-	FIT	
ES31484006	CAJA CATALUYA	3,19	28/12/2004	28/07/2009	A	FIT	
ES31484319	CAJA GALICIA	3,25	02/09/2004	02/09/2009	Aa3	MOO	

Table 2: Covered Bond Characteristics

Covered Bond	Issuer	Coupon	Issue Date	Maturity	Credit Rating	Agency	Amt. Outstanding
DE243098	DEUTSCHE POSTBANK	4,500	21/10/1998	21/10/2008	Aaa	MOO	20.451.675
DE243619	DEUTSCHE POSTBANK	4,125	09/08/1999	09/08/2007	Aaa	MOO	20.000.000
DE243583	DEUTSCHE POSTBANK	4,000	12/01/1999	12/01/2009	Aaa	MOO	50.000.000
DE251520	BAYERISCHE HYPO UND VEREINSBANK	5,500	18/12/1999	18/12/2009	AAA	FIT	30.000.000
DE251541	BAYERISCHE HYPO UND VEREINSBANK	6,000	10/05/2000	10/05/2010	AAA	FIT	50.000.000
DEHV0EB1	BAYERISCHE HYPO UND VEREINSBANK	1,350	03/06/2005	03/06/2008	AAA	FIT	125.000.000
DEHV0A1A	BAYERISCHE HYPO UND VEREINSBANK	2,250	02/03/2004	02/03/2009	AAA	FIT	50.000.000
DEHV0EBA	BAYERISCHE HYPO UND VEREINSBANK	3,500	03/02/2005	03/02/2015	AAA	FIT	1.500.000.000
DEHV0EB4	BAYERISCHE HYPO UND VEREINSBANK	2,500	22/06/2005	22/06/2009	AAA	FIT	1.250.000.000
DEHV0EDW	BAYERISCHE HYPO UND VEREINSBANK	3,750	01/06/2006	01/06/2010	AAA	FIT	20.000.000
DEBLB0T1	BAYERISCHE HYPO UND VEREINSBANK	4,000	31/03/2006	31/03/2010	AAA	S&P	250.000.000
DE212180	BAYERISCHE HYPO UND VEREINSBANK	5,370	03/01/2001	03/01/2011	AAA	FIT	200.000.000
DE213105	BAYERISCHE HYPO UND VEREINSBANK	5,250	13/03/2001	13/03/2009	AAA	FIT	1.500.000.000
DE212198	BAYERISCHE HYPO UND VEREINSBANK	3,150	06/06/2003	06/11/2007	AAA	FIT	50.000.000
DE212175	BAYERISCHE HYPO UND VEREINSBANK	4,000	12/01/1999	12/01/2009	AAA	FIT	300.000.000
DEBLB1YQ	BAYERISCHE HYPO UND VEREINSBANK	3,250	08/06/2005	08/06/2015	Aaa	MOO	1.250.000.000
DE212200	BAYERISCHE HYPO UND VEREINSBANK	2,250	27/06/2003	27/06/2008	AAA	FIT	200.000.000
DE147622	BAYERISCHE HYPO UND VEREINSBANK	3,650	04/08/2003	04/12/2008	AAA	FIT	50.000.000
DEBLB0T2	BAYERISCHE HYPO UNDVEREINSBANK	4,000	30/06/2006	30/06/2010	AAA	S&P	75.000.000

DE213107	BAYERISCHE HYPO UND VEREINSBANK	3,750	23/05/2003	23/05/2011	AAA	FIT	1.750.000.000
DE147616	BAYERISCHE HYPO UND VEREINSBANK	3,950	01/07/2003	29/10/2010	AAA	FIT	50.000.000
DEMHB002	MUNCHENER HYPOTHEKENBANK	4,000	11/07/2006	12/07/2010	Aaa	MOO	20.000.000
DEA0BNTF	MUNCHENER HYPOTHEKENBANK	3,000	03/11/2004	17/11/2008	Aaa	MOO	50.000.000
DEA0D4JU	MUNCHENER HYPOTHEKENBANK	1,7500	20/06/2005	22/06/2009	Aaa	MOO	50.000.000
DE533547	MUNCHENER HYPOTHEKENBANK	4,5000	03/01/2003	03/01/2013	Aaa	MOO	15.000.000
DE215870	MUNCHENER HYPOTHEKENBANK EG	5,7500	04/09/2000	03/09/2010	Aaa	MOO	1.000.000.000
DEA0EY1S	MUNCHENER HYPOTHEKENBANK	2,8750	21/09/2005	23/08/2013	Aaa	MOO	10.000.000
	CAJA MADRID	3,7500	22/10/2003	22/10/2009	Aaa	MOO	
	CAJA MADRID	5,5000	08/10/1999	15/01/2010	AA-	FIT	
	CAJA MADRID	5,2500	01/03/2002	01/03/2012	Aaa	MOO	
ES0414950610	CAJA MADRID	3,5000	25/03/2004	25/03/2011			2.000.000.000
ES0414950594	CAJA MADRID	5,0000	30/10/2002	30/10/2014			1.500.000.000
ES0414950636	CAJA MADRID	3,5000	14/12/2005	14/12/2015			2.000.000.000
ES0414950560	CAJA MADRID	5,7500	29/06/2001	29/06/2016			1.000.000.000
ES0414950669	CAJAMADRID	4,2500	05/07/2006	05/07/2016			2.500.000.000
ES0414950651	CAJA MADRID	4,2500	25/05/2006	25/05/2018			2.000.000.000
ES0414950628	CAJA MADRID	4,0000	03/02/2005	03/02/2025			2.000.000.000
ES0414950644	CAJA MADRID	4,1250	24/03/2006	24/03/2036			1.500.000.000
ES0414840274	CJ CATALANA	3,5000	07/03/2006	07/03/2016			1.750.000.000
ES0414840290	CJ CATALANA	4,0150	09/11/2006	09/11/2016			150.000.000
ES0414843146	CAJA GALICIA	4,3750	23/01/2007	23/01/2019			1.500.000.000

Table 3: Correlations

	ΔHIPCLI	ΔESTX	ΔLTSIR	ΔPTSIR	ΔVDAX
ΔHIPCLI	1	0.0384	0.4744	0.3823	-0.0382
ΔESTX		1	0.1821	0.0675	-0.7933
ΔLTSIR			1	0.4707	-0.1803
ΔPTSIR				1	-0.0244
ΔVDAX					1

Table 4. Descriptive Statistics for the Implicit Loss Function

BONDS						
	ILF_{DP}	**ILF_{BHV}**	**ILF_{MH}**	**ILF_{CM}**	**ILF_{CC}**	**ILF_{CG}**
Mean	0.034632	0.005637	0.008067	0.002829	0.007107	0.006083
Median	0.032585	0.004450	0.009678	0.002868	0.006441	0.006756
Maximum	0.075478	0.013912	0.015391	0.007781	0.010934	0.010224
Minimum	0.010349	0.001571	0.000102	0.000108	0.000969	0.000196
Std. Dev.	0.015719	0.003027	0.004669	0.001938	0.002108	0.002960
COVERED BONDS						
	ILF_{DP}	**ILF_{BHV}**	**ILF_{MH}**	**ILF_{CM}**	**ILF_{CC}**	**ILF_{CG}**
Mean	0.007152	0.003168	0.001479	0.002667	0.001885	0.001245
Median	0.007448	0.003210	0.001355	0.002751	0.002073	0.001226
Maximum	0.011300	0.005343	0.005152	0.004667	0.003996	0.001950
Minimum	0.002246	0.000513	0.000127	0.000717	0.000114	0.000621
Std. Dev.	0.002287	0.000929	0.000728	0.000725	0.001005	0.000272

Table 5: BONDS						
	ΔILF_{DP}	ΔILF_{BVH}	ΔILF_{MH}	ΔILF_{CM}	ΔILF_{CC}	ΔILF_{CG}
K	0.0001 (1.620)	1.2E-05 (0.622)	4.3E-05 (1.628)	2.1E-05 (1.190)	3.1E-05 (1.451)	1.4E-05 (0.619)
$\Delta HIPCLI$	0.0012 (0.437)	**0.0016** **(2.223)**	**0.0037** **(3.580)**	**0.0023** **(3.568)**	**0.0067** **(7.909)**	**0.0007** **(0.819)**
$\Delta ESTX$	2.7E-06 (1.145)	1.4E-07 (0.230)	1.1E-06 (1.390)	7.1E-07 (1.298)	7.4E-07 (1.141)	9.6E-07 (1.313)
$\Delta LTSIR$	**-0.0049** **(-1.895)**	**-0.0081** **(-11.847)**	**-0.0080** **(-8.622)**	**-0.0066** **(-11.100)**	**-0.0082** **(-11.092)**	**-0.0053** **(-6.562)**
$\Delta STSIR$	-0.0005 (-0.159)	0.0005 (0.663)	**0.0025** **(2.220)**	-0.0005 (-0.700)	0.0003 (0.381)	-0.0006 (-0.615)
$\Delta VDAX$	0.0001 (0.909)	-1.2E-05 (-0.334)	-5.3E-06 (-0.104)	3.1E-05 (0.981)	1.2E-05 (0.314)	1.8E-05 (0.412)
$Adj\ R^2$	0.0034	0.2480	0.1270	0.2281	0.2567	0.1090
SSR	0.0013	9.5E-05	0.0001	7.5E-05	7.2E-05	0.0001

Explaining the changes in the Implicit Loss Function of each Bond issuer using changes in market variables; HIPC-linked inflation Index, Eurostoxx 50 Index, the level and slope of the term structure of interest rates and implied volatility of the DAX Index. All parameters are obtained by a SURE estimation. T-statistics are reported below the coefficient values. Bold type shows significant variables at 5% significance level.

Table 6: COVERED BONDS						
	ΔILF_{DP}	ΔILF_{BVH}	ΔILF_{MH}	ΔILF_{CM}	ΔILF_{CC}	ΔILF_{CG}
K	3.0E-05 (1.373)	3.7E-06 (0.328)	1.1E-05 (0.822)	-4.2E-06 (-0.419)	1.9E-06 (0.145)	9.3E-06 (0.443)
$\Delta HIPCLI$	**0.0024** **(2.917)**	**0.0051** **(11.467)**	**0.0054** **(9.867)**	**0.0069** **(17.561)**	**0.0064** **(11.135)**	**0.0052** **(4.939)**
$\Delta ESTX$	1.04E-06 (1.499)	**8.2E-07** **(2.235)**	**9.8E-07** **(2.185)**	2.4E-07 (0.754)	**6.8E-07*** **(1.752)**	**1.0E-06*** **(1.787)**
$\Delta LTSIR$	-0.0066 (-8.525)	**-0.0072** **(-18.581)**	**-0.0073** **(-14.573)**	**-0.0074** **(-20.818)**	**-0.0075** **(-15.533)**	**-0.0067** **(-6.421)**
$\Delta STSIR$	0.0008 (0.9301)	-0.0004 (-0.873)	-0.0006 (-1.030)	**-0.0027** **(-6.369)**	**-0.0019** **(-3.271)**	**-0.0040** **(-3.98)**
$\Delta VDAX$	2.3E-06 (0.058)	1.2E-05 (0.572)	9.2E-06 (0.348)	9.6E-06 (0.508)	-2.7E-06 (-0.110)	3.1E-05 (0.726)
Adj R^2	0.1252	0.4336	0.3285	0.5582	0.4942	0.5372
SSR	0.0001	3.41E-05	5.10E-05	2.65E-05	1.76E-05	2.42E-06

Explaining the changes in the Implicit Loss Function of each Covered Bond issuer using changes in market variables; HIPC-linked inflation Index, Eurostoxx 50 Index, the level and slope of the term structure of interest rates and implied volatility of the DAX Index. All parameters are obtained by a SURE estimation. T-statistics are reported below the coefficient values. Bold type shows significant variables at 5% significance level. * shows significant variables at 5% significance level.

Table 7: Wald Test of Table 5		
Null Hypthesis	Chi-square Stat.	*P*-value
$\beta^{B}{}_{2,2} = \beta^{B}{}_{2,3} = \beta^{B}{}_{2,4} = \beta^{B}{}_{2,5}$	28.58	0.000003
$\beta^{B}{}_{2,2} = \beta^{B}{}_{2,3}$	2.77	0.095827
$\beta^{B}{}_{2,4} = \beta^{B}{}_{2,5}$	21.10	0.000004
$\boldsymbol{\beta^{B}{}_{4,1} = \beta^{B}{}_{4,2} = \beta^{B}{}_{4,3}}$	**1.41**	**0.492149**
$\beta^{B}{}_{4,4} = \beta^{B}{}_{4,5} = \beta^{B}{}_{4,6}$	7.289	0.026131
Bold type shows that we cannot reject the null hypothesis for significant variables at 5% significance level.		

Table 8. Wald Test for Table 6		
Null Hypothesis	Chi-square Stat.	*P*-value
$\beta^{CB}{}_{1,2} = \beta^{CBs}{}_{2,2} = \beta^{CBs}{}_{3,2} = \beta^{CBs}{}_{4,2} = \beta^{CBs}{}_{5,2} = \beta^{CBs}{}_{6,2}$	28.11	0.0000
$\beta^{CBs}{}_{1,2} = \beta^{CBs}{}_{2,2} = \beta^{CBs}{}_{3,2}$	11.63	0.0029
$\boldsymbol{\beta^{CBs}{}_{4,2} = \beta^{CBs}{}_{5,2} = \beta^{CBs}{}_{6,2}}$	**3.43**	**0.1796**
$\boldsymbol{\beta^{CBs}{}_{5,3} = \beta^{CBs}{}_{6,3}}$	**0.29**	**0.5885**
$\boldsymbol{\beta^{v}{}_{1,4} = \beta^{CBs}{}_{2,4} = \beta^{CBs}{}_{3,4} = \beta^{CBs}{}_{4,4} = \beta^{CBs}{}_{5,4} = \beta^{CBs}{}_{6,4}}$	**2.34**	**0.7999**
$\boldsymbol{\beta^{CBs}{}_{4,5} = \beta^{CBs}{}_{5,5} = \beta^{CBs}{}_{6,5}}$	**4.01**	**0.1352**
Bold type shows that we cannot reject the null hypothesis for significant variables at 5% significance level.		

Table 9. Descriptive Statistics for the Implicit Loss Function Ratio

	$ILFR_{DP}$	$ILFR_{BHV}$	$ILFR_{MH}$	$ILFR_{CM}$	$ILFR_{CC}$	$ILFR_{CG}$
Mean	0.6988	0.2623	0.5629	2.4278	0.2664	0.2333
Median	0.6834	0.2133	0.2163	0.8946	0.3462	0.2335
Maximum	2.1141	1.0635	10.449	11.958	0.6904	0.3367
Minimum	0.1420	0.0771	0.0143	0.1704	0.0122	0.1362
Std. Dev.	0.3570	0.1969	1.1540	2.9168	0.1537	0.0388

Table 10: ILF RATIOS

	$\Delta ILFR_{DP}$	$\Delta ILFR_{BVH}$	$\Delta ILFR_{MH}$	$\Delta ILFR_{CM}$	$\Delta ILFR_{CC}$	$\Delta ILFR_{CG}$
K	0.0006 (0.343)	-0.0013 (-0.312)	-0.0069 (-0.174)	-0.0407 (-0.628)	-0.0003 (-0.165)	0.0009 (0.223)
ΔHIPCLI	0.1022 (1.446)	**0.6528** **(3.823)**	-1.8119 (-1.162)	-2.2371 (-0.881)	**0.5282** **(5.721)**	**0.7675** **(3.564)**
ΔESTX	-1.2E-05 (-0.212)	0.0001 (1.018)	-0.0001 (-0.094)	-0.0028 (-1.391)	4.2E-05 (0.638)	0.0002 (1.807)
ΔLTSIR	**-0.1996** **(-3.106)**	-0.2160 (-1.392)	0.6871 (0.484)	**9.6017** **(4.161)**	**-0.7391** **(-9.009)**	**-0.9764** **(-4.638)**
ΔSTSIR	0.0501 (0.639)	-0.0925 (-0.489)	-2.1935 (-1.269)	-3.2464 (-1.153)	**-0.2852** **(-2.873)**	**-0.7278** **(-3.535)**
ΔVDAX	-0.0026 (-0.789)	-0.0001 (-0.023)	-0.0003 (-0.004)	-0.0819 (-0.004)	-0.0014 (-0.671)	0.0073 (-0.338)
Adj R^2	0.0202	0.0215	0.0083	0.0350	0.2781	0.4404
SSR	0.812	4.753	394.737	1048.226	0.468	0.096

Explaining the changes in the Implicit Loss Function Ratio between Covered Bonds and Bonds from the same issuer using changes in market variables; HIPC-linked inflation Index, Eurostoxx 50 Index, the level and slope of the term structure of interes rates and implied volatility of the DAX Index. All parameters are obtained by a SURE estimation. T-statistics are reported below the coefficient values. Bold type shows significant variables at 5% significance level.

Table 11: Kolmogorov-Smirnov Test

	DP	**BHV**	**MH**	**CM**	**CC**	**CG**
P = mean	75.50	43.82	51.21	24.87	15.89	1.37
P = median	74.56	52.81	12.45	17.47	21.01	1.38
P = 1	88.04	38.81	70.23	13.64	137.28	33.58

The table shows the test statistics of Ferreira and Gil (2004) for the null hypothesis of an Implicit Loss Function Ratio between Bonds and Covered Bonds equal to a proportional constant. Bold type shows that we cannot reject the null hypothesis. Critical-values : 2 (10%), 2.24 (5%)

4 Conclusiones finales

En este trabajo de Investigación se ha analizado las características del Mercado de Coverd Bonds Europeo desde varias perspectivas partiendo del caso Español. Primero el análisis se ha enfocado en la valoración y pricing de los CBs desde el punto de vista de un inversor que no tiene acceso a las características del colateral, para lo que se ha trabajado dentro del contexto de los modelos reducidos para la valoración de activos con riesgo de crédito. En segundo lugar el análisis se ha centrado en la tasa de recuperación de estas emisiones y su relación con la tasa de recuperación de otros bonos del mismo emisor.

El análisis realizado supone una aportación a la literatura sobre CBs tanto en términos cualitativos como cualitativos, ya que a pesar de la importancia de dichos activos solo existe literatura descriptiva de estos activos por parte de las entidades financieras emisoras, agencias de rating y órganos regulatorios europeos. En estos estudios se pone de manifiesto la importancia de dichos activos, sus características específicas y el enfoque dado por las agencias de rating para asignar el máximo nivel crediticio a la mayoría de las emisiones de CBs.

Los últimos sucesos en el mercado, las consecuencias de la "crisis de la liquidez", ponen de manifiesto la necesidad de profundizar en mayor medida en estos activos. Como consecuencia de la "crisis de la liquidez" los spreads pagados por estos activos, al igual que el de otros muchos activos con riesgo de crédito, se han incrementado muy por encima de lo que se podría esperar dado su calidad crediticia, ya que el mercado europeo no se han debilitado la calidad de las garantías. El principal efecto en el mercado ha sido una menor colocación de nuevas emisiones y la disminución de la negociación de estos activos. A pesar de los acontecimientos sucedidos, desde el verano del 2007 no se han dejado de realizar emisiones de CBs, aunque en muchos casos los propios emisores han sido los inversores finales. El incentivo para los emisores seguía siendo la utilización de los CBs como medio de financiación, ya que han podido utilizar los CBs como garantías para cubrir sus necesidades de liquidez.

Los resultados obtenidos en el primer capítulo, en el que se analizan las emisiones españolas, muestran que las variables macroeconómicas utilizadas como representantes de los tipos de interés y el ciclo económico ayudan a explicar la dinámica de los spread entre las CBs españoles y el activo libre de riesgo, especialmente a largo plazo. Las características propias de cada emisión ayudan a explicar una parte de las diferencias entre el nivel de los spreads de distintas emisiones. Los resultados obtenidos permiten identificar variables especificas tanto a nivel de los activos como al nivel de los emisores, lo que contrasta con la identificación de la función de perdidas con el rating del emisor. Las variables especificas de los activos explican solo una pequeña parte del nivel de los diferenciales de credito, especialmente si se comparan con los niveles de los diferenciales de credito entre las emisiones españolas y sus homologas europeas, especialmente las alemanas. Estas diferencias pueden recoger las discrepancias entre la legislación española sobre cedulas hipotecarias y sus homologas europeas, o deberse un exceso de oferta en el mercado de CBs españolas debído al boom de la vivienda durante 2002 y 2007.

Ya que el mercado de Covered Bonds es especialmente un mercado europeo liderado por Alemania, parece necesario, al tratar de encontrar las variables necesarias para postular un correcto modelo de valoración y pricing de estas emisiones, hacerlo dentro este marco. En el segundo capítulo a partir de emisiones de Alemania, Francia y España, analizamos las interrelaciones de los tres mercados, para estudiar que variables habría que considerar al especificar la función de perdidas del modelo. A partir del análisis de spread medio de cada país extraemos los siguientes resultados: Primero que, como esperábamos, el mercado alemán esta liderando los movimientos en el mercado europeo de CBs auque también habría que tener en cuenta los movimientos pasados en cada mercado. Segundo que las variables introducidas que recogen los efectos de tipo de interés y ciclo económico son relevantes a la hora de explicar la dinámica en los spread de crédito, especialmente los tipos de interés para el mercado francés y alemán y el ciclo económico, representado por un indice del mercado de renta variable europeo, para el mercado de CBs español. La relación existente entre estas variables y los diferenciales de credito es la esperada; los resultados muestran una relación negativa entre el nivel y la pendiente de la estructura temporal de tipos de interes. Al igual que una relación negativa con el ciclo ecomomico. Estos resultados son robustos independientemente de considerar la estacionariedad o no-estacionariedad de las variables independientes y confirman los obtenidos en el estudio del caso español en el primer capítulo.

A partir de estos resultados se ha propuesto como modelo de valoración *(pricing)* una adaptación del modelo de Jarrow 2001, en el que además de las variables relevantes de dicho modelo (tipo spot y índice de mercado) se ha introducido la dinámica del mercado alemán así como la de cada mercado local. Se han calibrado y estresado diferentes versiones de estos modelos, utilizando como benchmark el modelo de Jarrow. La comparación entre los distintos modelos se ha realizado tanto a través de la comparación de los ECM como de las diferencias estadísticas entre las series de errores. Los resultados obtenidos muestran que esta clase de modelos funcionan muy bien en un grupo de CBs “grupo adecuado”, aunque no se han conseguido identificar las características que conforman a dicho grupo. En casi todos los casos, aunque especialmente en el grupo adecuado” la inclusión de una variable que recoja la dinámica en el

mercado alemán mejora los resultados obtenidos por el benchmark, mientras que la inclusión de la variable local solo mejora algunos de los casos (especialmente en los activos españoles).
La obtención de un modelo de valoración óptimo para estos activos, en funcion de indicadores economicos es especialmente util en un contexto de falta de liquidez, en el que es difícil observar precios de mercado para estos activos o cuando no se dispone de toda la información sobre el colateral asociado. Así nuestro modelo de valoración nos puede permitir obtener un valor razonable para estos activos, comparar activos de distintos emisores y mercados como objetivos de inversión , o analizar el comportamiento de una cartera de CBS ante condiciones de estrés del mercado (*stress testing*) creando escenarios estresados de las variables economicas.

El tercer capítulo está enfocado en el estudio de los determinantes de la Recovery Rate. Obteniendo una función de perdidas implícita para Bonos y CBs del mismo emisor, a través de la comparación de ambos resultados, podemos identificar alguna de las diferencias que conforman la Recovery Rate de cada activo. Para completar el análisis hemos construido un ratio entre las funciones de perdidas implícitas (LGDR), en el que solo esperaríamos encontrar las diferencias entre las tasa de recuperación de ambos activos..

El análisis entre ambas funciones de perdidas implícitas muestra la influencia del nivel de la estructura de tipos de interés y de la inflación (medido a partir del índice HIPCLI) en la recovery de ambos activos. Numerosos trabajos muestran la influencia de los tipos de interés como determinante de la Recovery Rate, pero hasta nuestro conocimiento, ninguno muestra la influencia de la inflación. Por otra parte hemos encontrado que la variable Eurostoxx solo tienen un efecto significativo linear en la recovery de los CBs, y no en la recovery de los bonos, aunque este efecto no ha sido confirmado en el estudio del Ratio entre funciones de pérdidas implícitas

Por otra parte los resultados en el análisis del LGDR sugieren que la tasa de recuperación entre bonos y CBs no se mantiene constante a lo largo del tiempo, lo que sería consistente con la idea de que el mercado percibe una diferente evolución de ambas tasas de recuperación, a pesar de que ambos activos provienen de un mismo emisor.

La muestra analizada, aunque representativa del mercado, es escasa para establecer de forma univoca un criterio entre la relacion de la tasa de recuperación entre Bonos y CBs del mismo emisor, pero los resultados obtenidos concuerdan con lo esperable para esta clase de activos ya que en ambos casos la tasa de recuperación dependera de los activos en el balance de la entidad fianaciera emisora. La diferencia entre la tasa de recuperación de ambos activos difiere por la clausula de "acreedor preferencial" que los CBs confieren a sus inversores, y por la carcteristica de que la cartera que actua de garantia no necesita ser liquidada en el instante de quiebra del emisor. Por lo que parece razonable establecer una relacion entre las tasas de recuperación de ambos activos.

Los resultados obtenidos nos permiten relacionar las variables que afectan a ambas tasas de recuperación relacionando los resultados obtenidos al estudiar por separado las funciones de perdidas implicitas. Por lo que supone un analisis complementario al realizado por las agencias de rating a traves de su "analisis de experto" para los CBs. Una base de datos más profunda permitirá confirmar los resultados obtenidos y establecer una relacion más rigurosa entre las tasas de recuperación de ambos activos, no solo en terminos del emisor sino tambien del vencimiento de los activos.

Los resultados obtenidos en este trabajo se constriñen a las características del mercado de CBs antes de la crisis de 2007 y por lo tanto la extensión natural del trabajo será estudiar las características del mercado ante el nuevo prisma post-crisis. La primera lección que aprendida de los últimos acontecimientos sería la relación existente entre spread y fragilidad del nivel crediticio, así al inicio de este trabajo nos preguntábamos el porque de la diferencia de entre los spreads ofrecidos sobre el libre de riesgo de las emisiones de CBs catalogadas como AAA y otras emisiones con la misma calidad crediticia. Los últimos movimientos de los mercados nos permiten deducir una razón plausible para esta diferencia, hemos podido identificar como el mercado no solo tiene en cuenta la calidad crediticia de los activos sino también su estabilidad, así los activos con una mayor volatilidad o más sensibles al "contagio" son aquellos en los que el mercado estaba descontando una mayor rentabilidad por nivel de riesgo.

Por otra parte durante los ultimos meses la crisis de las hipotecarias Fanny Mae y Freddi Mac ha puesto en entredicho la función que dichas empresas semi-publicas prestan al sistema financiero, y a situado a los covered bonds como posible solución para la financiación hipotecaria. Como se puso de manifiesto en el "Mortgage Lending Forum 2008" en Virginia donde se expuso que el gobierno estaba trabajando con el Deposit Insurance Corp. Federal, la Reserva Federal y otras oficinas federales para explorar el potencial de los CBs, descritos como el "promising vehicle" que permitia incrementar el acesso a la financiación hipotecaria. Las emisiones de CBs en Europa estan respaldadas por la legislación especifica que cada país tiene sobre estos activos, por lo tanto parece necesario la creación de un marco judirico ad hoc en el mercado americano para que dichas emisiones tengan cabida en su mercado. La evolución de este mercado tendrá consecuencias interesantes para el mercado internacional de bonos, el estudio realizado sobre el mercado europeo de CBs nos permitirá analizar con una mejor perspectiva la evolución de este mercado.

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