Staff memo

Lämplig kapitalnivå i svenska storbanker – nya perspektiv

Johan Almenberg
Markus Andersson
Daniel Buncic
Cristina Cella
Paolo Giordani
Anna Grodecka
Kasper Roszbach
Gabriel Söderberg

Avdelningen för Finansiell Stabilitet

maj 2017

SVERIGES RIKSBANK

I ett staff memo kan medarbetare på Riksbanken offentliggöra lite längre kvalificerade analyser i relevanta frågor. Det är en tjänstemannapublikation som är fri från policyslutsatser och individuella ställningstaganden i aktuella policyfrågor. Staff memo godkänns av berörd avdelningschef.

Detta staff memo är framtaget av medarbetare från utrednings- och modellenheten samt enheten för finansiell policy och analys vid Riksbankens avdelning för finansiell stabilitet. Avdelningen ansvarar bland annat för Riksbankens arbete med att främja stabilitet och effektivitet i betalningsväsendet genom att övervaka, delta i regleringsarbete samt sprida information och på andra sätt verka för att förebygga risker i det finansiella systemet.

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Sammanfattning[1]

Riksbanken publicerade 2011 en studie om lämpliga kapitalnivåer för svenska banker där samhällsnyttan av högre kapitalnivåer vägdes mot eventuella samhällsekonomiska kostnader. Flera faktorer talar för att den samhällsekonomiska vinsten av högre kapitalnivåer för banker kan ha underskattats. En anledning är att tidigare studier kan ha underskattat vad en kris skulle kosta samhället. Den utdragna ekonomiska återhämtningen har visat att effekterna av den senaste globala finanskrisen har varit allvarliga och skapat större samhällsekonomiska kostnader, inte minst i Europa, än studier hade visat innan. Därtill kan tidigare studier ha överskattat vilka långsiktiga kostnader högre kapitalnivåer för banker kan medföra för samhället. Flera nya studier har också konstaterat att det kan vara samhällsekonomiskt motiverat med högre kapitalnivåer.

Mot denna bakgrund har Riksbanken gjort nya beräkningar av lämpliga kapitalnivåer, vilka redovisas i detta staff memo. Vi utgår ifrån samma tankeram som i riksbanksstudien från 2011 men nu med fokus på bruttosoliditet i stället för riskviktade kapitalmått. Vi beaktar också ny forskning som har tillkommit sedan 2011. I vår analys väger vi, liksom tidigare, eventuella förväntade samhällsekonomiska kostnader av högre kapitalnivåer mot den förväntade samhällsekonomiska vinsten. Kostnaden grundar sig i att högre kapitalnivåer kan öka bankernas finansieringskostnad vilket kan göra det dyrare för deras kunder att låna till investeringar och därmed kan BNP-nivån bli lägre. Denna kostnad ska vägas mot fördelen av att sannolikheten för bankkriser minskar om bankerna har mer kapital som en buffert mot stora förluster. Det är värdefullt eftersom kriser kan vara mycket kostsamma för samhället.

Våra beräkningar indikerar att högre kapitalnivåer än de som de svenska storbankerna har idag skulle ge en begränsad samhällsekonomisk kostnad, samtidigt som vi bedömer att en minskad risk för en svensk finanskris kan väntas medföra en vinst för samhällsekonomin. Sammantaget innebär det att även en förhållandevis liten minskning av sannolikheten för en kris kan vara tillräcklig för att det ska vara samhällsekonomiskt motiverat med högre kapitalnivåer än de bankerna har idag.

Beroende på vilka antaganden man gör ger beräkningarna stöd för att en samhällsekonomiskt väl avvägd nivå för svenska storbankers bruttosoliditet ligger någonstans i intervallet 5 till 12 procent. Beräkningarna är dock kringgärdade av stor osäkerhet.

[1] Vi vill tacka Stephen G. Cecchetti, Ingo Fender, Reimo Juks, Daria Finocchiaro, Xin Zhang, Thomas Jansson, Jens Iversen, Annukka Ristiniemi, Magnus Jonsson, Peter van Santen, Tomas Edlund och Yildiz Akkaya för kommentarer på tidigare versioner.

Lämplig kapitalnivå i svenska storbanker – nya perspektiv

Riksbanken publicerade 2011 en studie om lämpliga kapitalnivåer för svenska banker. I studien bedömdes en lämplig kapitalnivå ligga i intervallet 10-17 procent av riskvägda tillgångar. I slutet av 2011 slöt svenska myndigheter en överenskommelse att svenska storbanker ska ha kärnprimärkapital på minst 12 procent av sina riskvägda tillgångar.

Flera faktorer talar för att tidigare studier av optimala kapitalnivåer kan ha underskattat vilken samhällsekonomisk vinst högre kapitalnivåer skulle ge. En anledning är att studierna kan ha underskattat vad en kris kan kosta samhället. Den utdragna ekonomiska återhämtningen, i inte minst Europa, har med tiden visat att den senaste finanskrisen har medfört stora samhällsekonomiska kostnader. Det har också visat sig att länder med välkapitaliserade banker tenderar att återhämta sig bättre efter kriser (Jordà et al, 2017). Därtill kan tidigare studier, som exempelvis BCBS (2010), ha överskattat den negativa effekten av högre kapitalnivåer på bankernas finansieringskostnad och i förlängningen kostnaden för företag att finansiera produktiva investeringar. Flera nya studier som exempelvis Dagher et al. (2016), Federal Reserve Bank of Minneapolis (2016) och Firestone et al. (2017) finner att det kan vara samhällsekonomiskt lönsamt med höga kapitalkrav.

För svensk del har eventuella negativa effekter av höjda kapitalkrav visat sig vara begränsade. Bankernas lönsamhet har fortsatt att vara god och kreditgivningen har fortsatt att vara expansiv. För svenska banker har höjda kapitalkrav sammanfallit med en minskning av deras riskvikter och därmed en begränsad ökning av kapitalet i förhållande till bankernas balansomslutning. Det kan vara en förklaring till den fortsatt goda lönsamheten och starka kreditgivningen. Användningen av interna metoder för att beräkna kapitalkrav har över tid inneburit lägre riskvikter som gör att kapitaltäckningen stiger för en given mängd kapital. Men även om den riskviktade kapitalrelationen har ökat så har bankerna sannolikt inte ökat sin motståndskraft i samma utsträckning. Därför fokuserar vi i denna studie på bruttosoliditet i stället för riskviktade kapitalmått.

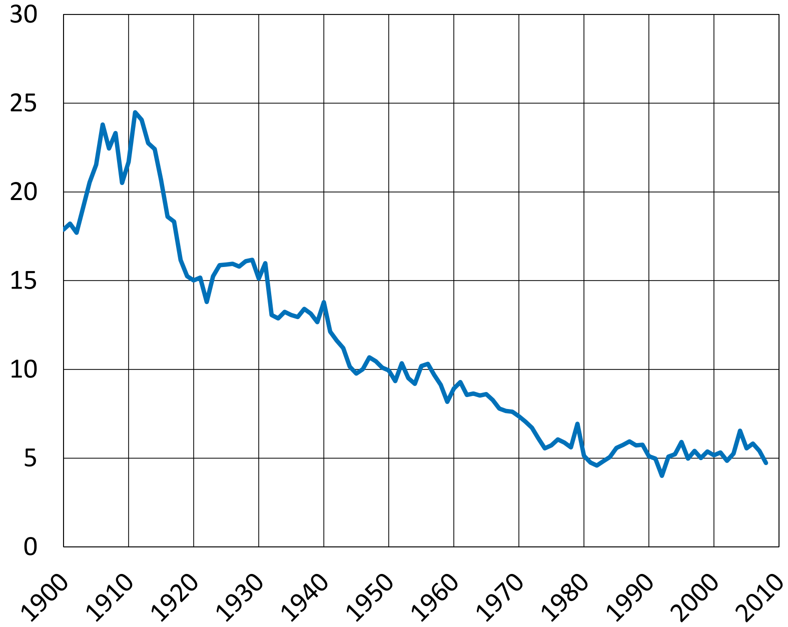
Mot denna bakgrund redovisar vi här nya beräkningar av lämpliga kapitalnivåer för svenska storbanker. Analysen bygger på samma tankeram som Sveriges riksbank (2011) men beaktar ny forskning på området som tillkommit sedan 2011. Utifrån de antaganden som görs i studien så ger beräkningarna stöd för att en samhällsekonomiskt väl avvägd nivå för svenska storbankers bruttosoliditet kan ligga någonstans i intervallet 5 till 12 procent. Eftersom resultaten i vår studie delvis bygger på data från en period då det inte fanns riskvikter för svenska bankers tillgångar medför en direkt översättning av den beräknade bruttosoliditeten till en riskviktad kapitalnivå en del tolkningssvårigheter. Det beräknade intervallet för bruttosoliditeten skulle i en rak översättning med dagens riskvikter innebära en kapitalnivå på cirka 25-60 procent av svenska storbankers riskviktade tillgångar.

Varför behövs kapitalkrav för banker?

De svenska storbankerna finansierar sig i hög utsträckning med lånat kapital, det vill säga skulder, jämfört med andra företag som i större utsträckning finansierar sig med eget kapital. I diagram 1 framgår att svenska bankers eget kapital som andel av totala tillgångar är låg ur ett historiskt perspektiv. Deras eget kapital uppgår i dag till omkring fem procent av de totala tillgångarna.

Diagram 1. Svenska bankers eget kapital som andel av totala tillgångar 1870-2008

Procent



Källa: Hortlund (2005, 2008).

För bankernas aktieägare kan den höga belåningsgraden ge hög avkastning på aktiekapitalet i goda tider. Nackdelen är att bankernas möjligheter att hantera stora förluster försämras när det egna kapitalet endast utgör en liten del av den totala finansieringen. Ju högre belåningsgrad, desto mer riskfylld är bankens verksamhet – både för aktieägarna och för samhället.

Banker tillhandahåller viktiga funktioner i ekonomin och om en enskild bank får problem så riskerar det att ge upphov till omfattande störningar i den övriga ekonomin. Dessutom är de svenska storbankerna sammanlänkade, bland annat eftersom de äger varandras säkerställda obligationer och är exponerade mot samma sektorer, vilket innebär att problem i en bank riskerar att sprida sig till de övriga.

Om en enskild bank inte beaktar att dess risktagande kan påverka andra aktörer i ekonomin negativt kan banken komma att ta för stora risker ur ett samhällsekonomiskt perspektiv. Banken bär ju inte själv de fulla konsekvenserna om utfallet av risktagandet blir dåligt. Vad som är en lämplig nivå på bankers eget kapital är därför sannolikt högre ur ett samhällsekonomiskt perspektiv än ur bankernas eget perspektiv.[2] Därmed kan kapitalkrav

[2] Sveriges riksbank (2011).

som säkerställer att banker håller en viss miniminivå av eget kapital bidra till en mer effektiv resursallokering.[3,4]

Kostnad och vinst av högre kapitalnivåer

Vad som är en samhällsekonomiskt lämplig nivå för bankers eget kapital kan analyseras på olika sätt. Till exempel kan man utföra stresstester som bedömer vilka kapitalnivåer som är lämpliga för att banker ska kunna stå emot olika typer av chocker. I den här studien har vi i stället tagit oss an frågan i samma anda som Baselkommitténs Long-term Economic Impact-studie från 2010 och riksbanksstudien Lämplig kapitalnivå i svenska storbanker från 2011, hädanefter BCBS (2010) respektive Sveriges riksbank (2011). De här två studierna utgår ifrån en tankeram där förväntade samhällsekonomiska kostnader av högre kapitalnivåer vägs mot den förväntade samhällsekonomiska vinsten.

Den samhällsekonomiska kostnaden beror på att högre kapitalnivåer kan öka bankernas finansieringskostnad. Om så är fallet och bankerna för över den kostnadsökningen på sina kunder blir det dyrare att låna i bankerna, vilket kan ge minskade investeringar och en lägre BNP-nivå.

Den samhällsekonomiska vinsten beror på att sannolikheten för en bankkris minskar om bankerna har mer eget kapital som kan utgöra en buffert i händelse av stora oväntade förluster. Det är värdefullt eftersom bankkriser kan medföra stora kostnader för samhället.

Skillnaden mellan kostnaden och vinsten ger oss den samhällsekonomiska nettobehållningen. Genom att beräkna kostnad och vinst vid gradvis högre kapitalnivåer kan man bilda sig en uppfattning om hur den samhällsekonomiska nettobehållningen utvecklas på marginalen, det vill säga hur nettobehållningen ändras om man tillför ytterligare eget kapital vid olika kapitalnivåer. Denna tankeram sammanfattas i Tabell 1.

Tabell 1. Tankeram

Samhällsekonomisk kostnad och vinst av högre kapitalnivåer för banker
(-) Kostnad
Mer eget kapital kan öka bankernas finansieringskostnad → Dyrare att låna från banker → Lägre BNP
(+) Vinst
Mer eget kapital minskar sannolikheten för en finansiell kris
En finansiell kris är kostsam för samhället
(=) Nettobehållning för samhället

Källa: Eget exempel baserat på Tabell 1 i Fender och Lewrick (2016)

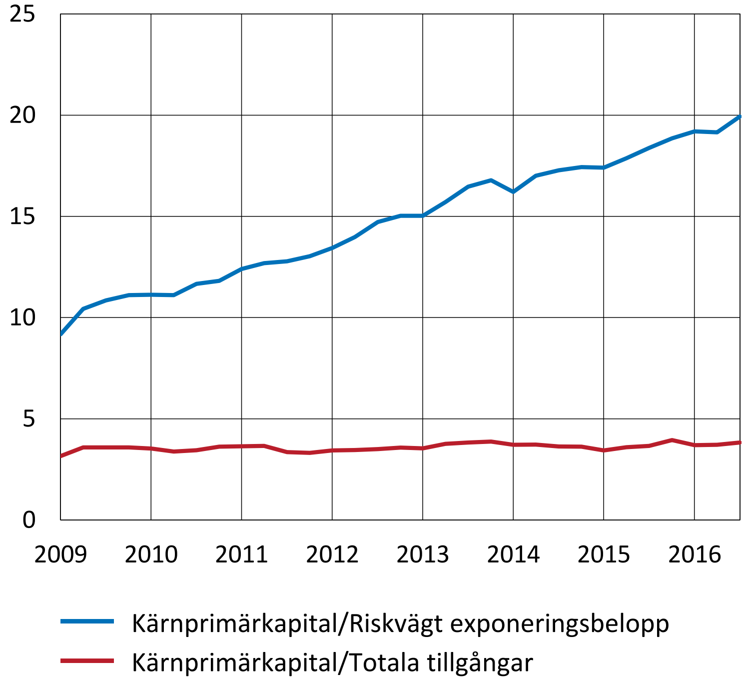
När kapitalnivån höjs avtar nettobehållningen av ytterligare höjningar gradvis, eftersom man förr eller senare når en nivå där sannolikheten för en kris inte längre minskar tillräckligt mycket för att uppväga de kostnader som eventuellt följer av att höja kapitalnivån ytterligare. Så länge en ytterligare höjning ger en vinst som uppväger kostnaderna är det samhällsekonomiskt motiverat att höja kapitalnivån. Den fråga vi ställer oss är vid vilken nivå de samhällsekonomiska kostnaderna skulle överstiga den samhällsekonomiska vinsten om kapitalnivåerna höjs ytterligare.

Våra beräkningar utgår från eget kapital i förhållande till totala tillgångar, det vill säga ett mått på bankernas bruttosoliditet. Sedan en tid tillbaka har Baselkommittén enats om ett bruttosoliditetsmått där en banks primärkapital sätts i förhållande till bankens exponeringar. I beräkningarna av en banks exponeringar inkluderas såväl åtaganden på som utanför balansräkningen. Eftersom historisk data för Baselkommitténs mått på bruttosoliditet är bristfällig så används inte denna för att skatta lämpliga kapitalnivåer. Istället fokuserar vi på en banks bokförda kapital i relation till bankens totala tillgångar på balansräkningen. För svenska storbanker skiljer sig för närvarande dessa två mått endast marginellt ifrån varandra.

[3] För en mer utförlig diskussion om kapitaltäckningens syfte och funktioner se Berger et al. (1995).
[4] Kapitalkrav kan utformas på många sätt, inklusive olika andelar av minimikrav och buffertkrav. Kapitalkravets utformning ligger utanför analysen i denna staff memo.

Flera tidigare studier, så som BCBS (2010) och Sveriges riksbank (2011) har istället för att studera bankernas bruttosoliditet valt att fokusera på bankernas kapital i förhållande till deras riskvägda tillgångar. För svensk del är resultaten av de studierna idag svåra att tolka eftersom de svenska bankernas riskvikter har ändrats förhållandevis snabbt. I Diagram 2 framgår att bankerna håller långt mer eget kapital än tidigare i förhållande till sina riskviktade tillgångar. Samtidigt har deras eget kapital som andel av totala tillgångar knappt ökat. Detta beror på till stor del på att bankernas riskvikter har minskat betydligt under senare år. Det talar för att bankerna sannolikt inte har ökat sin motståndskraft i samma utsträckning som den riskviktade kapitalrelationen har ökat.[5]

Diagram 2. Kapitalnivåer i svenska banker 2009-2016
Procent



Källa: Bankernas delårsrapporter och Riksbanken

I de följande avsnitten ger vi en kortfattad beskrivning av hur kostnaden och vinsten av högre kapitalnivåer kan beräknas. Beräkningarna redovisas mer utförligt i Appendix A-E. Först analyserar vi den samhällsekonomiska kostnaden, sedan den samhällsekonomiska vinsten. Därefter följer ett avslutande avsnitt där vi väger kostnaden mot vinsten vid olika kapitalnivåer.

Eget kapital är dyrare än lånat kapital men ger också lägre risk

I det här avsnittet analyseras om högre kapitalkrav ökar kostnaden för kreditgivning i ekonomin och, om så är fallet, hur stor den effekten kan tänkas vara. Eget kapital är vanligtvis en dyrare finansieringsform än lånat kapital. Detta som följd av att eget kapital normalt är mer riskfyllt.[6] Det är dock inte självklart att bankens totala finansieringskostnader ökar om andelen kapital ökar.

Det så kallade Modigliani-Miller-teoremet säger att under vissa antaganden påverkas ett företags totala finansieringskostnad inte av hur det blandar eget och lånat kapital för att finansiera sig (Modigliani och Miller, 1958). I praktiken finns dock ett antal friktioner kopplade till bankernas finansiering som ger skäl att tro att Modigliani-Miller-teoremet inte gäller fullt

[5] Se Sveriges riksbank (2015), Finansinspektionen (2014)

[6] Aktieägarnas avkastning är inte förutbestämd utan avgörs av hur mycket som blir över efter att firmans långivare fått sin avtalade ersättning. Detta kan sägas gälla både för den löpande avkastningen och vid konkurser. Det är då rimligt att vänta sig att investerare begär högre förväntad avkastning på eget kapital än för lånat kapital för att kompenseras för den högre risken.

ut. Två centrala exempel beskrivs kortfattat nedan. För en mer ingående diskussion, se Appendix A.

Skatter är ett exempel på en friktion som kan få till följd att bankens finansieringskostnad ökar när andelen kapital ökar. Det svenska skattesystemet ger avdrag för ränteutgifter men inte för utdelningar till aktieägare. När lånat kapital ersätts med eget kapital går banken därmed miste om ett skatteavdrag motsvarande räntekostnaden för det lånade kapitalet multiplicerat med bolagsskattesatsen. Men eftersom vi här talar om förhållandevis små ökningar av bankens eget kapital får detta bara en begränsad effekt. En bank som ersätter lånat kapital med eget kapital motsvarande en procent av de totala tillgångarna går miste om en skattefördel motsvarande omkring 0,01 procent, eller 1 baspunkt, sett till bankens totala finansieringskostnad.[7] Därtill kan vi konstatera att även om lånat kapital gynnas skattemässigt över eget kapital behöver det inte vara samhällsekonomiskt motiverat och det kan snedvrida företagens finansieringsbeslut (SOU 2014:40; IMF 2009). I den utsträckning ett kapitalkrav motverkar snedvridningarna i ekonomin kan den samhällsekonomiska kostnaden av mer kapital därmed väntas vara lägre än den privata kostnaden för bankerna.

Ett annat relevant exempel på friktioner är statliga garantier, till exempel i form av en insättningsgaranti eller genom att marknaden förväntar sig att staten skyddar bankernas långivare när bankerna får problem. Sådana friktioner kan göra lånefinansiering billigare än den annars skulle ha varit. Här är distinktionen mellan privata kostnader och sociala kostnader särskilt viktig. Om insättningsgarantin eller förväntningar om statligt ingripande får banker att ta mer risk än de annars skulle ha gjort så kan det vara samhällsekonomiskt motiverat med ett kapitalkrav som begränsar risktagandet. Även i det fallet kan den sociala kostnaden därför antas vara lägre än den privata kostnaden – eller rentav utgöra en vinst och inte en kostnad överhuvudtaget.

Om en bank ökar andelen eget kapital, som är en dyrare finansieringsform än lånat kapital, så innebär det alltså enligt ovan en ökad kostnad för banken. Men samtidigt blir banken mindre riskfylld i ett investerarperspektiv, vilket i sig minskar bankens finansieringskostnad både för lånat och eget kapital. [8] Den här effekten, som kallas för Modigliani-Miller-effekt[9], motverkar alltså i viss utsträckning den kostnadsökning som en större andel eget kapital innebär.

Tabell 2 sammanfattar skattningar av denna Modigliani-Miller-effekt från ett antal studier. Som framgår av tabellen är skattningarna av denna Modigliani-Miller-effekt förhållandevis stora. En skattad Modigliani-Miller-effekt på exempelvis 40 procent betyder att den skattade ökningen av bankernas finansieringskostnad är 40 procent lägre än vad man kunde ha väntat sig om en sådan dämpande effekt inte hade ägt rum.

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[7] Om vi antar att räntan för lånefinansiering är 5 procent och bolagsskattesatsen 22 procent så motsvarar skatteeffekten av att en procentenhet lånat kapital ersätts med en procentenhet eget kapital en kostnadsökning för banken på 0,05 x 0,22 x 0,01 = ca 0,01 % eller drygt en baspunkt. Se även Hanson et al. (2011) som finner liknande resultat för banker i USA.

[8] Detta gäller på sikt både lånefinansiering och eget kapital. Den som lånar till en bank löper större risk att inte få tillbaka hela beloppet om banken håller en liten andel eget kapital. Och högre belåningsgrad i en bank gör allt annat lika att bankens eget kapital blir mer riskfyllt eftersom värdet på det egna kapitalet då varierar mer över tid och risken för en konkurs ökar.

[9] Även kallad Modigliani-Miller *offset*.

Tabell 2. Exempel på studier som finner en Modigliani-Miller-effekt

Studie	Länder	Tidsperiod	Skattad Modigliani-Miller-effekt (%)
ECB (2011)	54 globala banker	1995–2011	41–73
Junge and Kugler (2012)	Schweiz	1999–2010	64
Miles et al. (2013)	Storbritannien	1997–2010	45–90
Shin (2014)	105 banker i utvecklade länder	1994–2012	46
Toader (2014)	Europeiska banker	1997–2011	42
Brooke et al. (2015)	Storbritannien	1997–2014	53
Clark et al. (2015)	USA	1996–2012	43–100

Anm. Den beräknade effekten i kolumn 4 anger i vilken utsträckning kostnaden av högre kapitalnivåer motverkas av den så kallade Modigliani-Miller-effekten. Denna effekt gör att bankens finansieringskostnad inte ökar lika mycket som annars skulle ha varit fallet. Se Appendix A för en mer ingående beskrivning av tabellen.

Även om det finns en viss dämpande Modigliani-Miller-effekt ger högre kapitalnivåer typiskt sett upphov till en kostnadsökning för bankerna. Då blir nästa fråga i vilken utsträckning denna kostnad förs vidare till bankernas kunder. I tabell 3 nedan redovisar vi en översikt av internationell forskning som studerar i vilken omfattning högre kapitalnivåer påverkar bankers utlåningsräntor.[10] Studierna undersöker olika länder under olika tidsperioder.

Tabell 3. Studier som skattar hur mycket bankerna ökar sina utlåningsräntor om de ökar sitt eget kapital med en procentenhet

Studie	Länder	Tidsperiod	Ökning av utlåningsräntor (baspunkter)
BCBS (2010)	Urval av OECD-länder	1993–2007	26
Junge och Kugler (2013)	Schweiz	1999–2010	0,7
Miles, Yang och Marcheggiano (2013)	Storbritannien	1997–2010	1,2
Bank of England (2015)	Storbritannien	1997–2014	25
Elliot (2009)	USA		20
Kashyap, Stein och Hanson (2011)	USA	1976–2008	3,5
Baker och Wurgler (2013)	USA	1971–2011	8,5
Cosimano och Hakura (2011)	Globalt	2001–2009	12
King (2010)	Urval av OECD-länder	1993–2007	30
Slovik och Cournede (2011)	Urval av OECD-länder	2004–2006	32
De Resende, Dib och Perevalov (2010)	Kanada		2,5
Corbae och D'Erasmo (2014)	USA		50
Kisin och Manela (2016)	USA	2002–2007	0,3
Medelvärde			**16,3**

Anm. För att underlätta en jämförelse mellan studierna gör vi två förenklande antaganden. För det första översätter vi riskviktade kapitalmått till bruttosoliditet utifrån antagandet att den genomsnittliga riskvikten är 50 procent, det vill säga de riskviktade tillgångarna uppgår till hälften av de totala tillgångarna.[11] För det andra skalar vi om den skattade effekten i varje studie till effekten av att eget kapital ökar med en procentenhet i förhållande till de totala tillgångarna. Vi antar då att effekten är proportionerlig, det vill säga effekten av att till exempel höja kapitalnivån med två procentenheter antas vara dubbelt så stor som effekten av att höja med en procentenhet. Se Appendix A för en mer ingående beskrivning av tabellen.

Sammantaget indikerar denna forskningsöversikt att bankernas utlåningsräntor kan väntas öka något om banker tvingas hålla en högre andel eget kapital, men att effekten är måttlig. Ett medelvärde av de olika studierna i tabellen ovan ger att om bankerna ökar sitt eget kapital i förhållande till totala tillgångar med en procentenhet så kan utlåningsräntorna

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[10] I litteraturen används ofta begreppet marginaler för detta, men för enkelhetens skull skriver vi istället räntor.

[11] Faktiska riskvikter skiljer sig åt mellan olika länder. Vårt antagande om 50 procent är högre än svenska storbankers riskvikter, som i genomsnitt ligger kring 20–25 procent, men är i linje med vad som observeras i andra länder – de svenska riskvikterna är låga i ett internationellt perspektiv. Vår bedömning är att antagandet om en genomsnittlig riskvikt på 50 procent gör att vi över- eller underskattar de skattade effekterna i enskilda studier men att vi sammantaget landar i rätt storleksordning.

väntas öka med omkring 16 baspunkter, eller 0,16 procentenheter. En del av de skattade effekterna i tabellen ovan framstår som höga ur ett svenskt perspektiv. Med en enkel överslagsberäkning ökar svenska storbankers genomsnittliga finansieringskostnad, allt annat lika, med omkring 10-12 baspunkter om de ersätter en procentenhet lånat kapital med eget kapital.[12] Men eftersom bankernas tillgångar även består av andra tillgångar än lån måste utlåningsräntorna ökas med mer än så om kostnaden helt ska föras vidare i form av högre räntor på lån.[13] Därtill inbegriper många av studierna ovan även indirekta effekter, t.ex. att konkurrensen mellan banker kan försämras. Det är en öppen fråga hur pass omfattande sådana indirekta effekter kan tänkas vara för svensk del. Sammantaget låter vi genomsnittet på 16 baspunkter utgöra vår bästa bedömning men det kan inte uteslutas att detta överskattar hur stor effekten skulle bli för svensk del. Man bör också komma ihåg att den fråga vi egentligen ställer oss inte är om högre kapitalkrav ökar kostnaden för att låna av banker utan vilka effekterna kan bli för kapitalkostnaden i stort i ekonomin. Företag som vill finansiera produktiva investeringar kan även tänkas låna från andra aktörer än banker eller finansiera sig med eget kapital i större utsträckning.[14] Av båda dessa skäl kan effekten på kostnaden för att finansiera investeringar väntas bli lägre än effekten på bankernas finansieringskostnader.

Bankernas kapitalnivåer kan påverka utlåning till investeringar

I förra avsnittet konstaterade vi att högre kapitalkrav kan göra det något dyrare för bankerna att finansiera sig och att bankerna i så fall kan komma att föra över kostnaden på sina kunder. I så fall blir det dyrare att låna i banken vilket kan ge en lägre BNP-nivå på lång sikt. Att BNP kan minska är kopplat till att en ökad kapitalkostnad i ekonomin kan göra att en del investeringar som var lönsamma tidigare slutar att vara det på grund av den högre kapitalkostnaden. Mindre investeringar minskar kapitalstocken på lång sikt och därmed blir produktionsnivån i ekonomin lägre.

För att bilda oss en uppfattning om hur stor denna BNP-effekt kan tänkas vara använder vi dels Riksbankens makroekonomiska modell RAMSES, dels en annan makromodell som mer explicit tar hänsyn till banksektorn. Våra beräkningar fokuserar på hur ekonomin påverkas på lång sikt.

Makromodellen med en banksektor är hämtad från Iacoviello (2015) och kalibrerad till svenska förhållanden. I modellen finns ett kapitalkrav för banker vilket gör den särskilt lämplig för våra syften. För att utvärdera effekterna av ett högre kapitalkrav kan man ändra värdet på kapitaltäckningskravet i modellen och studera effekterna på BNP. I linje med många andra studier bortser vi från den kortsiktiga effekten av högre kapitalkrav och fokuserar på effekten när ekonomin nått en ny långsiktig nivå.

RAMSES styrka i det här sammanhanget är att modellen är särskilt väl anpassad för att studera den svenska ekonomin.[15] Däremot finns det inte ett explicit kapitalkrav i själva modellen. I stället beräknas effekten av högre kapitalkrav indirekt i två steg. I det första steget skattas hur stor effekten blir på bankernas låneräntor om man ökar kapitalnivån med en procentenhet. Här använder vi medelvärdet i Tabell 3 ovan, dvs. 16 baspunkter. I det andra steget ökar vi låneräntan[16] i RAMSES för att studera de makroekonomiska effekterna på lång sikt. För en mer utförlig beskrivning av beräkningarna, se Appendix B.

Som framgår av Tabell 3 ger de två ansatserna ungefär samma resultat. Om vi ökar kapitalnivån med en procentenhet i förhållande till de totala tillgångarna beräknas det i båda fall ge en marginellt lägre BNP-nivå på lång sikt (0,13 respektive 0,09 procentenheter). Båda modellerna har olika för- och nackdelar. Vi låter därför ett genomsnitt av skattningarna

[12] Om kapitalkostnaden exempelvis uppgår till 12 respektive 2 procent för eget respektive lånat kapital och bolagsskattesatsen uppgår till 22 procent så ökar den genomsnittliga kapitalkostnaden med drygt 0,1 procent, eller 10 baspunkter, om lånat kapital ersätts av eget kapital i en omfattning som motsvarar 1 procent av de totala tillgångarna. Exemplet avser inte någon specifik bank eller specifik tidsperiod.

[13] Se Firestone et al. (2017) för en mer ingående diskussion.

[14] I den här studien gör vi ingen bedömning avseende i vilken utsträckning detta kan väntas ske.

[15] För en mer utförlig beskrivning av RAMSES, se Adolfson et al., 2013.

[16] Mer precist uttryckt är det lånemarginal men för enkelhetens skull skriver vi låneränta.

utgöra vår bästa bedömning av effektstorleken, vilket är ett vanligt förekommande sätt att hantera modellosäkerhet.

Tabell 4. Långsiktig effekt på BNP av högre kapitalkrav
Effekt på BNP-nivån av att öka kapitalkravet med 1 procent i förhållande till totala tillgångar

Modell	Experiment	Effekt på BNP-nivån på lång sikt (%)
Iacoviello (2015)	Höjning av kapitalkravet med 1 procentenhet	-0,13
RAMSES	Låneräntan ökar med 16 baspunkter	-0,09
Medelvärde		**-0,11**

Anm. Se Appendix B för en mer ingående beskrivning av tabellen

Skattningarna i tabellen ovan indikerar att högre kapitalkrav endast väntas ha en begränsad effekt på den långsiktiga BNP-nivån. I Appendix B jämför vi våra resultat med resultat från studier som avser andra länder och använder andra metoder.

Kriser medför stora kostnader för samhället

Bankkriser, och finanskriser mer allmänt, är mycket kostsamma för samhällsekonomin. Därför kan det vara av stort samhällsekonomiskt värde att bankerna stärker sin motståndskraft mot kriser genom att hålla en större andel eget kapital.

En växande forskningslitteratur försöker uppskatta samhällets kostnader för finansiella kriser utifrån historiska erfarenheter. Utifrån mer omfattande analys som redovisas i Appendix C ger vi här en kort redogörelse för den forskningen. Därefter gör vi en samlad bedömning av vad en bankkris skulle kosta för Sverige i dag.[17]

Det är praxis i litteraturen att fokusera på effekterna på produktionen i ekonomin, det vill säga BNP-nivån. Men man bör komma ihåg att BNP-effekten av en kris inte fångar alla aspekter av hur en kris påverkar samhället. Hushåll och företag drabbas i olika utsträckning i en kris, till exempel genom att vissa företag går i konkurs medan andra klarar sig, eller att vissa individer blir av med sina jobb när arbetslösheten ökar. För de individer som drabbas hårdast i en kris kan effekterna bli mycket långvariga, till exempel för att deras långsiktiga förutsättningar på arbetsmarknaden försämras till följd av en utdragen arbetslöshetsperiod under krisen, eller för att deras företag går i konkurs. Effekterna av finansiella kriser kan dessutom komma att bäras i större utsträckning av mindre delar av ett lands befolkning, varför välfärdseffekterna kan bli betydligt större än vad BNP-effekten antyder. Detta kan även bidra till långsiktiga politiska effekter med ytterligare negativa konsekvenser för samhället (Bromhead et al., 2009).

I resten av analysen bortser vi dock från dessa aspekter av kriser och fokuserar på effekten på produktion, det vill säga BNP-nivån. Det mått som vi fokuserar på är nuvärdet av att den framtida BNP-nivån blir lägre än vad som skulle ha varit fallet utan krisen. Vi hänvisar till detta som den ackumulerade kostnaden för en kris.

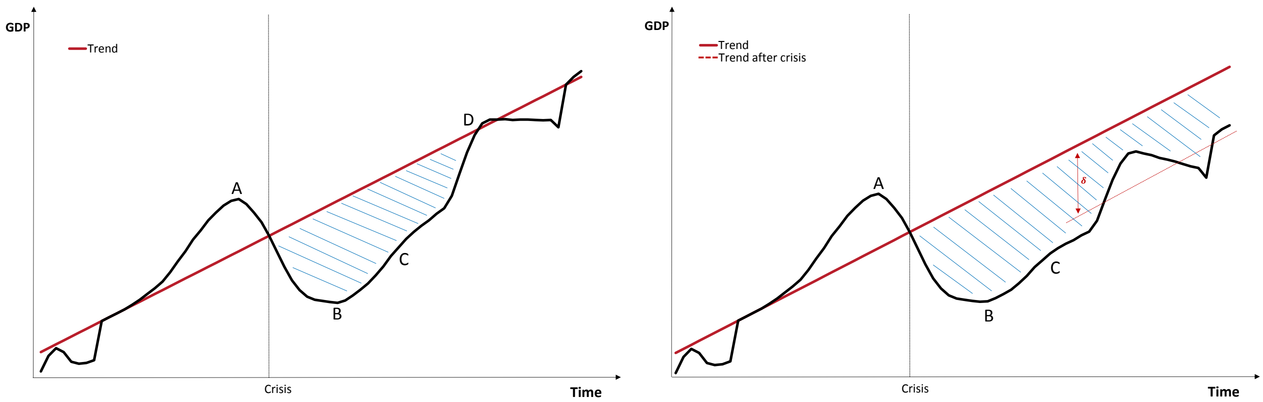
Skattningarna av den ackumulerade BNP-effekten av en kris skiljer sig åt förhållandevis mycket. Den stora variationen återspeglar olika historiska erfarenheter, olika definitioner av en kris och olika antaganden om effekten på längre sikt. När det gäller effekten på längre sikt är det av central betydelse om man bedömer att effekten av kriser är permanent eller övergående. Det finns i litteraturen ingen konsensus kring detta och bägge bedömningarna förekommer.

Figuren nedan visar två hypotetiska exempel på hur BNP kan utvecklas innan, under och efter en kris. I det första exemplet är krisens effekter på BNP-nivån övergående. Det betyder att ekonomin efter krisen växer snabbare än den långsiktiga trenden och på så sätt återkommer till den ursprungliga tillväxtbanan. I det andra exemplet är den långsiktiga tillväxttakten opåverkad, men ekonomin återhämtar inte det tapp i BNP-nivån som följt av krisen genom en initial period av högre tillväxt. I stället för den ursprungliga tillväxtbanan

[17] Det kan inte uteslutas att bankernas kapitalnivåer även påverkar kostnaden för en kris. Vi beaktar inte detta i analysen utan bankernas kapitalnivåer antas endast påverka sannolikheten för att en kris inträffar.

hamnar ekonomin på en parallell men lägre tillväxtbana och produktionen förblir lägre varje enskilt år än vad den skulle ha varit utan krisen.

Figur 1. Två principskisser avseende effekten av en kris
BNP-nivå



Källa: Fritt efter BCBS (2010)

I båda fallen uppkommer en samhällsekonomisk kostnad för krisen under varje år som BNP-nivån ligger under den ursprungliga tillväxtbanan. Men i det första exemplet tillkommer efter en tid inga ytterligare kostnader eftersom ekonomin helt återhämtat sig. I det andra exemplet tillkommer en kostnad varje år därefter, eftersom ekonomin inte når till den gamla banan. Krisen innebär då ett avbrott i den ekonomiska utvecklingen som man aldrig tar igen.

Nuvärdeskostnaden av krisen, sett från tidpunkten då krisen utbryter, motsvarar det skuggade området i respektive diagram diskonterat med en lämplig diskonteringsränta. Att framtida kostnader diskonteras återspeglar att kostnader som ligger längre fram i tiden är mindre betungande än kostnader som ligger nära inpå i tiden – eller annorlunda uttryckt, att människor brukar värdera konsumtion i dag högre än konsumtion i morgon.

I Tabell 5 sammanfattas resultaten från ett antal studier som försökt skatta den ackumulerade kostnaden för en kris. Som framgår av tabellen sträcker sig det skattade medelvärdet av den samhällsekonomiska kostnaden för en kris från drygt 8 till drygt 300 procent av BNP.[18] En anledning till den förhållandevis stora spridningen i skattningarna är att tidsperspektivet skiljer sig åt mellan studierna. De flesta räknar ut en ackumulerad kostnad över tid, men i vissa fall avses endast effekten under några få år i samband med krisen. Ball (2014) avser till exempel effekten under ett enda år medan exempelvis Boyd et al. (2005) också innehåller beräkningar på det diskonterade nuvärdet av den ackumulerade kostnaden med en oändlig horisont.

[18] Dessa skattningar är gjorda i många olika studier som skiljer sig åt vad gäller metodik, krisdefinitioner, tidshorisont samt länder på vilka studierna har gjorts.

Tabell 5. Samhällsekonomisk kostnad för finanskriser
Procent av BNP

Studie	Samhällsekonomisk kostnad			Antagande om långsiktig effekt på BNP-nivån
	Medelvärde	Min	Max	
Hoggarth et al. (2002)	**16**	0	122	Övergående
Laeven och Valencia (2008)	**20**	0	123	Övergående
Haugh et al. (2009)	**21**	10	40	Övergående
Cecchetti et al. (2009)	**18**	0	129	Övergående
Boyd et al. (2005)*	**97**	0	194	Övergående
Boyd et al. (2005)**	**302**	0	1041	Permanent
BCBS (2010)*	**19**	0	130	Övergående
BCBS (2010)**	**145**	0	1041	Permanent
Haldane (2010)	**268**	90	500	Permanent
Ball (2014)*	**8,4**	0	35	Övergående
Ball (2014)**	**180**	0	1035	Permanent

Anm. Tidsperspektivet skiljer sig åt mellan de olika studierna. Effekten avser i de flesta av studierna ovan nuvärdet av den ackumulerade kostnaden, uttryckt som procent av BNP. Några av studierna räknar på den ackumulerade kostnaden under endast några få år. Ball (2014) avser effekten under ett enda år. Därtill gör studierna olika antaganden om effekterna av en kris är övergående eller permanenta. Studier som inkluderar skattningar med såväl övergående som permanenta effekter markeras med * respektive ** beroende på vilket antagande som avses. Se Appendix C för en mer ingående beskrivning av tabellen

Eftersom vår studie avser kapitalnivåer för svenska banker är vi i första hand intresserade av den förväntade kostnaden för en bankkris i Sverige. Det finns skäl att vänta sig att en bankkris skulle få förhållandevis stora negativa konsekvenser för den svenska ekonomin. I Sverige har bankerna en stor roll i att förmedla krediter till både hushåll och företag. Bolån värdepapperiseras inte så som i till exempel USA, och företagssektorn finansierar sig i större utsträckning via bankerna än genom att emittera egna obligationer. Bland annat till följd av det, är det svenska banksystemet stort i förhållande till ekonomins storlek. Därtill är det koncentrerat och sammanlänkat. Dessutom har storbankerna en hög andel marknadsfinansiering, varav en stor andel är i utländsk valuta. Sammantaget gör det att banksystemet är känsligt för störningar och att en bankkris skulle kunna få betydande negativa samhällsekonomiska effekter.

För att bilda oss en ungefärlig uppfattning om vilka effekter en svensk bankkris kan tänkas få använder vi oss av den uppskattade kostnaden för den svenska bankkrisen i början av 1990-talet. Det finns visserligen faktorer som talar för att effekten skulle kunna vara både mindre och större idag, jämfört med 1990-talet. Å ena sidan har Sverige idag flytande växelkurs, starka offentliga finanser och har genomfört omfattande strukturreformer sedan 1990-talet som gör att ekonomin sannolikt har stärkt sin motståndskraft mot kriser. Å andra sidan är banksektorn i dag betydligt större i förhållande till BNP, ca 350 procent i dag mot 100 procent i början av 1990-talet.

En ytterligare faktor som tillkommit är resolutionsramverket som är tänkt att hantera banker som fallerat eller är nära att fallera. Ett syfte med ramverket är att öka förutsättningarna att kunna hantera problem i en enskild bank, bland annat genom att omvandla en del lånat kapital till eget kapital. Resolutionsramverket är emellertid oprövat och det är först i nästa kris som vi kommer att kunna bilda oss en tydligare uppfattning om i vilken utsträckning det kan lindra effekterna av en bankkris.

Boyd et al. (2005) uppskattar kostnaden för den svenska 1990-talskrisen, uttryckt som nuvärdet av att den framtida BNP-nivån blir lägre, till mellan 101 och 257 procent av BNP. Den lägre siffran utgår från antagandet att krisens effekter är övergående medan den högre siffran antar att effekten är permanent. Det är inte uppenbart vilken av dessa skattningar som ger bättre vägledning om hur stor kostnaden blir för en svensk kris i framtiden. På grund av denna osäkerhet, och i linje med hur andra studier har hanterat sådan osäkerhet, bedömer vi att ett genomsnitt av de två skattningarna skulle vara en tänkbar kostnad för en svensk kris. Vi landar då i 180 procent av BNP räknat som nuvärdet av BNP-bortfallet över tid.

Tabell 6. Samhällsekonomisk kostnad för en svensk finanskris
Procent av BNP

Källa	Kostnad i procent av BNP	Kommentar
Den svenska finanskrisen 1990–1994		
Boyd et al. (2005),	101	Antar övergående effekt på BNP-nivån
Boyd et al. (2005),	257	Antar permanent effekt på BNP-nivån
Medelvärde	**180**	
Internationellt genomsnitt		
Fender och Lewrick (2015)	100	
Ball (2014)	180	Nuvärdeberäkning gjord av Fender och Lewrick (2015)

Anm. Den samhällsekonomiska kostnaden avser nuvärdet det ackumulerade BNP-bortfallet till följd av en finanskris. Se Appendix C för en mer ingående beskrivning av tabellen

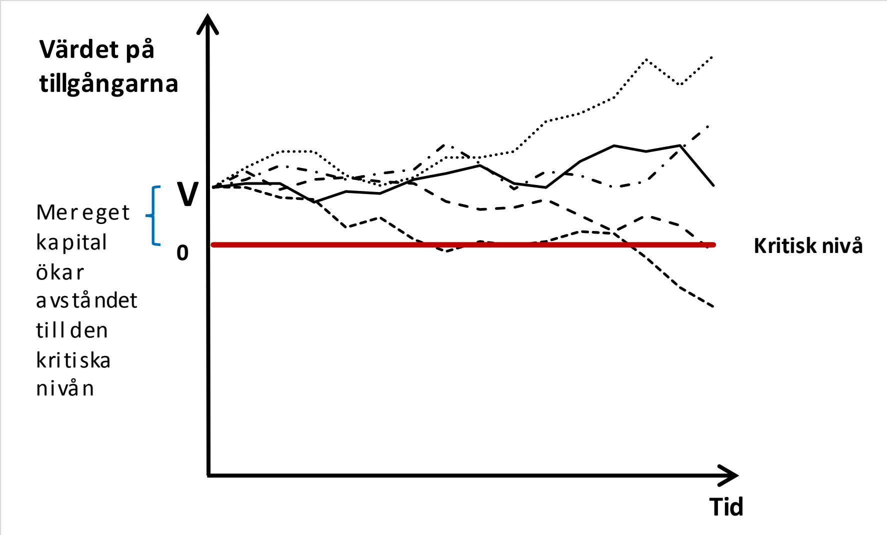
Bedömningen att en svensk kris kan väntas kosta 180 procent av BNP är något högre än det internationella genomsnitt på 100 procent som beräknats av Fender och Lewrick (2015). Men det finns omständigheter som gör att effekterna av en bankkris i Sverige sannolikt är större än det internationella genomsnittet, till exempel den svenska banksektorns storlek och struktur. En kostnad på 180 procent av BNP kan också sättas i relation till den skattade kostnaden av den senaste finanskrisen enligt Ball (2014) som beräknar att finanskrisen gett en 8,4 procent lägre BNP-nivå i genomsnitt bland OECD-länder. Om man antar att effekten är permanent och beräknar nuvärdet av detta så blir kostnaden för en kris 180 procent (se Fender och Lewrick, 2015), det vill säga en kostnad som motsvarar vår bedömning för Sverige.

Eget kapital minskar sannolikheten för en kris

Som vi skrivit ovan så minskar sannolikheten för en bankkris om bankerna har mer eget kapital som kan utgöra en buffert i händelse av stora oväntade förluster. Det är värdefullt eftersom bankkriser kan medföra stora kostnader för samhället. Nästa steg är därför att bilda oss en uppfattning om hur mycket risken för bankkriser minskar om man höjer kapitalnivån i bankerna. För att bedöma detta använder vi två olika modeller. Den första modellen är en standardmodell för kreditrisk, den så kallade Merton-modellen (”Modell 1”). Den andra modellen utgår ifrån bankernas historiska förluster för att skatta sannolikheten för riktigt stora förluster (”Modell 2”). Här ger vi en kortfattad beskrivning av hur vi har räknat. Mer ingående beskrivningar av modellerna återfinns i Appendix D (Modell 1) och Appendix E (Modell 2).

De två modellerna skiljer sig åt men bygger på samma grundidé. Bankerna har tillgångar vars marknadsvärde varierar över tid. Om värdet på en banks tillgångar understiger en viss nivå så får banken allvarliga problem eftersom risken blir stor att skulderna inte kan återbetalas med värdet i tillgångarna. Oavsett var man lägger den kritiska nivån där bankerna får problem gör en högre andel eget kapital i utgångsläget att banken får en större fallhöjd till den kritiska nivån. Därmed är risken mindre för att banken får problem. Grundidén illustreras i Figur 2 nedan.

Figur 2. Principskiss för kreditrisk



Källa: Riksbanken

Ett viktigt antagande är vid vilken kritisk nivå som bankerna kan väntas få allvarliga problem. En bank kan anses vara insolvent om värdet på tillgångarna är lägre än skulderna. Men historisk erfarenhet talar för att banker kan få allvarliga problem även när de fortfarande är solventa. Bankregleringen reflekterar detta genom att ställa minimikrav på bankers kapitaltäckning. Till exempel kan banker få problem med sin likviditet som följd av att en banks upplånade medel normalt förfaller till betalning innan den har fått tillbaka sina utlånade pengar. Banken måste därmed förnya sin finansiering flera gånger under lånens löptid. Om investerare ifrågasätter bankens återbetalningsförmåga vid något av dessa tillfällen kan banken tvingas finansiera sig till en högre kostnad eller så kan den kanske inte förnya finansieringen alls. Banken riskerar alltså att bli illikvid. Det kan i sin tur göra att banken tvingas sälja tillgångar snabbt vilket kan pressa tillgångarnas marknadsvärde. Eftersom bankerna i hög grad är exponerade mot samma typ av tillgångar kan då även andra bankers balansräkningar försvagas. Det kan förstärka den negativa spiralen, en så kallad *fire sale*-problematik (Schleifer och Vishny, 2011).

En tänkbar kritisk nivå för eget kapital är om en bank har avverkat stora delar av sina kapitalbuffertar och bryter, eller är nära att bryta mot kapitaltäckningsreglerna. Banken riskerar då att förlora sitt tillstånd och kan tänkas få svårigheter att finansiera sig eller försättas i resolution. Det finns inga generella bestämmelser vid vilken nivå banker försätts i resolution. I den här studien väljer vi att schablonmässigt anta att den kritiska nivån är 1,5 procent av de totala tillgångarna. Detta schablonvärde ska inte uppfattas som en tolkning av tillsynsmyndigheternas kriterier. Därtill antar vi för beräkningen med Modell 2 att den kritiska nivån sätts till tre procent.[19] Vi testar också, som beskrivs ovan, en kritisk nivå vid 0 procent, det vill säga när banken är insolvent i meningen att tillgångarna är mindre värda än skulderna.

När vi skattar hur högre kapitalnivåer förväntas påverka risken för en bankkris är det viktigt att komma ihåg att de samhällsekonomiska kostnaderna för en bankkris inte nödvändigtvis är unikt kopplade till att en bank blir insolvent. Banker som till exempel förlorar en del av sitt eget kapital kan prioritera att återställa sina kapitalnivåer genom att snabbt minska sin utlåning eller kraftigt öka sina lånemarginaler. I båda fallen riskerar bankens agerande att dämpa både investeringar och konsumtion och därmed förvärra lågkonjunkturen. Länder med välkapitaliserade banker tenderar att klara kriser bättre (Jordà et al, 2017). En förklaring till detta är sannolikt att den penningpolitiska transmissionen fungerar bättre om bankerna har en större andel eget kapital (Gambacorta och Shin, 2016).

[19] Inte heller det ska uppfattas som en bedömning för när en bank kan sättas i resolution.

Dessa faktorer talar för att det kan vara relevant att beakta högre kritiska nivåer för det egna kapitalet än de som räknas fram i denna studie.

Modell 1 – standardmodell för kreditrisk

Den första modellen som vi använder för att bilda oss en uppfattning om hur mycket risken för bankkriser minskar om man höjer kapitalnivån i bankerna (”Modell 1”) är en standardmodell för kreditrisk baserad på Merton (1974). Utgångspunkten är att en högre andel eget kapital i utgångsläget ger banken större marginal för variationer i marknadsvärdet av bankens tillgångar innan det närmar sig eller faller under en viss kritisk nivå. Variationen i marknadsvärdet för ett företags tillgångar, den så kallade volatiliteten, kan i många fall inte observeras. Modellen hanterar detta genom att utgå ifrån aktievolatiliteten, som kan observeras om ett företags aktier handlas på den öppna marknaden, för att skatta volatiliteten i tillgångsvärdet.

Modellen utgår enligt gängse metod från ett antal förenklande antaganden, och har därmed vissa begränsningar.[20] En av dessa begränsningar är att modellen behöver skattas utifrån historisk aktievolatilitet samt att data endast avser de fyra svenska storbankerna[21] under perioden 1997–2016. Detta riskerar att underskatta den långsiktiga sannolikheten för en bankkris av åtminstone två skäl. För det första varierar volatilitet över tid och det är långt ifrån säkert att den historiska volatiliteten är en bra indikation för volatiliteten i framtiden. Om den framtida volatiliteten är högre än genomsnittet under den studerade perioden kommer modellen att underskatta sannolikheten för en bankkris. För det andra omfattar den studerade perioden inte de mest allvarliga bankkriser som Sverige har genomgått, exempelvis bankkrisen i början av 1990-talet. Båda dessa faktorer talar för att modellen sannolikt underskattar risken för en kris.

Ju högre volatilitet, desto större sannolikhet för en bankkris eftersom ett tillgångsvärde som varierar mycket löper större risk att vid något tillfälle vara så pass lågt att det understiger en kritisk nivå. För att illustrera känsligheten för den historiska volatiliteten skattas modellen utifrån tre olika nivåer på volatilitet: genomsnittlig, hög och mycket hög.[22] Vilken nivå som ger den bästa vägledningen om volatiliteten i framtiden kan modellen inte bedöma. Däremot kan man konstatera att den studerade perioden överlag präglats av måttlig volatilitet och att volatiliteten i framtiden mycket väl kan tänkas vara högre.

För att göra en koppling mellan sannolikheten för att en enskild bank får problem och sannolikheten för att en bankkris utbryter antar vi att en bankkris utbryter om värdet på tillgångarna faller så pass mycket att det egna kapitalet kommer att understiga den kritiska nivån (som vi enligt ovan i denna modell antar är 1,5 eller 0 procent) för någon av de fyra storbankerna. Det är en förenkling men vanligt förekommande i litteraturen och inte orimligt med tanke på att de svenska storbankerna är nära sammanlänkade bland annat genom att de äger varandras värdepapper. Utöver det kan en kris i en bank skapa en kris också i andra banker genom att deras långivare och insättare försöker ta ut sina pengar en så kallad ”bank run”. Samma antagande görs i exempelvis Sveriges riksbank (2011) och i en bankkrismodell framtagen av Bank of England (se BCBS, 2010, s. 42). Det kan dock inte uteslutas att just detta antagande riskerar att överskatta sannolikheten för en bankkris. Mot det ska ställas att vi skattar modellen utifrån de historiska korrelationerna för de fyra storbankerna. Eftersom korrelationerna historiskt har varit starkare i oroliga tider minskar betydelsen av detta antagande.

Nedan redovisas sannolikheten för en bankkris när modellen skattas utifrån historisk volatilitet under de senaste 20 åren. I Diagram 3 visas två exempel där modellen skattas

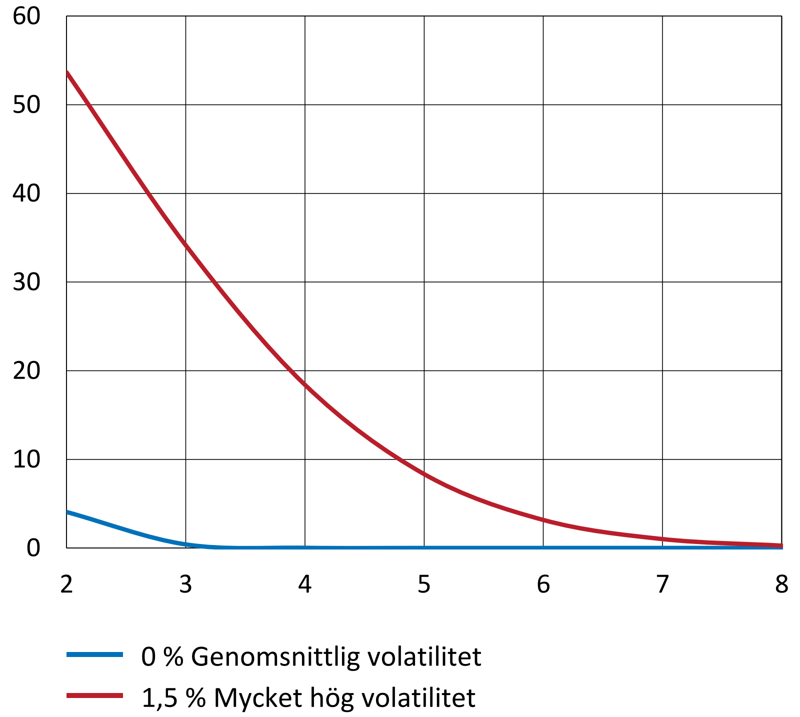
[20] Vi antar att företaget bara har en sorts lånat kapital och att kapitalmarknaderna fungerar helt friktionsfritt, det vill säga det förekommer inga skatter, transaktionskostnader eller andra hinder. I verkligheten har banker en mängd olika former av lånat kapital och en betydande del av finansieringen är på korta löptider, vilket skapar likviditetsrisker som inte beaktas i modellen. Därmed underskattar modellen sannolikt risken för att bankerna får problem. Vidare antar vi i modellen att en bank endast får problem om marknadsvärdet understiger den kritiska nivån i slutet av den tidsperiod som skattningen avser, det vill säga i slutet av året. Om marknadsvärdet understiger den kritiska nivån under året men därefter återhämtar sig antar vi alltså att banken inte får problem. Därmed underskattas sannolikheten för att en enskild bank får problem.

[21] Med storbankerna avses här Nordea, SEB, SHB och Swedbank.

[22] Nivåerna motsvarar 50:e, 75:e respektive 90:e percentilen i den observerade volatiliteten 1997–2016. Se Appendix D för en mer ingående beskrivning.

utifrån antaganden om dels genomsnittlig volatilitet och en kritisk nivå för eget kapital satt till 0 procent av totala tillgångar (blå linje), dels mycket hög volatilitet och en kritisk nivå på 1,5 procent (röd linje). På x-axeln visas kapital i procent av totala tillgångar och på y-axeln den skattade sannolikheten för en bankkris. Den blå linjen visar att redan vid kapitalnivåer kring två procent av totala tillgångar så är sannolikheten för bankkris förhållandevis liten (omkring fyra procent) för att sedan i princip gå mot noll kring nivåer över tre procent kapital, under förutsättning att marknadsvärdet på tillgångarna alltså inte varierar så mycket. Den röda linjen, som alltså utgår från en mycket hög volatilitet i värdet på tillgångarna, visar att vid kapitalnivåer kring två procent är sannolikheten för bankkris förhållandevis hög (cirka 50 procent) och att sannolikheten sedan faller i takt med att kapitalnivåerna ökar.

Diagram 3. Sannolikhet för en bankkris på ett års sikt med Modell 1
Sannolikhet vid olika kapitalnivåer, i procent



Anm. På x-axeln visas kapital i förhållande till totala tillgångar och på y-axeln sannolikhet för en bankkris.
Källa: Riksbanken

I tabell 7 nedan sammanfattas samma information som i diagrammet ovan men för sex olika kombinerade antaganden om en banks volatilitet och kritisk kapitalnivå. I tabellen framgår att sannolikheten för kris i regel är högre med ett antagande om en kritisk kapitalnivå på 1,5 procent av totala tillgångar jämfört med 0 procent. Därtill framgår att den volatilitet som legat till grund för beräkningarna är avgörande för hur sannolikt det är med bankkris i meningen att ju högre volatilitet desto större är sannolikheten för bankkris.

Tabell 7. Sannolikhet för bankkris med Modell 1
Sannolikhet vid olika kapitalnivåer i procent

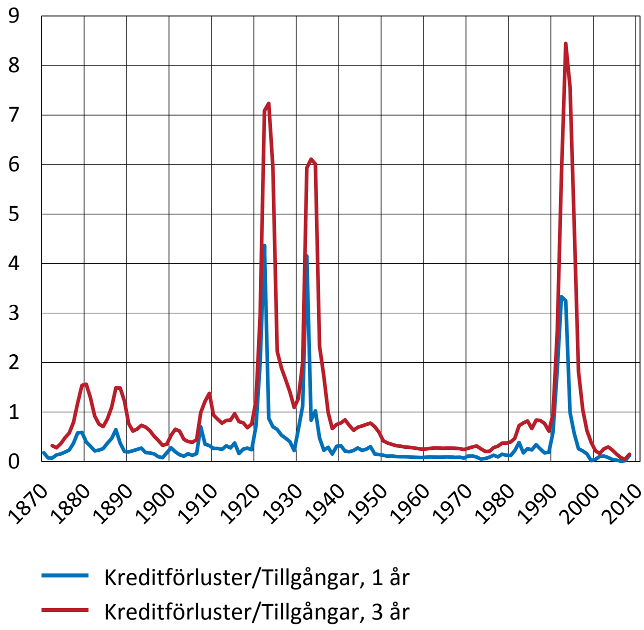
	Kritisk nivå 0 %			Kritisk nivå 1.5 %		
	Volatilitet			Volatilitet		
	Genomsnittlig	Hög	Mycket hög	Genomsnittlig	Hög	Mycket hög
2	4,06	13,12	25,61	35,54	45,61	53,66
3	0,40	3,79	12,66	9,89	21,55	34,16
4	0,02	0,79	5,25	1,40	7,34	18,41
5	0,00	0,12	1,82	0,10	1,80	8,34
6	0,00	0,01	0,53	0,00	0,33	3,16
7	0,00	0,00	0,12	0,00	0,04	1,00

Anm. Den första kolumnen avser kapitalnivån uttryckt som eget kapital i förhållande till totala tillgångar, i procent.
Källa: Riksbanken

Modell 1 är en standardmodell som på ett teoretiskt sätt hanterar problemet med att vi inte kan observera marknadsvärdet på ett företags tillgångar. Men som ofta är fallet med modeller är den känslig för vilka antaganden man gör och det är en öppen fråga i vilken utsträckning den ger god vägledning om sannolikheten för en kris.

En jämförelse av skattningarna ovan, som vi gjort med Modell 1 utifrån de senaste 20 årens data, med en längre tidsserie över kreditförluster i det svenska banksystemet tyder på att modellen kan underskatta risken för en bankkris i Sverige. Som framgår av Diagram 4 kännetecknas bankernas historiska kreditförluster av långa perioder med förhållandevis små förluster varvat med mindre vanliga men väsentligt större förluster, motsvarande tre till fyra procent av de totala tillgångarna under ett år. Dessutom tenderar år med mycket stora kreditförluster att följa varandra. Vid tre tillfällen under de senaste 100 åren uppvisar banksystemet kreditförluster motsvarande cirka 6 till 9 procent av de totala tillgångarna under en treårsperiod. Detta innebär att sannolikheten för mycket stora förluster ökar betydligt när tidshorisonten är längre än en ett år. Det är också viktigt att komma ihåg att denna data avser banksystemet som helhet. Enskilda banker har under samma period gjort större förluster.

Diagram 4. Kreditförluster i det svenska banksystemet 1870-2008
Kreditförluster som andel av totala tillgångar i procent



Anm. 1 år och 3 år avser historiska förluster på ett respektive tre års sikt.
Källa: Hortlund (2005) och Riksbankens egna beräkningar

Modell 2 – skattning av sannolikheten för förluster utifrån bankernas historiska förluster

Som kontrast till Modell 1 skattar vi även en alternativ modell (Modell 2) som i högre utsträckning tar hänsyn till hur bankernas historiska kreditförluster har sett ut.

I Modell 2 representeras banksystemet som en enda bank, det vill säga vi lägger ihop alla bankers tillgångar respektive skulder. Vi antar också att denna bank gör en vinst före kreditförluster som är konstant i förhållande till tillgångarna samtidigt som dess kreditförluster varierar över tid.[23]

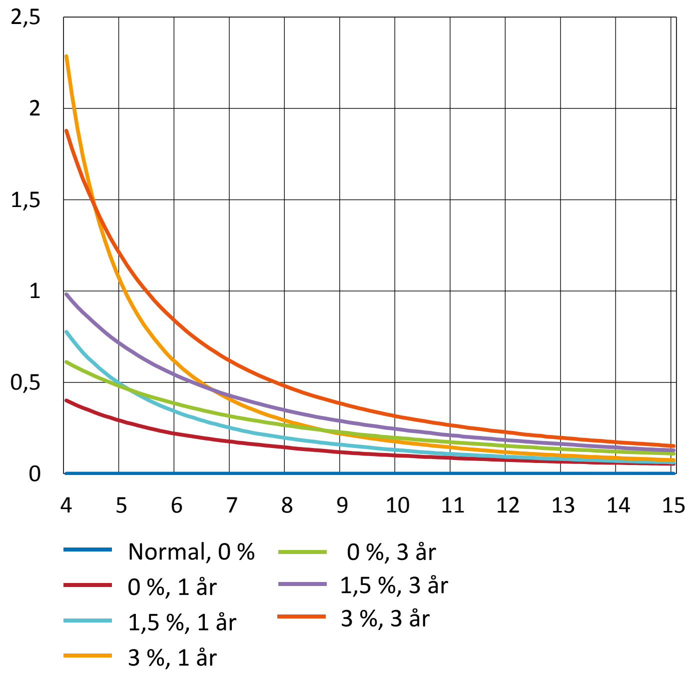
Tidsserien i Diagram 4 tyder på att sannolikheten för stora förluster är tämligen hög. I termer av sannolikhetsfördelningar är det alltså en fördelning med ”tjocka svansar”, det vill säga med högre sannolikhet för extrema utfall än normalfördelningen. Det är därför troligen missvisande att beskriva de historiska förlusterna med en normalfördelning som innebär att mycket dåliga utfall inte skulle vara särskilt sannolika. I Modell 2 antar vi därför att kreditförlusterna har en statistisk fördelning med förhållandevis hög sannolikhet för mycket dåliga utfall, en så kallad halv t-fördelning. För en mer ingående beskrivning se Bilaga E.

Diagram 5 illustrerar den skattade sannolikheten för en bankkris enligt Modell 2. Diagrammet visar sannolikheten för en bankkris på ett års sikt vid olika kapitalnivåer. Vi har skattat modellen dels utifrån historiska förluster på ett års sikt, som vi också gjorde i Modell 1, men också på tre års sikt för att ta hänsyn till att år med stora förluster tenderar att följa på varandra. Liksom för Modell 1 har vi skattat med en kritisk nivå för eget kapital på 0 respektive 1,5 procent av de totala tillgångarna. Utöver det skattar vi också Modell 2 med en kritisk nivå på tre procent av de totala tillgångarna. Det senare motiveras av att modellen avser förluster för banksystemet som helhet och att den kritiska nivån ska tolkas som ett genomsnitt. Enskilda banker kan däremot ha avsevärt högre förluster än genomsnittet i ett stressat läge och kan därför hamna i kris innan genomsnittet nått den kritiska nivån. Som vi argumenterat för ovan kan det räcka med att en bank hamnar i kris för att hela banksektorn ska göra detsamma. Det gör det lämpligt att höja den kritiska nivån något för att kompensera för risken att vi underskattar sannolikheten för en bankkris. Det ska dock inte tolkas som en bedömning av när en bank kan sättas i resolution för att den anses fallera eller vara nära att fallera. Som jämförelse inkluderar vi även en skattning av modellen där vi antar att kreditförlusterna är normalfördelade (mörkblå linje nära noll).

Precis som i Modell 1 faller sannolikheten för en bankkris i takt med att kapitalnivåerna ökar. Sannolikheten för en bankkris är högre ju högre den kritiska nivån sätts (som andel av totala tillgångar) samt högre när sannolikheten räknas på tre år i stället för ett (se Diagram 5 och Tabell 8).

[23] Detta antagande är viktigt för att kunna beräkna i vilken utsträckning förluster under en kris kan täckas utav löpande vinster. I praktiken är vinsterna inte konstanta. Ett sätt för banker att hantera stora förluster är att öka sina marginaler gentemot hushåll och företag. Om bankerna ökar sina marginaler i en djup lågkonjunktur riskerar det dock att förvärra det ekonomiska läget.

Diagram 5. Sannolikhet för en bankkris på ett års sikt med Modell 2
Sannolikhet vid olika kapitalnivåer i procent



Anm. Normal avser ett antagande om normalfördelning. Procentsatserna i legenden avser olika kritiska nivåer för eget kapital. 1 år och 3 år avser historiska förluster på ett respektive tre års sikt.

Källa: Riksbanken

Tabell 8. Sannolikhet i procent för bankkris med Modell 2 för olika kapitalnivåer
Sannolikhet vid olika kapitalnivåer, i procent

	Ett års horisont			Tre års horisont		
	Kritisk nivå för eget kapital			Kritisk nivå för eget kapital		
	0 %	1,5 %	3 %	0 %	1,5 %	3 %
3	0,61	1,48	9,59	0,83	1,47	3,45
4	0,40	0,78	2,29	0,61	0,98	1,88
5	0,29	0,49	1,04	0,48	0,71	1,19
6	0,22	0,34	0,61	0,38	0,54	0,83
7	0,18	0,25	0,40	0,31	0,42	0,61

Anm. Den första kolumnen avser kapitalnivån uttryckt som eget kapital i förhållande till totala tillgångar, i procent.

Källa: Riksbanken

Som framgår av Diagram 5 ovan medför användning av Modell 2 högre sannolikhet för bankkris jämfört med Modell 1 vid högre kapitalnivåer. Detta beror framför allt på att Modell 2 är skattad utifrån en lång tidsserie som täcker in flera historiska finanskriser medan Modell 1 skattats med data från en kortare period där kreditförlusterna varit förhållandevis låga.

Samhällsekonomisk nettobehållning av högre kapitalnivåer

Avslutningsvis lägger vi samman de beräkningar som beskrivits i tidigare avsnitt för att bilda oss en uppfattning om vad som kan vara en samhällsekonomiskt väl avvägd kapitalnivå för svenska storbanker.

Som beskrevs tidigare ger högre kapitalnivåer en samhällsekonomisk vinst genom att minska sannolikheten för kostsamma bankkriser. Samtidigt finns det en kostnad för högre kapitalnivåer genom att BNP-nivån blir lägre när bankernas utlåning blir dyrare. Samhällets nettobehållning av att höja kapitalnivåerna är därför vinsten minus kostnaden. Genom att marginellt öka kapitalnivåerna kan man beräkna hur den samhällsekonomiska nettobehållningen utvecklas när man tillför ytterligare kapital. För att det ska vara samhällsekonomiskt lönsamt att höja kapitalnivån behöver den förväntade vinsten överstiga den förväntade kostnaden.

Hur räknar man ut den samhällsekonomiska nettobehållningen?

I tabell 9 ger vi tre stiliserade exempel på hur kostnad och vinst kan förhålla sig till varandra för att illustrera hur den samhällsekonomiska nettobehållningen räknas samman.

Om bankens egna kapital vid någon viss nivå höjs med 1 procentenhet så minskar i detta exempel sannolikheten för en kris med 1 procentenhet. Om kapitalnivån därefter höjs med ytterligare 1 procentenhet minskar sannolikheten för en kris med 0,5 procentenheter till. Höjer man därefter med ytterligare 1 procentenhet minskar sannolikheten med ytterligare 0,1 procentenheter (se kolumn a). Kostnaden för en kris anges i kolumn (b). Med utgångspunkt i detta kan man genom att multiplicera (a) med (b) få fram den förväntade vinsten per år av att öka kapitalnivån med 1 procentenhet. Vinsten anges i kolumn (c) och motsvarar alltså minskningen i sannolikheten för en kris multiplicerat med kostnaden för en kris.[24]

Samtidigt innebär en högre kapitalnivå en kostnad i och med att det blir något dyrare för hushåll och företag att låna av banker, och den kostnaden anges i kolumn (d). Skillnaden mellan den förväntade vinsten av en högre kapitalnivå och kostnaden för densamma ger den samhällsekonomiska nettobehållningen i kolumn (e).

I tabell 9 framgår att kostnaden för en kris antas vara 180 procent av BNP. Samtidigt vet vi från tidigare avsnitt att en höjning av kapitalnivån med 1 procentenhet kan väntas medföra att bankerna ökar sina utlåningsräntor något vilket i sin tur kan ge en något lägre BNP-nivå på lång sikt. Med utgångspunkt i de beräkningar som redovisats i tidigare avsnitt blir den samhällsekonomiska behållningen av den första höjningen av kapitalnivån i exemplet 1,69 procent av BNP, se tabell 9. Den samhällsekonomiska nettobehållningen är positiv, det vill säga vinsten överstiger kostnaden, i alla tre fall.

Tabell 9. Exempel - Nettobehållning av att öka kapitalnivån med 1 procentenhet
Sannolikhet per år och vinst och kostnad som procent av BNP

Ökning av bankernas eget kapital som andel av totala tillgångar	Minskning av sannolikheten för en kris (procentenheter)	Kostnad för en kris (procent av BNP)	Förväntad vinst (a)×(b) (procent av BNP)	Kostnad (procent av BNP)	Samhällsekonomisk nettobehållning (c)-(d) (procent av BNP)
	(a)	(b)	(c)	(d)	(e)
1 procentenhet	1,0	180	1,80	0,11	1,69
Ytterligare 1 procentenhet	0,5	180	0,90	0,11	0,79
Ytterligare 1 procentenhet	0,1	180	0,18	0,11	0,07

Källa: Egna beräkningar

Höjning av kapitalnivån minskar risken för kris

Frågan är då vad som är den optimala kapitalnivån. För att räkna fram denna söker vi efter högsta möjliga kapitalnivå som vid en ytterligare ökning av kapitalnivån ger en positiv samhällsekonomisk nettobehållning (e) i Tabell 9. Detta görs i olika steg.

I ett första steg räknar vi fram ett så kallat tröskelvärde som ger brytpunkten efter vilken det inte längre är lönsamt att höja kapitalnivån. Tröskelvärdet beräknas genom att vi dividerar kostnaden för en högre kapitalnivå (kolumn d i Tabell 9) med kostnaden för en kris (kolumn b).

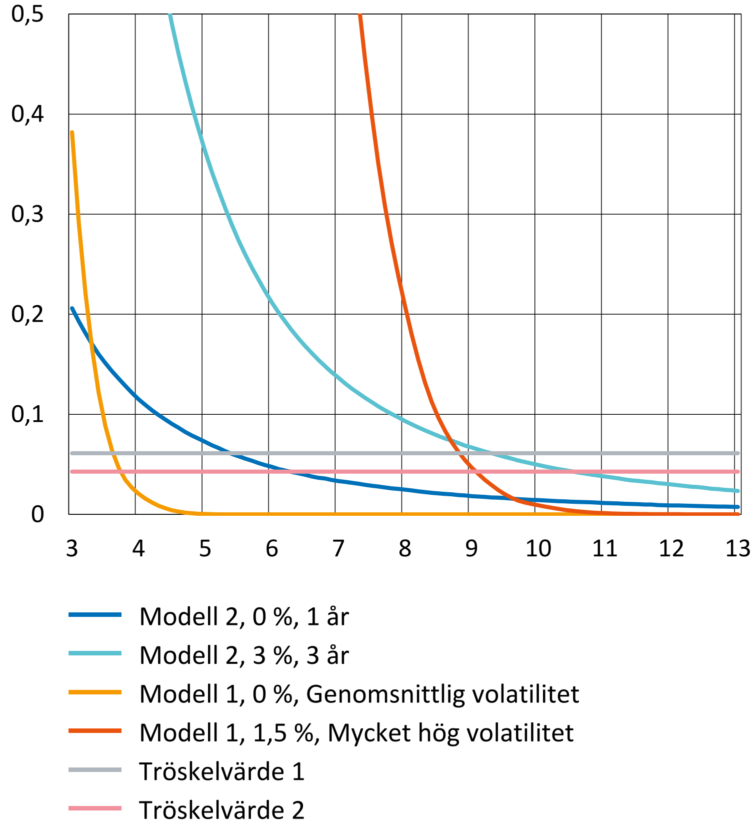
[24] Notera att nyttan ges av minskningen i sannolikheten för en bankkris på ett års sikt, multiplicerat med kostnaden av en kris som är ett nuvärde av framtida kostnader. Detta återspeglar att kriser antas resultera i en permanent lägre BNP-nivå varje gång de inträffar. Anta att man kunde betala en premie för att med säkerhet undvika kriser under ett års tid. Under antagande om riskneutralitet är det värt att betala premien så länge den inte överstiger sannolikheten för att en kris inträffar under det året multiplicerat med nuvärdet av en kris.

I ett andra steg kan vi sedan undersöka hur olika kapitalnivåer påverkar sannolikheten för en kris (a). Som nämnts ovan minskar sannolikheten för en kris med varje höjning av kapitalnivån, men effekten blir mindre ju högre kapitalnivå vi redan har. Om den positiva effekten av att höja kapitalnivån har blivit mindre än tröskelvärdet är det inte längre samhällsekonomiskt lönsamt att fortsätta höja kapitalnivån. Den samhällsekonomiska vinsten är då alltså lägre än kostnaden och därmed blir det ingen nettobehållning.

Vi har i ett huvudscenario beräknat tröskelvärdet utifrån bedömningarna av kostnaden för kris respektive kostnaden för ökade kapitalkrav på 180 procent respektive 0,11 procent som redovisats i tidigare avsnitt och som återges i Tabell 9 .[25] Vi har också skattat sambandet mellan en ökning av kapitalnivån och sannolikheten för att en kris inträffar med hjälp av Modell 1 och Modell 2.[26] I Diagram 6 jämförs dessa värden. De olika kurvorna utgör skattningar för olika antaganden. I diagrammets förklaring refererar 0, 1,5 samt 3 procent till den kritiska nivå vid vilken en kris antas utbryta. 1 år respektive 3 år refererar till tidshorisonten för förlusterna utifrån vilka modellen har skattats och Medel, Hög, respektive Mycket hög refererar till antaganden om volatiliteten.[27]

Skärningspunkterna mellan tröskelvärdena och de olika sannolikhetskurvorna visar vid vilken kapitalnivå det är lämpligt att höja med ytterligare en procentenhet men inte mer än så. Den lämpliga kapitalnivån, beroende på antaganden, ges alltså av kapitalnivån vid skärningspunkten ökat med en procentenhet.

Diagram 6. Effekten av högre kapitalnivåer på sannolikheten för kris för olika antaganden
Minskning av sannolikheten per år för en kris i procentenheter



Anm. Procentsatserna i legenden avser olika kritiska nivåer för eget kapital. 1 och 3 år avser att beräkningarna bygger på historiska förluster på 1 respektive 3 års sikt.

[25] Om kostnaden för en kris är 180 procent av BNP och kostnaden för att bankerna ökar sina låneräntor är 0,11 procent (påverkan på BNP) blir tröskelvärdet 0,11/1,8, det vill säga cirka 0,06 procentenheter.

[26] I Appendix D och Appendix E redogörs för 12 olika specifikationer av Modell 1 och 2 som ligger till grund för beräkningarna. Här illustreras endast ett urval i syfte att visa på spridningen i resultaten. Vår bedömning är att samtliga skattade varianter är relevanta och syftet med urvalet är att dels illustrera känsligheten för antaganden och fånga ytterligheterna givet de antaganden som görs.

[27] I det förra avsnittet beskriver sambandet i termer av nivån på sannolikheten för en kris och nivån för bankernas eget kapital. Här beskriver vi samma samband men uttryckt i hur mycket sannolikheten för en kris vid en given kapitalnivå minskar när kapitalnivån ökar med en procentenhet.

Källa: Riksbanken. Se Bilaga D och E för en mer ingående beskrivning

I diagrammet illustreras också ett alternativt tröskelvärde (tröskelvärde 2) som är framräknat utifrån ett alternativt scenario som antar en högre kostnad för en kris och en lägre kostnad för högre kapitalnivåer. Kostnaden för en kris antas i detta alternativa scenario vara 257 procent av BNP i nuvärdestermer, vilket motsvarar den högre skattningen för den svenska 1990-talskrisen i Boyd et al. (2005). Detta högre antagande motiveras av att den svenska banksektorn under de senaste decennierna har vuxit kraftigt i förhållande till BNP, blivit mer sammanlänkad och ökat sitt beroende av marknadsfinansiering. Som förklarades ovan är den uppskattade kostnaden för en kris dessutom känslig för valet av diskonteringsränta. Om man tar hänsyn till nu aktuella bedömningar av nivån på de långsiktiga räntorna kan det vara motiverat att nuvärdesberäkna framtida välfärdsförluster med en lägre diskonteringsränta. Med lägre diskonteringsränta blir värdet av framtida inkomster större och därmed blir välfärdsförlusten av kriser större. Därtill antas kostnaden för ökade kapitalnivåer vara hälften så stora i det alternativa scenariot jämfört med huvudscenariot. Det motiveras bland annat av att vår kostnadsberäkning är baserad på två olika modeller varav den ena inte inkorporerar den så kallade Modigliani-Miller-effekten. Detta innebär att det kan finnas en tendens att överskatta kostnaden. Dessutom kan företag tänkas finansiera investeringar på andra sätt än genom att låna av banker. Båda dessa faktorer talar för att effekten på investeringar och BNP kan bli mindre än i huvudscenariot.

En lämplig kapitalnivå ligger i intervallet 5-12 procent

Varje fallande linje i Diagram 6 visar hur mycket ytterligare en procentenhet kapital minskar sannolikheten för en kris skattat med Modell 1 och Modell 2 för olika antaganden om volatilitet, tidshorisont och kritisk nivå. Varje skärningspunkt mellan de fallande kurvorna och de horisontella linjerna (tröskelvärdena) indikerar en kapitalnivå där det är lämpligt att höja med ytterligare en procentenhet men inte mer än så, för en given uppsättning antaganden. De olika skärningspunkterna bildar därmed tillsammans ett intervall av kapitalnivåer för olika antaganden. Genom att lägga till en procentenhet till var och en av de kapitalnivåer där linjerna korsar varandra kommer vi fram till ett intervall för vad som kan tänkas vara en lämplig kapitalnivå.

Alla skärningspunkter ligger i ett intervall mellan cirka 4 och 11 procent kapital i förhållande till totala tillgångar. Den mest försiktiga skattningen finner alltså att det är lönsamt att höja med ytterligare en procentenhet från en kapitalnivå på omkring 4 procent till en nivå på omkring 5 procent. Samtliga skattningar talar med andra ord för att en väl avvägd kapitalnivå ligger på omkring 5 procent eller mer. De övriga skattningarna tyder på att det är samhällsekonomiskt lönsamt att höja även vid högre nivåer. Även vid en kapitalnivå på 11 procent kan det vara lönsamt att höja med ytterligare en procentenhet till 12 procent.

Sammanlagt visar våra beräkningar alltså att en lämplig kapitalnivå för svenska banker ligger i intervallet 5-12 procent av totala tillgångar.

Många andra studier visar liknande resultat

Flera nyare studier finner stöd för att det kan vara samhällsekonomiskt motiverat med kapitalnivåer i linje med våra resultat. Firestone et al. (2017) går exempelvis till väga på ett liknande sätt som i den här analysen och kommer fram till liknande kapitalnivåer för banker i USA. Dagher et al. (2016) finner utifrån paneldata från ett stort antal länder över lång tid att kapitalnivåer på 8-13 procent av bankernas totala tillgångar skulle ha varit tillräckligt för att kunna undvika merparten av de bankkriser som ägt rum i dessa länder sedan 1970.[28] Exempel på andra studier som också konstaterar att det kan vara samhällsekonomiskt motiverat med högre kapitalnivåer är Fender och Lewrick (2016), Bair (2015), Calomiris

[28] Definitionen av att undvika en kris i Dagher et al. (2016) är i huvudscenariot att bankerna har 1 procent eget kapital (i förhållande till total tillgångar) kvar efter kreditförluster under ett givet år. I ett alternativscenario sätter de denna säkerhetsmarginal till 3 procent.

(2013), Federal Reserve Bank of Minneapolis (2016) och Admati och Hellwig (2013).[29] Andra studier kommer fram till lägre nivåer. En av anledningarna till detta är att man valt att anta att kostnaden för en kris blir lägre, se exempelvis Brooke et al. (2015), med motiveringen att det nya resolutionsramverket kan förväntas minska kostnaden. En annan orsak till att skattningarna är lägre är att de avser riskviktade kapitalnivåer i andra länder. Eftersom riskvikterna i Sverige är jämförelsevis låga är det svårt att överföra dessa resultat till svenska förhållanden.

Avslutande kommentar

Att beräkna en lämplig kapitalnivå är behäftat med stor osäkerhet. Beräkningarna kan göras på många olika sätt och vilket man än väljer är resultaten känsliga för modellval och antaganden.

Med vår ansats, som i hög grad följer metoder som använts i flera tidigare studier, och med våra antaganden, är det samhällsekonomiskt lönsamt med kapitalnivåer i intervallet 5-12 procent av en banks totala tillgångar. Det kan inte uteslutas att en samhällsekonomiskt väl avvägd nivå ligger över eller under detta intervall. Våra resultat visar högre kapitalnivåer än de i riksbanksstudien från 2011 och detta återspeglar bland annat att kunskapsläget utvecklats. Resultatet är i linje med flera nyare studier.

För närvarande finns det inget krav på bruttosoliditet för svenska banker. Bankernas bruttosoliditet mätt som eget kapital i förhållande till totala tillgångar har fallit över tid och ligger nu kring fem procent. Beräkningarna visar att det kan vara samhällsekonomiskt lönsamt med högre kapitalnivåer än de som de svenska storbankerna har för närvarande.

[29] Studierna argumenterar för följande nivåer: Fender and Lewrick (2016): 4-5 %; Bair (2015): 8 %; Calomiris (2013): 10 %; Federal Reserve Bank of Minneapolis (2016): 15 %; Admati och Hellwig (2013): 20-30 %.

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Appendix A - Do higher capital requirements affect lending rates?

Cristina Cella

Introduction

In this memo, we discuss whether raising capital requirements[30] increases the cost of financial intermediation and, if so, how large this effect may be and whether borrowing for firms and households might be negatively affected.

Higher capital requirements make borrowing from banks more costly if both of the following apply:

(i) forcing banks to replace some of their debt financing with equity financing raises their average cost of capital, and
(ii) banks pass this higher cost onto borrowers by increasing margins on loans to firms and households.[31]

In theory, in the absence of frictions, an increase in capital requirements should have no effect on banks' funding costs, and hence on lending rates, in the long run. However, financial frictions exist and a review of international empirical research suggests that raising banks' equity to total assets by one percentage-point results in an increase in lending rates of 16 basis points on average.

To better understand why lending spreads may increase as a result of higher capital requirements, we discuss a number of market frictions of relevance to banks' cost of capital, and we also consider the potential effects that a possible increase in lending rates could have on the overall economy. In particular, we note that adverse effects on investment and GDP will materialise only if firms are unable to offset the higher cost of bank loans. If firms are able to access alternative financing sources, their cost of capital would increase by less than the increase in banks' lending rates, and the effects on the entire economy will be smaller than otherwise implied. In addition, some of the frictions that may contribute to raising banks' funding costs – if they reduce their leverage – are linked to subsidies for debt financing that may distort the allocation of resources in the economy and lead banks to take on too much debt from a social point of view. Keeping these factors in mind, we emphasise the distinction between *private costs* incurred by banks and *social costs* incurred by the economy as a whole when discussing the results.

[30] In this memo, we express capital requirements in terms of equity to total un-weighted assets. In particular, when we talk about an "increase in capital requirements" we refer to banks increasing equity to total assets by one percentage point.

[31] Note that the underlying assumption here is that the larger cost of funding that a bank may experience because of higher capital requirements is passed exclusively to borrowers. In particular, this assumption suggests that, to meet capital requirement while keeping its return on equity unchanged, a bank increases lending rates so that the increase in net income exactly cancels out the increase in funding costs. See King (2010) for a description of the mechanism.

The Modigliani-Miller framework

Whether or not increasing capital requirements – thereby forcing banks to finance themselves with more equity and less debt – affects a bank's overall funding cost is an empirical question.

In theory, the effect on banks' funding costs, and hence on the lending rates, could be zero in the long run. In their seminal paper published in 1958, Modigliani-Miller (hereinafter MM) show that, in a world without frictions, the combination of debt and equity with which a firm chooses to finance its operations is irrelevant to its average cost of capital. In such a frictionless world, reducing leverage[32] does not affect a firm's average cost of capital.

The MM framework recognises that issuing equity may be more expensive than financing with debt, but points to an offsetting benefit of additional equity. First, when leverage is reduced, the firm's outstanding debt becomes less risky, since there is more equity to absorb losses. Second, the probability of the firm's defaulting decreases and the volatility of the return on equity falls. This should make a firm's equity less costly. In a perfect world, the firm's weighted average cost of capital (WACC) remains unchanged.[33]

For financial institutions such as banks, the MM irrelevance theorem implies that, in a world without frictions, better capitalised banks can issue less risky – and hence cheaper – equity while maintaining the same portfolio of loans.[34] In that case, increasing a bank's capital requirements would not affect either its lending rates or its lending volumes. In practice though, banks face some specific frictions that make capital structure relevant for their cost of capital. Broadly speaking, one could put these frictions into two broad categories:

a. government intervention,
b. market frictions.

In the following, we give a brief description of each category and illustrate specific frictions that might be of particular relevance to a bank's cost of capital.

Government intervention

If the government intervenes with tax breaks or subsidies that make financing with debt more attractive that financing with equity, this distortion will affect the way companies may finance

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[32] Here we refer to leverage as the proportion of debt (D) over equity (E): debt-to-equity ratio (D/E). Keeping debt constant, leverage then decreases as the equity base increases. Note, though, that Basel III uses a different definition of leverage: Equity to Assets (E/D+E). Considering the Basel III definition of leverage, keeping assets constant, leverage decreases as the leverage ratio increases.

[33] Modigliani and Miller proposition I states that the sum of the market value of equity (E) and the market value of debt (D) is equal to the market value of the unlevered assets (U):

$$E + D = U \qquad (1)$$

This equation suggests that, by holding a portfolio of the firm's equity and debt, the investor is able to replicate the cash flows from holding the unlevered security. Because the return of a portfolio is calculated as the weighted average returns of the securities it contains, equality (1) implies that:

$$\frac{E}{E+D} Re + \frac{D}{E+D} Rd = Ru \qquad (2)$$

Where Re is the cost of (levered) equity, Rd is the cost of debt and Ru is the cost of unlevered equity or WACC (weighted average cost of capital). From equation (2), it follows that:

$$Re = Ru + \frac{D}{E}(Ru - Rd) \qquad (3)$$

A firm's cost of equity depends on the firm's operating risk (the riskiness of the cash flows of the assets absent any leverage) and the firm's financial risk, which depends on the firms' level of leverage. Modigliani and Miller proposition II states that the cost of levered equity increases with the firm's market value of the debt-to-equity ratio (D/E).

[34] See Admati, DeMarzo, Hellwig and Pfleiderer (2011) for an extended discussion.

their operations. The same type of distortion happens if the government offers (unpriced) guarantees of liabilities.

Frictions due to government intervention affect a bank's capital structure decisions in different ways. To begin with, in many countries, interest payments on debt are deducted against a firm's corporate income while dividends to shareholder are not. Hence, using debt gives rise to a valuable tax shield. So banks, like any other company, maximise the value of their tax shield by increasing leverage. If leverage is reduced, some of these benefits are lost, and this can affect (albeit marginally) a bank's cost of capital.

To give a concrete example, assume that new equity replaces long-term debt in a bank's capital structure, and that the only effect on the bank's cost of capital comes from the lost tax shield on debt. Let us assume that, in Sweden, the average coupon on the long-term debt is 5 per cent and the corporate tax rate is 22 percent. If equity increases one percentage point, the lost tax shield will be given by the coupon times the tax rate (0.05×0.22) = 0.011 per cent, or 1.1 basis points. This implies that, keeping assets constant, if banks had to issue one extra percentage point of equity, their cost of capital (WACC) could increase by about 1.1 bps.[35]

It is important to notice that a favorable tax treatment of debt over equity also creates potential "clientele effects" (Stiglitz (1973) and Miller (1977), among others). The clientele effect hypothesises that the common stocks of highly levered firms will be held by investors with low personal tax rates, while the shares of firms with little or no leverage will be held by individuals with high personal tax rates. Thus, in order to attract a certain type of investor, a company may not choose the capital structure that is best to support its operations, but that which reflects the specific preferences of its "preferred set" of investors. While the cost of this friction is difficult to quantify numerically, the existence of such a problem highlights the many ways in which government regulation can distort how banks finance their operations.

Other types of government intervention that could substantially affect banks' preference for high leverage are implicit (too-big-to-fail type) and explicit (deposit) guarantees.[36] Banks' shareholders benefit from these guarantees because they make the claim of debt holders and depositors less risky on average[37] and are thus less costly from the financing perspective of the bank. Replacing debt with equity might then result in a higher funding cost.

Importantly, the larger cost that banks may incur because of forgone guarantees is not a social cost but a private one. The existence of guarantees might encourage banks to take excessive leverage and/or hold more illiquid assets (Diamon and Rajan (2012)). This behaviour makes the portfolios of banks riskier, and shifts risk from the banks' equity holders to the banks' depositors and debt holders. Therefore, guarantees provide shareholders with a private benefit, but have no clear social benefit: a) in normal times, guarantees allow banks to fund themselves with cheaper-than-otherwise debt, thus giving them an incentive to lever up; and b) during a financial crisis, guarantees represent a transfer from taxpayers to shareholders. If guarantees generate inefficient behaviour, reducing their use might actually generate social benefits.

Government guarantees, or better, the existence of financial contracts used to overcome the lack of them, also create another friction known as the debt convenience premium. Banks not only raise money from retail depositors, but also largely rely on wholesale debt raised from institutional investors (such as sovereign wealth funds and mutual funds) and cash-rich companies that are not protected by deposit guarantees. To offer non-retail investors a safety

[35] These calculations are in line with the results of Kashyap, Stein and Hanson (2011) who also document a small increase in the representative US bank's cost of capital due to the lost tax shield.
[36] See Elliott (2009) and Miles et al. (2013) for an extended discussion of this topic.
[37] This is because debt holders and depositors are more likely to recover part if not all of their claims in bad states of the word.

net similar to that enjoyed by retail investors, banks use structured financial instruments that make their investment essentially default-risk free.

When institutional investors provide funds to a bank, they are paid an interest rate and receive collateral through an instrument similar to a repo agreement. The investor buys (at a discounted price) the collateral from the bank and the bank agrees to repurchase the same asset at a later date (usually the day after) at a higher price. If the bank defaults, the investor keeps the collateral and is therefore insured against default risk. This system allows institutional investors (and more specifically money market funds) to have a flexible and safe investment that not only produces some interest but also allows the funds to access their cash almost on demand.[38] Given this convenience, institutions are then willing to accept a lower interest rate from banks, and short-term wholesale debt has therefore become a highly attractive form of funding for banks. In other words, some wholesale short-term debt may carry a valuable money-like premium.[39]

Understanding the money-like premium is important because, when studying the impact of capital requirements, most authors assume that equity replaces long-term debt (which is more expensive than short-term debt on average). However, if banks are heavily funded with short-term wholesale debt, it is reasonable to assume that they may need to replace some of this debt with equity and lose the money-like premium they make. Nevertheless, this kind of cost might be quite small. For a one percentage-point increase in capital requirements, Kashyap, Stein and Hanson (2011) report that the lost money-like premium would make funding for the average bank in the US *at most* 1 bp more expensive.

Market frictions

In the perfect world postulated by Modigliani-Miller, markets are completely frictionless so firms have easy access to financing and can freely choose their capital structure. In reality, when a company tries to raise more financing, this could be quite expensive. Some important frictions in this context are related to asymmetric information issues and market competition.

Because of asymmetric information, financiers may be unable to correctly price the assets of a company and they may require higher compensation for risk than is otherwise necessary (Ross (1977) and Leland and Pyle (1977)). However, companies might not accept the lower price investors are willing to pay and may try to issue equity when the discount can be minimised (Myers and Majluf, 1984). Investors though anticipate that managers may issue equity when the stock is likely to be overpriced and react negatively to announcements of equity issues (i.e. the company stock price declines upon announcement) deterring managers from issuing equity in the first place. Managers may then choose to finance with retained earnings first, debt second and new equity in the final instance – following the "pecking order theorem" of Myers (1984).

Since banks have very opaque balance sheets, they could be more adversely affected by asymmetric information issues when raising new equity.[40] On the other hand, while asymmetric information issues might be particularly significant when a single bank tries to raise equity, if *all* banks need to issue new equity to meet the regulatory minimum capital requirement, asymmetric information may affect them less severely.

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[38] Gordon and Metrick (2010) provide a full description of the "securitise-banking" system and the use of repo agreements.
[39] Gorton (2010), Gorton and Metrick (2012) and Stein (2012) are among the first to discuss this specific friction.
[40] See Bolton and Freixas (2006) for more details about how asymmetric information may affect a bank's net worth.

Another important friction for banks is the degree of competition in the market. Market competition, however, may not directly affect a bank's cost of capital, but rather its ability to pass an increase in this cost on to its clients.

The main competitive advantage of banks is their ability to access cheap funding. If, in a competitive environment, banks' funding costs increase, some banks may not be able to compete and could be eventually run out of business. This would make the market more concentrated and could have adverse consequences for borrowers, since banks may increase interest rates more easily.

In already concentrated markets, increasing capital requirements might not reshape the industry structure, but might indeed affect lending rates: when unable to deleverage (assets are kept constant) but forced to raise equity, banks may charge higher interest rates and/or fees to their customers in order to compensate for the decrease in investors' return on equity (ROE) and keep their target ROE.[41,42]

With four big banks (Nordea, SEB, SHB and Swedbank) that dominate the industry with about 80 per cent of market share, Sweden has a very concentrated banking sector. Therefore, while the risk of further concentration in the local market may not be real, banks may indeed transfer all of the extra costs incurred by higher capital requirements directly onto borrowers. Still, banks do not necessarily have to increase lending rates to offset the increase in their funding cost. The ability of banks to charge more for loans is not only conditional on the degree of competition in the banking sector; it also depends on the availability of credit through private capital markets, and the elasticity of loan demand. King (2010) suggests that, before banks modify lending rates, they could (i) reduce operating expenses, (ii) increase non-interest sources of income, (iii) redirect activity towards more profitable lines of business, or (iv) absorb the higher costs and reduce ROE. These alternatives suggest that, also in a highly concentrated industry, lending rates need not to increase because of higher capital requirements.

The short discussion above very briefly summarises the tension between the benefits and costs of debt and equity financing, and suggests that frictions make a firm capital structure relevant to its cost of capital. Nonetheless, many studies document that, when companies substitute debt financing with equity financing, their overall cost of capital increases less than what it would have done in the absence of any mitigating effects, due to lower leverage and less risky equity. This effect is commonly referred to as the "Modigliani-Miller offset" and it is well-documented also for the banking sector, as Table 1 shows.[43]

The studies in Table 1 suggest that, once equity is raised, the actual cost of capital of a bank might not increase by as much as some critics suggest:[44] Consistent with the MM offset, replacing debt with equity makes a bank less risky (i.e. the bank's equity beta decreases[45]) and this benefit offsets in part the cost implied by potential frictions. Lately, though, some authors

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[41] Elliot (2009) discusses why banks may intend to keep their target ROE and Kashyap, Stein, and Hanson (2011) discuss the issue of competition in the banking sector.

[42] Kisin and Mandela (2016) suggest that banks may perceive equity to be arbitrarily costly. Theoretically, the costs could be substantial if the fragile capital structure is necessary for bank operation (Calomiris and Kahn (1991) and Diamond and Rajan (2001)). Admati, DeMarzo, Hellwig, and Pfleiderer (2011) and Admati and Hellwig (2013) suggest opposite arguments. Equity may also increase bank value by improving incentives (e.g., Holmstrom and Tirole (1997); Allen, Carletti, and Marquez (2009); Mehran and Thakor (2011)).

[43] To give an idea of the MM offset, we will refer to the example illustrated by Miles, Yang and Marcheggiano (2013). On page 13 of their paper, they show that, in the absence of any Modigliani ad Miller offset, a 15 percentage point increase in capital to un-weighted assets would increase the cost of capital of the average bank in the UK by approximately 33 bps. However, using their fixed effects estimate in Table 1, they show that the actual increase in the average bank cost of capital is only 18 bps, not 33 bps; in other words the actual increase is 45 per cent lower than in the case without MM offset.

[44] See for instance the study that the Institute of International Finance (IIF) published in 2010.

[45] Kashyap, Stein, and Hanson (2010) show that in a panel of large banks, those with less leverage have significantly lower values of both beta and stock-return volatility.

have questioned the existence of the MM offset, suggesting that a different issue may be particularly important to consider in this contest: the low-beta anomaly.

Table 1. Evidence of the Modigliani-Miller offset.

(1)	(2)	(3)	(4)
Paper	**Country**	**Data Period**	**MM Offset**
ECB (2011)	54 Global Banks	1995-2011	41%-73%
Junge and Kugler (2013)	Switzerland	1999-2010	64%
Miles et al. (2013)	UK	1997-2010	45%-90%
Shin (2014)	105 Advanced Economy Banks	1994-2012	46%
Toader (2015)	European Banks	1997-2011	42%
Bank of England (2015)	UK	1997-2014	53%
Clark et al (2015)	US	1996-2012	43%-100%

Column (1) records the title of the papers, column (2) describes the countries involved in the study, column (3) reports the time period used in the study, and column (4) shows the Modigliani and Miller (MM) offset documented by the paper.

The standard Capital Asset Pricing Model (CAPM) postulates that investors should be compensated for taking systematic risk (beta). However, Ang, Hodrick, Xing and Zhang (2006) document that stocks with lower beta have historically earned higher returns than stock with higher beta. The existence of this anomaly suggests that, all else equal, companies with low risk may have to pay more, not less, for raising extra equity financing, and thus end up with a higher cost of capital (Baker and Wurgler, 2014). Then, even in a perfect world, the Modigliani-Miller capital structure irrelevance theorem fails (Baker and Wurgler, 2015). Baker and Wurgler (2015) estimate that, because of the low-beta anomaly alone, the weighted average cost of capital of the average US bank may increase 8.5 bps after a one percentage-point increase in capital requirements.

The discussion above highlights that, because of frictions, after increasing equity to total un-weighted assets by an additional percentage point, banks might experience an increase in their cost of capital and they may pass this increase to borrowers by increasing lending rates. So, the next question is: how much does a one percentage-point increase in equity to total assets affect lending rates? This issue is discussed in the following section.

Existing literature on lending rates

The literature on how capital requirements affect lending rates has evolved quite substantially from initial attempts in the aftermath of the financial crisis. Data availability and more sophisticated estimation frameworks have contributed to more direct and better developed studies.

Table 2 summarises some of the most cited papers in this fairly extensive literature. For the sake of simplicity, the studies have been divided into those that explicitly employ the MM framework (row (1)–(7) of Table 2), and those that use alternative methodologies (row (8)–(13) of Table 2).[46] All of the results have been harmonised so that we always report the change in

[46] The papers that use alternative methodologies mostly employ structural models, including general or partial equilibrium models, and accounting equations. Just to give an intuition, structural econometric models use economic theory to develop mathematical statements about how a set of observable "endogenous" variables (y) are related to another set of observable "explanatory" variables (x) and unobservable variables (z). Methods using accounting identities start by the basic principle that total assets must equal total liabilities and use stylised balance sheets and calibrations based on a representative bank.

lending rates associated with a one percentage-point increase in equity to total assets, also when the original study investigates capital to risk-weighted-assets (RWA) type of requirements.[47]

The studies that use the MM framework proceed in two steps: (a) they study how the cost of capital of a bank is affected by the change in capital requirements; and (b) they study how much of the change in the bank's cost of capital is passed on to clients, and thus how much more expensive it becomes for (corporate) customers to finance their investments. As supported by existing empirical literature (De Bondt (2005), Harimohan, McLeay and Young (2016) and Mojon (2000)), most studies assume that the increase in funding costs is fully transferred onto borrowers.[48]

Table 2. Empirical evidence of the impact of a one percentage-point increase in capital requirements on lending rates.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Study	**Year**	**Country**	**Time Period**	**Type of Study**	**Methodology**	**MM Offset**	**Δ Lending Rates (bps)**
	A. Papers using the MM framework:							
(1)	BCBS*	2010	13 OECD countries	1993-2007		Calibration		26
(2)	Junge and Kugler	2013	Switzerland	1999-2010		Calibration	64%	0.70
(3)	Miles, Yang and Marcheggiano	2013	UK	1997-2010		Calibration	45%	1.20
(4)	Bank of England	2015	UK	1997-2014		Calibration	53%	25
(5)	Elliot	2009	US			Calibration	Implicit	20
(6)	Kashyap, Stein and Hanson	2011	US	1976-2008		Calibration	Implicit	3.50
(7)	Baker and Wurgler	2013	US	1971-2011		Empirical + Calibration	Implicit	8.50
							Average	**12.13**
	B. Papers NOT using the MM framework:							
(8)	Cosimano and Hakura	2011	Global	2001-2009	Structural Model	Empirical		12
(9)	King*	2010	13 OECD countries	1993-2007	Accounting Identities	Calibration		30
(10)	Slovik and Cournede*	2011	3 OECD countries	2004-2006	Accounting Identities	Calibration		32
(11)	De Resende, Dib and Perevalov*	2010	Canada		General Equilibrium Model	Calibration		2.50
(12)	Corbae and D'Erasmo*	2014	US		Structural Model	Calibration		50
(13)	Kisin and Manela*	2016	US	2002-2007	Partial Equilibrium Model	Empirical		0.30
							Average	**21.13**
							Overall Average	**16.28**

Column (1) records the title of the papers, column (2) reports the year of the last available version, column (3) describes the countries involved in the study, column (4) reports the time period used in the study, column (5) briefly summarises the type of study, column (6) describes whether the study was conducted using an empirical, regression-based, approach or a calibration approach. Column (7) reports the estimated MM offset and column (8) reports the effect of a one percentage-point increase in capital to un-weighted total assets on lending rates (in basis points). * Indicates papers that originally investigate the effect of a one percentage-point increase in capital to risk-weighted-assets (RWA). To harmonize the results, RWA is assumed to be 50 per cent on average of total un-weighted assets.

Overall, the main takeaway of Table 2 is that a one percentage-point increase in capital requirements has a relatively small impact on funding costs and therefore on lending rates (about 16 bps on average), and more recent evidence (see for instance Kisin and Manela (2016)) finds smaller effects. These results though should be interpreted with caution.

To begin with, banks face different institutional settings in each country and thus most of the results depend on the banking sector's country-specific characteristics. Another potential problem is that changes in capital requirements are studied in isolation from other policy changes. The results obtained might therefore only capture an incomplete part of the actual effect. For instance, if several pieces of regulation change together, the collective effect of these changes could result in larger (or smaller) estimates than those reported in the aforementioned studies.

[47] To harmonise all the papers, we translate all of the results assuming that on average RWA is 50 per cent of total assets. This is currently the best we can do because of the lack of information on the actual proportion of risk-weighted-assets (RWA) to total assets in countries around the world. Data was requested from BIS but our request could not be met because of privacy issues.

[48] Miles et al. (2013) and Junge and Kugler (2013) are the only two papers that deviate from this assumption in their main conclusion. However, to better compare the results across all papers, in Table 2 their results are adjusted so that the pass-through is 100. Note that this assumption makes the magnitude of their effects larger than otherwise reported in their papers.

It is also important to note that most of the studies use highly simplified assumptions: banks have only loans in their portfolios, all equity is common equity, equity replaces long-term debt, the tax rate is constant (this affects the tax value of the debt tax shield) and banks are not able to change their assets. Changing one or more of these assumptions may substantially affect the final estimates. Lastly, studies that use calibrations are very sensitive to the way inputs are obtained.

To conclude, it is important to keep in mind that, when interpreting the results collected in this very brief survey, the borrowers must be considered too. While banks may be willing to charge higher lending rates to their customers, corporate borrowers may look for credit elsewhere (less regulated institutions or shadow banks may capture part of the market of more regulated banks), and may even choose to adjust their own capital structures. Faced with more market competition, banks may then reconsider the decision to pass a large part of their increased funding costs onto their customers. Therefore again, the structure of the banking and financial system plays a crucial role when assessing the real economic consequence of changes in capital requirements.

Existing evidence on lending volumes

Another aspect to consider to fully assess the impact that changes in capital requirements may have on the real economy, is how they affect lending volumes in the steady state.

While banks could react to higher capital requirements by increasing lending rates, they could also choose to keep their lending rates at the same level and instead reduce the amount of credit to the economy to minimize the cost of monitoring borrowers in order to avoid losses. They might of course concurrently increase lending rates and reduce lending volume. While a reduction in the supply of credit to households and corporates may have strong consequences for the real economy, one should not forget that a demand side effect is also possible. In well-functioning markets, keeping investment opportunity constant, if banks increase lending rates as a consequence of higher capital requirements, borrowers might look elsewhere for credit. This latter effect would create an observational equivalence: while it might seem that banks have reduced credit to the economy, in fact, it is customers that are borrowing less from banks to finance their consumption and businesses. If this is the case, changes in capital requirements should be have quite limited effects on the real economy in the long run.

Also if unable to distinguish between a demand-side effect and a supply-side effect, many authors have been studying the consequences that changes in capital requirements could have on lending volumes. Since the aim of this review is to focus on lending rates, we will only briefly review two (more recent) papers that contribute to the literature on how changes in capital requirements might affect lending volumes. We refer readers to the BIS report no. 30 published in March 2016 for a richer summary.

Mendicino, Nikolov, Suarez and Supera (2015) show results not only on lending rates but also on volumes. The authors incorporate the banking system in a standard DSGE model and consider a framework in which banks lend to both households and corporates and where all borrowers may default on their lenders due to idiosyncratic and aggregate shocks. They calibrate their model using data from the euro zone over the period 1999–2013. While the original paper does not directly report results for lending rates and lending volumes, the BIS paper no. 30, published in March 2016, reports authors' calculations (see Table 1 and Table 2 in the report). In the BIS report, the authors suggest that, in the long run, an increase of one percentage-point in the ratio of capital to risk-weighted (un-weighted assets[49]) is associated

[49] RWA=50 per cent*Total Assets

with an increase in lending rates of 2.8 (5.6) bps for households' mortgages and 4.9 (9.8) bps for corporate loans. Moreover, credit growth falls by about 0.15 per cent (0.3 per cent) for households and 0.43 per cent (0.86 per cent) for corporates. Small effects are also documented by Noss and Toffano (2014) who, using data on UK banks over the period 1986–2010, find that an increase of 15 bps in un-weighted capital requirements is associated with a median reduction of around 1.4 per cent in the level of lending after 16 quarters. If we consider an increase of equity to total un-weighted assets of just one percentage-point, the median effect on lending volumes amounts to 0.093 per cent in the level of lending after 16 quarters.

The modest effects found by Mendicino et al. (2015) and Noss and Toffano (2014) are also confirmed by a large body of literature. These studies, like those on lending rates, conclude that the effect of capital regulation on lending volumes should be quite modest in the long run.

Conclusion

In the above, we have taken the Modigliani-Miller theorem as a starting point for a discussion of how banks' funding costs may be affected by higher capital requirements. The theorem predicts that, in the absence of taxes and other frictions, banks' funding costs may not be affected at all in the long run. In practice, there are relevant frictions to consider that may cause banks' funding costs to increase somewhat as a result of higher capital requirements. Yet, existing research also finds support for the existence of some degree of Modigliani-Miller offset. Overall, the studies reviewed in this memo show that raising banks' equity to total un-weighted assets by one percentage-point may result in an increase in lending rates that ranges between 0 and 50 bps, 16 bps on average.

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Appendix B - The impact of higher capital requirements on GDP

Anna Grodecka

Introduction

Higher capital requirements, while reducing the probability of a crisis, may also be costly for society. More specifically, they may increase banks' funding costs, and banks may respond by raising lending rates.[50] This could have a negative impact on the investment of companies that finance their production with bank loans, and on the spending of households that use bank credit to finance their consumption, potentially resulting in a lower GDP level.

There is uncertainty about how much capital requirements would actually raise the cost of capital in the economy. The extent to which banks' funding costs could increase due to higher capital requirements and are passed on to banks' clients depend on country- and regulation-specific factors and the degree of the Modigliani-Miller offset (for a more detailed discussion, see Appendix A). The Modigliani-Miller theorem states that funding costs of a bank should not depend on the mix of equity and debt financing (Modigliani and Miller, 1958).[51] With higher equity, a bank becomes safer, and as such, the required return on equity should fall, making it relatively less expensive. However, due to various frictions including, but not limited to, tax subsidies for debt financing and explicit and implicit government guarantees, this Modigliani-Miller offset does not fully materialize in reality. Thus, if we require banks to hold more equity, their funding costs will likely increase. However, it should be noted that, in order for higher capital requirements to reduce corporate investment, the Modigliani-Miller theorem has to fail twice, both at the bank level and the company level.

We evaluate the long-run GDP effect of increased capital requirements using two general equilibrium models with different characteristics. These models capture feedback effects between different sectors in the economy. We focus on the impact on GDP once the economy has settled into a new equilibrium (steady state), rather than transitory effects.

The first model contains banks and a capital requirement that allows us to perform the analysis in one step (Iacoviello, 2015). The second model requires two steps: first, an estimation of the effect on banks' lending rates, for which we rely on the estimates from Appendix A. Second, we evaluate the effect of such an increase in lending spreads in the Riksbank's macroeconomic model, RAMSES.[52] Iacoviello (2015) is particularly well-suited to our policy experiment because, unlike many DSGE models, it contains a capital requirement for banks. A benefit of using RAMSES is that the model is particularly apt for the Swedish economy.

Both approaches generate similar results. Our analysis suggests that a 1 percentage-point increase in the equity to total assets ratio may lower the long-run GDP level by about 0.09–0.13 per cent, depending on the model used.[53]

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[50] See Appendix A "Do higher capital requirements affect lending rates?" In this Appendix, we use the terms lending rates and lending spreads interchangeably. We refer to the lending spread as to the difference between lending rates and deposit rates. If capital requirements do not have an impact on the deposit rate (as in the models discussed in this Appendix), the change in the lending spread will be entirely due to the change in lending rates.

[51] Note that the Modigliani-Miller theorem refers to *having* equity and not *raising* new equity. It might be that raising new equity may increase bank funding costs temporarily, but not permanently, if no further frictions occur. See the discussion in Miller (1995).

[52] RAMSES is a DSGE model used at the Riksbank to produce a macroeconomic forecast, alternative scenarios, and for monetary policy analysis. See http://www.riksbank.se/sv/Press-och-publicerat/Publicerat-fran-Riksbanken/Ovriga-rapporter/Occasional-Paper-Series/2013/No-12-Ramses-II--Model-Description/.

[53] These estimates do not change with the starting capital ratio, or change very little.

Different ways of calculating the impact of capital regulation on GDP

Our analysis compares results from different methods. Specifically, we use a one-step and a two-step approach for Sweden and we compare our results with estimates for other countries that have mainly been estimated using a two-step approach. Hence, the results that we discuss belong to three categories, with the last one mainly used for robustness:

1. Steady-state comparison in the Iacoviello (2015) model	One-step
2. Long-run effects of a higher lending spread in RAMSES model	Two-step
3. Empirical and semi-structural estimates of the relationship between lending spreads and GDP for other countries	Two-step

It is not a priori clear which of these methods is superior. Making the calculations in one step puts a lot of faith into one specific model, while spreading the analysis over multiple steps introduces uncertainty at each step of the analysis. Given this uncertainty, we find it suitable to use both (1) and (2) in our analysis for Sweden, and relate the magnitude of that estimate to (3).

Table 1 summarises the results from all three approaches. The remainder of this Appendix discusses the calculations in more detail.

Table 1. Comparison of the results obtained with different approaches

<table>
<tr><th>Method/model</th><th>Experiment</th><th>Change in GDP</th><th colspan="2">Change in lending volume</th><th>Change in lending spreads</th><th>Change in investment</th></tr>
<tr><td colspan="7">One-step analysis</td></tr>
<tr><td rowspan="3">Iacoviello (2015)</td><td rowspan="3">permanent 1 p.p. increase in NRWCR[54]</td><td rowspan="3">-0.13%</td><td colspan="2">-1.6%</td><td rowspan="3">+46 bp</td><td rowspan="3">-0.36%</td></tr>
<tr><td>Firms</td><td>Hhs</td></tr>
<tr><td>-1.5%</td><td>-1.9%</td></tr>
<tr><td colspan="7">Two-step analysis</td></tr>
<tr><td>RAMSES</td><td>permanent 16.3 bp increase in lend. rates[55]</td><td>-0.09%</td><td colspan="2">-</td><td>+16 bp</td><td>-0.27%</td></tr>
<tr><td colspan="7">Empirical and semi-structural estimates for other countries</td></tr>
<tr><td>Minneapolis Plan (2016)</td><td>permanent 10 bp increase in lend. rates</td><td>-0.1%</td><td colspan="2">-</td><td>-</td><td>-</td></tr>
<tr><td>Bank of England (2015)</td><td>permanent 10 bp increase in lend. rates</td><td>-0.05%</td><td colspan="2">-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Locarno (2011)</td><td>temporary persistent 12 bp increase in lend. rates</td><td>[-0.03%, -0.39%]</td><td colspan="2">-</td><td>-</td><td>-</td></tr>
<tr><td>permanent 1 p.p. increase in RWCR[56]</td><td>-0.18%</td><td colspan="2">-</td><td>-</td><td>-</td></tr>
<tr><td>Gambacorta (2011)</td><td>permanent 2 p.p. increase in RWCR</td><td>-0.19%</td><td colspan="2">-0.36%</td><td>+5 bp</td><td>-</td></tr>
</table>

[54] NRWCR stands for non-risk-weighted capital ratio.
[55] The experiment in RAMSES is designed to engineer a 1 p.p. increase in the equity to total assets ratio.
[56] RWCR stands for risk-weighted capital ratio.

Analysis using the Iacoviello (2015) model

The model of Iacoviello (2015) allows us to assess the GDP effects of increased capital requirements in one step, since it features banks facing capital requirements set by a regulator.[57] Banks in the model serve as financial intermediaries, collecting deposits from household-savers and extending loans to entrepreneurs and households that borrow against housing collateral. The capital ratio in the model is defined as the inverse of leverage, in other words, it refers to capital to total assets. The model does not feature risk weights.

The mechanism that ultimately leads to a lower GDP level in the model as a result of an increased capital ratio is best explained in terms of the balance sheet channel. To meet the target of a higher capital requirement, banks can either adjust the asset side of their balance sheet (by deleveraging, thus reducing lending) or the liability side (by raising more capital). If they decide to raise capital, their funding costs increase (in a world with frictions, the Modigliani-Miller theorem does not hold and thus equity is more expensive than debt) and they will pass these higher costs onto their customers, i.e. companies and households, in the form of increased lending rates. In the model, banks adjust both sides of their balance sheet to meet higher capital requirements. As demonstrated in Table 1, they reduce the lending and increase the lending rates, which makes the investment by companies, as well as consumption smoothing and financing by households more difficult. As a result, GDP falls. Note that to the extent that a Modigliani-Miller offset would actually occur, the model we are using will overstate the negative effect on GDP. Analogously, to the extent that companies can use financing sources other than banks, our estimate should be seen as the upper bound on the drop in GDP.

The original model has been calibrated to the US data. We change the calibration to match some aspects of the Swedish data, in particular the ratio of household indebtedness and corporate loans to GDP, the required return on bank equity, and the LTV ratio for mortgages.[58] The steady-state capital ratio is set at 5 per cent and in our experiment, we look at the effects of a 1 percentage-point increase in the capital ratio, from 5 per cent to 6 per cent. As presented in Table 1, GDP decreases by 0.13 per cent. This effect takes into account increased lending rates and a fall in lending to both the corporate and the household sector. Given high levels of household indebtedness in Sweden, the latter effect is important to account for since it points to a channel whereby capital requirements may reduce the cost of a financial crisis, by making households' – not just banks' – balance sheets more resilient (if we believe that there may be too much debt in the economy, which could lead to debt overhang effects).

Comparison with the macroeconomic model used in Sveriges Riksbank (2011)

In 2011, the Riksbank published a study (Sveriges Riksbank, 2011) assessing the real economy costs of higher capital requirements using another DSGE model with banking, developed by Meh and Moran (2010). In our view, several features of the Meh and Moran (2010) model used in the Riksbank (2011) make it less apt for our analysis. In contrast to Iacoviello (2015), in Meh and Moran (2010) the capital requirement is not set by the regulator, but arises endogenously as a result of a moral hazard problem between banks and household-depositors.[59] In practice, this endogenously arising capital requirement means that the capital ratio in Meh and Moran (2010) is a function of other model parameters, and is not one fixed number that can be changed when the experiment of increased capital requirements is conducted.

The endogenous capital level in Meh and Moran (2010) is interesting from a research perspective but arguably makes it less appropriate for evaluating capital requirements from a policy perspective. The reason is that in this model, it is possible to arrive at a capital ratio that is 1 percentage-point higher in multiple ways, by different combinations of parameters

[57] We use the extended model presented in the paper to address our question. Unlike the basic model that features only corporate borrowing, the extended model features both corporate and household borrowing.

[58] In our steady state, mortgage debt to GDP is at 52 per cent, corporate loans to GDP at 117 per cent, ROE at about 12.5 per cent, LTV ratio for mortgages is set at 85 per cent. We match these moments by adjusting the discount factors of economic agents in the model, changing the LTV ratios for households and companies, as well as the capital ratio.

[59] Ensuring investment in good projects involves monitoring costs. Because households cannot observe the extent to which the banks actually monitor, they require the banks to also invest their own funds in the lending operations. This gives the banks "skin in the game", ensuring that they monitor the companies.

influencing the endogenous capital ratio in equilibrium. This can undermine the robustness of the results. Moreover, it seems that reality is more closely aligned with the Iacoviello (2015) model, as banks often have to be forced to hold more capital. The effects on GDP of an experiment in which the parameters are changed to ensure that the economy optimally arrives at a particular capital ratio (as in the Meh and Moran, 2010, model), are likely to be very different from an experiment in which the banks are forced to hold more capital (as in the Iacoviello, 2015, model).

The more recent modelling approach of Iacoviello (2015), which was not available at the time of the Riksbank 2011 analysis, offers a more realistic description of the regulatory framework, as well as a unique and non-disputable way to arrive at higher capital requirements providing for a more transparent analysis. Moreover, while the Meh and Moran (2010) model is silent on household borrowing, the Iacoviello (2015) framework gives mortgage lending an important role. In the face of rising household indebtedness linked to increasing housing prices in Sweden, this channel of bank lending should not be ignored and hence, we opt for using Iacoviello (2015) as our benchmark.

We also compare our estimates to results of similar studies conducted for other countries. Angelini and Gerali (2012) conduct an experiment similar to ours, based on a Gerali, Neri, Sessa and Signoretti (2010) framework estimated for the euro area. Angelini and Gerali (2012) estimate the long-run GDP effect of a 1 percentage-point increase in the risk-weighted capital ratio to range from a minimum of 0 per cent to a maximum of -0.36 per cent, which could potentially imply much higher costs than those reported in this study and in Sveriges Riksbank (2011).

Analysis using RAMSES

The models used to evaluate GDP effects of higher capital requirements in the two-step approach do not have a banking sector or capital requirements incorporated, but they still allow for an examination of the effects of higher lending rates on GDP. A necessary input to this analysis is the lending rate increase whose effects one wants to evaluate. In Appendix A, we summarise a range of studies that estimate the effect of increased capital requirements on lending rates for other countries. We use the average of the estimates found in these studies as input to the further general equilibrium analysis. Comparing different estimates, we find that a 1 percentage-point increase in the capital ratio (non-risk-weighted) on average leads to an increase in lending rates of 16 bps (see Table 2 in Appendix A "Do higher capital requirements affect lending rates?"). This is a lower estimate than that obtained from the Iacoviello (2015) model. It may be due to the fact that the computed average relies both on studies using the Modigliani-Miller framework, and studies not using the Modigliani-Miller framework. Depending on the assumed Modigliani-Miller offset (absent in Iacoviello, 2015), the increase in lending rates due to higher capital requirements differs. Interestingly, despite the differences in the lending rate, both models suggest a similar GDP response, which emphasises the need to use more than one model to ensure the robustness of our results.

RAMSES is a general equilibrium model estimated on Swedish data used at the Riksbank for the purpose of forecasting and monetary policy analysis.[60] Lending spreads in the model are endogenous and are a function of entrepreneurial net wealth amongst other variables. When entrepreneurs have less of their own funds to invest, the lending spreads increase, which raises their cost of investment. In the long run this reduces the capital stock and pushes GDP down.

RAMSES has been used as input for the analysis reported in the Monetary Policy Report from July 2014, that assesses the effects of stricter capital requirements on the economy (Sveriges Riksbank, 2014). Given that lending spreads arise in the model endogenously, in the steady state of the model, the spread is not a fixed parameter, but a function of other model parameters, similar to the capital ratio in the Meh and Moran (2010) model. Changing the

[60] For a description of RAMSES, see Adolfson et al (2013). In the model the repo rate is set according to a simple monetary policy rule in which the repo rate depends on the deviation in inflation from 2 per cent and on resource utilisation, measured as the difference between actual hours worked and potential hours worked.

steady-state lending spread thus requires a judgemental decision and can be done in many different ways. That is why, in our experiment, instead of comparing the steady-state values, we choose to look at the long-run dynamic responses of the log-linearised model to a shock that permanently pushes up the lending spreads.[61] An exogenous shock that drives up the lending spreads by 16 bps leads in RAMSES to a decline in GDP of around 0.09 per cent in the long-run equilibrium, as reported in Table 1.

Empirical and semi-structural estimates for other countries

Apart from conducting the experiments with the models adapted to the Swedish economy, we look at estimates that were made for other countries that attempted to address the question of real economy effects of increased capital requirements using their own general equilibrium or reduced form models. In this section, we briefly report their results that are presented in Table 1.

The Minneapolis Plan[62]

The Minneapolis Fed presented its "Minneapolis Plan" in November 2016. The Plan is a proposal for sharply increased capital requirements with the aim of ending the existence of 'too big to fail' financial institutions in the United States. Part of the plan entails increasing capital levels held by the banks and weighing the benefits thereof against the costs. The cost analysis proceeds in two steps and in the second step, the effects of higher lending spreads on GDP are estimated.

To translate the increase in lending spreads into a GDP effect, the Fed's FRB/US model is used. It is a substantial macroeconometric model containing approx. 300 equations used for forecasting, simulating scenarios and evaluating policy options.[63] The model does not include a banking sector, but it includes a range of different interest rates. The increase in the loan spread is assumed to affect commercial lending. The results from the FRB/US model suggest that a permanent 10 bps increase in lending spreads would reduce the GDP level annually by 0.10 per cent in equilibrium.

Bank of England (2015) calculations

A recent Financial Stability Paper published by the Bank of England uses the two-step approach to estimate real economy effects of increased capital requirements (Brooke et al., 2015). The authors use a set of semi-structural macroeconomic models (not further specified) in order to translate the estimated increase in the lending spread into the GDP effect. Their results suggest that a 10 bps increase in lending spreads could reduce output by up to 0.05 per cent in equilibrium. The authors note that their assessed cost is lower than the estimates from the LEI report, published by the Basel Committee in 2010 (BCBS, 2010).

Locarno (2011), BIQM model

Locarno (2011) assesses the impact of Basel III on the Italian economy with the use of a BIQM (Bank of Italy Quarterly Model), which is a semi-structural large-scale macroeconometric model. The study assesses that an increase in lending spreads of 12 bps can lead to maximum GDP decline that occurs during the transition period in the range of 0.03–0.39 per cent. Using a different approach (not specified in the paper), Locarno (2011) reports that in the steady state, the decline in GDP is estimated to be 0.18 per cent as a response to a 1 percentage-point increase in the risk-weighted capital ratio. The study was used in the LEI report.

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[61] In the model, the entrepreneurial wealth shock is the main driver of lending spreads. We look at impulse responses to this shock (persistence parameter is set at 1) in order to infer the GDP response.

[62] https://www.minneapolisfed.org/~/media/files/publications/studies/endingtbtf/the-minneapolis-plan/the-minneapolis-plan-to-end-too-big-to-fail-2016.pdf?la=en

[63] The FRB/US model is different from DSGE models as the expectations of agents are formed in a different way. They may be either consistent with the full knowledge of the model (as in DSGEs) or based on projections from estimated VAR models. The optimisation problems of the agents in the FRB/US model are more short-term, resulting in an effective planning horizon close to five years, as opposed to an infinite horizon in the DSGE models. Moreover, the FRB/US model allows for nonlinear interactions among endogenous variables, while most DSGE models are linearised around the steady state.

Gambacorta (2011), VECM model
Gambacorta (2011) uses a VECM (Vector Error Correction Model) estimated on the US data from 1994 to 2008 to assess the effects of Basel III reforms. Like Locarno (2011), it is a study that was used in the LEI report. Gambacorta (2011) reports steady-state effects of increasing the risk-weighted capital ratio by 2, 4 or 6 percentage-points. The estimates suggest that a 2 percentage-point increase in the capital to risk-weighted assets ratio leads to a GDP decrease of 0.19 per cent and a decrease in lending of 0.36 per cent. The effect is almost linear, so for a 1 percentage-point increase in the capital to risk-weighted assets ratio, the GDP decline is around 0.09 per cent. If we assume that risk-weighted assets correspond to around 50 per cent of total assets, the results would suggest that a 1 percentage-point increase in the capital to total assets ratio corresponds to a fall in GDP of 0.18 per cent.

Conclusion

In this short note, we present various estimates of the GDP effects of higher capital requirements on the Swedish economy in the long run. Our one-step analysis using the Iacoviello (2015) model suggests that raising the non-risk-weighted capital ratio by 1 percentage-point can lower the long-run GDP level by about 0.13 per cent. In our two-step analysis, the increase in lending spreads due to higher capital requirements is taken as given, and the GDP response is calculated using RAMSES, a DSGE model developed at the Riksbank and estimated on Swedish data.[64] This experiment suggests that a 16 basis-point increase in lending spreads (corresponding to a 1 percentage-point increase in the non-risk-weighted capital ratio) could lead to a fall in GDP of around 0.09 per cent.

How do our results compare to other studies? Generally speaking, more recent studies suggest a GDP response to higher lending spreads and capital requirements in the ballpark of our estimates obtained with Iacoviello(2015) and RAMSES, while older studies, such as those used in the BSBC (2010) calculations, suggested larger effects.[65]

Given that we have access to new data and new types of models compared to 2010, when models incorporating banking and financial frictions were at an early stage of development in the wake of the global financial crisis, we believe that some of the earlier estimates of the impact of higher capital levels on economy need to be reassessed with the use of new data and methods. Furthermore, it is important to note than in many DSGE models, like Iacoviello (2015) that we use in our analysis, the Modigliani-Miller offset is absent, so if we were to consider the possibility that banks' shareholders may demand lower return on equity, when the banks become more capitalised, the ultimate increase in lending spreads, and thus, the GDP effect, would be even lower. As discussed in Appendix A, many studies report evidence of a Modigliani-Miller offset of at least 40–50 per cent.

[64] The extent to which higher capital requirements will increase lending spreads is an empirical question and it has not been examined for Sweden yet. That is why, in the first step of the two-step analysis, we need to rely on estimates for other countries.
[65] While comparing the effects of different studies it is important to account for the difference in capital ratio used therein. Given that risk-weighted capital ratios are country-specific and the increase in them can be driven both by an increase in capital and by a decrease in risk weights, we choose the more rigorous approach and examine the effects of an increase in the non-risk-weighted capital ratio. Thus, any translation of our results into risk-weighted capital ratios has to be time-dependent, taking into account the levels of capital, assets and bank risk weights in a given period of time.

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Appendix C - The economic cost of financial crises

Gabriel Söderberg

Introduction

Financial crises have historically involved large social costs. Most recently, the global financial crisis that started in 2007 led to a severe downturn in the global economy. Moreover, ten years after its outbreak, recovery remains sluggish in many parts of the world. The question of how costly a future financial crisis will be is highly relevant for determining an appropriate level for capital requirements for banks.

This memo gives an overview of the economic costs of financial crises. Past experience of financial crises is a good starting point for assessing the expected cost of any future crisis. The literature on how to estimate the cost of a financial crisis is, however, still in its infancy.[66] We summarise recent research drawing on past experience from a large number of countries, as well as some studies that look specifically at the Swedish crisis in the 1990s. There are reasons to expect a financial crisis to be particularly costly for an economy like that of Sweden. Based on existing empirical estimates of the cost of the Swedish crisis in the 1990s, our assessment is that the cost of a future Swedish crisis could be in the vicinity of 180 per cent of GDP in present value terms, or possibly even higher.

Methods for estimating the cost of a crisis

In the literature, the cost of a crisis is typically defined in terms of foregone output, expressed as a reduction in gross domestic product (GDP). This definition facilitates comparisons between different crises but also disregards the social costs of a crisis, which are not adequately captured in GDP statistics. Government bailouts of the banking sector, as well as fiscal stimulus, might reduce the fall in GDP, but lead to lasting government debt problems. Some costs are also borne unequally. For example, individuals who become unemployed as a result of a crisis are likely to suffer larger welfare losses in both the short and the long run, compared to those that retain their jobs throughout the crisis. An increase in unemployment following a crisis can lead to losses in job skills, which tends to make it more difficult for the individuals concerned to secure future employment. In addition, it has been argued that economic conditions caused by a financial crisis might fuel political extremism with far-reaching social consequences.[67]

Empirical estimates of the output loss, in terms of national GDP, that follows from a financial crisis differ considerably.[68]. The dot-com bubble in 2001 was not particularly costly in terms of real economic effects, while the subprime crisis in 2008 entailed substantial costs. Financial crises also appear to be more costly in developed countries than in less-developed countries.[69]

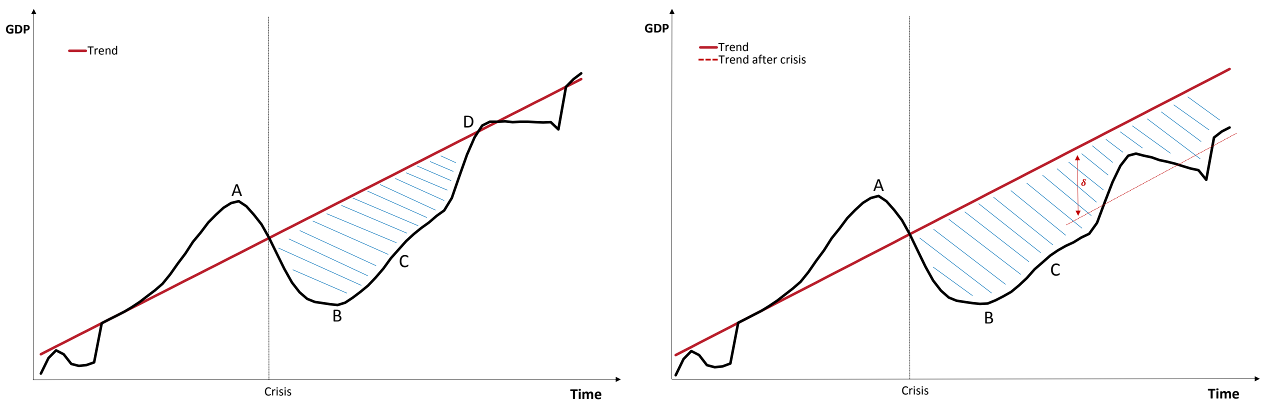
Moreover, there is no universal definition of a financial crisis. With a narrow crisis definition, for instance only crises that are systemic in nature, the sample will contain fewer and often larger crises, which tend to increase the estimate. A broad definition of crisis instead means that the sample will include a greater number of small crises, which reduces the estimate. An example of this is Romer and Romer (2015) which uses a very broad

[66] Haldane (2010).
[67] Bromhead et al. (2012).
[68] Haugh et al. (2009), p. 24.
[69] Hoggarth et al. (2002), Cerra and Saxena (2008).

definition of crisis: a rise in the cost of credit intermediation.[70] With this broad definition Sweden had eight financial crises between 1992 and 2010. Unsurprisingly, given this broad definition, the paper finds that the impact of financial crisis tends to be moderate.

Another difference between studies, with significant implications for their results, is the end point of the cost estimate. In particular, the results are typically highly sensitive to whether the effects of a crisis on the GDP level are assumed to be temporary or permanent.[71] In Chart 1 the example on the left shows a hypothetical economy in which the financial crisis results in output loss, but the economy subsequently recovers to the pre-crisis growth trend. The example on the right, in contrast, shows an economy in which the crisis has a permanent effect and the economy is shifted onto a lower growth trend.

Figure 1. Assessing the costs of financial crisis



Source: BCBS (2010), p. 9.

Chart 1 also illustrates four different approaches to setting start and end points of cost calculations:[72] (i) From the pre-crisis peak in GDP to the lowest point before GDP starts to increase again (between point A and B). (ii) From the pre-crisis peak to the point where the GDP growth rate, i.e. the slope of the curve, returns to its pre-crisis level (A to C. (iii) From the pre-crisis peak until the GDP level returns to its pre-crisis growth trend (A to D in the left-hand example). (iv) Allow for permanent effects of the crisis whereby the economy shifts to a lower growth path. The difference between the pre- and post-crisis trend is denoted δ in Chart 1.

Permanent effects and cumulative losses mean that the cost of the crisis is measured during all years from the onset of the crisis and over an infinite horizon. This is not as dramatic as it sounds. In effect, it means that a crisis entails "lost" years that are not subsequently recouped. The economy returns to its pre-crisis growth rate, but the lost years mean that in each subsequent year the GDP level is lower than it would have been without the crisis.

In case of permanent effects the present value of the future output loss can be calculated according to the following formula:

$$Cumulative\ loss = \frac{\delta}{1-\alpha}$$

where $\alpha = \frac{1}{1+r}$ and r is the discount rate.[73]

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[70] Romer and Romer (2015), p. 8.
[71] In many studies there is no explicitly stated assumption about whether the effect is permanent or temporary. However, if only measuring the cost between a start and an end point, permanent costs are not taken into account. For the sake of simplification, we will refer to such studies as estimating non-permanent effects.
[72] This section is based on BCBS (2010).
[73] BCBS (2010), p. 34.

Some studies seek to estimate the reduction in GDP during a specific year, or during a specified interval immediately following the crisis such as peak-to-trough. Such short-run estimates will invariably look modest compared to estimates of the cumulative effect of a lower GDP level in the future. The difference is particularly stark if the crisis is assumed to have permanent effects, in which case the economy never returns to its pre-crisis growth path. One way to arrive at cumulative estimates based on such studies is to calculate the present value under the assumption that the estimated short-run effect persists into the future (see for example the studies listed as Infinite horizon (permanent effects) in Table A1.1 in BCBS, 2010).[74]

Literature review

We review the literature in two parts. The first part covers studies that estimate short-run effects of financial crisis, i.e. costs from the onset of the crisis to point B, C, or D in Chart 1. The second part covers studies that look at costs in the long run.

Short-run effects

Using a sample of 15 developed countries and 22 less-developed countries, Hoggarth et al. (2002) estimate the difference between trend and actual output during a crisis. They find that the cumulative effect of a financial crisis for developed countries on average amounts to around 21 per cent of annual GDP, and around 16 per cent for less-developed countries. These estimates refer to the cumulative effect during the crisis itself, but do not take into account long-run effects on the GDP level.

Laeven and Valencia (2008) estimate the cost in terms of GDP from the crisis and the three following years. This results in estimates ranging from zero per cent of GDP to around 100 per cent with a mean of around 20 per cent. An update, Laeven and Valencia (2012), includes a larger sample and an estimate of the cost of the 2007–2008 financial crisis. The average output loss for the latter is estimated to be 23 per cent of annual GDP in the euro area and 31 per cent in the United States.

Based on the definition and database of Laeven and Valencia (2008), Cecchetti et al. (2009) finds "tremendous diversity" in the outcomes of different crises.[75] Cost is measured as the cumulative loss in GDP over the duration of the crisis in per cent of its pre-crisis peak level. Using this method ten out of the 40 crises in the sample are found to have losses of above 25 per cent of pre-crisis GDP.

Haugh et al. (2009) studies the effects of financial crisis using OECD data on the gap between output and potential output. The conclusions are that the costs varied between different crises in different countries, with the crisis in the early 1990s of Japan being the only one that permanently seems to have lowered the country's growth rate.

Long-run effects

Some studies analyse whether a financial crisis can be expected to have permanent effects on GDP, but without estimating the size of the effect. For example, Cerra and Saxena (2005) argued that Sweden's financial crisis in the 1990s led to a *permanent* reduction in GDP. Cerra and Saxena (2008) use a sample of 190 countries to find further evidence that the output loss is highly persistent. Ramírez (2009) instead studies the effects of a single crisis, that of 1893 in the United States. The results suggest that states which experienced the financial crisis, such as Nebraska, had lower growth than states that were unaffected, such as West Virginia, for a long time after the crisis had been resolved. This suggests that effects of financial crisis are long-term. Abiad et al. (2009) likewise find that the growth rate in general tends to return to its pre-crisis level in the medium run, but not the pre-crisis trend. This would imply permanent or at least long-term effects of the crisis.

[74] Hoggarth et al. (2002), p. 837; BCBS (2010), p. 33.
[75] Cecchetti et al. (2009), p. 12.

Other studies seek to estimate the size of a long-run effect. Boyd et al. (2005) estimates the actual cost of financial crises in a sample of 23 countries selected from both developed and less developed countries. The study estimates output loss in per cent of the real GDP of the year preceding the crisis year, both assuming that the effect of crisis is permanent and non-permanent. The estimates vary with a mean of 95 per cent for non-permanent effects and 302 per cent for permanent effects.

Haldane (2010) assumes different levels of output loss from the global financial crisis in 2007–2008 that is permanent (ranging from 25 to 100 per cent). Given these assumptions, the results range from between 130 and 520 per cent of annual GDP for the UK, and between 90 and 350 for the world.

BCBS (2010) puts together a large set of different estimations, encompassing many different methodologies in order to assess the benefits of higher capital levels. For estimates assuming non-permanent effect, the median is 19 per cent of pre-crisis GDP, and for estimates assuming permanent effects, 158 per cent. Putting together both non-permanent and permanent estimates, the median is 63 per cent. Since the study includes both assumptions of non-permanent and permanent effects, the benchmark cost of a crisis for assessing the benefit of higher capital levels is set at 63 per cent of pre-crisis GDP.

Recent research indicates that the cost of a financial crisis may be higher than previously thought. In particular, experience since the outbreak of the recent global financial crisis suggests effects that are more severe than initially expected. Ball (2014) finds that the effect of the financial crisis was very diverse across countries, but that there was evidence for strong long-term effects. The weighted average output loss in the year 2015 alone was estimated at 8.4 per cent.

Fender and Lewrick (2015) translates the one-year estimate from Ball (2014) to a present value of future output losses, assuming permanent effects, to find an implied a cost of 180 per cent of pre-crisis GDP.[76] Using this and other recent estimates, the study subsequently updates the 63 per cent estimate of BCBS (2010) to 100 per cent to account for the economic downturn of the global financial crisis proving to be longer, and hence the cost of the crisis higher, than was expected in 2010.

Table 1 summarises the results of the studies discussed above.

Table 1. Estimates of the cumulative cost of financial crisis

Per cent of GDP

Study	*Mean*	*Min*	*Max*	*Assumption*
Hoggarth et al. (2002)[77]	16	0	122	Non-permanent
Laeven and Valencia (2008)	20	0	123	Non-permanent
Haugh et al. (2009)	21	10	40	Non-permanent
Cecchetti et al. (2009)	18	0	129	Non-permanent
Boyd et al. (2005)*	97	0	194	Non-permanent
Boyd et al. (2005)**	302	0	1041	Permanent
BCBS (2010)*	19	0	130	Non-permanent
BCBS (2010)**	145	0	1041	Permanent
Haldane (2010)	268	90	500	Permanent
Ball (2014)*	8.4	0	35	Non-permanent
Ball (2014)**[78]	180	0	1035	Permanent

Note: For studies in which estimates for both non-permanent and permanent effects are given, the non-permanent are marked with * and permanent effects are marked with **.

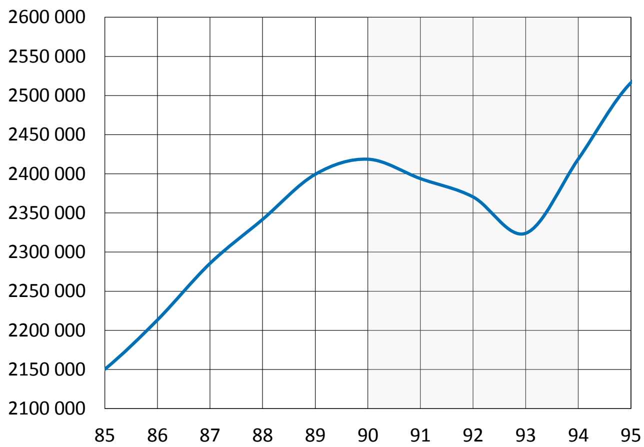
[76] BCBS (2015), p. 48.
[77] Estimates are for industrial countries, using GAP2 methodology. See Hoggarth et al. (2002) for further details.
[78] Re-estimated for mean by Fender and Lewrick (2015), and maximum by the present author.

Cost of a Swedish financial crisis

The banking crisis that Sweden experienced in the early 1990s sheds some light on the possible magnitude of a future crisis in Sweden. On one hand some factors suggest that this cost might have increased. Above all the Swedish banking sector has grown substantially since the early 1990s. In the year before the crisis the assets of the Swedish banking sector accounted for roughly 100 per cent of GDP.[79] Today the number is closer to around 350 per cent of GDP. Problems in a proportionally bigger banking sector, all else being equal, are likely to have a greater impact on an economy. On the other hand some factors including a number of reforms since the 1990s suggest a lower cost. These reforms include for instance independence of the central bank, new regulations and new resolution framework. It is difficult to objectively weigh these different factors against each other, so our best estimate, is that it is not unlikely that the cost of a future crisis in Sweden might be similar to that of the 1990s.

Effects of the 1990s crisis
The financial crisis of the early 1990s entailed a significant decline in economic output between the start and the end of the crisis (Chart 2).

Chart 1. Swedish real GDP
Million, SEK

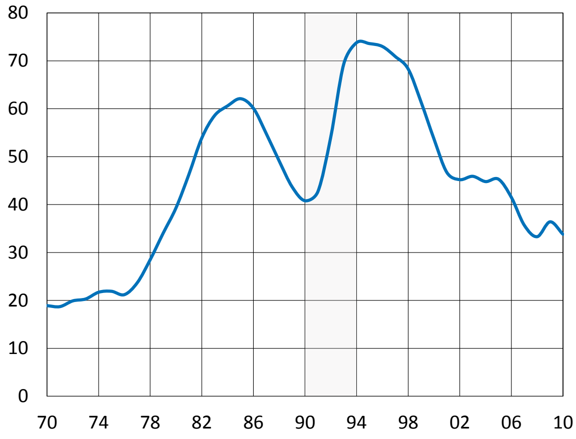


Source: National Institute of Economic Research

The crisis entailed considerable public costs. Government debt increased sharply (Chart 3), in part due to a government bailout of the banking sector, but also to a crisis-induced reduction in tax revenues and increases in public expenditures.

[79] Based on calculations from Statistisk årsbok för Sverige 1992, p. 224, 277.

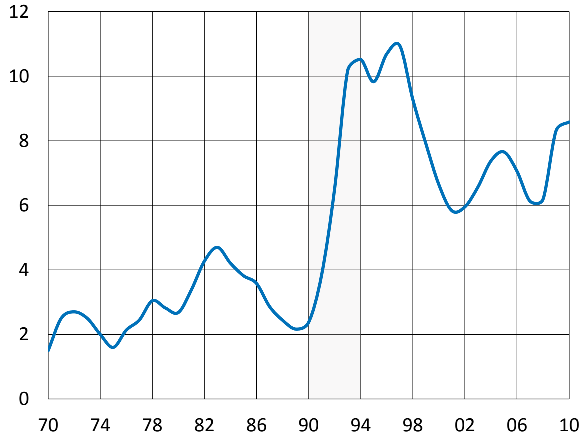
Chart 2. Swedish government debt
Per cent of GDP



Source: Swedish National Debt Office

Unemployment increased from around two per cent to around ten per cent (Chart 4). When the crisis was over, unemployment was reduced, but settled on a level that was higher than before the crisis. Although there are several potential reasons for this increase, one interpretation is that the crisis brought on a permanent increase in unemployment.[80]

Chart 3. Swedish unemployment rate
Per cent of workforce

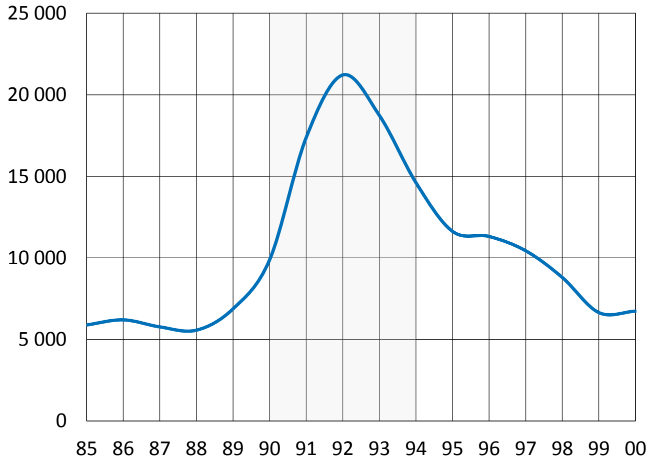


Source: Statistics Sweden

The crisis also caused an upsurge in the number of bankruptcies (Chart 5).

[80] Cerra and Saxena (2005).

Chart 4. Total number of bankruptcies for companies in Sweden



Source: Compiled from Statistical Yearbooks of Sweden

Against a backdrop of sharply increased default rates and high unemployment levels, the number of heavily indebted individuals grew. New legislation enacted in 1994 to mitigate the problem was only partially successful. In 2013 there were still 95,000 people who had debt with the Swedish Enforcement Agency (*Kronofogdemyndigheten*) that originated from around the time of the 1990s crisis.[81]

What would the output loss of a Swedish crisis be?

Several factors suggest that the cost of crisis in Sweden can be expected to be higher than an international mean. The Swedish banking sector is large in relation to the size of the economy, equivalent to approximately 350 per cent of GDP. In addition, it is highly concentrated, dominated by four major banks that are highly interconnected. Banks also play a dominant role in the provision of credit to companies and households: the corporate bond market is small, and mortgages are provided by banks and are typically not securitised. This implies that alternative sources of finance may be more difficult to access if Swedish banks are under stress, suggesting that a banking crisis would result in a more severe credit crunch than in less bank-oriented economies. Overall, these factors indicate that a future Swedish crisis could be more severe than an international mean.

There have been a number of attempts to estimate the cost of the Swedish crisis in the 1990s (see Table 2 for summary of different estimates of the cost of a crisis in Sweden). Most of them however only assume non-permanent effects which risks understating the cost in the event of the effects being permanent or long-run.[82] The study that has been chosen here as the benchmark estimate for the cost of the 1990s crisis is Boyd et al. (2005). The main reason is that it is the only study that estimates a cumulative net present value cost of the 1990s crisis in Sweden assuming both non-permanent effects and permanent effects and within a coherent framework. Assuming non-permanent effects, Boyd et al. (2005) estimate the cost to be around 101 per cent of GDP, and 257 per cent assuming permanent effects.[83]

In order to reach a baseline estimate, the average of the estimates of the cost for non-permanent and permanent effects is calculated. The result is roughly 180 per cent of pre-crisis GDP. An estimated cost of crisis of 180 per cent can be compared to the updated international median estimated by Fender and Lewrick (2015) at around 100 per cent. Based on Ball (2014) Fender and Lewrick (2015) also reach the number of 180 per cent for the

[81] SOU 2013:78, p. 37.
[82] See Laeven and Valencia (2008), Haugh et al. (2009), Cecchetti et al. (2009).
[83] Boyd et al. (2005) also performs a calculation in which the end point of summing the costs is simply when they run out of actual data. The authors note that this is "surely inappropriate" and so we ignore this number (Boyd et al., 2005, p. 994).

financial crisis of 2007–2008.This result is based on the assumption of a discount rate of 5 per cent. Recent analysis suggests however that equilibrium interest rates may have declined which would suggest that using a lower discount rate would be appropriate.[84] In general a lower discount rate means that the present value of the future output loss increases, pointing to a higher cost of crisis. This serves to strengthen our argument that our estimates are high but not unreasonable.

Table 2. Ballpark estimate of the cost of a future systemic Swedish financial crisis

Per cent of pre-crisis GDP

Estimate	Cost (per cent of GDP)	Comment
Sweden, crisis 1990–1994		
Boyd et al. (2005), non-permanent	101	
Boyd et al. (2005), permanent	257	
International average		
Fender and Lewrick (2015)	100	
Ball (2014)	180	Re-estimated by Fender and Lewrick (2015)
Riksbank (2017) baseline estimate	**180**	**Average of Boyd et al. (2005) high and low**

Conclusion

In the above, we have described common approaches to estimating the cost of financial crises and reviewed relevant empirical literature. We have argued that there are reasons to expect a financial crisis to be particularly costly for an economy like that of Sweden. Drawing on existing empirical estimates of the cost of the Swedish crisis in the 1990s, our conclusion is that the cost of a future Swedish crisis could amount to 180 per cent of GDP in present value terms, or possibly even higher. This estimate is broadly in line with other comparable studies. While recognising the uncertainty surrounding estimates of this kind, we conclude that existing research provides strong support for the notion that financial crises can entail very large social costs.

[84] Sveriges Riksbank (2017), p. 14–17.

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Appendix D - Structural estimates of the probability of a banking crisis at different levels of capital

Markus Andersson and Daniel Buncic

Introduction

The probability of a banking crisis is linked to the default probability of individual banks. A large body of literature deals with the estimation of default probabilities of individual firms. While the nature of banking activities make banks a distinct type of firm, we can nonetheless draw on this literature to shed some light on the default probability of banks.

In essence, there are two different approaches to modelling probabilities of default. One is reduced form, the other is structural. Reduced form models approximate the properties of the observed data as closely as possible without being confined by potentially constraining assumptions of a theoretical model. Structural models are derived from asset pricing theory and require clear definitions about the stochastic properties of the process of interest.

We implement a standard structural probability of default (PD) model based on Merton (1974). The Merton model is commonly used as a benchmark structural PD model when new models are proposed (see for instance, Bharath and Shumway, 2008; and, with an application to banks, Nagel and Purnanandam, 2016), and is still widely used by specialised practitioners in the financial industry.

While the standard Merton model approach provides a benchmark, we are aware that it has several drawbacks when it comes to estimating the probability of default of a bank (some of these are discussed further in a more general setting in Nagel and Purnanandam (2016) and others). In particular, the estimated PDs are sensitive to the volatility of the banks' assets, which is an unobserved process and needs to be estimated from data. Moreover, once the distance to default is determined from the model parameters, the likelihood of default is determined under a normal or Gaussian distribution, which does not allow for fat tails, a feature commonly encountered with data on historical bank losses. This property of the Merton model based PD estimates is likely to indicate a larger reduction in the probability of default for increasing levels of capital and for a fixed level of volatility than seems plausible from empirically observed loss distributions. In Appendix E of this staff memo, a reduced form analysis is presented which uses a long time-series of historical losses in the entire Swedish banking system and a more flexible statistical model that is not confined by the assumptions of a theoretical model, to offer a contrasting approach.

While recognizing the drawbacks of the Merton model, the intention of this study is to perform a scenario based analysis of the probability of default obtained from a standard and well known model for different levels of capital. More specifically, we ask the following question: "What is the likelihood of a banking crisis at different levels of capital, assuming that asset value volatility can take on values that have historically been experienced in the Swedish data?" We show that more equity in relation to total assets significantly reduces the probability of a banking crisis.

Modelling the probability of default of a bank

In the Merton model, Equity (*E*) is a call option on the "Value" (*V*) of the assets of a firm, with a strike price equal to the face value of Debt (*D*), due at maturity *T*.[85] Equity is defined by the Black-Scholes-Merton (BSM) equations as:

$$
\begin{aligned}
E &= V\Phi(d_1) - \exp\left(-r_f T\right) D\Phi(d_2) \\
d_1 &= \frac{\ln\left(\frac{V}{D}\right) + (r_f + 0.5\sigma_V^2)T}{\sigma_V\sqrt{T}} \\
d_2 &= d_1 - \sigma_V\sqrt{T}\,,
\end{aligned}
\tag{1}
$$

where r_f is the risk-free rate, Φ is the cumulative density function (cdf) of a standard normal random variable, and σ_V is the volatility of *V*. From the (option's) delta of the equity, equity volatility is related to asset volatility by:

$$\sigma_E = \frac{V}{E}\Phi(d_1)\sigma_{V,} \tag{2}$$

where σ_E is equity volatility. The above results are derived under the assumption that the value of the assets of a firm follows a Geometric Brownian Motion (or diffusion process):

$$dV_t = \mu_V V_t\, dt + \sigma_V V_t\, dW_t\,, \tag{3}$$

where W_t is Brownian motion (increments are standard normal), and μ_V is a drift term, so that the log of the V_t process is distributed normal:

$$
\begin{aligned}
&\ln(V_t) \sim N(\ln(V_0) + (\mu_V - 0.5\sigma_V^2)T, \sigma_V^2 T) \\
&\text{or} \\
&\ln(V_T) = \ln(V_0) + (\mu_V - 0.5\sigma_V^2)T + \sigma_V\sqrt{T}Z_T,
\end{aligned}
\tag{4}
$$

where Z_T a is standard normal distributed random variable. Default occurs when $V_T < D$, i.e. the value of a firm's assets at maturity *T* are less than the debt obligation *D* payable at maturity. Using the relations above, the probability of default is then defined as:

$$
\begin{aligned}
\Pr(V_T < D) &= \Pr(\ln(V_T) < \ln(D)) \\
&= \Pr\left(\ln(V_0) + (\mu_V - 0.5\sigma_V^2)T + \sigma_V\sqrt{T}Z_T < \ln(D)\right) \\
&= \Pr\left(\sigma_V\sqrt{T}Z_T < \ln\left(\frac{D}{V_0}\right) - (\mu_v - 0.5\sigma_V^2)T\right) \\
&= \Pr\left(Z_T < \frac{\ln\left(\frac{D}{V_0}\right) - (\mu_v - 0.5\sigma_V^2)T}{\sigma_V\sqrt{T}}\right).
\end{aligned}
\tag{5}
$$

[85] The Merton model assumes that debt is a zero-coupon bond with face value *D* and maturity *T*. Moreover, markets are assumed to be frictionless, i.e., there are no transaction cost or any other fees, and that the firm cannot pay out dividends or issue new debt. For a full list of assumptions underlying the Merton model, we refer the reader to the review by Sundaresan (2013). Sundaresan (2013) also offers a discussion on how reasonable these assumptions are.

The fraction in the last expression in (5) can be rewritten as:

$$\frac{\ln\left(\frac{D}{V_0}\right)-(\mu_v-0.5\sigma_V^2)T}{\sigma_V\sqrt{T}}=-\frac{\ln\left(\frac{V_0}{D}\right)+(\mu_v-0.5\sigma_V^2)T}{\sigma_V\sqrt{T}}=-dd, \tag{6}$$

where

$$dd=\frac{\ln\left(\frac{V_0}{D}\right)+(\mu_v-0.5\sigma_V^2)T}{\sigma_V\sqrt{T}}. \tag{7}$$

The term *dd* is known as the "distance to default". The probability of default follows as:

$$\Pr(V_T<D)=\Phi(-dd). \tag{8}$$

Two of the key inputs into the Merton model pricing equations are the *market value* of assets of the firm (*V*), and its volatility (σ_V). Since these two are unknown and/or unobservable, they are obtained from the BSM option pricing relations defined by:

$$\begin{aligned} E &= V\Phi(d_1)-\exp\{-r_fT\}\,D\Phi(d_2)\\ \sigma_E &= \frac{V}{E}\Phi(d_1)\sigma_V, \end{aligned} \tag{9}$$

for given values of *E*, r_f, *D*, σ_E, and time to maturity *T*.
To solve for *V* and σ_V in (9), the following inputs are required:

1) The market value of equity (*E*). This is computed as the number of outstanding shares on issue (Bloomberg Code: EQY_SH_OUT) multiplied by the stock price (Bloomberg Code: PX_LAST).
2) Equity volatility σ_E. This is estimated from daily log returns of the stock prices, where returns are computed as $\ln\left(\frac{P_t}{P_{t-1}}\right)$.
3) The risk-free rate r_f. We use the one year treasury (government) rate (Bloomberg Code: C2591Y Index). We set a floor for the risk-free rate of 10 basis points (bp).
4) The face value of debt *D* at maturity. We take total liabilities for debt (Bloomberg Code: BS_TOT_LIAB2).

We source all data from Bloomberg. Due to the different frequencies of the series used, the starting dates as well as the length of the available samples differ across banks and variables. For instance, equity prices as well as the risk-free rate are available at daily frequencies from 2nd of January 1990 for SEB, 4th of January 1993 for SHB, 9th of June 1995 for Swedbank, and 8th of December 1997 for Nordea, and from 25th of February 1994 for the one year rate. Both, the book value of Debt (total liabilities) and the number of outstanding shares on issue are accounting data and are only available at a quarterly frequency. Debt data start in March 1997 for SEB and SHB, and March 1999 for Nordea and Swedbank, while the number of shares outstanding are available from March 1992 for SHB, June 1995 for Swedbank, and March, respectively, June 1998 for Nordea and SEB. All daily data end on 27th of April 2017, while the quarterly series are available until the end of March 2017.

We follow standard practice and use total liabilities as the face value of debt (see Bharath and Shumway (2008), page 1344 and Crosbie and Bohn (2003) page 7). While it is possible that firms may continue to trade once total liabilities exceed the value of their assets due to the long-term nature of some of their liabilities, which may not require servicing at maturity *T*, it is true that the default point lies somewhere between total liabilities and current/short-term liabilities. Taking total liabilities as the default point is thus more conservative and is the common approach in practice (see also the discussion on page 7 in Crosbie and Bohn (2003)).

As is discussed in more detail on pages 10–11 in Crosbie and Bohn (2003), it is the *market value* of the firm's assets that matters for the probability of default in the Merton model, and therefore for the firm that is analysed. The interest rate spread that firms pay over the default-free rate is directly linked to the market's perception (pricing) of the firm's ability to service and repay its debt obligations. Put differently, the (default) risk premium that is paid by the firm is a function of the market's computed probability of default. As market prices of assets are "forward-looking", so will be the market price of the value of the firm, and thus also its PD. The book value of the firm is a backward-looking variable.

For a fixed level $\ln\left(\frac{V_0}{D}\right)$ in (7), it is the volatility of the firm's asset value (σ_V) that is the key parameter in the Merton model. Given the link between asset value volatility and equity volatility in (9), and the empirical fact that equity volatility is not time-invariant, it should be clear that asset value volatility (σ_V) is also time-invariant. It thus seems unlikely that the simple diffusion specification in (3) with time-invariant volatility is a realistic process for V_t. Further, (unconditional) asset returns are known to exhibit "fat tails". A convenient way to address these deficiencies is to specify a time-varying volatility process. Moreover, it is well known that rescaling unconditional asset returns by an appropriate measure of asset variability will substantially reduce, if not eliminate, "fat tails" (see for example Corsi et al. (2013), p. 286, for an illustration of S&P 500 log-returns rescaled by an unconditional volatility and an appropriate "realised volatility" measure).

Nagel and Purnanandam (2016) discuss in more detail the importance of allowing for a time-varying volatility process and how low volatility states adversely reduce the probability of default in the Merton model (see in particular pages 16–19).[86]

To be able to capture volatility states (or changes in volatility) in equity returns and then map them to asset volatility, Nagel and Purnanandam (2016) use a 1-year (backward) rolling window of data to compute (time-varying) volatility (see page 21). The Merton model, nevertheless, requires forward-looking volatility over the horizon of the maturity of the asset of interest. This forward-looking volatility is commonly replaced by a backward-looking measure by practitioners, that is, either a 1-year rolling window as in Nagel and Purnanandam (2016), or a 3-year rolling window based on weekly equity return data.

We construct 1-year *forward* rolling window estimates of the volatility of equity. Our motivation for doing this is to be as consistent with the definition of volatility in the Merton model as possible. That is, we define equity volatility σ_E to be used in (9) to back out V_t and σ_V as the unconditional volatility computed from equity returns over the next 1-year horizon, that is, over the next 252 days. We roll forward through the sample to get daily estimates. Note that these 1-year forward rolling window estimates are numerically identical to the 1-year backward rolling window estimates, the approach used in Nagel and Purnanandam (2016). The only difference are the recorded time stamps. Our preference for using a 1-year *forward* rolling window is driven by the fact that we have the benefit of hindsight and know exactly how equity prices, and hence equity volatilities, have evolved over the year ahead from a given point in time, that is, over the maturity horizon considered in the PD calculations. Evidently, this is not feasible when wanting to construct real time PD estimates.

[86] Note here that the objective of Nagel and Purnanandam (2016) is not to model asset volatility, but to introduce a new double contingent claim-based default model that takes into account the fact that bank risk dynamics are non-linear in the sense that the upside is capped. However, what is clear from the discussion on pages 16–19 in Nagel and Purnanandam (2016), and also from the default probability plot comparison on page 24 (Figure 8 in their paper), is that the Merton model consistently underestimates default probabilities in low volatility states, while it performs reasonably (sometimes overstating PDs) in states of high volatility.

However, since our objective is to implement a scenario based analysis, where we compute PD estimates based on various historical asset value volatilities and different capital levels, our approach eliminates an additional layer of uncertainty with regards to one of the key input parameters in the model. In the analysis that follows, we use the percentiles of the estimated historical asset value volatilities σ_V in a scenario based analysis of the effect of different capital levels on the probability of a banking crisis in Sweden.

PD estimates of individual banks

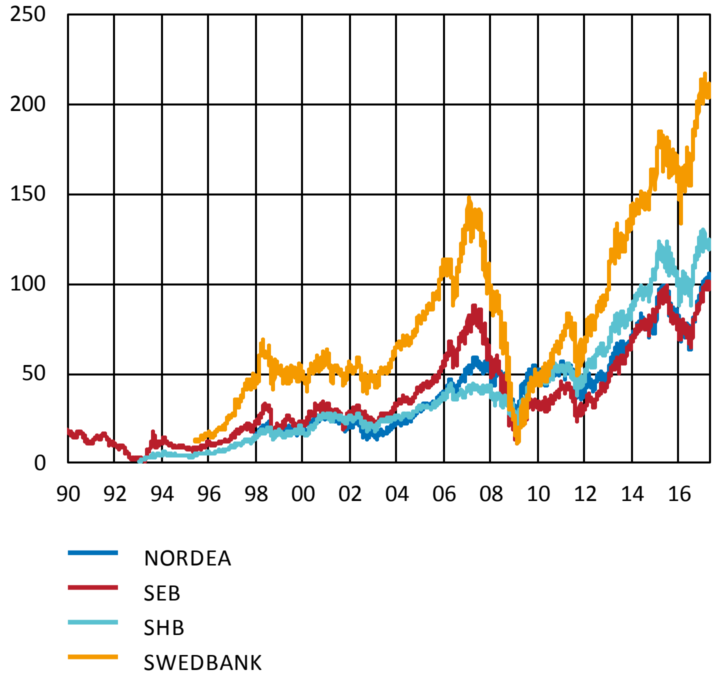
To compute the PDs, we initially need to extract the unobserved components V_t and σ_V from the BSM option pricing relations in (9). As discussed above, we use (daily) 1-year forward rolling window estimates of the volatility of equity (σ_E) in (9). All remaining accounting data, i.e., the number of outstanding shares on issue and total liabilities (debt) are at quarterly frequencies. We create daily accounting data from the quarterly series and fill missing entries with the most recent known values from the quarterly series. Thus, if debt information (total liabilities) is available for the March quarter (31.03), we fill all following daily date entries with the same value until the June quarter figures are available from 30.06 onwards. For all PD calculations, we use a maturity horizon of one year.

Charts 1 to 3 below show daily time series plots of equity prices for the four largest Swedish banks (Nordea, SEB, SHB and Swedbank) together with estimates of (annualised) 1-year forward equity volatility (σ_E), and the corresponding 1-year forward asset value volatility (σ_V) computed from the Merton model relations in (9), all expressed in percent and plotted over the entire available data range for the respective series of interest. The first two charts illustrate the familiar relationship between equity prices and equity volatility. Volatility is generally low when equity prices are rising, and tends to rise when equity prices drop (the leverage effect). Moreover, equity volatility is time-varying and tends to cluster. Asset value volatility (σ_V), shown in the last chart, is also strongly time-varying and clusters. Note from chart 2 that the highest value of equity volatility (σ_E) of around 120 per cent for SEB occurs at the end of 1992. However, this highest level of equity volatility is not captured in our sample of asset value volatility (σ_V), due to the lack of accounting data (debt data start in March 1997 for SEB) needed to back out σ_V from the relations in (9). We think that this is important to highlight here and should be kept in mind when considering what equity volatility magnitudes seem plausible from a historical perspective, which are then used as an input in the *dd* formula for the construction of the scenario based PDs. That is, the maximum value of the observed historical 1-year forward equity volatility is 20 percentage points higher than the maximum in our sample for which debt data are available, i.e., from 1998 onwards.

The direct impact of changes in σ_V on the probability of default in the Merton model is most clearly seen from the distance to default (*dd*) relation in (7), where σ_V not only enters in the denominator, which amplifies or dampens the magnitude of *dd*, but also in the numerator, which shifts the location of the mean (the $-0.5\sigma_V^2 T$ term).

Chart 1. Equity price, the four major Swedish banks

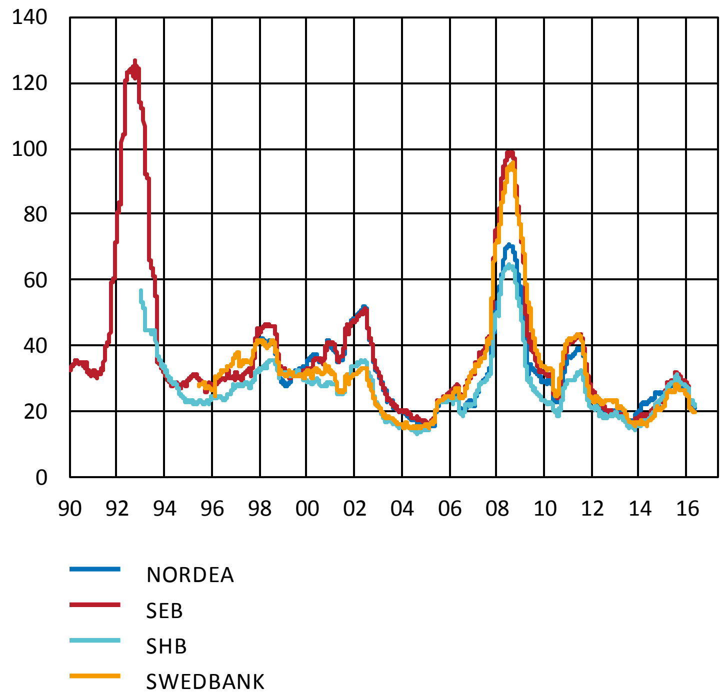
SEK



Source: Bloomberg

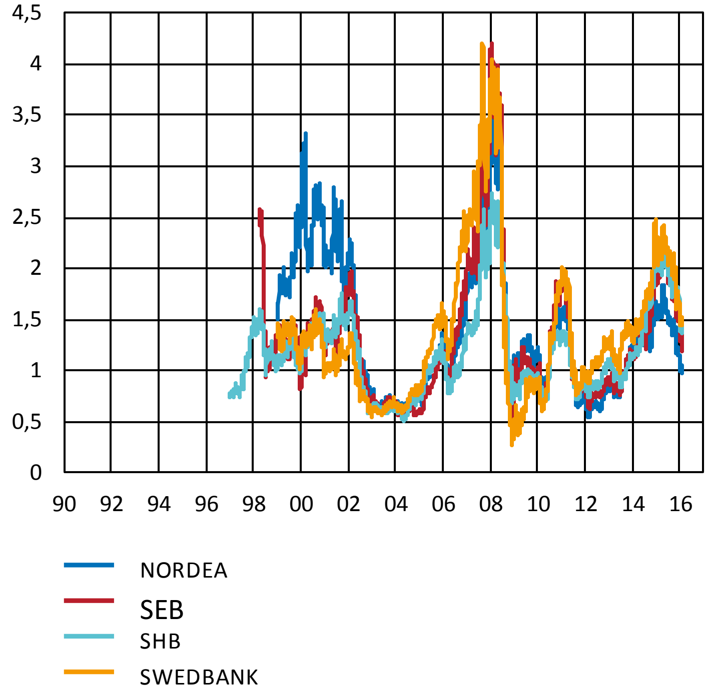
Chart 2. Equity volatility, the four major Swedish banks

Per cent



Source: Bloomberg and the Riksbank

Chart 3. Asset volatility, the four major Swedish banks
Per cent



Source: Bloomberg and the Riksbank

In the analysis that follows, we consider a total of five different "plausible" values of asset value volatility σ_V that have historically been observed when we construct PDs for the four banks, and later on for the entire Swedish banking system. These are based on the 50th, 75th, 90th, 95th and 99th percentiles of σ_V. Two other inputs needed for the Merton model-based PD calculations to be implemented are the drift term of asset value (μ_V) and $\ln\left(\frac{V_0}{D}\right)$. We use the cross-sectional mean of the time series average of the book value of return on assets (ROA) to proxy the growth rate of assets. This value is around 0.62 per cent in the sample that is available to us. Overall, and with the exception of the 2008–2009 period, ROA seems to be a fairly stable process, ranging between 0.4 and 0.8 per cent (in annualised terms).[87] We set the drift term at 0.62 per cent for all four banks and all five scenarios.

The final input in the Merton model formula is the $\ln\left(\frac{V_0}{D}\right)$ term, that is, (log) assets over debt. Since we are interested in the effect of different levels of capital (Equity/Assets) on the probability of a banking crisis in Sweden, we rewrite the following relations as:

$$Assets = Debt + Equity$$

$$\frac{Assets}{Assets} = \frac{Debt}{Assets} + \frac{Equity}{Assets}$$

$$1 = \frac{Debt}{Assets} + Leverage$$

[87] One approach taken by practitioners is to use equity return data to compute a (log) return on equity from historical data, and then "deleverages" that return to obtain a measure of ROA that can be used to approximate the drift term μ_V. Using the historical (log) equity returns, the cross sectional mean of the time series averages is about 12 per cent (per annum) in our data. Average leverage across time and across the banks is about 23. This implies a deleverage return on equity of about 0.52 per cent, which is somewhat lower than our considered value of 0.62 per cent. In Riksbank (2011), the growth rate of assets was set to 0.75 per cent for all banks, which was based on a long history of US bank data. Our value of 0.62% is thus approximately in the middle of these two values. Alternatively, the drift term μ_V could be estimated using an iterative procedure where one first fixes the volatility μ_V at some initial value, then solves for V with the second equation in (9), compute log asset value returns, and then update the μ_V and σ_V estimates by their (unconditional) sample mean and standard deviation of the return sequence. The new estimate of σ_V is then plugged in the second equation in (9), solved for V, μ_V, and σ_V is recomputed. This process continues until convergence.

$$(1 - Leverage) = \frac{Debt}{Assets}$$

$$(1 - Leverage)^{-1} = \frac{Assets}{Debt}$$

$$-\ln(1 - Leverage) = \ln\left(\frac{Assets}{Debt}\right), \tag{10}$$

and replace $\ln\left(\frac{V_0}{D}\right)$ with $-\ln(1 - Leverage)$ in the *dd* relation in (7). The effective computation of the PDs based on different capital requirements is then based on the following modified distance to default (dd^*) formula:

$$dd^* = \frac{-\ln(1 - Leverage) + (\mu_V - 0.5\sigma_V^2)T}{\sigma_V\sqrt{T}}. \tag{11}$$

We estimate the model for capital levels (or leverage ratios) ranging from 2 to 20 per cent of total assets. In the tables and discussion that follow below, we refer to the total equity to total assets ratio as the leverage ratio, or simply, as leverage.

An important question is what level of equity to total assets to consider as critical or a default point (see also the introduction or main document for additional discussion). We examine two cases. If the value of assets falls below the face value of debt, the firm is insolvent. This corresponds to an equity level of 0 per cent and is the first case we consider. Past experience, however, suggests that banks can run into serious difficulties also before equity is depleted. Setting the critical level at higher levels than 0 per cent results in higher PD estimates. One relevant level to consider is when the bank is violating existing capital regulations and risks either losing its licence or entering resolution. Current regulation focuses on risk-weighted ratios. In terms of equity to total assets, we let the level of 1.5 per cent represent this threshold, as an approximation. This is the second case that we consider.

Estimating the probability of a banking crisis

We use the model described above to generate (physical or historical) PD estimates for the individual banks. Taking these individual estimates as a starting point, we turn to the question of the probability of a banking crisis in Sweden. In order to map the PDs of the individual banks to the probability of a banking crisis – in effect, a PD for the banking system – we need to specify more clearly what a banking crisis is considered to be.

We define a banking crisis as the occurrence of one (or more) of the four large Swedish banks defaulting. The same assumption was made in Riksbank (2011). Given the high degree of concentration and interconnectedness in the Swedish banking system, we find this assumption to be reasonable. In addition, we take into account the historically observed positive and time-varying correlations between the banks' equity returns.

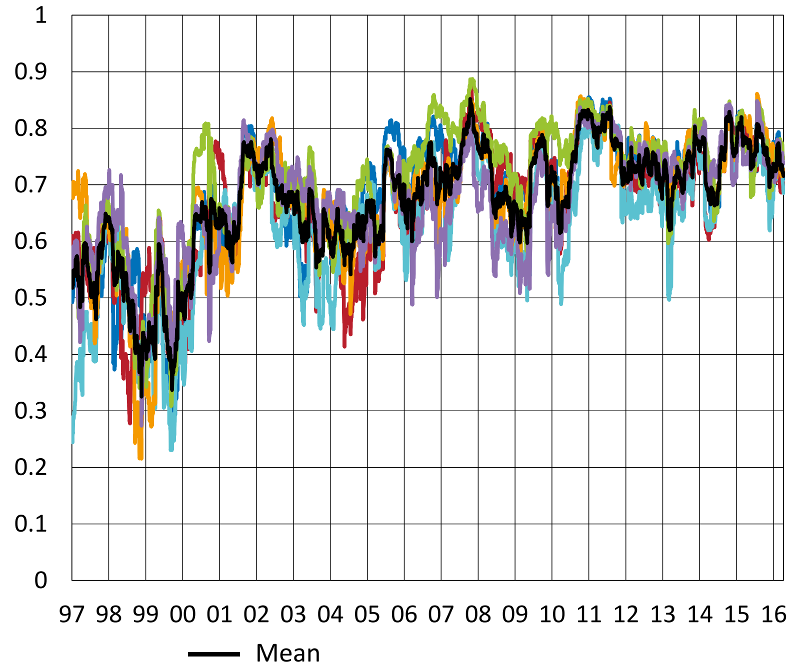
Given these assumptions, the probability of a banking crisis can then be obtained as 1 minus the probability of all banks *not* defaulting. Let dd_j^* denote the (modified) distance to default for bank *j*, with the probability of default for bank *j* in the Merton model given by $\Phi(-dd_j^*)$ or $1 - \Phi(dd_j^*)$. The probability of a bank not defaulting is thus $1 - \Phi(-dd_j^*) = 1 - \left(1 - \Phi(dd_j^*)\right) = \Phi(dd_j^*)$. To compute the joint probability of all banks not defaulting, we need to compute the joint cdf. For independent events, this joint cdf is the product of the marginal (individual) cdfs, so that the probability of all banks not defaulting is $\prod_{i=1}^{4} \Phi(dd_j^*)$. The probability of at least one bank defaulting thus follows as the complement:

$$1 - \prod_{i=1}^{4} \Phi(dd_j^*). \tag{12}$$

For dependent default events, we compute the joint cdf from the individual marginal cdfs, a correlation matrix *R*, and aggregate these using a Copula (linking) function. For consistency with the Merton model, we use a Gaussian Copula and estimate a time-varying correlation matrix of equity returns using the DCC GARCH model of Engle (2002). The six pairwise correlations that are estimated from the model are shown in the chart 4 below. We compute the cross-sectional average of the six pairwise correlations and superimpose a plot of this average in black in the chart below.

Chart 4 shows that all correlation pairs are always strictly positive, and that the correlations vary over a fairly narrow range between 0.4 and 0.8 for the largest part of the sample. Given the rather narrow variation in the correlations (correlations are defined over the -1 to 1 interval), we follow the approach used for the drift term and use a single correlation matrix *R* which corresponds to the "average" correlation matrix for all five considered scenarios. This correlation matrix is set to the one that corresponds to the time series mean of the cross sectional average correlations.

Chart 4. Pairwise correlations between the four major Swedish banks



Given the correlation matrices *R* and the individual banks' probabilities of not defaulting $\Phi(dd_j^*)$, we compute the joint probability of not defaulting as $C(\Phi(dd_1^*), \Phi(dd_2^*), \Phi(dd_3^*), \Phi(dd_4^*), R)$, where $C(\cdot)$ is the Gaussian Copula function. The probability of a banking crisis is again computed as the complement event $1 - C(\Phi(dd_1^*), \Phi(dd_2^*), \Phi(dd_3^*), \Phi(dd_4^*), R)$. Tables 1 and 2 below show these probabilities computed for correlated asset returns for the two examined threshold levels of equity less than zero, and equity less than 1.5 per cent of total assets, respectively.

Table 1. Equity less than zero, correlated assets
Per cent

Leverage ratio	99th Percentile	95th Percentile	90th Percentile	75th Percentile	50th Percentile
2	41.95	33.24	25.61	13.12	4.06
3	29.97	19.99	12.66	3.79	0.40
4	19.97	10.66	5.25	0.79	0.02
5	12.38	5.02	1.82	0.12	0.00
6	7.13	2.09	0.53	0.01	0.00
7	3.80	0.75	0.12	0.00	0.00
8	1.87	0.24	0.02	0.00	0.00
9	0.85	0.06	0.00	0.00	0.00
10	0.35	0.02	0.00	0.00	0.00

Table 2. Equity less than 1.5 per cent of total assets, correlated assets
Per cent

Leverage ratio	99th Percentile	95th Percentile	90th Percentile	75th Percentile	50th Percentile
2	61.39	57.51	53.66	45.61	35.54
3	48.40	41.02	34.16	21.55	9.89
4	35.76	26.17	18.41	7.34	1.40
5	24.68	14.83	8.34	1.80	0.10
6	15.87	7.43	3.16	0.33	0.00
7	9.49	3.28	1.00	0.04	0.00
8	5.26	1.27	0.26	0.00	0.00
9	2.70	0.43	0.05	0.00	0.00
10	1.27	0.12	0.01	0.00	0.00

We also consider the scenario where bank defaults are independent of one another ("uncorrelated assets") as an alternative, where the joint cdf is computed as the product of the marginal cdfs of the individual banks, with a banking crisis again defined as in (12) before. However, to conserve space, we do not report these estimates here, but rather point out that the PDs with independent defaults are *higher* than those based on correlated ones.

Intuitively, this is best understood in the context of an example with two events (*A* and *B*). From fundamental probability theory we know that the union of events *A* and *B*, that is, *A*, and/or *B* occur, is defined as:

$$\begin{aligned} P(A \cup B) &= P(A) + P(B) - P(A \cap B) \\ &= P(A) + P(B) - P(A|B)P(B). \end{aligned} \tag{13}$$

When events *A* and *B* are independent, $P(A|B) = P(A)$, so that the probability of the union becomes:

$$\begin{aligned} P(A \cup B) &= P(A) + P(B) - P(A)P(B) \\ &= P(A) + P(B)[1 - P(A)], \end{aligned} \tag{14}$$

while for the case when the events are perfectly “correlated”, or *A* is predictable with certainty once *B* has occurred ($\mathrm{P(A|B)} = 1$), we obtain $\mathrm{P(A|B)P(B)} = \mathrm{P(B)}$, so that the relation in (13) becomes:

$$P(A \cup B) = P(A) + P(B) - P(B)$$
$$= P(A). \qquad (15)$$

Thus, unless $P(B)\,[1 - P(A)] = 0$ (when either $P(B) = 0$ or $P(A) = 1$) the probability of the union of the events is always going to be larger under the independent scenario than under the perfectly correlated one.

Note here also that, although we have used the Copula linking function to compute the joint cdf of no bank defaulting, one can always build up the joint cdf from the product of the conditionals (and an initial marginal) as:

$$P(A \cap B \cap C \cap D) = P(A|B \cap C \cap D)P(B|C \cap D)P(C|D)P(D). \qquad (16)$$

To do this, all that is needed from the Merton model is one (marginal) cdf of not defaulting (available from the individual bank PDs), and some statements about the conditional probabilities, i.e., $P(A|B \cap C \cap D)$, $P(B|C \cap D)$, and $P(C|D)$ above in (16). Banking supervisors and/or specialists may have a fairly strong view on what these conditional probabilities should look like, based on, for instance, their institutional knowledge. As an example of how this can be done, if one knows that bank *D* did not default, then one might be confident to say that bank *C* will default only with a low probability of 3 per cent. Similarly, if both *C* and *D* did not default, then the probability of *B* defaulting (given *C* and *D* did not default) is even smaller at 0.5 per cent, etc. The joint cdf in (15) can then be built up iteratively as the product by starting from the marginal cdf taken from the Merton model PDs, and (subjective) assumptions on the conditional cdfs.

Conclusion

We use a standard Merton model to estimate the probability of default for the four large Swedish banks. Based on these PDs and the historical correlation between the banks’ equity returns, we estimate the probability of a banking crisis at different levels of capital to total assets, where a banking crisis is defined as the probability of at least one of the four major banks failing. Our model estimates show that additional equity reduces the probability of a banking crisis. However, the reduction in the probability of a crisis that follows from an increase in equity declines quite rapidly at higher capital levels. The reason for this is that the amount of tail risk is modest as a result of both the assumptions of the model and the scenario based analysis that we implement.

While our results serve as a benchmark, we wish to emphasise that this approach has several drawbacks. In particular, the estimated PDs are sensitive to the estimate of the volatility of the banks’ assets. Although we proxy the time-varying nature of volatility by using a 1-year *forward* rolling window to capture the actual volatility realized over the default horizon of one year that we consider, performing a scenarios based analysis for different levels of capital to total assets and the historically observed asset value volatilities does not capture the fact that bank losses are generally fat tailed distributed and that they cluster. Another drawback is that we cannot capture the high level of equity volatility experienced during the 1990s housing crisis due to the lack of accounting and equity price data going back that far which are needed to back out asset value volatilities. Both of these limitations are likely to lead us to underestimate the probability of a banking crisis in the Swedish banking system.

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Appendix E - A reduced form model for assessing the probability of a banking crisis

Paolo Giordani

Introduction

In order to evaluate the effects of higher capital requirements, we need to estimate their impact on the probability of default of Swedish banks. The most common approach is to use some version of the Merton model, which does not require knowledge of the value of assets, as in Appendix D.

Here, we complement Appendix D by opting for a different approach. We use a long time series for credit losses in the Swedish banking system and model such losses directly rather than inferring them via stock market prices, as in the Merton model.

We base our analysis on a historical dataset (Hortlund, 2005; 2008) covering the period 1870–2008 for a yearly aggregate of Swedish banks, reporting: a) credit losses, b) total assets, and c) capital. Since the historical dataset only gives aggregate data, our analysis will make statements about the aggregate of all Swedish banks, in effect treating the entire system as one large bank. As a result, the default probabilities will be lower than if we had data on individual banks and defined a default event for one major bank in default.

The dataset includes credit losses but not profits or overall return on equity. To calculate profits after credit losses, we assume that performing loans earn a net margin of 0.75 per cent. In the historical dataset this would correspond to an average return on assets, after credit losses, of 0.4 per cent, which, at current leverage ratios (capital to assets of 4–5 per cent) translates into a return on equity of 8–10 per cent on average (including periods of high losses). Outside the three crisis periods (see Chart 1), credit losses are smaller and the corresponding return on equity at current leverage ratios is 12–17 per cent. Returns on assets in any given year are thus computed as:

$$Return\ on\ assets = L + 0.0075\,(1 + L)$$

$$L = -\frac{Credit\ \ Losses}{Assets}$$

To compute a probability of default as a function of the capital ratio (equity over assets), we then require a definition of what constitutes default, and a statistical model for credit losses. Equity here is assumed to be capital to total (i.e. non-risk-weighted) assets, so no model of risk weights is needed.

Default is defined as capital over assets falling behind a given threshold. For example, if the threshold is 0 (so that default requires the entire capital to be wiped out), default requires

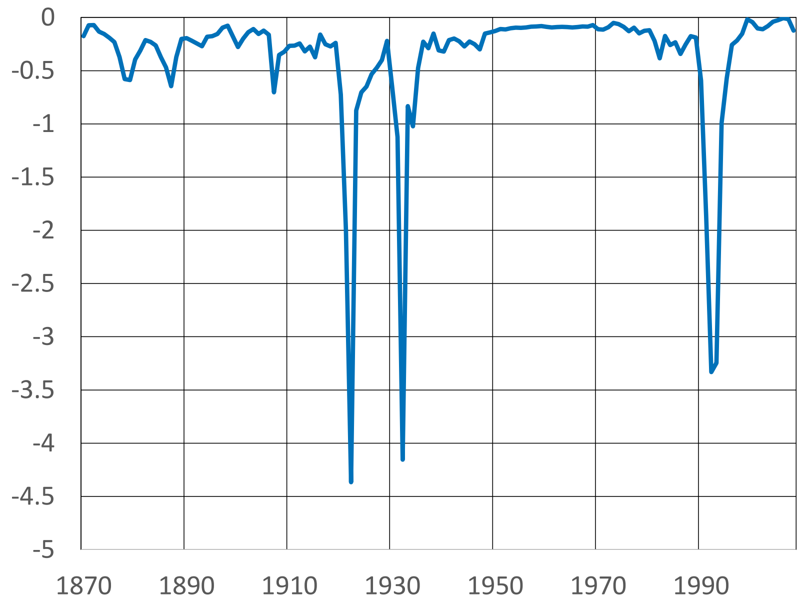
$$Capital\ ratio + Return\ on\ assets < 0$$

We consider three critical levels: 0, 1.5, and 3 per cent, as discussed in the main body of this staff memo.

A statistical model for credit losses

Yearly data on credit losses are shown in Chart 1 below. Losses are very small in most years, and very large in three historical episodes. After 1950, losses in most years are extremely small, whereas during the crisis of the early 1990s they are comparable to losses in the 1920s.

Chart 1. Historical losses/assets, 1 year
Per cent



Source: Hortlund (2005; 2008)

The empirical distribution is challenging to fit for standard statistical distributions. We therefore make a non-standard choice and fit a half-t distribution. This is simply a student-t distribution with zero density for positive values. The probability density function is

$$P(x) = 2 \cdot t(x, 0, s^2, v) \ for \ x < 0 \ (\text{and } P(x) = 0 \ for \ x > 0),$$

where $t(x, 0, s^2, v)$ is a student-t distribution with mean zero, degrees of freedom v and dispersion s^2. The density is multiplied by two so that it integrates to one. The half-normal and half-t distribution is sometimes used as a prior in Bayesian analysis. We are not aware of any application of a half-t to model an actual time series, but for the series of losses shown in Chart 1 it may be hard to improve on it (see Chart 2). A more commonly employed alternative may have been a Generalized Pareto distribution, or a Generalized Hyperbolic distribution (see McNeil et al. 2015), which are strictly non-negative and also have semi-fat tails. In our particular dataset, visualised in Chart 1, these distributions do not perform nearly as well as a half-t (in log-likelihood), perhaps due to difficulty in capturing the many observations at near-zero values.

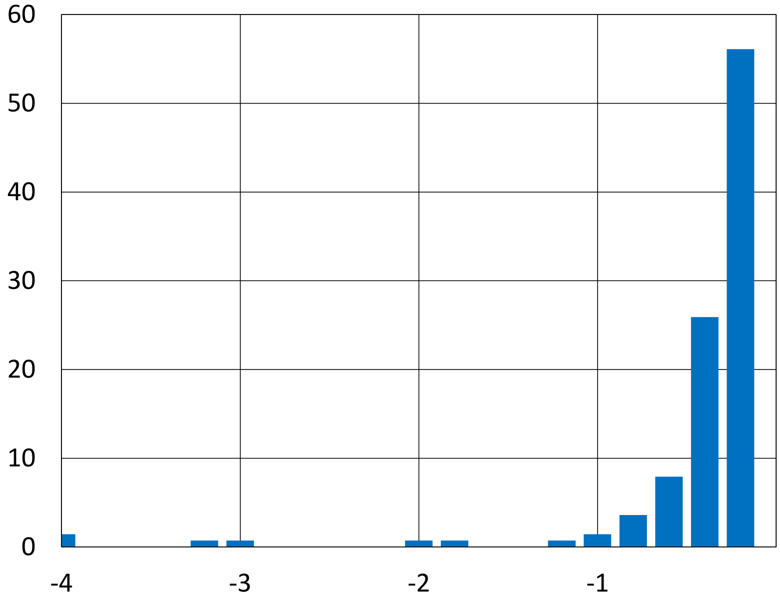
The model is estimated with Bayesian methods using fairly disperse priors on $\log(s^2)$ and $\log(v)$, which imply a lower bound of 1 for v. Maximum-likelihood estimates give very similar results, except for extremely low probability events (losses much larger than those observed in sample), where even small changes in the prior affect the results and the averaging over draws of $\log(v)$, as opposed to conditioning on one value as in maximum likelihood, resulting in fatter tails.

Results for a one-year horizon

Chart 2 shows a histogram of losses (the same data that are shown as a time series in Chart 1) in the first panel, and Chart 3 shows the corresponding histogram (using the same intervals for the bins as in Chart 2) produced by the estimated model. The posterior distribution of the degrees of freedom has a mean of 2, and almost 10 per cent of the draws are between 1 and 1.5. This generates an extremely fat left tail, and yet the model if anything falls short of matching the largest losses in the data. A Gaussian distribution or even a symmetric student-t would be inadequate in our case. While the variance of a student-t distribution is not defined unless v is larger than 2, the mean absolute error is defined for v larger than 1. At $v = 1$ the student-t distribution is equivalent to the Cauchy distribution.

Chart 2. Empirical histogram of losses over assets (horizon 1 year). Losses are in per cent.

Per cent (frequency)



Source: Hortlund (2005; 2008)

Chart 3. Model-implied histogram of losses over assets (horizon 1 year). Losses are in per cent.

Per cent (frequency)

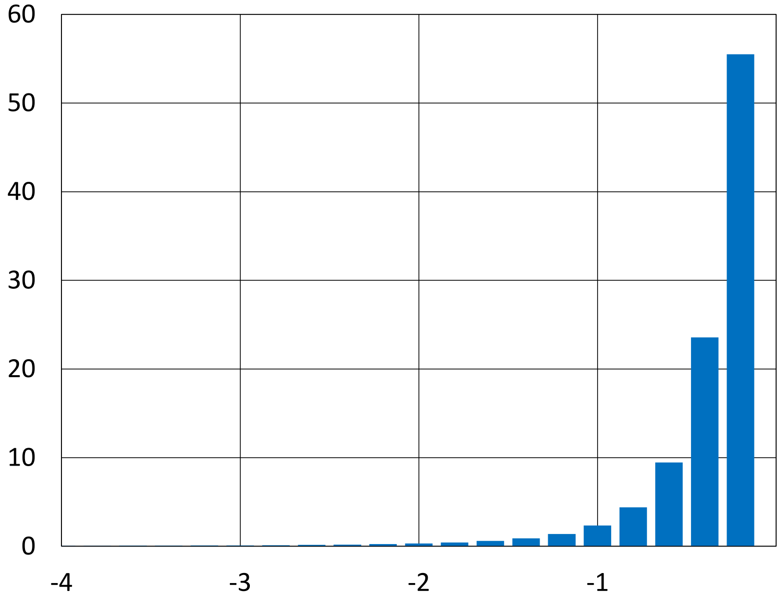


Chart 4 shows the entire distribution implied by the model in the first panel, and Chart 5 zooms in on the tail. For very large losses, the density approaches zero very slowly, showing near power-law behaviour as a consequence of very low degrees of freedom. Importantly, this implies that, unlike a Gaussian distribution, this model can generate losses substantially larger than those observed in sample.

Chart 4. Density of the estimated half-t distribution (horizon 1 year)

Density, normalized to 1 at x = 0

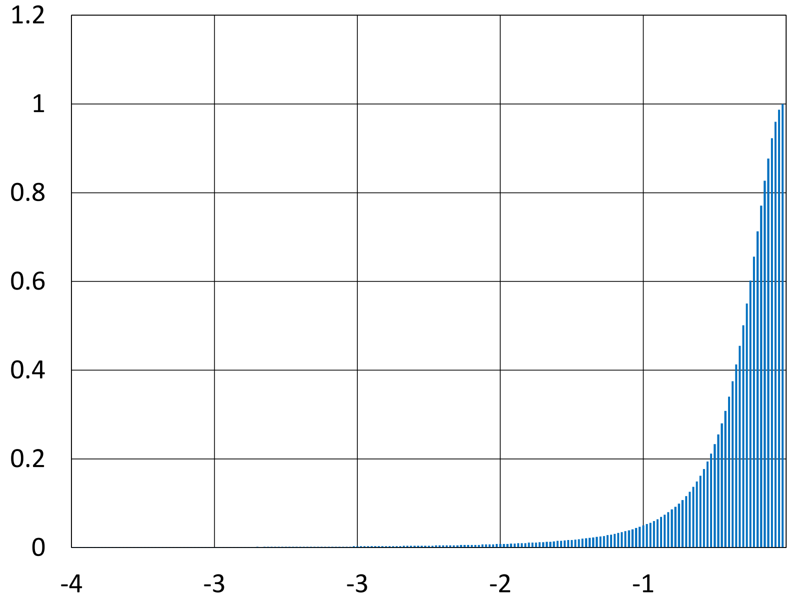
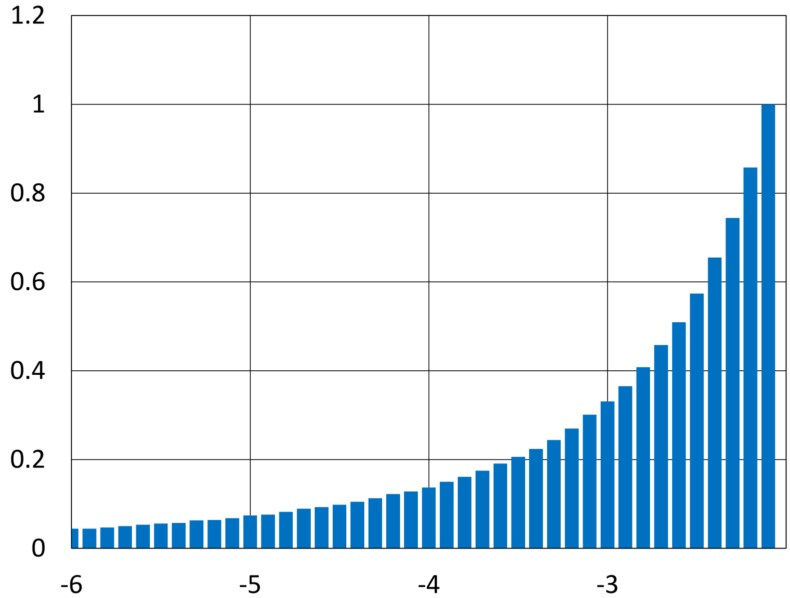


Chart 5. Density of the estimated half-t distribution (horizon 1 year), $x < -2$

Density, normalised to 1 at x = -2



Charts 6–8 plot default probabilities as a function of starting values of the capital/assets ratio, for three definitions of default, corresponding to capital over assets below 0, 1.5 per cent and 3 per cent respectively.

Chart 6. Probabilities of default as a function of the capital ratio, default at 0 per cent

Probability of default

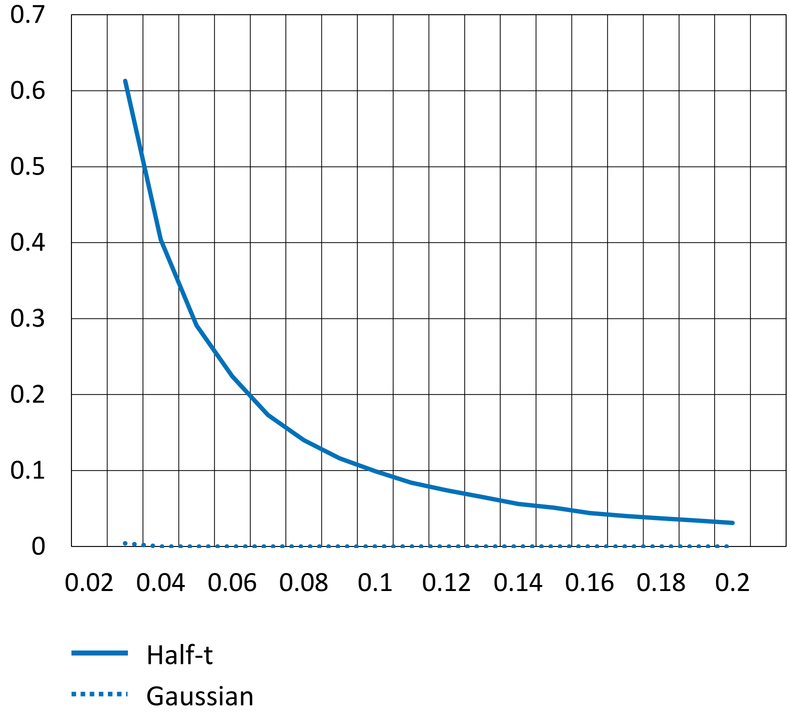


Chart 7. Probabilities of default as a function of the capital ratio, default at 1.5 per cent

Probability of default

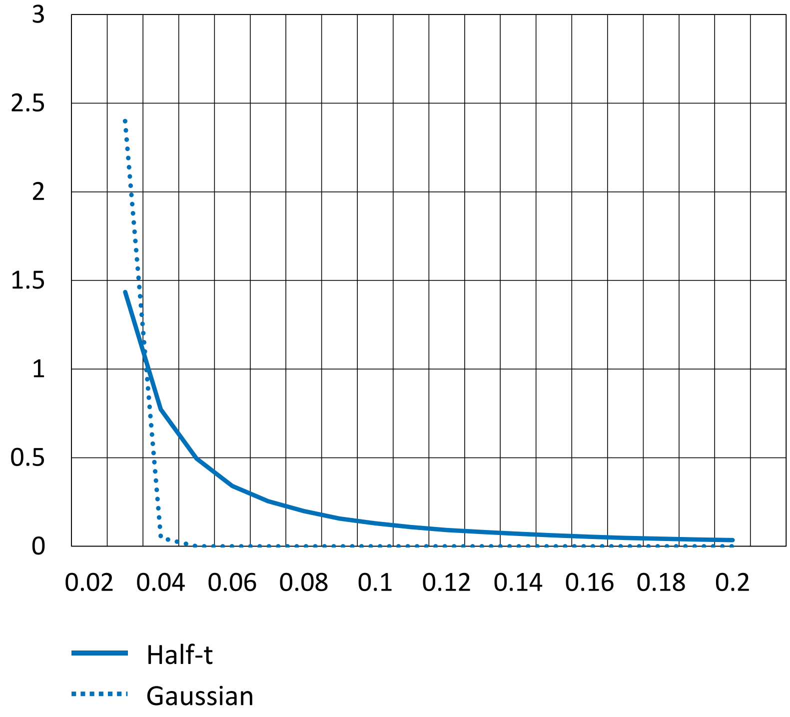
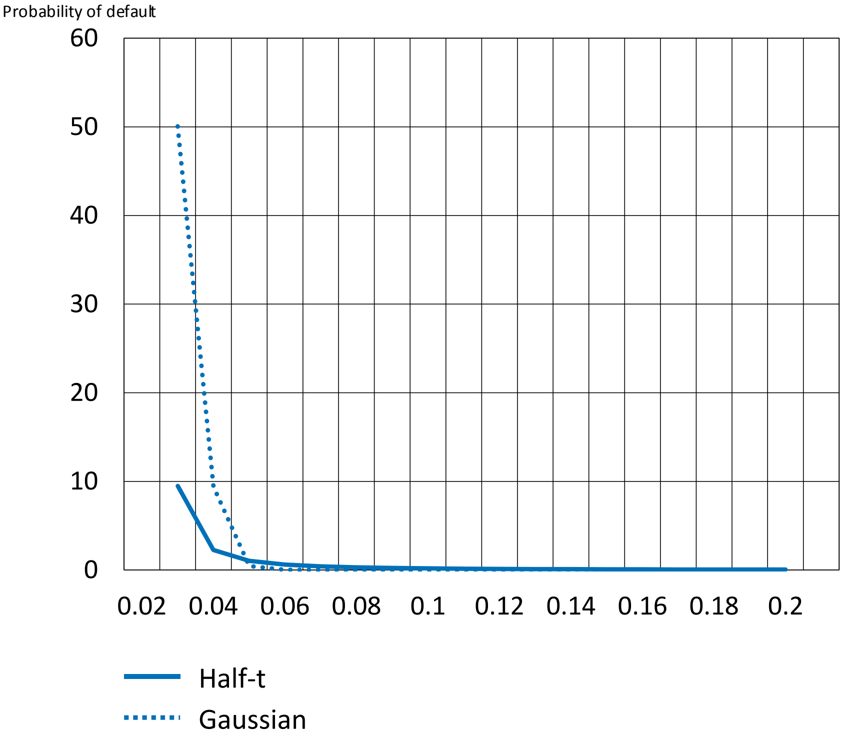


Chart 8. Probabilities of default as a function of the capital ratio, default at 3 per cent



Referring to Charts 6–8, the default probabilities implied by the half-t distribution decrease smoothly, whereas those implied by the Gaussian (a symmetric and thin-tailed distribution), decrease sharply. As a consequence, compared to a Gaussian, conclusions on default probabilities are less sensitive to modest changes in the estimated mean and variance.

Results for a three-year horizon

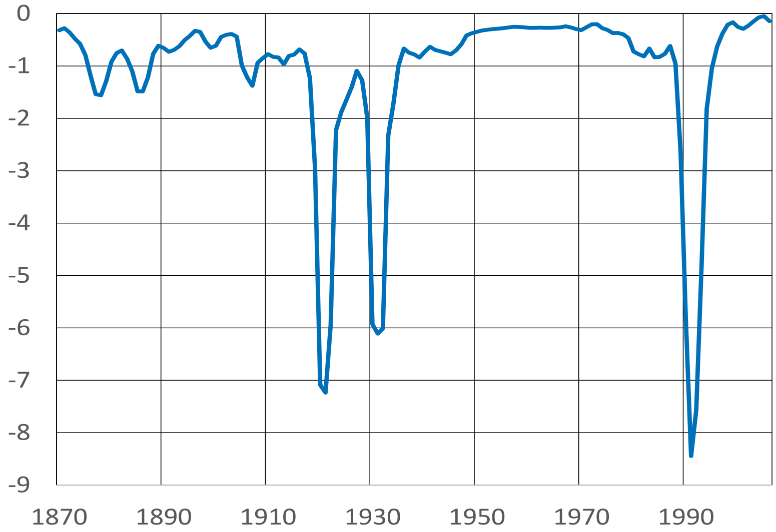
The model at a one-year horizon captures the extremely long tail in bank losses in any given year, but a one-year horizon is almost certainly too short considering that in the data large losses cluster, so that a bad year tends to be followed by another bad year. It is therefore possible for a bank's equity to be wiped out gradually in the course of a few years rather than in a single year. To work with a multi-year horizon we require further assumptions both in defining defaults and for the statistical model.

To define defaults, we assume that banks cannot raise equity within each three-year window, but must rely entirely on equity available at the beginning of the period and on earnings. We also assume that the profit margin on performing loans is constant at 75 basis points. During the crisis of the early 90s, Swedish banks were in fact able to substantially increase their margins, particularly at the expense of households and companies with floating-rate loans. It is not obvious whether banks would be able to repeat this behaviour to the same extent today (Sweden joined the European Union in 1995, after the crisis). Even if they were able to boost margins, the negative macroeconomic and social implications may be sizable.

In terms of modelling, one option would be to build a dynamic model so that yearly losses are not independent. A main advantage of this approach is that we could define a default if an established lower bound for capital over assets is breached *at any point* during the period (say three years). An obvious disadvantage is the need to introduce further modelling assumptions and parameters. We opt instead for a direct modelling approach, in which cumulative losses over equity are modelled directly at the horizon of interest. This requires less additional assumptions, but it does have the drawback that we can only make statements concerning outcomes at the end of the multi-year period. The probabilities of default produced by a direct modelling approach should therefore be interpreted as a lower bound, since they exclude the possibility of banks being in default at some point during the time horizon of interest but not at the end of it. Chart 9 shows the cumulative three-year losses. The distribution is just as asymmetric as at the one-year horizon, if not more.

Chart 9. Cumulative three-year losses over equity

Per cent



Source: Hortlund (2005;2008)

The degrees of freedom parameter is again around two (mean value), producing a thick and gently sloping left tail similar to the one shown in Charts 3–4.

Charts 10–12 show the probability of default at the three-year horizon, which should be interpreted as the probability of banks not having sufficient capital at the end of the three-year period. Charts 13–15 show the same data without a comparison with the Gaussian distribution. The main feature of interest is that the default probabilities implied by a Gaussian can be high at low capital ratios (recall that the Gaussian is symmetric, centred at the average loss), but drop very sharply, whereas the half-t produces gently sloping default probabilities, never particularly high in any given period, but never quite hitting zero either, so that higher capital ratios continually reduce the probability of default.

Chart 10. Probabilities of default as a function of the capital ratio, default at 0 per cent (3-year horizon)

Probability of default

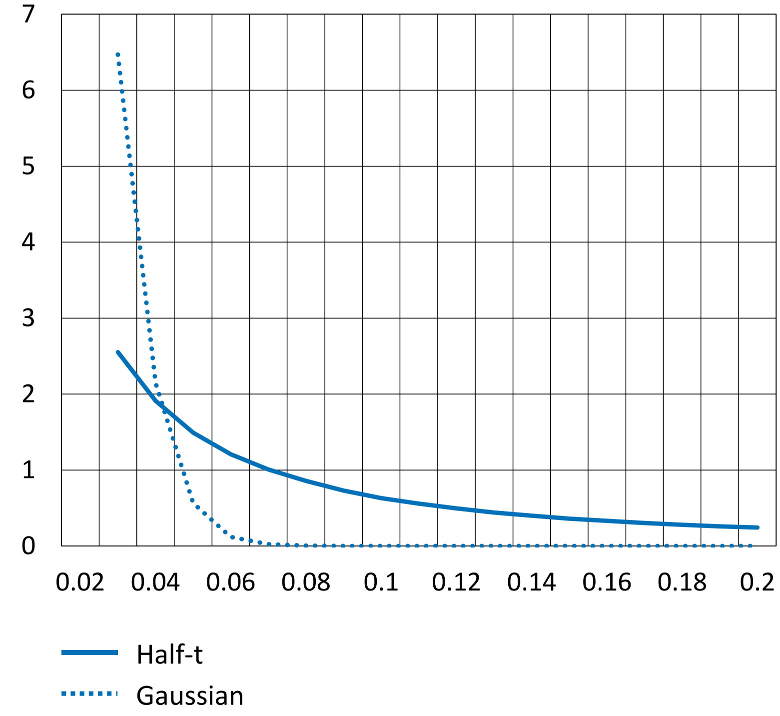


Chart 11. Probabilities of default as a function of the capital ratio, default at 1.5 per cent (3-year horizon)

Probability of default.

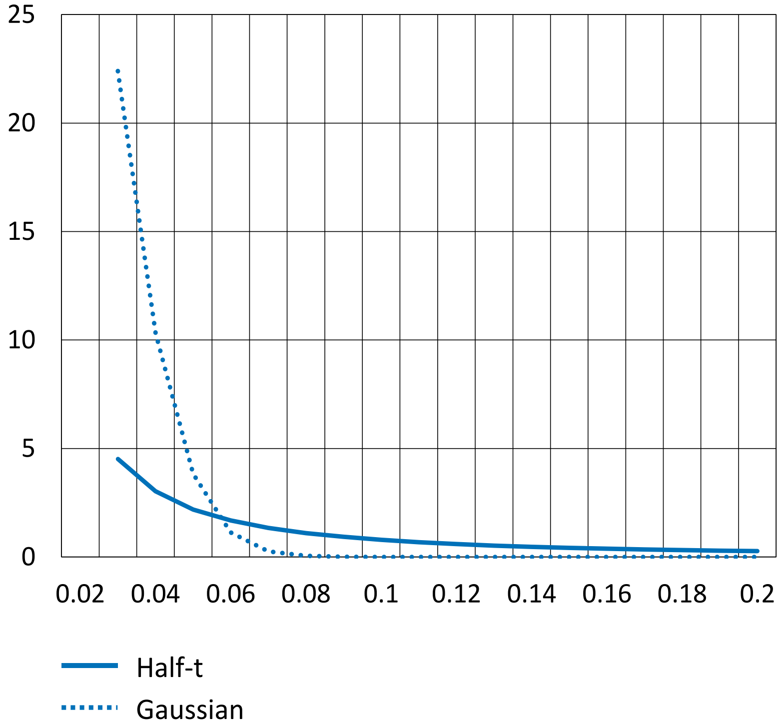


Chart 12. Probabilities of default as a function of the capital ratio, default at 3 per cent (3-year horizon)
Probability of default

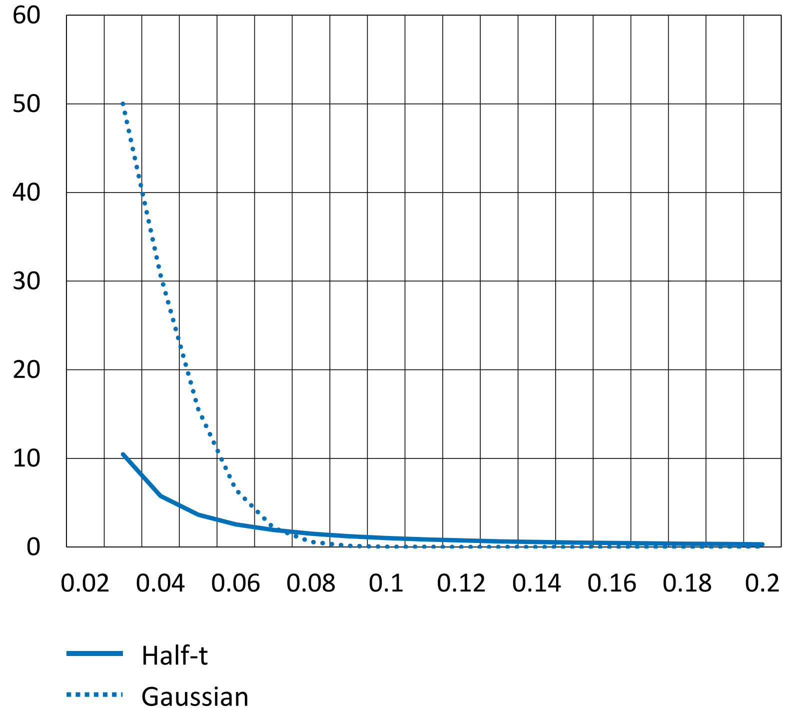


Chart 13. Probabilities of default as a function of the capital ratio, default at 0 per cent (3-year horizon)
Probability of default

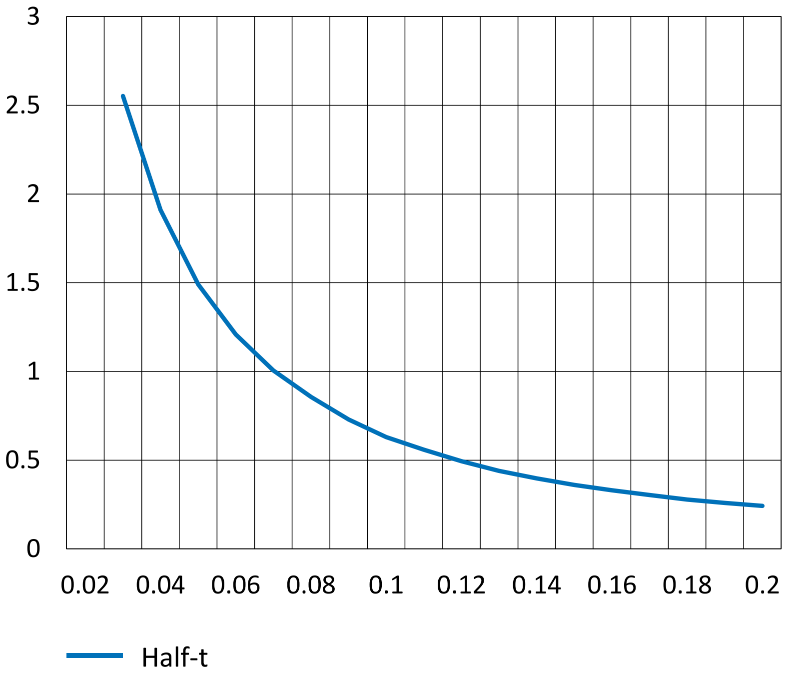


Chart 14. Probabilities of default as a function of the capital ratio, default at 1.5 per cent (3-year horizon)

Probability of default

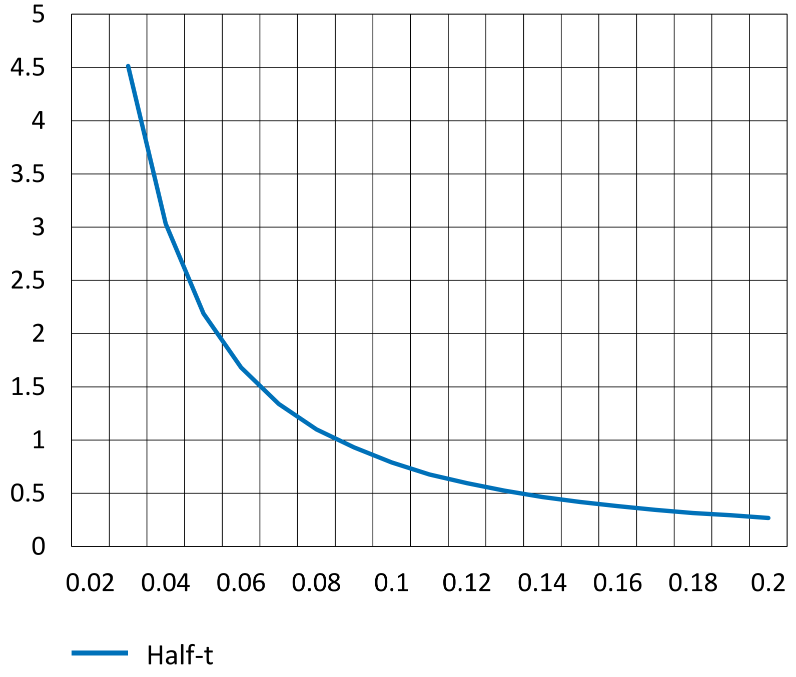
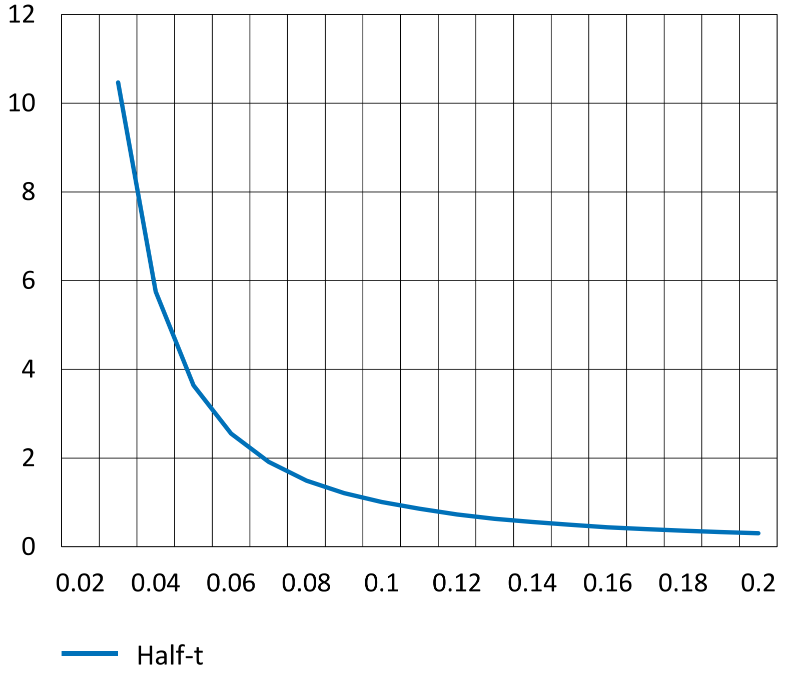


Chart 15. Probabilities of default as a function of the capital ratio, default at 3 per cent (3-year horizon)

Probability of default



An advantage of replacing a Gaussian or a similarly thin-tailed symmetric distribution with a less unrealistic alternative is that results are more robust to variations in assumptions and sample. Charts 5–7 and Charts 10–12 show how the default probabilities implied by the Gaussian are much more sensitive to the threshold used to define default. From the same Charts we can safely imply that the half-t will also be less sensitive to the precise definition of the capital ratio (for example to different risk weights).

Conclusion

We have presented a simple model in which losses for the Swedish banking system are modelled directly rather than being inferred from stock prices. The most salient feature of the historical data, which cover the period from 1870 to 2008, is that long periods of small losses are interrupted by shorter periods of very large losses. A half-t distribution with very low degrees of freedom does a much better job than a Gaussian at reproducing these features of the data, and yet even this model struggles to match the largest losses in the data.

In interpreting the results it is also useful to keep in mind that computations of low probability events necessarily rely on assumptions more heavily than computations of higher probability events, and therefore that the further out in the tail (i.e. the smaller the probability), the more results are driven by assumptions (in our case, by the choice of a half-t distribution) and by sampling error.

The main conclusion of our exercise is that, compared to a Gaussian distribution, a more accurate statistical model of bank losses lead to substantially different conclusions regarding the effects of different capital ratios. Using a half-t distribution typically (though not always) results in smaller probabilities of hitting a critical value when banks are very highly levered. Technically, this reflects the properties of highly asymmetric and fat-tailed distributions (of which the half-t is an example), in which small deviations from the mode are more frequent than in the Gaussian. Intuitively, this means that even a dangerously levered bank may survive without a critical event for decades. On the other hand, the probabilities of critical events fall off much more gently (as the capital ratio is increased) using a half-t distribution, reflecting a larger probability of big losses compared to the Gaussian. Hence increasing equity continues to meaningfully reduce the probability of default at capital ratios for which a Gaussian implies (incorrectly) a near-zero default probability. Because probabilities of critical events obtained under a Gaussian assumption fall so rapidly with the capital ratio, they are also more sensitive to assumptions about the appropriate threshold for a critical event and to parameter estimates, implying that conclusions draws from Gaussian assumptions in actual applications are likely to prove very fragile to differences between in-sample and out-of-sample data.

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SVERIGES RIKSBANK
103 37 Stockholm
(Brunkebergstorg 11)

Tel 08 - 787 00 00
Fax 08 - 21 05 31
registratorn@riksbank.se
www.riksbank.se