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The social costs and benefits of too-big-to-fail banks: A "bounding" exercise ☆

John H. Boyd [a,1], Amanda Heitz [b,*]

[a] Department of Finance, Carlson School of Management, University of Minnesota, 321 19th Ave S., Minneapolis, MN 55455, United States
[b] Department of Finance, A.B. Freeman School of Business, Tulane University, Goldring/Woldenberg Hall II, 7 McAlister Dr., New Orleans, LA 80118-5645, United States

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ABSTRACT

While the policy of too-big-to-fail has received wide attention in the literature, there is little agreement regarding economies of scale for financial firms. We take the stand that systemic risk increases when the larger players in the financial sector have a larger share of output. Calculations indicate that the cost to the macro-economy due to increased systemic risk is always much larger than the potential benefit due to scale economies. When distributional and intergenerational issues are considered, the potential benefits to economies of scale are unlikely to ever exceed the potential costs due to increased risk of a banking crisis.

1. Introduction: banks, economies of scale, and externalities

It is essential that definitions be precise. By *bank* we intend a very broad definition, not limited to commercial banks. We mean, essentially, all privately owned U.S. financial intermediary firms that borrow and lend. Besides commercial banks, this would include investment banks, thrift institutions, Fannie and Freddie and, for that matter, hybrid affiliates like GE Capital. We do not mean to include life or casualty insurers or securities markets.

By "*economies of scale*," we have a very conventional definition in mind: production efficiencies that are achieved as a firm grows in size. In particular, we are studying production efficiencies of the very largest banks - so called "economies of super-scale". Technically, such economies are properties of the production technology. It is our essential that they be kept logically separate and distinct from any "externalities" associated with TBTF banks. There are negative externalities associated with the failure of such firms, and there is a large literature on this topic. Specifically, TBTF firms, if they fail, may have negative effects on the macroeconomy. That is the *raison d'etre* of the TBTF policy. Both concepts, economies of super-scale and externalities, are fundamental to the cost-benefit analysis that follows. The costs that we calibrate are those associated with the failure of a TBTF bank(s). The benefits that we calibrate are those associated scale.

2. Introduction: statement of a problem

Many argue that the market's *ex ante* belief in a public policy of too-big-to-fail (TBTF) caused the excessive risk that produced the recent banking crisis. It is further believed that the government's ex-post actualization of that TBTF policy produced a series of massive government bailouts (Boyd and Jagannathan, 2009; Johnson and Kwak, 2011, Volcker (cited in Casey, 2010). Some of these same individuals have argued that the TBTF banks are inherently costly to society and should be broken into smaller independent pieces. Boyd et al. (2009) provide empirical evidence that the twenty largest banking firms took extraordinary risks in the 2000s and suffered extraordinary losses beginning around 2007. Importantly, the rest of the banking industry did not experience losses to nearly the same extent, and only after the crisis had severely damaged the real economy, did small and medium sized banks begin to report serious problems. Arguably, problems at small and medium-sized banks were an effect of the banking crisis, not a cause.

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* Corresponding author. Tel.: +1 (504) 314 7575.
E-mail addresses: boydx002@umn.edu (J.H. Boyd), aheitz@tulane.edu (A. Heitz).
[1] Tel.: +1 (612) 624 1834.

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2.1. An estimation problem

A counter-argument to the above is that very large banks exhibit economies of scale, and if they are broken into pieces, efficiency gains will be lost. It is widely believed, however, that scale economies in banking are extremely difficult to estimate. There is a large literature on this topic, and the only general point of agreement is that very small banks (less than a few hundred million in assets) are generally not efficient. One problem for the empirics is that, for this industry, output is difficult to measure. Theory tells us that commercial banks provide three broad classes of economic functions: payments services, inter-temporal risk management in the sense of Diamond and Dybvig (1983), and delegated monitoring in the sense of Diamond (1984) or Boyd and Prescott (1986). The first function is susceptible to measurement using proxy variables such as cash provided and checking account balances/transactions. However, the second two economic functions change the nature of the macroeconomic equilibrium (see studies cited above) and are almost impossible to measure. Various authors have taken different approaches to this problem, but none of this empirical literature can claim to be derived from the theory.

The policy of TBTF complicates the estimation problem further. This policy provides an obvious advantage to very large banks; they have de facto insurance of all their liabilities. Other banks do not. This advantage looks like a funding cost efficiency and affects Tobin's Q and related measures in the same manner. Unfortunately, the correlation between size and TBTF coverage is believed to be close to one hundred percent. TBTF is not any kind of a scale economy - it is just favorable treatment of a few banks by the government.

Recently, it has been argued that reliable estimates of scale economies for very large banks cannot be obtained in the current environment with a rapidly changing technology and industrial structure. As DeYoung (2010) points out, there are two main problems in using traditional statistical techniques on modern banking data. First, the distribution of bank size is severely skewed.[2] Second, the largest banks differ from smaller banks in kind, not just size. Small and big banks operate differently and make money in different ways.[3]

2.2. A policy dilemma

If these arguments are correct, then the policy-maker cannot ascertain whether the social cost of these large institutions exceeds the social benefit or vice versa. However, the policy-maker must make decisions in real time, and to ignore the issue is a decision in itself. This is especially significant at the present time, since the recent bailout greatly increased concentration in the US banking industry (Wheelock and Wilson, 2012). We believe we have found a new and different way to investigate this issue.

Some readers may not be familiar with our "bounding" approach, and it is essential that they understand one particularly nice aspect of it. We are not obliged to produce the best possible estimates of either costs or benefits. Instead, we seek to produce benefits estimates that, as the reader will agree, are extremely generous. Similar, we try to produce cost estimates that are extremely conservative on all counts. Numerous assumptions are made with this intent and will be described as we proceed. If the reader agrees that our estimates are substantially biased in both ways, our job is essentially done-for we still find that the social costs of TBTF substantially exceed the social benefits.

In this study, we place "bounds"[4] on the social costs and benefits of TBTF banks. We estimate the social cost of the recent banking crisis assuming (initially) that the crisis was strictly caused by the TBTF banks. We use assumptions that are consistently biased so as to produce the lowest conceivable crisis cost estimates. Next, we estimate the economies of scale benefits of TBTF banks and make similarly Herculean assumptions about economies of scale so as to obtain the largest imaginable social benefits estimates. Then, we compare costs and benefits using a methodology due to Boyd et al. (2005), hereafter BKS). Their method converts both costs and benefits into a comparable metric: the present value-added to (or lost from) real per-capita GDP at a base date.

As we will see in the next section, the costs are assumed to cover a relatively short time period, while the benefits are assumed to go to infinity. Therefore, we must employ a social discount factor to compare the two. There is an old and ongoing debate on how this is to be done, and therefore, we employ several methods.

2.3. Findings

We find that even under these extreme assumptions, the social costs of TBTF banks substantially exceed the benefits. Mostly, this is because the estimated crisis cost, even though intentionally biased downward, is very large. Our median crisis cost estimate is $14.83 trillion in 2007 dollars. The estimates include output losses extending a number of years into the future. Such large cost estimates may not be so surprising given some estimates already available in the literature (Rogoff et al., 2004).

Now, it could be that TBTF was only one of several factors leading to the crisis. Therefore, we make probability calculations showing how large the role of TBTF banks would have needed to be such that the costs and benefits were equated. Our results show that if the policy of TBTF increases crisis probabilities by even a modest percentage, then the cost of the policy exceeds the benefit.

3. Estimating the social cost of the banking crisis

To estimate the costs associated with the TBTF banks, we estimate the real per capita output losses associated with the recent banking crisis. These real cost estimates include output lost during the crisis as well as output lost during the time it takes the economy to recover to its pre-crisis trend level of output. Using the methodology of BKS, we assume that had the banking crisis not occurred, output would have continued to grow at the long-run trend real growth rate of the economy. We use two methods to estimate the long-run trend in output. The first estimate is simple – a 25-year arithmetic average of historical US growth rates in real per-capita GDP over the period 1983–2007. That rate is 2.27%.

The second trend estimator employs the maximum likelihood estimator proposed by Easterly et al. (1993). With this method, the trend estimate depends on the United States' growth rate and the world growth rate. If we define g_t as the estimated growth rate in real per capita GDP for the United States in period t, w_t as the world growth rate in period $t, \bar{g}_t$ as the historical average growth rate as of year t, and n as the number of years used to compute the historical average, then the Easterly et al. (1993) estimate yields a growth rate estimate of 2.16% from the years 1983–2007. This trend rate of real GDP growth is defined as:[5]

[2] Econometric tools provide the most accurate estimates for average companies, but they become less precise for firms that are substantially larger or smaller. The three largest banks, holding more than $2 trillion in assets, are almost ten times as large as the thirteenth largest bank.

[3] The literature on economies of super scale is mixed at best. Some studies using panel data across countries have found evidence of diseconomies of scale in very large banks (De Nicolo, 2000). Moreover, there is evidence that although large banks are better diversified than smaller banks, they offset this advantage by increasing risk in other ways, especially through the use of financial leverage (Boyd and Runkle, 1993).

[4] It should be clear from above that we do not mean bounds in the mathematical sense. What we essentially mean is "unreasonably biased in a systematic manner."

[5] The estimate obtained using the method of Easterly et al. (1993) provides a trend rate of 2.16%, which is lower than the average rate of 2.27%. This consequently leads to smaller estimated output losses resulting from the banking crisis when the Easterly et al. (1993) method is used.

$$g_t = \left[n \times \frac{var(w_t)}{var(\bar{g}_t) + n \cdot var(w_t)}\right] \times \bar{g}_t + \left[n \times \frac{var(\bar{g}_t)}{var(\bar{g}_t) + n \cdot var(w_t)}\right] \times w_t \quad (1)$$

We then use these two trend estimates to obtain the hypothetical real per capita GDP per capita values for 2007 and after – economic performance that might have been obtained had the crisis not occurred.[6]

We also need to know the economy's actual output path. We use reported US real per capita GDP figures for 2007–2013. To be conservative in estimating the crisis cost, we assume that the crisis ends in 2013, so for the years 2014 and after, we assume real per-capita GDP has risen to the pre-crisis trend. Thus, the trend GDP line and the actual GDP lines come together in 2014, forcing the loss estimates to be zero from that date onward. The result of this procedure is shown in Fig. 1. Our estimate of the social loss is the discounted integral of the area between the two lines in Fig. 1.

Assuming that the banking crisis is over rather quickly in 2014 and there are no further economic losses after that date is a conservative assumption that massively reduces our crisis cost estimates.[7] By contrast, BKS find that only four out of twenty-three countries in their sample of historical banking crises re-attain their pre-crisis trend level of output within seventeen years after a crisis onset. Papell and Prodan (2012) find that in developed countries, the return to the potential GDP path following recessions associated with financial crises takes an average of nine years. As will be seen in a moment, we obtain cost estimates of about 45% of base year (2007) GDP. This may be contrasted with BKS who find an average lower bound cost estimate of 63% of base year GDP and an upper bound of 302%.

3.1. Cost computation

First, we compute the actual and trend rates for each crisis year. Next, we assume that each annual loss continues to grow by the growth rate in each period. Then, all annual losses are discounted back to 2007 and expressed as a percentage of 2007 real per capita GDP. Essentially, we integrate the difference between the actual real per capita GDP and the trend values but allow these costs to grow at the growth rate, g. A similar procedure will be employed later for the benefits stream. Define c_t as the annual crisis cost in year t. The present value of the total crisis cost is:

$$C = \sum_{t=1}^{6} \frac{c_t(1+g)^{6-t}}{(1+o)^t} \quad (2)$$

where o is a social discount rate to be discussed in the following section.

As shown in Table 1, when a simple average historical growth is used for the historical growth trend, this estimate ranges between 24.57% and 27.25% of 2007 real per-capital GDP. When trend growth is estimated with the Easterly et al. (1993) method, cost estimates range between 22.55% and 24.97% of 2007 real per capita GDP.

To conclude this section, we note another source of conservatism in our crisis cost estimates. We are assuming that all economic costs are represented by lost real output in the United States and *assign no weight to economic problems elsewhere in the world*. We know that the US banking crisis did have economic consequences and caused real output losses around the world. However, estimating these costs is almost impossible, and we cannot derive a credible way to disentangle the magnitude to which these losses impacted or compounded the US crisis costs. Presumably, crisis losses around the world were large. However, if TBTF banks exacerbated these costs, which in turn increased the US crisis cost, then this chain of reasoning still leaves US TBTF banks at the root of US losses.

4. The social discount rate

In conducting a cost-benefit analysis, it is necessary to reduce both costs and benefits to a single date in order to compare them. For risky projects, a higher social discount rate is typically used in order to reflect the riskiness of the project. We believe that both the social costs and benefits of TBTF banks are inherently risky and thus, a risky social discount factor seems appropriate. The future benefits to TBTF banks depend on technology advances and on the industrial organization of the banking industry, both difficult to predict. The future costs of financial crises depend on a myriad of things that are also extremely hard to predict. To be abundantly conservative, however, we use three different estimates of the social discount rate. The definition and estimation of these rates is discussed in Appendix A.1.

We note that the risk-free social discount rate of 3.63% is designed for extremely safe public projects. This discount rate is not realistic, considering, as we have pointed out, that both costs and benefits are difficult to predict. However, the results are reported in order to indicate a minimum discount rate in order for the reader to examine the upper obtainable bound for benefits and lowest cost number. By computing a riskless social discount rate, which is designed to reflect a level of risk less than TBTF costs and benefits, this allows the reader to see the most conservative cost to benefit ratios. A more detailed discussion of this is included within Appendix A.1.

5. Estimating the benefits of economies of scale in tbtf banks

Hughes et al. (2001) have obtained some of the largest banking scale economy estimates in the literature, and we shall first use their benefits estimates in our calculations.[8] Mester (2010) has recently argued that these scale economies currently remain intact and would be lost if the largest banks were broken up. The literature on scale economies in banking, including my own studies, suggests that imposing a strict size limit would have unintended consequences and work against market forces. (*op. cit.*, page 10). Hughes, Mester, and Moon (*op. cit.*) and that when managers are allowed to make value maximizing decisions and rank projects based on both their profitability and risk, scale economies increase with bank size, suggesting that even mega-mergers are exploiting scale economies.[9]

[6] This method is explained in detail in Easterly et al. (1993). FootNote 15 describes that the maximum likelihood is derived by solving a signal extraction problem. A Dickey–Fuller test on the maximum likelihood estimator alleviates concerns that the process is non-stationary or has a unit root, indicating a test statistic of −3.023 (p-value of 0.0328). The Phillips–Perron test for unit root produced a test statistic of −2.890 and a p-value of 0.0466. The stationary process further biases our cost estimates down. If the process was non-stationary, then this would indicate that the actual level of real per capita GDP may never approach pre-crisis levels, essentially making the cost estimates even larger.

[7] It's necessary to distinguish between crisis end date and business cycle end date. Within the context of this paper, we associate crisis costs with the length of time that real per capita is determined to be below pre-crisis trend levels. NBER, however, declared that the business cycle ended in 2009. This is different than our definition of a crisis end date because by looking at the real per capita GDP numbers in 2009, it can be seen that they are still significantly below trend. The business cycle may have ended, but the real output losses continued.

[8] Several other studies have found economies of scale in large banks including Hughes et al. (1996), Berger et al. (1980), Hughes and Mester (1998), Hughes et al. (2000), Bossone et al. (2004), Feng and Serletis (2010), Wheelock and Wilson (2012), Hughes and Mester (2013).

[9] An important innovation of this study is that it identifies and measures scale economies not just in terms of operating costs but also in terms of risk management. The authors argue that to ignore scale economies in risk management results in a serious miss-specification.

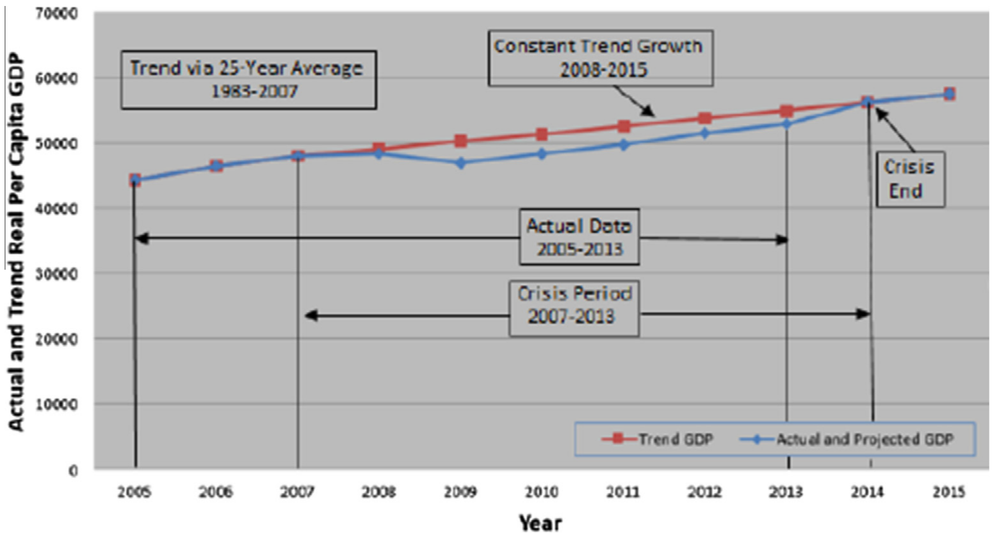

Fig. 1. Fig. 1 shows the actual and trend real per capita GDP lines corresponding to the assumptions within the paper. The trend line is computed via a 25-year arithmetic average between 1983–2007 and is assumed to be constant. The lower line plots the actual real per capita GDP path from 2005–2013. In 2014, the trend and actual GDP lines come together by construction. The area between the actual and trend GDP lines depicts the crisis cost estimate.

Table 1
Estimated economic losses due to the banking crisis.

Social discount rate (o) (%)	Loss as a percentage of 2007 Real GDP per capita (C) (%)
Panel A: trend predicted using 25-year average rate of 2.27%	
6.77	24.57
5.25	25.81
3.60	27.25
Panel B: trend predicted using Easterly et al. method rate of 2.16%	
6.77	22.55
5.25	23.67
3.60	24.97

Table 1 compares the estimated losses employing varying GDP growth rate and trend assumptions. Column 1 shows the social discount rates used. Column 2 shows the loss values as a percentage of 2007 real per capita GDP for each of the corresponding social discount rates in Column 1. Panel A estimates the losses based on trend calculations, which are the average growth rate of real per capita GDP of 2.27% over the period 1983–2007. Panel B estimates losses based on trend calculations of 2.16% with the method proposed by Easterly et al. (1993) over the period from 1983 to 2007.

Their measure of scale economies is the inverse cost elasticity of output.

For their full sample, the mean measure of scale economies for the banking industry is 1.145, while the largest banks with assets of more than $50 billion have scale economies of 1.25. This implies that TBTF banks are on average (1.25–1.145)/1.145 = 9.2% more efficient than the overall industry.[10] We define the returns-to-scale parameter as l. For our first benefits calculations, we assume that the largest banks obtain economies of scale that, *ceteris paribus*, increase their contribution to national output by l = 9.2%. This value added is being produced under the current banking arrangement and would, by assumption, be lost if the TBTF banks were broken up. Thus, the benefit we estimate is effectively a counter-factual: an estimate of existing economic benefits that could be lost.

Wheelock and Wilson (2012) obtain economies of super-scale estimates that appear to be even larger than those obtained by Hugheset al., (*op. cit.*). We next assume their economy of scale results in our calculations. However, they do not provide a breakdown that allows us to compare TBTF banks (roughly the largest 20) with the rest of the banking industry. What they do provide is an estimate of the economies of scale advantage of the largest four banks *vis-a-vis*, the costs that would obtain if the largest four were broken into eight equal sized banks. This cost advantage estimate is 16%, and that is what we shall employ in what follows (Wheelock and Wilson, *op. cit*. p. 18).[11]

We have intentionally chosen these two studies from a substantial literature because they have the largest estimates of economies of super-scale. The reader should note that there is an on-going debate as to whether economies of super-scale in banking even exist. Other studies, such as De Nicolo (2001), and as much evidence of scale diseconomies as of scale economies. The De Nicolo study employs an international panel dataset giving it an international dimension (and statistical power) that is absent in most of this literature.

5.1. Numerical implementation: national income account

We next calculate the percentage of total real per capita GDP provided by TBTF banks, s, from the National Income Value-Added Accounts. First, we obtain the data for the sector called Federal Reserve Banks, Credit Intermediation, and Related Activities and employ an average of this sector's percentage value-added to national output over the twenty-year period between 1988 and 2007. We obtain $s = 3.63\%$.

This number is vastly overstated for our purposes, since it includes all of the banks in this entire sector including the Federal Reserve Banks. Our next goal is to determine the fraction of this sector, f, that represents only the TBTF banks. The Federal Reserve releases quarterly data on domestically chartered insured commercial banks that have consolidated assets of $300 million or more. The largest 25 banks have about $5,855 million in assets, the largest 100 banks have $7,214 trillion in

[10] Recall that this study was published in 2002 and employs data earlier than that. Thus, at this time banks with assets exceeding $50 billion were clearly TBTF. Their sample includes 15 banks in this size category which were the largest banks in the United States at that time.

[11] Note that their estimated cost advantage must be considerably larger when the top four banks are compared with the overall industry.

assets, while the total domestic financial assets $68,301 trillion in assets. Thus, the largest 25 banks represent approximately 8.57% of the sector, while the largest 100 banks are approximately 10.56%.[12] In the proceeding analysis, we attribute the scale economies to either the fraction of financial assets, f, that are held by the largest 25 or 100 banks, which are listed in Appendix A.4.

The annual social benefit attributable to economies of scale in TBTF banks now is $G_t \cdot s \cdot l \cdot f$, where G_t is real per capita GDP in year t. G_t is growing, and we need to take that into account in our estimates. Our empirical proxies for real output growth will be the two trend growth rate estimators presented in the last section. To realize real growth, the TBTF banks, like all firms, must retain earnings so they can invest in real capital. The fraction of their earnings that is retained, r, is not available for consumption in the current year and must be subtracted from current benefits. For empirical purposes, we obtained the average retention ratio of commercial banks, defined as the difference in the average net income after taxes and average dividends declared over the period 1990–2007 divided by average net income after taxes for all US commercial banks over the period 1990–2007. We obtained $r = .3226$.

In the base year, the annual social benefits of TBTF are $G_t \cdot s \cdot l \cdot f$, and it is assumed that these benefits are growing and continue indefinitely into the future. Therefore, accounting for retention, we have:

$$V = \frac{s \cdot l \cdot f \cdot (1 - r)}{o - g} \tag{3}$$

where V is the period zero value of the entire future stream of economies of scale additions to real economic output going out to infinity, expressed as a percent of period 0 real per capita GDP.[13]

From Table 2, we can see that when we employ the 25-year arithmetic average growth rate of 2.27% and the Moon et al. (*op. cit.*) scale estimates are employed, the discounted value of TBTF benefits ranges between 0.53% and 1.80% of base year per capita output for the Top 100 banks, while the largest 25 banks realize benefits between 0.43% and 1.46%. When the larger Wheelock and Wilson scale estimates are employed, the benefit calculations are larger and range between 0.75% and 2.54% for the largest 25 banks. The largest 100 banks exhibit scale economies between 0.92% and 3.12% of 2007 real per capita GDP. Table 3 shows that when 2.16% is used as the growth rate, consistent with the method proposed by Easterlyet al., the results are very similar. When scale economies are attributed to the largest 100 banks, estimates range from 0.52% to 2.89% of base year real per capita output, while the estimates pertaining to the largest 25 banks range from 0.42% to 2.34% of base year per capita output.

[12] We thank David Humphrey for the suggestion of appropriately attributing TBTF benefits to just TBTF banks, opposed to the entire banking sector.

[13] We assume that the fractions l and s are fixed forever. This produces a bigger net benefit than would be obtained by putting TBTF banks' value added into a conventional production function, which would exhibit diminishing returns to factors. This treatment is consistent with our general approach of biasing the benefits of TBTF upward. However, we do not allow the super-normal growth of TBTF banks to feed back and affect the growth rate of the economy. To do that would require a two technology general equilibrium growth model. Further, if that growth model did not impose some kind of convergence restriction, the TBTF banks would come over time to be 100% of the economy (which would be growing at the super normal rate).

Table 2
Estimated social value-added of TBTF banks estimated social value-added of TBTF banks resulting from economies of scale growth rate calculated using 25-year average 2.27%.

Social	Benefit as a percentage of 2007 real per capita GDP (V)	
Discount rate (o) (%)	Top 25 banks (%)	Top 100 banks (%)
Panel A: Moon et al. measure of scale economies 9.2%		
6.77	0.43	0.53
5.25	0.65	0.80
3.6	1.46	1.80
Panel B: Wheelock & Wilson measure of scale economies 16%		
6.77	0.75	0.92
5.25	1.13	1.39
3.60	2.54	3.12

Table 2 shows the benefits of Too Big to Fail Banks (TBTF) where the growth rate of real per capita GDP is calculated using the arithmetic average of the previous growth rates, 1983–2007. Column 1 shows the varying social discount rates. Column 2 shows the benefits as a percentage of 2007 real per capita GDP where 2007 is assumed to be the year of crisis onset and scale economies are attributed to the largest 25 banks as classified by asset size, while Column 3 shows estimates attributing scale economies to the largest 100 banks. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012).

Table 3
Estimated social value-added of TBTF banks estimated social value-added of tbtf banks resulting from economies of scale growth rate calculated using easterly method for trend growth 2.16%.

Social	Benefit as a percentage of 2007 real per capita GDP (V)	
Discount rate (o) (%)	Top 25 banks (%)	Top 100 banks (%)
Panel A: Moon et al. measure of scale economies 9.2%		
6.77	0.42	0.52
5.25	0.63	0.77
3.6	1.35	1.66
Panel B: Wheelock & Wilson measure of scale economies 16%		
6.77	0.73	0.90
5.25	1.09	1.34
3.60	2.34	2.89

Table 3 shows the benefits of Too Big to Fail Banks (TBTF) where the growth rate of real per capita GDP is calculated using the method proposed by Easterly et al. (1993) over the period 1983–2007. Column 1 shows the varying social discount rates. Column 2 shows the benefits as a percentage of 2007 real per capita GDP where 2007 is assumed to be the year of crisis onset and scale economies are attributed to the largest 25 banks as classified by asset size, while Column 3 shows estimates attributing scale economies to the largest 100 banks. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012).

6. Comparing costs and benefits

We can now compare cost and benefits estimates. Table 4a shows the cost and benefits estimates obtained when the 25-year average is used to approximate trend growth in real, per capita GDP. The cost benefit ratio ranges from a high of 57.03 to a low of 8.72, depending on the measure of scale economies used as well as the number of banks that are assumed to receive these scale economies. Table 4b shows the cost and benefit estimates obtained when the method from Easterly et al. (1993) is used to approximate trend growth in real per capita GDP. These cost benefit ratio ranges from a high of 53.63 to a low of 8.65. In all of the cases in Tables 4a and 4b, including the most extreme, the estimated cost of TBTF exceeds the estimated benefit by a wide margin.

Table 4a
Summary of Costs and Benefits as a percentage of 2007 real per capita GDP calculated using 25-year average method for trend growth 2.27%.

Social Discount rate (o) (%)	Cost estimates (C) (%)	Benefit estimate (V) Top 25 banks (f) (%)	Top 100 banks (f) (%)	Cost benefit ratio Top 25 banks (f)	Top 100 banks (f)
Panel A: Moon et al. measure of scale economies 9.2%					
6.77	24.57	0.43	0.53	57.03	46.28
5.25	25.81	0.65	0.80	39.67	32.19
3.60	27.25	1.46	1.80	18.70	15.17
Panel B: Wheelock & Wilson measure of scale economies 16%					
6.77	24.57	0.75	0.92	32.79	28.61
5.25	25.81	1.13	1.39	22.81	18.51
3.60	27.25	2.54	3.12	10.75	8.72

Table 4a shows the Summary of Costs and Benefits as a percentage of 2007 real per capita GDP where the growth rate is calculated using the 25-year arithmetic average from 1983 to 2007. Column 1 shows the varying social discount rates. Column 2 shows the cost estimates as a percentage of 2007 real per capita GDP. Column 3 shows the benefits estimate as a percentage of 2007 real per capita GDP when scale economies are attributed to the largest 25 banks as classified by asset size, while Column 4 shows the estimates when attributing scale economies to the largest 100 banks. Column 5 shows the cost to benefit ratio for the largest 25 banks, which is the ratio of Column 2 to Column 3. Column 6 shows the cost to benefit ratio for the largest 100 banks, which is the ratio of Column 2 to Column 4. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012).

Table 4b
Summary of Costs and Benefits as a percentage of 2007 real per capita GDP growth rate calculated using easterly method for trend growth 2.16%.

Social Discount rate (o) (%)	Cost estimates (C) (%)	Benefit estimate (V) Top 25 Banks (f) (%)	Top 100 Banks (f) (%)	Cost benefit ratio Top 25 Banks (f)	Top 100 Banks (f)
Panel A: Moon et. al. measure of scale economies 9.2%					
6.77	22.55	0.42	0.52	53.63	43.52
5.25	23.67	0.63	0.77	37.72	30.61
3.60	24.97	1.35	1.66	18.55	15.05
Panel B: Wheelock & Wilson measure of scale economies 16%					
6.77	22.55	0.73	0.90	30.84	25.03
5.25	23.67	1.09	1.34	21.69	17.60
3.60	24.97	2.34	2.89	10.66	8.65

Table 4b shows the Summary of Costs and Benefits as a percentage of 2007 real per capita GDP where the growth rate is calculated using the method proposed by Easterly et al. (1993) over the period 1983–2007. Column 1 shows the varying social discount rates. Column 2 shows the cost estimates as a percentage of 2007 real per capita GDP. Column 3 shows the benefits estimate as a percentage of 2007 real per capita GDP when scale economies are attributed to the largest 25 banks as classified by asset size, while Column 4 shows the estimates when attributing scale economies to the largest 100 banks. Column 5 shows the cost to benefit ratio for the largest 25 banks, which is the ratio of Column 2 to Column 3. Column 6 shows the cost to benefit ratio for the largest 100 banks, which is the ratio of Column 2 to Column 4. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012).

7. The payback period

Tables 5 and 6 use a different metric for comparing costs and benefits one that is not so dependent on the choice of the social discount rate o. This is the payback period, a commonly used analytical tool in accounting. In this application, the payback period measures how many good, non-crisis years it would take to make up for the social cost of a single crisis. TBTF benefits are not discounted in these calculations, but the 6 years of crisis costs must be reduced to a single cost number. To do that, we go back to

Table 5
Payback period calculated using 25-year averages for trend growth 2.27%.

Growth rate (g) (%)	Cost estimates (%)	Top 25 banks	Top 100 banks
Panel A: Moon et al. measure of scale economies 9.2%			
2.27	31.29	62	62
Panel B: Wheelock & Wilson measure of scale economies 16%			
2.27	31.29	45	45

Table 5 shows the payback period where the growth rate is calculated using the 25-year arithmetic average from the years 1983 to 2007. Column 1 shows the growth rate of the 25-year arithmetic average. Column 2 shows the loss estimates from 2007–2014. Column 3 shows the estimated payback period when scale economies are attributed to the largest 25 banks, as classified by asset size. Column 4 shows the estimated payback period when scale economies are attributed to the largest 25 banks, as classified by asset size. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012). Please note that the payback period is the first integer year where benefits exceed costs. This is a form of rounding which explains why they two estimates above are the same.

Table 6
Payback period calculated using Easterly et al. method for trend growth 2.16%.

Growth rate (g) (%)	Cost estimates (%)	Top 25 banks	Top 100 banks
Panel A: Moon et al. measure of scale economies 9.2%			
2.27	28.84	61	61
Panel B: Wheelock & Wilson measure of scale economies 16%			
2.27	28.84	43	43

Table 6 shows the payback period where the growth rate is calculated using the method proposed by Easterly et al. (1993) over the period 1983–2007. Column 1 shows the growth rate of the 25-year arithmetic average. Column 2 shows the loss estimates from 2007 to 2014. Column 3 shows the estimated payback period when scale economies are attributed to the largest 25 banks, as classified by asset size. Column 4 shows the estimated payback period when scale economies are attributed to the largest 25 banks, as classified by asset size. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012). Please note that the payback period is the first integer year where benefits exceed costs. This is a form of rounding which explains why they two estimates above are the same.

the original cost estimates shown in Fig. 1 and define c_t as the annual crisis cost in year t. In computing the payback period, the crisis cost number is defined as:

$$\sum_{t=1}^{6} c_t \cdot (1+g)^{6-t} \tag{4}$$

We express this cost as a percentage of 2007 real GDP per capita. This is symmetric with our treatment of the TBTF benefit stream, which is also assumed to grow at the rate g. To estimate the payback period benefits, we use the expression:

$$\sum_{t=0}^{n} l \cdot s \cdot f \cdot (1-r) \cdot (1+g)^t \tag{5}$$

The actual solution procedure is to solve for the integer value of n above that renders expressions 4 and 5 approximately equal.

When the 25-year average growth rate is used to estimate trend real per capita growth (Table 5), these payback period estimates vary between 45 and 62 years. When the Easterly et al. (*op. cit*) method is used to estimate trend real per capita growth (Table 6), they vary between 43 and 61 years. Therefore, the shortest payback period, under the most extreme assumptions, is 43 years.

7.1. Crisis arrival rates under TBTF: actual experience

Laeven and Valencia (2008) document 124 systemic banking crises in 161 countries over a 37 year period. The average country is present in their sample for 34.5 years. This means there are 161*34.5 country-year points (total data points) and 124 systemic crises documented. Therefore, the average world crisis-arrival rate in recent years has been $124/(161 \times 34.5) = 0.0223$ or a crisis arrival approximately every 45 years. It is important to note that virtually all modern systemic banking crises have involved some form of TBTF policy. Thus, the estimates of Laeven and Valencia (2008) give us a modern estimate of crisis frequencies in the presence of TBTF.

We can now compare the payback period to the average actual crisis arrival rate based on recent international experience. The shortest payback period in Tables 5 and 6 is 43 years. The median payback period is 53 years, which is approximately 1.17 times the average world time between crises.

8. What if TBTF is one among several causes of banking crises? some probability calculations

Even without TBTF banks, banking systems can exhibit crises as is demonstrated by centuries of monetary history. In this section, we allow for that possibility in a simple model in which crises can occur with or without TBTF.

In what follows, there are two regimes: *i* TBTF banks are present and *ii* TBTF banks are not present. Banking crises can occur in either regime. In the TBTF regime, TBTF banks are assumed to provide social benefits in all years including crises. We assume that the annual social benefit of TBTF banks' scale economies, as a percent of real per-capita GDP, is at the mid-point of our previous estimates. We start with the formula $s \cdot l \cdot f \cdot (1-r)$. The midpoint of the scale estimates previously examined (16% and 9.2%) is 12.6%. The midpoint of the fraction of assets held by TBTF banks is the midpoint of the largest 25 banks (8.57%) and largest 100 banks (10.565%), which is 9.565%. The sector size and retention ratio are unchanged. This leaves with a median benefit of .000296.

The structure of the two regimes is depicted in Fig. 2. In the no-TBTF regime, the social benefits of economies of scale are never obtained. In both regimes, when a crisis occurs, we assume the same social cost of a banking crisis that was estimated earlier.

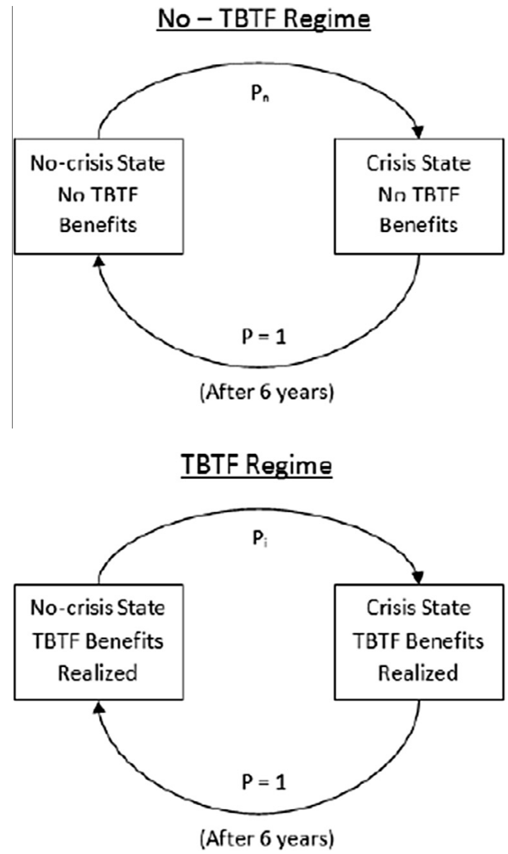

Fig. 2. Fig. 2 depicts the two regimes discussed in Section 8. In the No-TBTF regime, there are no TBTF banks present and scale benefits are not realized. The economy enters a banking crisis with probability p_n. Once a banking crisis occurs, it lasts for six years and then reverts back to a non-crisis state. In the TBTF Regime, TBTF banks are present and scale benefits are realized. Banking crises occur with probability p_i. After six years of banking crises, the economy reverts to a non-crisis state.

We further assume that when a crisis occurs, it lasts six years (as in the previous analysis the crisis was assumed to last from 2008 to 2013). A crisis realization is assumed to produce a cost at the midpoint of our previous crisis cost estimates in Tables 5 and 6, which is 0.30067 This represents the cost of the crisis in terms of lost real GDP per capita over six years, *C*. We treat a crisis as a single event and including all six years of costs appropriately discounted. That's because once the economy enters a crisis state, it remains there for six years. Then, by assumption, the economy always returns to a non-crisis state. With this structure, there is no randomness in leaving a crisis state; the single random variable is the probability of going from a non-crisis to crisis state.

In this analysis, it is assumed that TBTF (weakly) increases the probability of a crisis. If this were not assumed, the TBTF regime would always dominate the no-TBTF regime by construction. The TBTF regime would exhibit weakly lower expected crisis costs and would also have positive returns in non-crisis states. The No-TBTF regime would never have positive returns in non-crisis states. Thus, there could be no trade-off. [14] This is not assuming a result. If

[14] We are assuming, therefore, that the policy of TBTF*ceteris paribus* increases the probability of a crisis by at least some amount. This is hardly a strong assumption, since there is an enormous literature on this topic. Virtually, all of the literature finds that the policy of TBTF increases risk. Here, we mention just a few examples in this literature. One is the seminal theoretical work on moral hazard in banking written by our colleagues (Karaken and Wallace, 1978). Another example is the empirical study by Houston et al. (2010), which finds that banks classified as TBTF engage in significantly more risk taking than other banks (p. 22–23).

Table 7
Present discounted value under different regimes.

Crisis frequency under TBTF, P_i	25	35	45	55	65
Total crisis loss at break even point	−1.06%	−0.71%	−0.52%	−0.40%	−0.31%
Break even probability, P_n	3.91%	2.76%	2.12%	1.72%	1.44%
Difference as a percentage of TBTF crisis probability	2.37%	3.35%	4.34%	5.32%	6.31%

Table 7 shows the present discounted value under different regimes. Row 1 shows the crisis frequency under the regime where TBTF banks are present, p_i. Row 2 shows the total crisis loss for both regimes when evaluated at the break even probability, p_n. Row 3 shows the value of this breakeven probability, P_n, for each frequency, and Row 4 shows $(p_i - p_n)/p_i$, which is the percentage difference in crisis probabilities associated with the breakeven point.

the assumption is contradicted by the parameters, that will become obvious.

With this structure, one can directly compute expected welfare by calculating the *ex ante* expected cost/benefit in any year. Given the simple probability structure, this will be the same at all times. In the TBTF regime, the expected social return is $p_i \cdot C + (1 - p_i) \cdot f \cdot s \cdot l \cdot (1 - r)$, where p_i is the probability of a crisis arrival in the TBTF regime. In the No-TBTF regime, the expected welfare next year is $p_n \cdot C$, where p_n is the probability of crisis in this regime.

The results are shown in Table 7, where it is assumed that the crisis arrival rate in the TBTF regime is once every 25, 35, 45, 55, or 65 years as shown in row 1. We center the computations on one crisis every 45 years, since this was indicated by the results of Laeven and Valencia (2008). The second row shows the total crisis loss at the point where the TBTF and No-TBTF regimes break even, which corresponds to the crisis frequency under TBTF. The third row shows the break-even probability – that is, the value of p_n. which would give the two policies the same expected return. If we assume that a crisis occurs once every 45 years, this break-even value is 2.12%. Finally, the last row in Table 7 shows the object $(p_i - p_n)/p_i$. This represents the percentage difference in crisis probabilities associated with the break-even point. The interpretation is straightforward. For the case of a crisis occurring once every 45 years, we can interpret column 4 as meaning, "If the presence of TBTF increases the probability of a crisis by more the 4.34%, then TBTF is not good policy and is dominated by No-TBTF." A more detailed version of Table 7 is explained in Appendix A.2.

We have some values of crisis arrival occurring more frequently than the Laeven and Valencia (2008) benchmark case and some values occurring less frequently. What these cases show is that the lower the probability of a crisis under TBTF, the larger the percentage increase at the break-even point. This should be intuitive; the longer the average elapsed time between crises, the more years TBTF benefits have to accumulate. However, even when crises only arrive once every sixty five years on average (see Table 7 Column 6) the break-even occurs at p_n = 1.44%. Even in this case, if the presence of TBTF increases the probability of a crisis by more than 6.31%, it is not good policy.

Table 7 and Appendix A.2 are both centered about a crisis every 45 years, since this is what Laeven and Valencia (2008) find. If the reader believes that crises occur more or less frequently, then more emphasis can be placed on the other columns in Table 7. However, all Table 7 columns suggest that the presence of TBTF only needs to increase the probability of a crisis by a small percentage in order to be more of a detriment to society than a benefit.

8.1. A robustness check 1: "perhaps a banking crisis would have occurred in 2007 even if there were no TBTF banks"

This is a comment we have gotten frequently from readers and discussants. If it is true, our cost estimates may be biased upward by the assumption (adopted from BKS) that absent a banking crisis, the economy would have continued to grow at its long term trend rate. But, maybe not. Maybe there would have been a recession in 2007 anyway. Our methodology is supposed to deal with this problem indirectly because the estimated growth rate, g, is a long run trend rate that is intended to average across business cycle frequencies. However, we can deal with the criticism directly, by forcing a recession into our counter-factual growth rate assumptions.

In this robustness check, we assume that a representative post-World War II crisis would have occurred in 2007 even in the absence of TBTF banks. To determine the length of the hypothetical crisis, we examined all recessions occurring after World War II as declared by the National Bureau of Economic Research with the exception of the recession starting in 2007. The NBER declared eleven recessions between 1945 and 2001 and these recessions had an average length of about ten months. For these recession periods, we obtained quarterly data on real per capita GDP growth and found that real per capita GDP grew by 0.35% on average. Thus, our summary of a representative Post-WWI recession is 0.35% growth for 10 months or.0035(12/10) = 0.0042% annually. We assume that such a recession occurred in calendar 2007, and in 2008, the economy reverted to its normal long run trend growth. Therefore, we simply assume that the growth rate for 2007 is 0.0042% and subsequent growth rates are consistent with either the arithmetic mean or method proposed by Easterly et al. (1993).

The cost to benefit ratios assuming the hypothetical crisis costs are shown in Tables 8a and 8b. Not surprisingly, the cost to benefit ratios are smallest when the Wheelock and Wilson scale economies are attributed to the largest 100 banks, smallest social discount rate, and Easterly Trend estimate are all utilized. The opposite extremes lead to the highest cost to benefit ratios. Tables 8a and 8b indicate that the cost to benefit ratios range between 4.24 and 28.78. Tables 4a and 4b had ratios ranging between 8.65 and 57.03 for the same implemented assumptions. The difference between the two groups of tables is due to the fact that the growth rate for 2007 for the calculations within Tables 8a and 8b is 0.0042%, while Tables 4a and 4b use the same trend estimate (either 2.27% or 2.16%) for all years from 2007 to 2013.

8.2. A robustness check 2: other potential benefits due to TBTF, magnitude

Many have commented regarding the potential biases regarding our benefits. As stated in the introduction, the benefits that the first section of the paper have in mind are strictly scale benefits that resolve from a production function. However, many have argued that there could be other benefits that are due to TBTF banks, such as technological advances, better diversification, or increased growth before the crisis.[15] This section of the paper is

[15] Baxamusa and Boyd (2013) even find that large banks are more likely to fail than small banks.

Table 8a
Summary of costs and benefits as a percentage of 2007 real per capita GDP assuming an average banking crisis calculated using 25-year averages for trend growth 2.27%.

Social	Cost estimates (C) (%)	Benefit estimate (V)		Cost benefit ratio	
Discount rate (o) (%)		Top 25 banks (f) (%)	Top 100 banks (f) (%)	Top 25 banks (f)	Top 100 banks (f)
Panel A: Moon et al. measure of scale economies 9.2%					
6.77	12.40	0.43	0.53	28.78	23.36
5.25	13.04	0.65	0.80	20.05	16.27
3.60	13.79	1.46	1.80	9.46	7.68
Panel B: Wheelock & Wilson measure of scale economies 16%					
6.77	12.40	0.75	0.92	16.55	13.43
5.25	13.04	1.13	1.39	11.53	9.35
3.60	13.71	2.54	3.12	5.44	4.41

Table 8a shows the cost to benefit ratios assuming there would have been an average banking crisis in 2007. Thus, the growth rate in 2007 is assumed to be 0.0042%, while the growth rates from 2008 forward are calculated using the 25-year arithmetic average from 1983 to 2007. Column 1 shows the varying social discount rates. Column 2 shows the cost estimates as a percentage of 2007 real per capita GDP. Column 3 shows the benefits estimate as a percentage of 2007 real per capita GDP when scale economies are attributed to the largest 25 banks as classified by asset size, while Column 4 shows the estimates when attributing scale economies to the largest 100 banks. Column 5 shows the cost to benefit ratio for the largest 25 banks, which is the ratio of Column 2 to Column 3. Column 6 shows the cost to benefit ratio for the largest 100 banks, which is the ratio of Column 2 to Column 4. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012).

Table 8b
Summary of costs and benefits as a percentage of 2007 real per capita GDP assuming an average banking crisis calculated using Easterly et al. method for trend growth 2.16%.

Social	Cost estimates (C) (%)	Benefit estimate (V)		Cost Benefit Ratio	
Discount rate (o) (%)		Top 25 banks (f) (%)	Top 100 banks (f) (%)	Top 25 banks (f)	Top 100 banks (f)
Panel A: Moon et al. measure of scale economies 9.2%					
6.77	11.04	0.42	0.52	26.26	21.30
5.25	11.59	0.63	0.77	18.47	13.90
3.60	12.23	1.35	1.66	9.08	7.37
Panel B: Wheelock & Wilson measure of scale economies 16%					
6.77	11.04	0.73	0.90	15.09	12.25
5.25	11.59	1.09	1.34	10.62	8.62
3.60	12.23	2.34	2.89	5.22	4.24

Table 8b shows the cost to benefit ratios assuming there would have been an average banking crisis in 2007. Thus, the growth rate in 2007 is assumed to be 0.0042%, while the growth rates from 2008 forward are calculated using the method proposed by Easterly et al. (1993) over the period 1983–2007. Column 1 shows the varying social discount rates. Column 2 shows the cost estimates as a percentage of 2007 real per capita GDP. Column 3 shows the benefits estimate as a percentage of 2007 real per capita GDP when scale economies are attributed to the largest 25 banks as classified by asset size, while Column 4 shows the estimates when attributing scale economies to the largest 100 banks. Column 5 shows the cost to benefit ratio for the largest 25 banks, which is the ratio of Column 2 to Column 3. Column 6 shows the cost to benefit ratio for the largest 100 banks, which is the ratio of Column 2 to Column 4. Panel A estimates Too Big to Fail (TBTF) benefits based on scale economies obtained by Hughes et al. (2001), and Panel B estimates TBTF benefits based on scale economies obtained by Wheelock and Wilson (2012).

designed to determine how big TBTF benefits, from scale economies or otherwise, would need to be in order to overturn the findings within the paper.

For the first exercise within this section, we begin with our most conservative cost-benefit ratio from Table 8b Panel B, which is 4.24. This panel assumes the largest scale benefit estimates along with the assumption that a crisis would have already occurred even without the presence of TBTF banks, affecting the growth rate in 2007. Under these conservative circumstances, in order for the costs to equate to the benefits, the additional benefit component would have to be 12.23–2.89% = 9.34% of 2007 real per capita GDP, which is more than three times the benefits estimate of 2.89% that applies to that scenario. We argue that this dramatic benefit increase seems too large to be realistic.

In an additional robustness check, we back out the percentage of benefits associated with TBTF banks that would be needed in order to offset the costs. We set the cost estimates from Table 1, C, equal to the benefits formula from Formula 3. However, because we are considering all benefits of TBTF banks, not just scale economies, we replace the l in Eq. (3) with a b, which now represents TBTF benefits of any kind.

$$C = \frac{s \cdot b \cdot (1 - r)}{o - g} \tag{6}$$

In Table 9, we examine the benefits from Table 1 that vary with the fraction of banks examined, f, displayed in Columns 3 and 4 and growth rates, g, show in Panels A and B. Since the sector size, s, and retention ratio, r, are both fixed, we can back out the corresponding benefits level, b, that is necessary to equate costs to benefits. Rearranging Eq. (6) allows us to solve for b.

$$b = \frac{C \cdot (o - g)}{f \cdot s \cdot (1 - r)} \tag{7}$$

In Eq. (7), b represents the entire benefit that would need to come from TBTF banks from any conceivable source including but not limited to technological advances, scale economies, additional diversification, etc. The smallest benefits estimate is

Table 9
Benefits estimate necessary to equate crisis costs.

Social Discount rate (o) (%)	Loss as a percentage of 2007 real per capita GDP (C) (%)	Benefits Metric Top 25 banks (f) (%)	Top 100 banks (f) (%)
Panel A: trend predicted using 25-year average rate of 2.27%			
6.77	11.04	0.42	0.52
5.25	11.59	0.63	0.77
3.60	12.23	1.35	1.66
Panel A: trend predicted using Easterly et al. method rate of 2.16%			
6.77	11.04	0.73	0.90
5.25	11.59	1.09	1.34
3.60	12.23	2.34	2.89

Table 9 shows how large benefits from TBTF banks need to be in order to overcome the crisis cost computations. Column 1 shows the social discount rates used. Column 2 shows the loss values as a percentage of 2007 real per capita GDP for each of the corresponding social discount rates in Column 1. Columns 3 and 4 indicate the necessary benefits that must come from TBTF banks in order to equalize the costs presented in Column 2. Column 3 shows how large the TBTF benefits must be if the largest 25 banks, as classified by asset size, are considered too-big-to-fail, while Column 4 assumes that the largest 100 banks are considered too-big-to-fail. Panel A estimates the losses based on trend calculations, which are the average growth rate of real per capita GDP of 2.27% over the period 1983–2007. Panel B estimates losses based on trend calculations of 2.16% with the method proposed by Easterly et al. (1993) over the period from 1983 to 2007.

138% of 2007 real per capita GDP, which is unreasonably large. Given relative magnitudes of costs and benefits, we argue that there is no way that unmeasured benefits could be that large.

8.3. A robustness check 3: "perhaps TBTF wasn't the sole contributor to the financial crisis"

Though we strongly believe that TBTF banks were responsible for the financial crisis, we are aware that not everyone shares those beliefs. In this section, we relax the assumption that TBTF banks were entirely responsible for the financial crisis. Instead, we assume that only some portion of the real per capita GDP losses as previously shown in Table 1 were due to US TBTF banks.

Acharya et al. (2015) provides a useful framework to use the Marginal Expected Shortfall (MES) for predicting a bank's capital shortfall in the event of a potential future crisis. The MES is estimated by taking the 5% worst days of the market days from the previous year and then compute the average equity returns for those days for every bank in the sample. This represents the expected equity loss per dollar invested in this firm if the overall market lies within one of these tail events.

The smallest cost to benefit ratio estimated by our methods is 4.24, and it is found by using the assumptions spelled out in Table 8b. This means, that the costs are 4.24 times as large as the benefits, indicating that the systemic risk imposed by TBTF banks would need to be more than 23.59%.

We use the values from December 31, 2007 from Dr. Viral Acharya's website,[16] though the findings are robust to using any of the months ends from 2007. Because we had previously assumed that the largest 25 or 100 banking institutions exhibited scale economies, we first focus on the twenty-five most systemically important financial institutions according to Acharya et al. (2015). The ratio of the systemic risk of these banks as a proportion to the entire banking sector, which is 96.12%, which is significantly larger than the 23.59% that would have been needed to overturn the findings.

If we assume only a smaller proportion of banks caused the crisis, such as the largest five or ten banks, these percentages decrease to 47.18% and 73.91%, respectively. In fact, the two most systemically important financial institutions, JP Morgan and Citibank, represent a 23.81% contribution to the systematic risk, which is still not enough to overturn the findings within this paper.

9. Conclusion

Our work needs to be further tested and we encourage others to consider the bounding methodology as an alternative to econometric techniques. The policy-maker needs to make decisions and cannot wait while economists experiment with new empirical methods or search for new data. Our main point is that the costs of TBTF seem to substantially exceed the benefits. This suggests that the link between TBTF banks and financial crises needs to be broken. One way to achieve that is to break the largest banks into smaller pieces as argued by Boyd and Jagannathan (2009). However, there are other policies that could be effective. If economies of super-scale are actually as large as some believe and go on without limit, an attractive policy would be to turn the TBTF banks into something like regulated public utilities. This would require regulating their rates of return on capital and managerial compensation as is done by state public utility commissions. A third alternative is to require them to hold very high capital ratios – as high as 20% or 30%. It has recently been argued by Hellwig (2010) that such capital requirements are only costly because of policy interventions in the form of tax deductibility of interest expense and the policy of TBTF.

Appendix A

A.1. Estimating a social discount rate

To estimate a risky social discount rate, we use the methodology of Boardman et al. (2006). We average the real pretax rate of return on Moody's AAA long-term corporate bonds over the period 1947–2007 and get an estimate of 6.77%. Our second estimate of 5.25% is taken from BKS.[17]

In order for the benefits formula shown in Formula 3 to hold, it's necessary to make certain that the social discount rate, o, is larger than the growth rate, g. The appropriate social discount rate should reflect the riskiness of the project being examined, which are the costs and benefits of TBTF banks. There are risks associated with almost every project or investment, even risk-free treasury notes. In order to construct a lower bound for the social discount rate, we focus on a method that is designed for extremely safe public projects.

Our third estimate uses the optimal growth model proposed by Ramsey (1928) and reviewed in Moore et al. (2004). We do not believe that this discount rate is appropriate, since both costs and benefits associated with TBTF are inherently risky. However, it's necessary to determine the lowest feasible option for the social discount rate in order to examine the robustness of our conclusions, since the lower the social discount rate, the higher the benefits estimate. Thus, this leads to a lower cost to benefit ratio. For Formula 3 to hold, it's also necessary for the social discount rate to be larger than the growth rate, which is what we find.

To obtain this estimate, we estimate the absolute value of the rate at which the marginal value of consumption decreases as

[16] http://vlab.stern.nyu.edu/analysis/RISK.WORLDFIN-MR.GMES.

[17] This is computed as the average real rate of return of equity for the twenty-three countries in their sample. We do not update these estimates because that would include the crisis years and result in an unreasonably low estimated cost of equity.

Table B.1
Present discounted value under different regimes elaboration.

Panel A: Assume Crisis Occurs Every 45 Years (p_i = 0.0222)				
Assumed probability Under no-TBTF regime (p_n)	p_n = 0.005	p_n = 0.01	p_n = 0.013	p_n = 0.0173
TBTF regime crisis cost	−0.64%	−0.64%	−0.64%	−0.64%
no-TBTF regime crisis cost	−0.15%	−0.30%	−0.39%	−0.52%
Break even probability, p_n				**2.12%**
Difference as a percentage of TBTF crisis probability				**4.34%**
Panel B: assume crisis occurs every 25 years (p_i =.04)				
Assumed probability under no-TBTF regime (p_n)	p_n = 0.020	p_n = 0.025	p_n = 0.030	p_n = 0.0351
TBTF regime crisis cost	−1.17%	−1.17%	−1.17%	−1.17%
no-TBTF regime crisis cost	−0.60%	−0.75%	−0.90%	−1.06%
Break even probability, p_n				**3.91%**
Difference as a percentage of TBTF crisis probability				**2.37%**
Panel C: assume crisis occurs every 35 years ($p_i = 0.02857$)				
Assumed probability under no-TBTF regime (p_n)	p_n = 0.010	p_n = 0.015	p_n = 0.020	p_n = 0.0237
TBTF regime crisis cost	−0.83%	−0.83%	−0.83%	−0.83%
no-TBTF regime crisis cost	−0.30%	−0.45%	−0.60%	−0.71%
Break even probability, p_n				**2.76%**
Difference as a percentage of TBTF crisis probability				**3.35%**
Panel D: assume crisis occurs every 55 years (p_i = 0.018182)				
Assumed probability under no-TBTF regime (p_n)	p_n = 0.005	p_n = 0.0075	p_n = 0.010	p_n = 0.0132
TBTF regime crisis cost	−0.52%	−0.52%	−0.52%	−0.52%
no-TBTF regime crisis cost	−0.15%	−0.23%	−0.30%	−0.40%
Break even probability, p_n				**1.72%**
Difference as a percentage of TBTF crisis probability				**5.32%**
Panel E: assume crisis occurs every 65 years (p_i = 0.015385)				
Assumed probability under no-TBTF regime (p_n)	p_n = 0.003	p_n = 0.005	p_n = 0.007	p_n = 0.0095
TBTF regime crisis cost	−0.43%	−0.43%	−0.43%	−0.43%
no-TBTF regime crisis cost	−0.09%	−0.15%	−0.21%	−0.31%
Break even probability, p_n				**1.44%**
Difference as a percentage of TBTF crisis probability				**6.31%**

Table B.1 shows the present discounted value under different regimes. Row 1 shows the crisis frequency under the regime where TBTF banks are present, p_i. Row 2 shows the total crisis loss for both regimes when evaluated at the Break even Probability, p_n. Row 3 shows the value of this breakeven probability, p_n, for each frequency, and Row 4 shows (p_i - p_n)/p_i, which is the percentage difference in crisis probabilities associated with the breakeven point. If the presence of TBTF increases the probability of a crisis by more the TBTF crisis probability in bold, then TBTF is not good policy and is dominated by No-TBTF. Panel A assumes that Crisis occur every 45 years, as Laeven and Valencia (2008) have documented. Within each panel, crisis probability under no-TBTF regime is allowed to vary, which is shown in columns 2–5. Columns 3–5 make the same calculations for successively higher values of p_n. Column 5 contains all calculations for the breakeven probability. Panels B, C, D, and E perform the same calculations assuming crises occur every 25, 35, 55, and 65 years respectively.

per capita consumption increases e, a utility discount rate d, which measures the rate society discounts the utility of future per capita consumption, and the growth rate of per capita consumption, g. The social discount rate, o, is then defined

$$o = d + g \cdot e \tag{8}$$

We regress the natural logarithm of real per capita aggregate consumption on time over the period 1947–2007 and use the slope coefficient to obtain our estimate of g. Based on the previous literature by Brent (2006) and Arrow et al. (1996), we use $e = 1$. Arrow suggests a figure of around 1% for d. Thus, with estimates of $g = 3.6\%$, $e = 1$, and $d = 1$ we obtain the estimate of the (gross) social discount factor o by substituting into Eq. (8).

$$o = d + g \cdot e = 1.0 + 0.036 \times 1 = 1.036 \tag{9}$$

A.2. Probabilistic calculations explained

In this section, we expand the discussion of the probabilistic calculations from Section 6. The results are shown in Table B.1, where it is assumed that the crisis arrival rate in the TBTF regime is once every 25, 35, 45, 55, or 65 years. Panel A in Table B.1 shows results when crisis occur once every 45 years or $p_i = .0222$ – as reported by Laeven and Valencia (2008). What is allowed to vary in the panel is the crisis probability under the No-TBTF regime. For example, in column 1 it is assumed that pn = .005 and we can see the net benefits under both regimes. Clearly, No-TBTF is better with these probabilities since −0.15% > −0.64%. Columns 3, 4, and 5 makes the same calculation allowing for successively higher values of p_n. As would be expected, the advantage of No-TBTF declines as pn rises. In the fourth row, last column in Panel A Table B.1, we have the break even probability – that is, the value

Table C.1
Crisis costs from Boyd et al. (2005) sample.

Country name	Total crisis cost expressed as a percentage of year zero GDP (%)	Crisis dates
Australia	62.4	89–92
Columbia	109.0	82–87
Denmark	49.5	87–92
Spain	143.3	77–85
Finland	182.9	91–94
France	24.7	94–95
Greece	86.7	91–95
Hong Kong	140.0	82–86
Italy	96.2	90–95
Jamaica	104.8	94-?
Jordan	207.9	89–90
Japan	140.4	90-?
Korea	232.5	97-?
Norway	111.3	87–93
New Zealand	66.7	87–90
Peru	194.1	83–90
Sweden	100.8	91
Zimbabwe	34.4	95–98
Mean	116.0	
Median	106.9	

Table C.1 shows the crisis costs of the sample from Boyd et al. (2005). Column 1 shows the country name, and Column 2 shows the total crisis cost for that country expressed as a percentage of GDP of the last pre-crisis year. Column 3 shows the crisis dates in years. A question mark indicates that the crisis was not officially over at the time BKS were writing.

Table C.2
Payback period from Boyd et al. (2005) sample.

Country name	Total crisis cost expressed as a percentage of year zero GDP (%)	Cost benefit ratio	Payback period
Australia	62.4	2.28	68
Columbia	109.0	3.99	90
Denmark	49.5	1.81	60
Spain	143.3	5.25	101
Finland	182.9	6.69	11
France	24.7	0.90	39
Greece	86.7	3.17	80
Hong Kong	140.0	5.12	100
Italy	96.2	3.52	85
Jamaica	104.8	3.84	88
Jordan	207.9	7.61	116
Japan	140.4	5.14	100
Korea	232.5	8.51	121
Norway	111.3	4.07	90
New Zealand	66.7	2.44	71
Peru	194.1	7.10	113
Sweden	100.8	3.69	86
Zimbabwe	34.4	1.26	48
Mean	116.0	4.25	87.1
Median	106.9	3.91	89.0

Table C.2 shows the payback period in years of the sample from Boyd et al. (2005). Column 1 shows the country name, and Column 2 shows the total crisis cost for that country expressed as a percentage of GDP of the first pre-crisis year. Column 3 shows the cost benefit ratio, which is defined as the crisis cost divided by 3.12%, which is assumed to be the benefit. This benefit number represents the U.S. benefits using the Wheelock and Wilson estimates of 16%, low social discount rate of 3.6%, and arithmetic average of the previous growth rates from 1983 to 2007, which is 2.27%. Column 4 shows the estimated payback period for sample cost estimates in years when costs are assumed to be those from Boyd et al. (2005), and benefits are assumed to grow at the constant growth rate of 2.27%. The scale measure of 16% found by Wheelock and Wilson (2012) is also used. Please note that the payback period is the first integer year where benefits exceed costs.

of p_n which would give the two policies the same expected return. This is 2.12%. Finally, the last row and column in each panel of Table B.1 shows the object $(p_i - p_n)/p_i$. This represents the percentage difference in crisis probabilities associated with the break even point. The other panels in Table B.1 are similar to Panel A, except that in each panel we change p_i, the probability of crisis arrival under TBTF.

Panels B, C, D, and E show the various losses and break-even points as crisis occur less frequently. The lower the probability of a crisis under TBTF, the larger the percentage increase at the breakeven point. This means that the longer the average elapsed time between crises, the more years TBTF benefits have to accumulate. Panel B shows the same types of calculations when crisis occur more frequently than the data suggest. If we assume that a crisis occurs every 25 years, opposed to every 45 years as Laeven and Valencia (2008) suggest, then we see that if the presence of TBTF increases the probability of a crisis by more than only 2.37%, then it is not a good policy. If we assume crisis occurrence is very infrequent, occurring once every 65 years, then Panel E indicates that TBTF only needs to increase the probability of a crisis by 6.31% in order for it to be detrimental to the economy.

A.3. Realistic crisis cost assumptions

In this section, we briefly drop the bounding approach and employ realistic crisis cost estimates for eighteen countries studied by BKS. We continue to assume the TBTF scale benefits that we have just presented. The idea is to see how much of a difference it makes to drop one important biasing assumption and substitute realistic estimates.

We assume those parameter values that tend to most inflate TBTF benefits. We use the lowest discount rate, $o = .036$ and the highest economies of scale parameter $l = 0.16$ attributed to the largest 100 banks. We also use the average growth rate, since it is larger and associated with larger benefits estimates. This amounts to us using the largest benefit estimates from the paper, which are 3.12%. In essence, this part amounts to a half-bounding exercise costs estimates are realistic and benefits are intentionally overstated.

Table C.1 shows the eighteen countries from BKS, their crisis dates, and the estimated cost of their crises as a present discounted percentage of base year real GDP.[18] In Table C.1, the crisis cost estimates vary enormously – from 24.7% in the case of France to 232.5% in the case of Korea.[19]

Table C.2 Column 3 shows the cost to benefit ratios for the eighteen countries with the parameter assumptions discussed above. These are highly variable. One country, France, has positive net benefits due to TBTF. However, the mean (median) cost benefit ratio is 4.25 (3.91), suggesting an extremely unfavorable trade-off for TBTF. Column 4 shows the payback period calculations for these eighteen countries estimated with the same parameters. Recalling that the historical average crisis arrival rate from Laeven and Valencia (2008) is 45 years, there is only one country with a shorter estimated payback period. The mean (median) payback period in Table C.2 is 87.1 (89) years, almost double the estimated arrival rate from Laeven and Valencia (2008). In sum, both the cost-benefit and payback calculations indicate that TBTF appears to be an undesirable policy.

[18] There are four crisis countries that BKS do not report because their estimated crisis costs are zero or negative. However, as is clear from BKS (footnote 5), the bias from this omission will be very small. These cost estimates come from Table 4, column 2 of BKS and do not include the estimated losses for four countries that never converge to the original growth path. Thus, we are not employing the upper bound estimates from BKS.

[19] The crisis in France involved the failure of just one large bank, Credit Lyonaise. The sample mean (median) crisis cost is large at 116% (106.9%).

A.4. List of top 100 banking institutions

Bank Name / Holding Co Name	National Rank	Bank Location	Consol Assets (Mil $)	Domestic Assets (Mil $)
JPMORGAN CHASE BK NA/JPMORGAN CHASE & CO	1	COLUMBUS, OH	1,318,888	778,101
BANK OF AMER NA/BANK OF AMER CORP	2	CHARLOTTE, NC	1,312,794	1,182,833
CITIBANK NA/CITIGROUP	3	LAS VEGAS, NV	1,251,715	598,178
WACHOVIA BK NA/WACHOVIA CORP	4	CHARLOTTE, NC	653,269	613,130
WELLS FARGO BK NA/WELLS FARGO & CO	5	SIOUX FALLS, SD	467,861	467,696
U S BK NA/U S BC	6	CINCINNATI, OH	232,760	231,574
HSBC BK USA NA/HSBC NORTH AMER HOLD	7	WILMINGTON, DE	184,492	171,405
SUNTRUST BK/SUNTRUST BK	8	ATLANTA, GA	175,108	175,108
FIA CARD SVC NA/BANK OF AMER CORP	9	WILMINGTON, DE	161,692	148,175
NATIONAL CITY BK/NATIONAL CITY CORP	10	CLEVELAND, OH	138,755	138,068
REGIONS BK/REGIONS FC	11	BIRMINGHAM, AL	137,050	130,573
STATE STREET B&TC/STATE STREET CORP	12	BOSTON, MA	134,002	110,201
RBS CITIZENS NA/CITIZENS FNCL GROUP	13	PROVIDENCE, RI	128,863	128,863
BRANCH BKG&TC/BB&T CORP	14	WINSTON-SALEM, NC	127,698	127,477
PNC BK NA/PNC FNCL SVC GROUP	15	PITTSBURGH, PA	124,782	123,194
BANK OF NY/BANK OF NY MELLON CORP	16	NEW YORK, NY	115,672	60,422
CAPITAL ONE NA/CAPITAL ONE FC	17	MCLEAN, VA	97,518	97,518
KEYBANK NA/KEYCORP	18	CLEVELAND, OH	95,862	93,429
CITIBANK SD NA/CITIGROUP	19	SIOUX FALLS, SD	78,941	78,941
CHASE BK USA NA/JPMORGAN CHASE & CO	20	NEWARK, DE	77,748	77,748
LASALLE BK NA/BANK OF AMER CORP	21	CHICAGO, IL	74,424	74,424
MANUFACTURERS & TRADERS TC/M&T BK CORP	22	BUFFALO, NY	64,073	64,073
COMERICA BK/COMERICA	23	DALLAS, TX	62,539	61,032
BANK OF THE WEST/BANCWEST CORP	24	SAN FRANCISCO, CA	61,830	61,830
FIFTH THIRD BK/FIFTH THIRD BC	25	CINCINNATI, OH	61,463	61,463
NORTHERN TC/NORTHERN TR CORP	26	CHICAGO, IL	58,398	36,758
UNION BK OF CA NA/UNIONBANCAL CORP	27	SAN FRANCISCO, CA	55,157	54,102
HUNTINGTON NB/HUNTINGTON BSHRS	28	COLUMBUS, OH	54,099	54,099
M&I MARSHALL & ILSLEY BK/MARSHALL & ILSLEY CORP	29	MILWAUKEE, WI	53,721	53,721
FIFTH THIRD BK/FIFTH THIRD BC	30	GRAND RAPIDS, MI	53,431	53,431
TD BANKNORTH NA/TD US P & C HOLD ULC	31	PORTLAND, ME	45,486	45,486
COMMERCE BK NA/COMMERCE BC	32	PHILADELPHIA, PA	45,217	45,217
COMPASS BK/BBVA USA BSHRS	33	BIRMINGHAM, AL	43,811	43,811
HARRIS NA/HARRIS FC	34	CHICAGO, IL	41,467	41,435
MELLON BK NA/BANK OF NY MELLON CORP	35	PITTSBURGH, PA	39,674	27,653
LASALLE BK MIDWEST NA/BANK OF AMER CORP	36	TROY, MI	36,922	36,922
FIRST TENNESSEE BK NA MMPHS/FIRST HORIZON NAT CORP	37	MEMPHIS, TN	36,726	36,726
BANK OF AMERICA RI NA/BANK OF AMER CORP	38	PROVIDENCE, RI	35,705	35,705
DEUTSCHE BK TC AMERICAS/TAUNUS CORP	39	NEW YORK, NY	35,425	29,360
CAPITAL ONE BK/CAPITAL ONE FC	40	GLEN ALLEN, VA	33,884	31,501
DISCOVER BK/MORGAN STANLEY	41	GREENWOOD, DE	30,700	30,486
WF NB SOUTH CENTRAL/WELLS FARGO & CO	42	FARIBAULT, MN	30,108	30,108
RBC CENTURA BK/ROYAL BK HOLD	43	RALEIGH, NC	26,148	26,148
COLONIAL BK NA/COLONIAL BANCGROUP	44	MONTGOMERY, AL	25,937	25,937
ASSOCIATED BK NA/ASSOCIATED BANC-CORP	45	GREEN BAY, WI	21,336	21,336
ZIONS FIRST NB/ZIONS BC	46	SALT LAKE CITY, UT	18,454	18,453
T D BK USA NA/TD US P & C HOLD ULC	47	PORTLAND, ME	18,049	18,049
BANK OF AMER CA NA/BANK OF AMER CORP	48	SAN FRANCISCO, CA	17,964	17,964
WEBSTER BK NA/WEBSTER FNCL CORP	49	WATERBURY, CT	17,064	17,064
TCF NB/TCF FC	50	WAYZATA, MN	16,041	16,041

Bank Name / Holding Co Name	National Rank	Bank Location	Consol Assets (Mil $)	Domestic Assets (Mil $)
CITY NB/CITY NAT CORP	51	BEVERLY HILLS, CA	15,394	15,394
COMMERCE BK NA/COMMERCE BSHRS	52	KANSAS CITY, MO	14,741	14,741
BANK OF AMER OR NA/BANK OF AMER CORP	53	PORTLAND, OR	14,651	14,651
BANK OF OK NA/BOK FC	54	TULSA, OK	14,649	14,649
WELLS FARGO BK NW NA/WELLS FARGO & CO	55	OGDEN, UT	14,625	14,625
CAROLINA FIRST BK/SOUTH FNCL GROUP	56	GREENVILLE, SC	13,845	13,845
FROST NB/CULLEN/FROST BKR	57	SAN ANTONIO, TX	13,633	13,633
FIRST-CITIZENS B&TC/FIRST CITIZENS BSHRS	58	RALEIGH, NC	13,602	13,602
BANCO POPULAR N AMER/POPULAR	59	NEW YORK, NY	13,358	13,358
BANCORPSOUTH BK/BANCORPSOUTH	60	TUPELO, MS	13,192	13,192
UNITED STATES TC NA/BANK OF AMER CORP	61	NEW YORK, NY	13,149	13,149
VALLEY NB/VALLEY NBC	62	PASSAIC, NJ	12,721	12,721
FIRST HAWAIIAN BK/BANCWEST CORP	63	HONOLULU, HI	12,597	11,905
CITIZENS BK/CITIZENS REPUBLIC BC	64	FLINT, MI	12,525	12,525
AMEGY BK NA/ZIONS BC	65	HOUSTON, TX	11,836	11,836
EAST WEST BK/EAST W BC	66	PASADENA, CA	11,833	11,744
UNITED CMRL BK/UCBH HOLD	67	SAN FRANCISCO, CA	11,783	10,755
STERLING SVG BK/STERLING FC	68	SPOKANE, WA	11,744	11,744
MELLON TR OF NEW ENGLAND NA/BANK OF NY MELLON CORP	69	BOSTON, MA	11,058	11,058
WHITNEY NB/WHITNEY HC	70	NEW ORLEANS, LA	11,007	11,007
FIRST BK/FIRST BKS	71	SAINT LOUIS, MO	10,857	10,857
NORTHERN TR NA/NORTHERN TR CORP	72	MIAMI, FL	10,625	10,625
BANK OF HAWAII/BANK OF HI CORP	73	HONOLULU, HI	10,448	9,811
FIRSTMERIT BK NA/FIRSTMERIT CORP	74	AKRON, OH	10,395	10,395
CATHAY BK/CATHAY GEN BC	75	LOS ANGELES, CA	10,388	10,367
CALIFORNIA B&TC/ZIONS BC	76	SAN DIEGO, CA	10,156	10,156
WILMINGTON TC/WILMINGTON TR CORP	77	WILMINGTON, DE	10,064	10,064
ARVEST BK/ARVEST BK GROUP	78	FAYETTEVILLE, AR	9,714	9,714
INTERNATIONAL BK OF CMRC/INTERNATIONAL BSHRS CORP	79	LAREDO, TX	9,439	9,439
FIRST NB OF OMAHA/LAURITZEN CORP	80	OMAHA, NE	9,250	9,250
ISRAEL DISCOUNT BK OF NY/DISCOUNT BC	81	NEW YORK, NY	9,132	8,036
TRUSTMARK NB/TRUSTMARK CORP	82	JACKSON, MS	8,827	8,827
CORUS BK NA/CORUS BSHRS	83	CHICAGO, IL	8,761	8,761
TEXAS ST BK/BBVA USA BSHRS	84	MCALLEN, TX	8,489	8,489
UMPQUA BK/UMPQUA HC	85	ROSEBURG, OR	8,331	8,331
RABOBANK NA/RABOBANK INTL HOLD BV	86	EL CENTRO, CA	8,170	8,170
UMB BK NA/UMB FC	87	KANSAS CITY, MO	8,124	8,124
FIRST MIDWEST BK/FIRST MIDWEST BC	88	ITASCA, IL	8,040	8,040
MB FNCL BK NA/M B FNCL	89	CHICAGO, IL	7,811	7,810
OLD NB/OLD NAT BANCORP	90	EVANSVILLE, IN	7,695	7,695
BARCLAYS BK DE/BARCLAYS GROUP US	91	WILMINGTON, DE	7,470	7,470
METLIFE BK NA/METLIFE	92	BRIDGEWATER, NJ	7,407	7,407
PACIFIC CAP BK NA/PACIFIC CAP BC	93	SANTA BARBARA, CA	7,381	7,381
FULTON BK/FULTON FNCL CORP	94	LANCASTER, PA	7,191	7,191
UNITED CMNTY BK/UNITED CMNTY BK	95	BLAIRSVILLE, GA	7,046	7,046
SUSQUEHANNA BK PA/SUSQUEHANNA BSHRS	96	LITITZ, PA	6,595	6,595
GREATER BAY BK NA/WELLS FARGO & CO	97	PALO ALTO, CA	6,474	6,474
PROSPERITY BK/PROSPERITY BSHRS	98	EL CAMPO, TX	6,364	6,364
CITIZENS BUS BK/CVB FC	99	ONTARIO, CA	6,280	6,280
PROVIDENT BK OF MD/PROVIDENT BSHRS CORP	100	BALTIMORE, MD	6,191	6,191

Notation

b	all benefits from TBTF banks
C	the present discounted value of social output losses due to the banking crisis, in 2007 dollars
c_t	annual crisis cost in year t
d	the utility discount rate, which measures the rate society discounts the utility of its future per capita consumption
e	the absolute value of the rate at which the marginal value o that consumption decreases as per capita consumption increases
g	the growth rate of per capita consumption
g_t	estimated growth rate in real per capita GDP for the United States in period t
G_t	real per capita GDP in year i
$\bar{g}_t$	historical average growth rate as for year t
l	efficiency advantage of TBTF banks relative to the banking industry
o	the social discount rate
p	probability of a crisis arrival
p_i	transition probability of going from the no crisis to crisis state in TBTF regime
p_n	transition probability of going from the no crisis to crisis state in No-TBTF regime
s	share of total real per capita GDP that is produced by TBTF banks (Estimate from Flow-of-Funds data, $s = 3.63\%$)
V	discounted 2007 value of the net social benefit of TBTF banks (in terms of their contribution to real per capita GDP)
w_t	world growth rate in period t

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