Paulson's Gift

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Abstract

We calculate the costs and benefits of the largest ever U.S. Government intervention in the financial sector announced the 2008 Columbus-day weekend. We estimate that this intervention increased the value of banks' financial claims by $131 billion at a taxpayers' cost of $25 -$47 billions with a net benefit between $84bn and $107bn. By looking at the limited cross section we infer that this net benefit arises from a reduction in the probability of bankruptcy, which we estimate would destroy 22% of the enterprise value. The big winners of the plan were the three former investment banks and Citigroup, while the loser was JP Morgan.

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The 2008 financial crisis witnessed the largest intervention of the U.S. government in the financial sector. The stated goal of this intervention was to "restore confidence to our financial system", [1] through a massive transfer of resources from the taxpayers to the banking sector. From an economic point of view, such an intervention is justified only in the presence of a market failure that the government could help alleviate. If this market failure is present, then the government intervention should create, not just redistribute, value. Did this intervention create value or was it simply a massive transfer of resources from taxpayers to financial institutions? If it did create value, why? What can we learn about the possible cost of financial distress in financial institutions?

To answer these questions we estimate the costs and benefits of the largest U.S. government intervention into the financial sector, announced on Monday, October 13, 2008. The plan included a $125bn preferred equity infusion in the nine (ten if we consider Wachovia still independent) largest U.S. commercial banks joined by a three year Government guarantee on new unsecured bank debt issues. For brevity, throughout the paper we refer to the U.S. Treasury – FDIC joint plan as the "Paulson's Plan," after the name of the then U.S. Treasury Secretary, Hank Paulson.

Given the worldwide changes in financial markets occurring between Friday the 10^{th} and Tuesday the 14^{th}, it is impossible to estimate the systemic effects of the intervention. However, it is possible to estimate its effects on the banks involved. If the intervention stopped a bank run, for instance, it should have created some value in the banking sector. To compute the intervention's effect on the value of banks we do not limit ourselves to the changes in the value of common and preferred equity, but we look at the changes in the entire enterprise value by looking also at changes in the value of existing debt. In fact, by using liquid credit default swap (CDS) rates, we introduce a new way to perform event studies on debt.

To separate the effect of the Paulson Plan from that of other events occurring at the same time, we control for the change in the CDS rates of GE Capital, the largest non-bank financial company. This difference-in-difference approach estimates the total increase in debt value due to the plan at $119bn. If we add to these changes, the abnormal

[1] Statement by Secretary Henry M. Paulson, Jr. on Actions to Protect the U.S. Economy, October 14, 2008. http://www.financialstability.gov/latest/hp1205.html.

variation in the market value of common equity (-$2.8bn) and of preferred equity (+$6.7bn), we obtain that the enterprise value of the 10 banks involved in the first phase of the plan increased by $128bn. If we add the value increase in the derivative liabilities and the reduction in the value of the FDIC deposit guarantee, we come to a total increase of $131bn.

This increase, however, came at a cost to the taxpayers. By computing the value of the preferred equity and the warrants the Government will receive in exchange for the $125bn investment we obtain an estimate between $89 and $112 bn. Hence, the preferred equity infusion costs taxpayers between $13bn and $36bn. We also estimate the cost of the debt guarantee extended by the FDIC on all the new bank debt to be worth $11bn. This brings the total taxpayers' cost at between $25bn and $47bn. Hence, the plan added between $84 and $107 billion in value. Even if we account for a 30% deadweight cost of taxation (see Ballard et al. 1985, and Feldstein, 1999), the plan created between $71bn and $89bn in value.

Where does this added value come from? What friction did the plan help to resolve? Who are the main beneficiaries of the plan?

To address these questions we exploit the (very small) cross section of results at our disposition. We find that the bulk of the value added stems from the banks that were more at risk of a run. For each bank, we compute a "bank run" index, which measures the difference between the (risk neutral) probability of default in the immediately following year and the (risk neutral) probability of default between year 1 and year 2, conditional on surviving at the end of year one. When this index is large it means that investors believe that the bank is very likely to default soon.

We find a very high correlation (96%) between the ex-ante value of the bank run index and the percentage increase in a bank enterprise value at the announcement of the plan. The big beneficiaries of the intervention were the three former investment banks and Citigroup, while the loser was JP Morgan whose total asset value decreased even before the benefit of the Paulson plan is accounted for. This result is not so paradoxical. In spite of the benefits of the Paulson plan, banks might lose value because their participation provides a negative signal to the market about the true value of the assets in place, because the government future interference in banks' affair reduces value, or because intervention has redistributive effects across banks.

Since all the major banks were "forced" to participate by a very strong arm-twisting exercised by Treasury Secretary Paulson, it is unlikely that participation might signal any inside information about the value of the assets in place. A more realistic interpretation is that the government intervention has two conflicting effects: a negative one linked to the government future interference in banks' affairs, and a positive one, associated with the reduction in the probability of bankruptcy and hence the expected cost of bankruptcy. Exploiting the firm variation in this latter probability, we estimate that the expected cost of government interference is about 2.5% of enterprise value, while the cost of bankruptcy is about 22% of enterprise value.

Given the extreme volatility of markets during this period one may wonder whether the observed outcome represents a fair assessment of the intervention's effects. For this reason, we evaluate the plan on an ex ante basis by using the standard Black and Scholes (1973) and Merton (1974) model of equity as an option on the value of the underlying assets. When we keep the assets' value constant (i.e., the intervention neither creates nor destroys any value) the model grossly underestimates the market response. According to the model, the shareholders should have lost \$25bn and instead lost only \$3bn. The debtholders should have gained \$49bn and instead gain \$119. To bridge this difference we need to hypothesize an increase in the value of the underlying assets. It is only if we assume an increase in the value of assets of \$113bn that the model can approximate well the actual changes in the value of debt and equity. This alternative method confirms the magnitude of the asset increase.

Finally, we try to evaluate whether the same objective achieved by the plan could have been obtained at a lower cost to taxpayers. If the main goal was to make banks solvent, we assume that the objective is to achieve a reduction in the CDS rates equivalent to the one observed in the data after the plan. We analyze four alternative plans: the original Paulson plan where bank's assets were purchased at market value, the original Paulson plan with bank's assets purchased above market (we assume a 20% above), a British-style equity infusion without any debt guarantee, and a debt-for-equity swap. We rate these alternatives on the basis of up-front investment required by the

Government, taxpayers' expected cost, taxpayers' value at risk, and Government ownership of banks. While expensive with respect to a debt-for-equity swap, we find that the revised Paulson plan strikes a reasonable compromise in terms of the various cost metrics.

The rest of the paper proceeds as follows. Section 1 describes the 2008financial crisis and discusses the potential reasons for a government intervention. It also describes the details of the plan announced by U.S. Treasury and FDIC on October 13, 2008. Section 2 analyzes the effect of the plan on the prices of the bonds, the common equity, and the preferred. Section 3 computes the net cost of the preferred equity infusion and the debt guarantee. Section 4 analyzes the plan from an ex ante point of view. Section 5 studies the cost of alternative plans that would have achieved the same objective. Conclusions follow.

1. The 2008 Financial Crisis and Rationale of Government Intervention

In this section we analyze the financial environment in the weeks before the announcement, and the likelihood of possible inefficiencies that would justify the Government action. We then detail the government response in October 2008.

1.1 Debt Overhang

The events leading up to the massive government intervention on 10/14/2008 strongly suggest that banks were reluctant to provide credit to individuals and corporations independently of their creditworthiness. For instance, Ivashina and Scharfstein (2008) show that new loans to large borrowers fell almost 50% in the third quarter of 2008 compared to one year earlier.

Why wouldn't a bank lend money to credit worthy borrowers? As it is known since Myers (1977), if a firm is burdened by a large (risky) debt, then an equity infusion provides a safety cushion to debt in those states of the world in which it would not have been paid in full. As a result, the value of risky debt goes up when new equity is raised. This transfer of value, which is also known in the literature as debt overhang or co-insurance effect, is what makes so unattractive for equity holders to raise new equity. If banks need to raise private capital to extend new loans, they may be prevented to do so because private equity holders refuse to provide the capital. Thus, banks may pass up on positive NPV projects, losing value.

If this is the case, a government intervention that injects new capital in banks would prevent this loss in valuable investment opportunities. If the banking sector were perfectly competitive, the entire value saved would accrue to the companies receiving the financing. But if the banking sector were perfectly competitive, then the loss of a few banks will have no negative consequences in the economy, because the others would step in to provide the financing with no friction. Hence, if debt overhang is the main inefficiency that the government intervention is meant to solve, then we should find that after the intervention:

(1) Change in enterprise value of banks > Cost of rescue for taxpayers

1.2 Liquidity Crisis and Bank Run

A second possible justification for the U.S. Government intervention is that after Lehman Brothers' bankruptcy on September 15, 2008, the banking system was subjected to a run. To run were not the depositors, as in traditional bank runs, but short term lenders, who refused to roll-over their short term lending. In particular, Gorton and Metrick (2009) talk about a run in the repurchase agreement market, in spite of the security offered by the collateral. Since bank runs can be inefficient (Diamond and Dybvig (1983)), stopping a bank run can create value.

Was there a liquidity crisis or a bank run in early October 2008? We can partly answer this question by looking at the behavior of credit default swaps rates. The credit default swap (CDS) is a contract that in case of default by the reference entity provides the buyer with the opportunity to exchange the defaulted debt with an amount of cash equal to the face value of that debt minus any amount recovered from the defaulted security. In other words, a credit default swap is an insurance against the risk of default. The party obtaining insurance pays a quarterly premium, called the CDS rate, which is quoted as basis points of premium per year per notional amount of $100. CDS rates are generally available for all the maturities between one and five years.

Since the one-year CDS reflects the probability of default this year, while the two-year CDS reflects the average probability of default over the next two years etc., the term structure of CDS rates can be used to obtain the conditional probability of default in any given year

We obtain CDS rates data from Datastream (see Figure 1). Appendix A contains the details of the bootstrap procedure used to obtain the probabilities of default. In particular, we compute the following conditional (risk neutral) probability:

(2) *P(n)=Prob(Default in year n | No Default before year n)*

In a normal environment the conditional probability of bankruptcy in any given year is increasing over time, since the variance in assets' value is increasing over time. The one exception is when a bank is facing the risk of a run. If today an otherwise solvent bank faces the risk of a run, its probability of bankruptcy in the near term would be much higher than the probability of bankruptcy in the future, conditional on surviving this year. If a bank run is likely, then we should find $P(1)>P(2)$, as it is more likely that default occurs in the short term than in the longer term, conditional on surviving. Conversely, if $P(1)<P(2)$ then it is unlikely that a bank is subject to a bank run. We therefore compute the Bank Run index as

$$R=P(1)-P(2) \tag{3}$$

to gauge whether a bank is at risk of a run. We compute the Bank Run index for the banks that are the first recipients of Government funding, namely, the nine largest commercial banks (ten with Wachovia), including in this category also the three investment banks that either filed to become commercial banks or were going to merge with one. (See discussion in Section 1.5.) Unfortunately, CDS data on State Street and Bank of NY Mellon are not available.

Figure 2 shows the time series of these indices for the eight banks. The vertical dotted line corresponds to 10/10/2008, the Friday before the Government announcement of the Revised Paulson's plan. As it can be seen, on 10/10/2008, Citigroup, Wachovia and the three investment banks had a positive Bank Run index R, an indication that potentially a bank run was indeed taking place on them. It is interesting to note that before Lehman's bankruptcy on September 15, 2008, only two banks, Morgan Stanley and Merrill Lynch, displayed a positive index *R*. At the time of Lehman Bankruptcy, Goldman Sachs bank Run Index *R* also turned positive, and a few weeks later Citigroup, while the other commercial banks indices remained unchanged.

If the main source of inefficiency is the risk of a bank run, then a government intervention that reduces the risk of a run should mainly benefit the banks at risk of a run. In other words, at the announcement of the government intervention banks with a positive bank run index should experience an increase in the value of their assets that far exceed the subsidy, while banks with a negative index should not.

1.3 Knightian Uncertainty

Caballero and Krishnamurthy (2007) present a model where after a liquidity shock investors hoard an excessive amount of liquidity because they face a Knightian uncertainty about the probabilities of subsequent liquidity shocks. Even assuming that the government has the same information and Knightian uncertainty as market participants, Caballero and Krishnamurthy show that the government can mitigate the externality associated with the excessive demand for liquidity by committing to be a lender of last resort when rare events occur.

It is unclear how to detect when Knightian uncertainty is present, but the week preceding the government intervention is a good candidate. Equity prices (especially of banks) experienced a very severe decline. On 10/10/2008 the so-called "fear index" (given by the volatility implied in the prices of options) reached the record level of 69.25% (see Figure 3).

If Knightian uncertainty and the desire to hoard liquidity affected bank's valuation, it should affect all banks, but in particular those that have more to risk from an additional liquidity shock. Conversely, the relief provided by government intervention should benefit all banks but in particular those that were more at risk of an additional liquidity shock.

1.5 Possible inefficiencies caused by of government intervention

Besides the potential benefit, a Government intervention can have negative effects too. First, the government can impose restrictions on banks decision (for example, executive compensations or lending requirements) that reduce a bank's profit. Second, the government can introduce political criteria into the lending decisions, reducing bank's profitability (Sapienza, 2004). Finally, the government intervention can delay or block the natural transfers of assets to the more efficient managers, reducing the overall profitability of the banking industry. The first and second effects are more likely to be present in banks where government ownership becomes larger, while the third one is likely to manifest itself in the price of the better run banks, which will be prevented to take advantage of the acquisition opportunities.

1.5 Systemic versus Idiosyncratic Benefits

If the source of inefficiency is debt overhang (Section 1.1), a bank run or liquidity crisis (Section 1.2), then the systemic effects of government intervention occur only through the banking sector. Hence the effect of an intervention should be bigger in the banking sector than in the rest of the economy. In contrast, if the government intervention resolves investors' Knightian uncertainty, or prevent a systemic crisis, then the benefit to the rest of the economy may be larger than the benefit to the banking sector itself.

While our empirical methodology is not able to measure the systemic effect of the government intervention, as such an effect is commingled with many other events taking place at the same time, we will be able to estimate the differential impact of the government intervention on the banking sector compared to the rest of the economy. If the source of the inefficiency is debt overhang, a bank run or liquidity, we should find evidence that the banking sector is in fact the main beneficiary of the government help. If we do not find such a differential effect, however, then we should conclude that the main effect has been to stave off a panic or a systemic event unrelated to the banking sector. Thus, in particular, we should not expect such intervention to generate any additional lending in the economy, for instance.

1.6 Government Response to the Crisis and the Paulson Plan

On Friday, October 3, 2008 the U.S. Treasury Secretary Hank Paulson obtained Congressional approval to buy distressed assets for a total of US$ 700bn, but this plan failed to reassure investors about the solvability of the banking sector. The following week the U.S. stock market had its worst week ever with a negative return of 18%. All the world exchanges followed suit.

During the weekend of the 11^{th}-12^{th} of October, British Prime Minister Gordon Brown announced his own stabilization plan, which included an injection of Government money in the capital of troubled banks and a guarantee on the new debt issued by banks. On Monday, October 13, 2008, the U.S. Treasury, the Federal Reserve, and the FDIC jointly announced the government decision to follow the British Prime Minister's footsteps. That day, the Chief Executive Officers of the main nine banks were called for a meeting in Washington and briefed on government plan. According to a *New York Times* article, the CEOs were taken by complete surprise and were coaxed into accepting the deal (Landler and Dash, 2008).

Paulson's revised plan, summarized in Table 1, has three parts. First, the Government injects $125 billion preferred equity investment in the nine largest U.S. commercial banks (ten including Wachovia which has accepted an offer to be purchased by Wells Fargo). In this broad category, we include also the three surviving investment banks that either filed to become commercial banks (Goldman Sachs and Morgan Stanley) or are merging with a commercial bank (Merrill Lynch). In exchange for this preferred equity infusion, the government receives an amount of preferred equity with a nominal value equal to the amount invested. This preferred equity pays a dividend of 5% for the first five years and 9% after that. In addition, the government receives a warrant for an amount equal to 15% of the value of the preferred equity infusion with a strike price equal to the average price of the stock in the twenty working days before the money is actually invested.

The second part of the plan, contextually announced by the Federal Deposit Insurance Corporation, includes a three-year government guarantee for all new issues of unsecured bank debt until June 30, 2009.[2] The FDIC guarantee is for a maximum of 125% of the sum of the unsecured short-term debt and the long-term debt maturing between then and June 2009. To provide this guarantee, the FDIC will charge a fee. When the program was first announced (on 10/14/2008) this fee was set at 75 basis points. On November 12, it was changed and differentiated according to the maturity of the debt. Since we want to calculate the value at the announcement, we will use the 75 bps for all the maturities in our calculations. The last column of Table 1 approximates this debt using all the unsecured short-term debt plus the long-term debt maturing in 2008 plus half of the long term debt maturing in 2009.

The third part is an extension of the FDIC deposit insurance to all the non-interest bearing deposits. While on October 3, 2008, the FDIC had increased deposit insurance from $100,000 to $250,000 per depositor, as part of the Temporary Liquidity Guarantee Program announced October 14, the FDIC provided for a temporary full guarantee for funds held at FDIC-insured depository institutions in noninterest-bearing transaction accounts above the existing deposit insurance limit. While we do not have the exact amount of these accounts, we can approximate it by looking at the amount of non interest bearing accounts (column 2 of Table 2) and the percentage of insured deposits(column 2 of Table 2), as reported in the bank call reports for September 2008.[3]

Table 2a reports other relevant information about of the capital structure of these banks before the announced deal and Table 2b some key market value information about these banks.

2. Effect of the Plan Announcement on the Value of the Banks' Financial Claims

In this section we test the effectiveness of the Government intervention through a case study analysis. Event studies have generally focused on the changes in the market value of equity since the value of equity, which is a residual claim, is most sensitive to information and/or decisions. However, when a company is highly levered (as banks are), bond prices are also very sensitive to the value of the underlying assets. Unfortunately, bond prices are generally not very liquid and, generally, it is very difficult to undertake a

[2] For more information see http://www.fdic.gov/news/news/press/2008/pr08100b.html.

[3] These reports are available on line at http://www2.fdic.gov/idasp/main.asp.

proper event study on the value of debt. However, the development of the credit default swap market has made such a study possible.

2.1 An Event Study on Bonds

The market for CDSs, barely existing in 1999, reached more than $57 trillion of notional amount by June 2008. Given the high volume, this market provides a reliable measure of the changes in the value of debt, much more reliable than the sparse quote on bonds. In fact, the availability of daily CDS rates open the possibilities of systematic event studies on bonds and so on the entire value of the enterprise. In what follows we outline how.

2.1.1 Methodology

If a debt becomes less risky, it appreciates in value. When we cannot observe this appreciation directly, we can measure it by looking at the reduced cost of insuring this debt with a CDS. This cost will go down since a reduction in the risk of default translates into a reduction in the CDS rates. If we ignore the counterparty risk, the market value of a bond (B) plus the present value of the cost of insuring it with the CDSs equals the value of a government bond (GB) with similar rate and maturity or[4]

$$B + PV(Insurance\ Cost) = GB. \tag{4}$$

The present value of the insurance cost can be obtained as the discounted value of the cost of insuring the existing debt (as measured by the CDS rate) in each year *t* (from today to the maturity of the longest maturity bond) multiplied by the probability the company did not default up to year *t* times the amount of existing debt *D(t)* that will not have matured by year *t*:

[4] Equation (4) represents an arbitrage free condition that holds in general, but during the Fall of 2008 many basic arbitrage conditions were violated and this was no exception. It is our understanding that the violations were due to the illiquidity of the corporate bond market and not of the CDS market. Nevertheless, for our exercise to hold we do not need that this condition holds precisely, but only that the magnitude of the deviation did not change (or did not change much) over the two days we consider.

(5) $$PV(Insurance\ Cost) = \sum_{t=0}^{T} \frac{CDS(t)}{10000} D(t)Q(t)Z(t)$$

where *Z(t)* is the risk free discount factor, and *Q(t)* is the risk neutral probability of not defaulting up to time t, obtained in (A2) in Appendix A.

A decline in the risk of a bond not triggered by a change in the bond's rate and/or maturity should not affect the value of its corresponding government bond. Since the right hand side of (4) remains constant, an increase in the value of *B* due to a reduction in risk translates into an equivalent reduction in the present value of the insurance cost.

$$\Delta B = -\Delta PV(CDS),$$

with

(6) $$\Delta PV(CDS) = \sum_{t=0}^{T} \frac{CDS_1(t)}{10000} D(t)Q_1(t)Z(t) - \sum_{t=0}^{T} \frac{CDS_0(t)}{10000} D(t)Q_0(t)Z(t),$$

where the index 1 indicates after the fact and the index 0 before the fact.

2.1.2 Application

We obtain from Datastream CDS rates for contracts up to 5 years for all banks, except for the two smallest banks, Bank of New York and State Street, for which CDS contracts are unavailable. Given the small amount of outstanding debt these two banks have, we can ignore them without much of an effect on the results. Figure 1 plots the 5-year CDS rates for the eight banks for which they are available from 1/1/2007 to 10/14/2008.

To gauge the magnitudes of the change, we report the 5 year CDS rates for the relevant dates in Table 3. The risk neutral probabilities of no default *Q(t)*, computed in the Appendix A, depend on an assumption about recovery rate. We report our results for an intermediate value, 20%.[5] Since this choice is somewhat arbitrary, Section 3.6 discusses the robustness of our conclusion to various assumptions, including larger or smaller recovery rates.

To measure the changes in the value of the debt surrounding the announcement of the new Paulson plan, we look at the changes in CDS rates between Friday, October 10

[5] The historical average recovery rate of bonds is about 40%, but it declines to about 20% during recessions (see e.g. Chen (2008)).

and Tuesday October 14 (see Table 3). We then apply formula (6) to estimate the change in value of debt.

There are however two problems in using the raw variation in CDS to measure the effect of the plan. First, this variation reflects only the additional value of the revised plan vis-à-vis the old one. Given the vague description of the original troubled asset purchase plan, the poor market response (the week of October 3rd through October 10th had the worst performance on record), we are not too worried about this problem. Nevertheless, we should interpret all the results as differential impacts.

The second problem is that a lot of things changed during the weekend of 11th-12th of October, including the rescue organized by the Europeans. At the same time, several bad events did not happen. For example, a feared international ban on short sales that was rumored to be introduced at the G-8 meeting during the week-end did not occur. Since CDS are an alternative to short sales to bet on the value of a company falling, the fear of a ban on short sale could have artificially pushed up CDS rates before the week-end.

To identify the impact that other factors could have had on the CDS rates of financial firms we look at the CDS rates of the largest financial firm not involved in the intervention: GE Capital. Interestingly, the 5-year CDS rate of GE Capital dropped from 590 to 466 basis points over those two trading days. Since the Government did not intervene on GE Capital and hence this drop could not be a direct effect of the plan, this change can be used as a control for all the other events that occurred during the weekend including possible systemic effects of the plan.[6]

To isolate the effect of the Paulson's strategy itself, we apply the same methodology widely used to correct for market movements in event studies on stocks. In particular, for each bank we subtract from the raw change in insurance cost given in expression (6) the percentage change in insurance costs of GE capital (our control) multiplied by the ex-ante cost of insurance of the bank:

$$(7) \qquad Adjusted\,\Delta PV(CDS) = \Delta PV(CDS) - PV_0(CDS) \times \frac{\Delta PV^{GE}(CDS)}{PV_0^{GE}(CDS)}$$

[6] The Warren Buffett investment in General Electric had been announced on October 1st, so it could not have impacted the CDS rates between the 10th and the 14th. Some of the guarantees offered to banks were later extended to GE capital, but this was not expected at the time.

The results are in column 6 of Table 3. Overall, the bonds gained $124bn in value. The bonds of the three old investments banks gained the most from the plan. The adjusted gains of the three were $87bn. Among the old commercial banks Citigroup stood to gain the most, both in level, $21bn, and in percentage of outstanding debt, 5.3%. Section 3.7 discusses the robustness of these results to changes in the assumptions.

2.2 An Event Study on Common Stock

Table 4a reports the results of a standard event study on the value of common stock around the announcement of the revised Paulson plan. Like the bond prices, we use the period from Friday, October 10th to Tuesday, October 14th as the event window. During that period the market rose by 11%, while the stock of the companies involved in the plan rose by 34%. This might seem as a huge difference, but we need to compute the beta of each of these securities since the equity betas of firms close to default can be very high. In fact, when we estimate the beta of the common stock of these banks by using the daily return from 1/1/2007 to 10/9/2008 we obtain on average a beta of 2.2. Our estimates are reported in the second column of Table 4.

When we market-adjust these changes, the average return over the event period drops to 10%, with huge variation: from -24% of Wachovia to a +103% return of Morgan Stanley. Once again the return on Morgan Stanley could be the effect of the announcement of the finalization of the Mitsubishi investment. It is important to keep in mind, though, that ignoring the impact of this news has the effect of overestimating the benefits of the Paulson's plan.

We obtain the value added to common equity by the plan when we multiply the abnormal return and the market capitalization as of Friday the 10th. If we adjust the individual stock movement for the market movement by using the actual beta, we learn that overall banks' shareholders do not benefit from the plan (-$2.8bn). There is, however, a wide variation. While JP Morgan shareholders lose $34bn, Morgan Stanley's gain $11bn, while Citigroup and Goldman shareholders gained roughly $8bn each.

2.3 An Event Study on Preferred Equity

We perform a similar analysis for the preferred. Given the amount of preferred outstanding, these numbers will not change the overall results. Nevertheless, it is useful to add this piece of information.

The biggest problem in performing this event study is the definition of the preferred. Several of these firms have different classes of preferred and not all these classes are traded. Hence, as a reference price for all the preferred shares outstanding we choose the most recently issued preferred that is actively traded. The numbers and the results are presented in Table 4b.

All the preferred increased in price by +36%, well above the market return of +11%. To compute excess returns, we estimate the beta of each preferred stock using the daily returns from 1/1/2007 to 10/9/2008.[7] The results are reported in Table 4b. Once these differences are accounted for, the preferred increased in value at the announcement of the plan by $6.7bn.

2.4 Other Claims

We have only computed the change in value of debt and equity claims, but we have not computed the changes in the value of the other liabilities. In particular, we know that there is a dense network of positions in derivative contracts and credit default swaps, whose value depends upon the counterparty value and hence it is affected by the Paulson Plan. While this is certainly true, it might only impact our conclusions as far as we look at individual companies, but it can hardly impact our overall conclusions. The reason is that the vast majority of these contracts are within the group of these ten banks. Indeed, recently released DTCC data show that about 90% of the transactions on credit derivative are between security dealers. Since we focus the 10 largest banks, they must account for most of the transactions. In addition, a 2007 ISDA survey on Counterparty Risk Concentration – carried out before the current crisis – found that inter-dealer exposure are modest, as among the top 10 dealers, almost 100% of derivatives are covered by Credit Support Annexes, which establish guidelines for credit risk mitigation. The same survey also shows that among the top 10 dealers, collateralization in derivative transactions

[7] In a few cases, the span is shorter because we could not find any preferred traded on Bloomberg.

reduces the risk exposure of about 80% from their five largest counterparties. Although we do not have aggregate numbers and self reported survey results should be taken with a degree of suspicion, these findings do suggest that derivative transactions are highly collateralized, and mainly taking place among the largest security dealers.

While the results above suggest that the impact on the aggregate results from including other liabilities should be modest, we nonetheless quantify the gain from counterparty exposure as follows: First, from the balance sheet we obtain the net liability position from derivative securities. Second, we impute the maturity of these derivative positions from the Bank for International Settlement tables, which report the average maturity of various OTC derivatives. Finally, we treat these liabilities as "debt" and use the same methodology illustrated in Section 2.1 to compute the increase in value of these liabilities. The raw value of this computation is report in the last column of Table 3.

When we follow this procedure, the total value of derivative liabilities increases by $26 billion at the announcement of the Paulson Plan. This amount grossly overestimates the impact of the plan on the net derivative liabilities, since collateralization reduces by 80% the actual exposure to counterparty risk. When we adjust for this the next value increase is only $5.2 billion. Section 3.6 discusses the robustness of our conclusions to variations in this assumption.

2.5 Overall Increase in Value

In Table 5, we compute the overall value increase due to the plan as the sum of the three most variable components on the right-hand side of the balance sheet. The market value of debt increased by $119bn, the aggregate derivative liabilities by 5.5bn, the market value of preferred by $6.7bn, while the market value of equity dropped by $2.8bn. Overall, the total value of financial claims in the top ten banks increased by $128bn as a result of the plan.

This increase cannot be considered as the value added of the plan, since the government is planning to spend considerable resources to implement this plan. To assess the net aggregate effect of the revised plan we need first to compute the cost taxpayers paid for this plan.

3. Taxpayer's Cost and Aggregate Effects

3.1 Cost of the Preferred Equity Infusion

On October 13th, the government announced that it will invest $125 bn in the top ten banks. The $125bn represents the size of the investment, not its costs, since the government receives in exchange some claims on the underlying companies. Thus, the actual cost is the difference between the amount invested and the value of those claims.

In order to calculate these claims -- preferred equity and warrants — we need to make some assumptions. First, we assume that the preferred equity will be redeemed after five years, i.e. right before it starts to pay a 9% dividend. This assumption over-estimates the value of preferred equity because only firms whose cost of capital will be above 9% will choose not to redeem, but that would be bad news for the government, as it would receive 9% instead of a higher market value.

The second key assumption in the valuation of the Government's claim is at what rate we discount the 5% dividend paid by the preferred in the first five years. Since there is room for disagreement we adopt two different approaches. In Table 6A we compute the present value of the preferred dividend by using the yield on existing preferred shares, as reported by Bloomberg. As discussed earlier, we use the data from most recent issued Preferred Shares with available data. Instead, in Panel B we use a capital asset pricing model with the beta estimated from common stock.

Third, we compute the value of warrants as 10-year American options on the stocks, adjusted for the usual dilution adjustment (see Table 2a). In this calculation, we assume that dividend disbursement remains constant at their latest level. Given that the recent banking crisis did not spur banks to decrease dividend disbursement in the past year, assuming constant dividends seems plausible.[8] Note that Paulson's plan forbids banks from increasing dividends without authorization from the Treasury only for the first three years. Thus, there is a serious risk that the banks will increase their dividends after that, reducing the value of the Government's warrants. For this reason, we use two hypotheses. In Table 6A we use the actual maturity of the warrant (ten years). In Table

[8] Indeed, we think this assumption is in fact conservative, as it would be in the interest of banks to increase dividends after the three year lock out, in order to decrease the value of outstanding warrants.

6B we assume the effective maturity of three years, assuming that the banks' shareholders will pay dividends so to eliminate any gain for the Government.

In both cases we value the warrants by using the implied volatility from at-the-money call options with the longest maturity available. The implied volatility is also reported in Table 2b.[9] In neither case do we price in the option banks have to buy back the warrant at an agreed "fair market" price. In so doing we are overestimating the value of the warrant received by the government, since we are not pricing in the likely discount the government will grant when the banks want to buy the warrants back.[10]

Table 6A, which contains the most optimistic estimates of the value of the Government's claim, estimates the value of the preferred at $101bn and the value of the 15% of warrants at $10.5bn, for a total value of $112bn. By contrast, Table 6B, which contains the most conservative estimates of the value of the Government's claim, values the preferred at $82bn and the value of the 15% of warrants at $7bn, for a total value of $89bn. Hence, depending on the estimates the preferred equity infusion cost taxpayers between $13 and $36bn.

Finally, we price these warrants assuming a constant volatility. With jumps and stochastic volatility these long-maturity warrants could be substantially more valuable. Since this will only reduce the cost of the government intervention, it would only increase the size of the value created by the plan.

The total values of the securities in Table 6 can be compared with the results of the February Oversight Report from the Congressional Oversight Panel, released on February 6, 2009. The international valuation firm Duff & Phelps was retained by the U.S. government to assess the fair valuation of the securities obtained in exchange of the capital infusion. Although not all banks we analyze were included in the report, we can assess the difference in valuation on the common set of firms. Citigroup: $15.5bn, Bank of America: $12.5bn; JPMorgan Chase $20.6bn; Wells Fargo plus Wachovia: $23.2bn; Goldman Sachs: $7.5bn; Morgan Stanley: $5.8bn. These values mostly fit between our optimistic and pessimistic case, except for Citigroup and the two investment banks,

[9] The value of American options, both for exchange traded and the warrants, are computed through a standard finite difference method.

[10] According to several reports (e.g, Beals, 2009), in several instances the Government has been too accommodating. For example, Old National, the first one to repurchase the warrants, bought back warrants over $15m-worth of shares for $1.2m (Beals, 2009).

whose values are even below our pessimistic estimates. Substituting these values into our optimistic case leads to a total cost of $28.4bn, while substituting them into our pessimistic case leads to a total cost of $39.7bn. These findings lend support to our pricing methodology.

3.2 Cost of the Debt Guarantee

The FDIC offered a government guarantee to all new issues of unsecured bank debt until June 2009 for three years.[11] To measure the ex ante cost of this guarantee we will make use once again of the CDS rates, albeit this time the three year maturity CDS since the guarantee is a three-year one.

Thanks to this FDIC guarantee, the nine (plus one) banks can issue unsecured debt guaranteed by the government. Thus, it is as if they save the cost of insuring their own new debt issues for three years. The rate the FDIC charges for this is 75 basis points. Since this guarantee is limited to 125% of the existing unsecured short-term debt plus the long-term debt maturing up to June 2009, in Table 7, we compute the guaranteed amount and we multiply by CDS rates minus the 75 basis points. This is the annual cost, which discounted over the three years using the Treasury discount curve leads to $11 bn. The biggest beneficiaries of this guarantee are Goldman Sachs, $3.5bn; Citigroup $3bn; and Morgan Stanley $2.1bn .

Some might argue that this is a hypothetical cost. If none of these banks fail, the realized cost of this guarantee will be zero (in fact negative, since the banks pay a fee to insure themselves). Yet, there are two reasons why this argument is false. First, if an option ends up expiring out of the money does not imply that the ex ante value of that option is zero nor that the firm underwriting it does not pay any cost. In fact, our Value-at-Risk calculation in the Section 5 shows it is quite likely the Government will be called to guarantee the debt of some bank. Second, the increase in the national debt and contingent liability has significantly increased the rate of CDSs on the U.S. government debt from a few basis points to more than 30. With a government debt equal to $10.5

[11] In an earlier version of the paper we assumed that the guarantee was for all the new issues of debt and not just the unsecured component. This makes an enormous difference, especially for the investment banks for which most of the short term debt is secured. A careful reading of the Temporary Liquidity Guarantee Program (http://www.fdic.gov/news/board/08BODtlgp.pdf) confirmed that the guarantee was extended only to unsecured new debt issued.

trillion, each additional 10 basis points on the CDS correspond to \$10.5bn of additional cost for the taxpayers.

3.3 The Cost of the Extended Guarantee on Uninsured Transactional Accounts

For completeness we try to calculate the value of the extended insurance on the non-interest bearing accounts. To estimate the amount of non-interest bearing accounts that were uninsured as of October 12, we take the total amount of non-interest bearing accounts as of September 30, 2008 from the call report and multiply it by the percentage of uninsured deposits (also from the call report). This amount is reported in column V of Table 7.

As is well known from the work of Merton (1977) the FDIC deposit guarantee can be considered a put option on the asset of the firm, and thus its value can be computed from the (modified) Merton's model discussed in the Appendix B and illustrated in Figure 4. In this model, we assume that bank can either default in a short period, $T_S = 3$ month, when it rolls over its short term debt (and deposits), or much later, when long term debt matures. At time T_S the firm may also be hit by a liquidity shock, with probability p, which makes its asset value drop to $x\%$ of its pre-shock value. This assumption allows us to obtain a calibration of the model that is able to match both the short-term and the long-term CDS rates. We calibrate the model CDS rates, equity value and return volatility to the data on 10/10/2008, before the announcement, using the procedure described in Appendix B, which also contains more details of the model. To be conservative, however, we consider the value of the put option on 10/14/2008, after the government announcement, so that we take into account the resulting higher value of assets and lower probability of default. To control for other confounding news between 10/10/2008 and 10/14/2008, we exploit the estimation results in Sections 2.1 and 2.2, and use the adjusted value of equity and debt in the calibration for the latter date. Given the calibrated values of the (modified) Merton model, we can compute the value of the FDIC deposit guarantee put option.

The estimated value of this put option for the additional debt insured is reported in column VI of Table 7. The amounts are very small. The biggest beneficiary is Citigroup with \$390 million. Overall, the total cost of this guarantee is \$0.7 bn.

3.4 The Savings on the FDIC Put Option on Commercial Banks

One qualification to the previous calculations is that the government intervention, both the preferred equity infusion and the FDIC guarantee on debt, will decrease the value of the FDIC guarantee on deposits. This is an implicit gain for the government. We resort to our structural model in order to compute the change in value of this put option.

We calibrate the (modified) Merton's model to both equity and debt (CDS) data before and after the government announcement, i.e., 10/10/2008 and to 10/14/2008, respectively, as explained above. Given the calibrated models, we compute the value of the put options on these two dates, and then calculate the difference. The result is in the last column of Table 7, which shows a small effect on the value of the put option. The reason is that in order to match short term CDS rates, on both dates the model implies small probabilities of default, but large decreases in asset value in case of default. The increase in asset values and the decrease in the probability of default are small compared the losses in case of a liquidity shocks. Thus, the change in value of put options is small as well.

3.5 Aggregate Analysis

Table 5 summarizes the overall effects of the revised Paulson plan. As stated in Section 2, the plan increased the value of banks' financial claims by \$128bn. If we add the \$3.7bn of reduction in the cost of the FDIC deposit insurance, the total value increase amounts to \$131.5bn. This goal was achieved at a cost that in the more optimistic valuation is \$25bn and in the less optimistic one \$47bn, with a net effect between \$84 and \$107bn.

These estimates are obtained attributing all the gains of Morgan Stanley to the Paulson Plan. If we exclude Morgan Stanley from the analysis, the value increase is only \$66bn, with a cost between \$21 and \$42, with a net benefit oscillating between \$24bn and \$45bn. Where does this value come from? We try to answer this question in section 3.7. Before doing so, however, we check the robustness of our results to different assumptions.

3.6 Robustness

In this section we investigate the robustness of our conclusions to a wide array of alternative hypothesis about the underlying quantities. The summary results are contained in Table 8, which reports only the final aggregate values in the last column of Table 5, for six cases: pessimistic, Oversight Report, optimistic scenarios, with and without Morgan Stanley. For instance, the first row of Table 8, the base case, shows the same results reported in the last column of Table 5. Each subsequent row contains the estimates of the value added in the six scenarios when one hypothesis is changed (explained in the first column) from the base case.

3.6.1 Recovery Rates and Discounts

The first robustness check has to do with the assumptions we made about the recovery rates, a key assumption to compute the risk neutral probabilities of default, used then to compute the value of debt insurance. In the body of the text we assume 20%, which is below the standard value assumed for single name CDSs, which is 40% instead. Table 8 shows that changing the value of recovery rate from 20% to 0% or to 40% changes the result, but not the conclusion. In particular, with 0% recovery, the best (optimistic with Morgan Stanley) and worst (pessimistic without Morgan Stanley) cases are $116bn and $25bn, respectively. With 40% recovery, instead, the best and worst cases are $98bn and $20bn, respectively.

One additional concern pertains to the discount rate used to compute the present value of insurance. In the body of the paper we use the U.S. Treasury curve. However, since security dealers may default it is customary to use the LIBOR curve to price CDS contracts. Using the LIBOR curve also does not change our conclusions, as the best and worst possible cases are now $107bn and $24bn, respectively.

3.6.2 CDX as control

A reasonable concern about our control is that General Electric Capital may have being affected by its own idiosyncratic shocks during the event window. Therefore, as an additional robustness check we use the CDX index as a control. The CDX index represents the cost of insurance against default on a diversified portfolio of 125 firms. In particular, the insurance buyer pays a quarterly premium during the life of the insurance, and in exchange it receives from the insurance seller the notional minus recovery anytime any of the underlying names defaults.

There are two complications on performing the adjustment in expression (4): The first is that CDX quotes are only available for 5 year contracts. We therefore assume that CDX quotes are constant across maturities. The second complication is that we do not have the outstanding debt for the reference entity (the 125 names in the index). To circumvent this problem we proceed as follows: for each bank i we first compute the present value of insurance costs (formula (5)) using the CDX index, which we denote by $PV^i(CDX)$. We then use expression (4) with $PV^{GE}(CDS)$ substituted by $PV^i(CDX)$ to compute the adjusted change in the value of the bonds. The resulting ratio $\Delta PV^i(CDX)/PV_0^i(CDX)$ provides the percentage change in the value of firm i debt were the CDX its insurance premium, instead of CDS^i. The results are again similar. In particular, the best and worst cases have \$120bn and \$33bn, respectively.

3.6.3 Beta Estimates

To compute the change in value of common stock we controlled for the change in the stock market. The resulting adjusted equity values are therefore just an estimate, and we must consider their standard errors in our analysis. We check the robustness of our results to these estimation errors by computing the total costs and benefits after shifting of the regression coefficients by plus/minus two standard errors, which amounts to assume that all regression coefficients are perfectly correlated, a strong, but conservative assumption. Once again, Table 8 shows that our conclusions remain the same: a two-standard deviation decrease in betas leads to a best and worst cases of \$120 and \$35 respectively, while these numbers are \$100bn and \$16bn when we increase the betas by two standard errors.

3.6.4 Full Exposure Derivatives Net Positions

As our final check we consider the case in which in aggregate security dealers bear the full credit risk exposure in their derivative net positions. This is clearly an overstatement, as most of these transactions are between them, and not with respect to other counterparties. Still, it is informative to see how important this exposure is in our calculations. We find that accounting for the full net derivative liabilities, the best and worst case scenarios are $119bn and $36bn, while a 50% exposure leads to $106bn and $30bn, respectively. Again, our major conclusions remain.

3.7 Some Evidence on the Sources of the Costs and Benefits of the Plan

Where does the value increase come from? One possibility is that the capital infusion and the renewed access to funds enables banks to take advantage of the positive net present value lending opportunities. Yet, we know from Ivashina and Scharfstein (2009) that the discretionary lending of the major banks went down, not up during this period. Of course, one could argue that in the absence of the intervention the positive NVP lending would have dropped even further. Unfortunately, since this counterfactual is difficult to pin down, this proposition seems untestable.

By contrast, it is possible to test, albeit with very few observations, the proposition that the value created arise from the reduction of the risk of a bank run. As described in Section1.2, we can construct an index of the probability of a bank run by looking at the difference between the probability of bankruptcy over the next year and over the following one, conditional on not going bankrupt this year. In Figure 5A we plot the net percentage gain produced by the Paulson Plan on the index of the probability of a bank run. As we can see, the observations lay on almost a straight line (a linear regression has an R-squared of 92%). Note that there is nothing mechanical about this relationship. The explanatory variable is a difference between probabilities of bankruptcy embedded in CDS rates as of 10/10/08, while the dependent variable is a relative increase in enterprise value, where the adjusted change in CDS rates from 10/10/08 to 10/14/08 plays a role. The data seems to confirm that the banks more at risk of a run gained the most during this period.

In Figure 5B we repeat the same exercise with the difference that the explanatory variable is a bank past performance (measure as stock return from 7/1/07 to 10/10/08). Even in this case we obtain a very high fit, where the banks that performed the worst gained the most. Performance during this period, however, is highly correlated with the probability of bank run at the end of the period. When we run a regression with both, only the probability of a bank run remains significant.

Reducing the probability of a run implies reducing the probability that a firm will face the direct and indirect costs of bankruptcy. Given our estimates of the gain and of the changes in the probability of bankruptcy, we can verify whether the costs of bankruptcy implicit in our estimates are reasonable.

The value of any firm can be written as the discounted value of the future cash flow (CF_t) minus the expected value of the future bankruptcy costs:

$$V = \frac{CF_1 - p_1 BC}{1+r} + \frac{CF_2 - p_2(1-p_1)BC}{(1+r)^2} + \frac{CF_3 - p_3(1-p_1)(1-p_2)BC}{(1+r)^3} + ...$$

where we have assumed that the probability of bankruptcy p_i is independent from period to period. If, in addition, we assume that the probability of bankruptcy is constant after year five we can rewrite this expression as

$$V = \sum_{t=0}^{\infty} \frac{CF_t}{(1+r)^t} + BC[\frac{p_1}{1+r} + \frac{p_2(1-p_1)}{(1+r)^2} + \frac{p_3(1-p_1)(1-p_2)}{(1+r)^3} + \frac{p_4(1-p_1)(1-p_2)(1-p_3)}{(1+r)^4}$$
$$+ \frac{p_5(1-p_1)(1-p_2)(1-p_3)(1-p_4)}{(1+r)^5} + \frac{\frac{p_5}{r+p_5}}{(1+r)^5}]$$

Under the (strong) assumptions that the announcement of the Paulson Plan does not alter the future cash flow values and does not change the bankruptcy costs (but only the probability of bankruptcy), we can infer the cost of bankruptcy from the changes in the enterprise value before and after the announcement of the Paulson Plan as[12]

(8) $$BC = \frac{\Delta V}{\Delta p}$$

where ΔV is the change in the enterprise value at the announcement and

[12] In section 4.5 we will provide some evidence that the cost of bankruptcy conditional on entering bankruptcy does not change much during the event windows.

$$\Delta p = [\frac{p_1^0}{1+r} + \frac{p_2^0(1-p_1^0)}{(1+r)^2} + \frac{p_3^0(1-p_1^0)(1-p_2^0)}{(1+r)^3} + \frac{p_4^0(1-p_1^0)(1-p_2^0)(1-p_3^0)}{(1+r)^4} + \frac{p_5^0(1-p_1^0)(1-p_2^0)(1-p_3^0)(1-p_4^0)}{(1+r)^5} + \frac{\frac{p_5^0}{r+p_5^0}}{(1+r)^5}] -$$

$$[\frac{p_1^1}{1+r} + \frac{p_2^1(1-p_1^1)}{(1+r)^2} + \frac{p_3^1(1-p_1^1)(1-p_2^1)}{(1+r)^3} + \frac{p_4^1(1-p_1^1)(1-p_2^1)(1-p_3^1)}{(1+r)^4} + \frac{p_5^1(1-p_1^1)(1-p_2^1)(1-p_3^1)(1-p_4^1)}{(1+r)^5} + \frac{\frac{p_5^1}{r+p_5^1}}{(1+r)^5}]$$

where p_t^0 is the (risk neutral) probability of bankruptcy in year *t* embedded in the CDS rates before the announcement of the Paulson Plan and p_t^1 is the same probability after the announcement.

Table 9 reports such estimates. The inferred bankruptcy costs oscillate between \$34bn and \$164bn, corresponding to between 5 and 17 percent of the enterprise value. These estimates seem reasonable, but decisively on the low side. Andrade and Kaplan (1998) find that the cost of financial distress for firms that underwent a leverage buyout (and so are likely not to have very high cost of financial distress) are between 10 and 20% of firm value.

One possible reason for such low estimates is that the assumption of invariance of cashflow at the announcement is false. In fact, government intervention per se (without any cost of financial distress) might be a bad news for future cashflow. If we drop the invariance of cashflow we can write the percentage change in enterprise value at the announcement of the plan as

$$\frac{V^1 - V^0}{V^0} = \frac{\sum_{t=0}^{\infty} \frac{CF_t^1}{(1+r)^t} - \sum_{t=0}^{\infty} \frac{CF_t^0}{(1+r)^t}}{\sum_{t=0}^{\infty} \frac{CF_t}{(1+r)^t}} + BC\Delta p$$

Since Δp varies from company to company, if we regress the percentage change in enterprise value at the announcement on a constant and Δp we obtain

$$\frac{V^1 - V^0}{V^0}_i = -0.025^{***} + 0.22^{***}\Delta p_i$$

These estimates suggest that the cost of government intervention (which reduces the ordinary cash flow independent of the probability of bankruptcy) is equal to 2.5% of the enterprise value, while the potential cost of bankruptcy is 22% of the enterprise value. These estimates appear quite reasonable and can potentially be used in the future to estimate the benefit of a government rescue of a bank.

4. The Ex Ante Effects of the Plan

Given the extreme volatility of markets during this period, it is legitimate to ask whether our estimates represent a fair assessment of the ex-ante costs and benefits of the revised Paulson plan. For this reason, in this section we try to evaluate the plan on an ex-ante basis, by using an extended version of the Merton (1974) model, where we introduce the risk of a liquidity shock/bank run. The goal of this section is twofold. On the one hand, to provide a reality check to the above results. On the other hand, to show that a simple extension of the Merton model can be used ex ante to provide accurate estimates of what the effects of various interventions will be.

4.1 The Model

Since the seminal work of Black and Scholes (1973) and Merton (1974), it has been recognized that claims on a firm's assets, such as equity and debt, can be valued as options on the assets of the firm. To illustrate the logic in a simple setting, consider a bank (or a firm, more generally) with an amount $A(0)$ of assets at time 0. These assets are financed by short-term debt, long-term debt or equity. Assume for simplicity that the principal on short-term debt and long-term debt is the same, $D_L = D_S$, and that debt carries no coupon payments. Finally, we let short-term debt be senior to long-term debt. The value of a bank's assets changes over time, due to cash inflows and outflows, as well as the willingness of market participants to purchase such assets. For instance, if some of these assets are Mortgage Backed Securities, then their market value may decrease in price if market participants expect higher mortgage defaults in the future.

In this simplified setting, consider the bank now at maturity of the short-term debt T_S. There are two possibilities: either the bank has a sufficient amount of assets to pay for these short-term liabilities or not. If the market value of the assets of the firm is below the principal of short-term debt D_S, the bank defaults. In this case, equity and long-term debt holders are wiped out and short-term debt holders seize the remaining assets $A(T_S)$. If assets are instead above the principal D_S, the bank pays for its short-term debt by liquidating some of its assets and proceeds on with its operations.

To take into account the possibility of a bank run or a liquidity shock, we assume that at time T_S there is probability p that the market value of assets drops to $x\%$ of its value before the shock. If $A(T_S)< D_S,$ the bank defaults, equity and LT debt holders are wiped out and ST debt holders seize the remaining assets $A(T_S)$. If $A(T_S)>D_S$, the bank pays D_S and proceeds on with its operations.

At maturity of the long-term debt T_L, the situation is similar. If assets $A(T_L)$ are below the principal due at T_L, the bank defaults, equity holders receive nothing, and debt holders receive the assets $A(T_L)$. Conversely, if assets are sufficient to pay for the principal, debt holders receive their principal D_L back and equity holders obtain the remaining assets $A(T_L) - D_L$.

Figure 4 illustrates these two scenarios: the two vertical dotted lines correspond to the maturities of the short-term and long-term debt. The solid curved line represents one hypothetical path of assets over time, while the shaded areas correspond to possible asset values at T_S and T_L from the perspective of a market participant at time 0. The solid curved line represents the case in which no default on long-term debt takes place, neither at T_S nor at T_L. In contrast, the dashed line that starts at T_S represents a hypothetical path leading to default of the bank: at T_L the bank does not have enough to pay in full its obligations to debt holders.

What is the value of debt and equity as of time 0, then? Using the option pricing methodology developed by Black and Scholes (1973) and Merton (1974), the value at time 0 is the expected discounted value of the payoff at maturity, adjusted for risk. The only noteworthy point is to recall that the payoff at time T_L may be zero because default occurs at T_S. Appendix B contains more details on the model, as well a discussion on how we treat various forms of liabilities.

There are four unobservable entries in this model's formulas: the value of assets today $A(0)$, the volatility of assets σ_A, the probability of a liquidity shock p, and the loss in case of a shock x. We choose these quantities to match four observables: the market capitalization of each bank on Oct 10th, 2008, the volatility of equity, as well as an estimate of market values of ST debt and LT debt on the same day. The estimated market value of debt is computed from CDS rates. [13] Table 2 reports the other data used in our estimations. In particular, for each bank this table reports the bank's capital structure – namely, the deposit amounts, short-term debt, long-term debt etc. – as well as the firm market cap and equity volatility.

4.2 The Co-insurance Effect

Table 10 contains the results of the estimation. The first two columns report the estimated market value of long term bonds and the firm market capitalization as of Friday, October 10, 2008. The next two columns report the same quantities after the $125bn preferred equity infusion. In particular, the $125bn preferred equity infusion increases the overall value of the equity of these ten banks by only $80bn, reported in column 7.

This increase in the value of debt is exactly what is predicted by Myers (1977). When debt is risky, by definition there are several states of the world in which is not paid in full. An equity infusion, provide a safety cushion to debt in those states of the world in which it would not have been paid in full. As a result, the value of risky debt goes up when new equity is raised. This transfer of value, which is also known in the literature as debt overhang or co-insurance effect, is what makes so unattractive for equityholders to raise new equity.

Overall, the size of the transfer in favor of debtholders is $38bn (see column 6), equal to 29% of the value of the money invested. However, the magnitude of this transfer varies across firms depending on the extent of their leverage and the volatility of their assets. It is highest (in relative terms) for Morgan Stanley (68%), Wachovia (49%), Merrill Lynch (48%), Goldman Sachs (44%), and Citigroup (38%). It is smaller for JP Morgan (17%) and Bank of America (22%) and Wells Fargo (13%).

4.3 Explaining the Changes in the Market Value of Debt

Table 11 compares the model's prediction about the changes in market value of debt and equity to the actual changes in the market. All these calculations are made under

[13] It is worth to point that the CDS implied yields under-estimates the true yield of bonds (see e.g. Longstaff et. all (2004)) and thus we over-estimate the value of debt in this case. We also computed the value of debt and implied transfers by treating the principal value as a zero coupon bond itself, thereby grossly under-estimating the value of debt. The transfers from equity holders to debt holders were very similar.

the assumption that the overall assets value does not change. As we saw in section 3.5, however, there is strong evidence that it did change. These model-based comparisons will lead to the same answer.

Table 11A shows that the model predicts an increase in the market value of debt equal to 49bn: 38bn coming from the value transfer from the preferred equity infusion and 11bn from the FDIC debt guarantee. This estimate falls $72bn short of the actual increase, equal to 120bn. This amount is hard to rationalize without assuming an increase in the value of assets. Even if we were to assume that the government intervention eliminates the risk of a liquidity crisis (and thus we put at zero in the model the probability of a run), we can explain only another $19 bn of value increase, still $52bn of the actual amount.

4.4 Explaining the Changes in the Market Value of Equity

We reach similar conclusions if we look at the impact of the plan on equityholders (Table 11B). The model predicts a loss of $25bn, the net result of a gain of $13bn from the preferred equity infusion and a loss of $38bn due to the value transferred to debt holders – see Table 11A, column 3. The actual change is -2.8bn, with a difference of $25 bn. We could argue that the equity captures some of the value provided by the FDIC debt guarantee. But even if the entire value were captured by equity, this would not explain the value increase (and would make explaining the increase in the value of debt even more difficult).

4.5 Inferring the Changes in the Value of Assets from the Model

If we maintain the value of the underlying assets constant the model is unable to account for the observed changes in the value of debt and equity. This result could imply that the model does not fit the data well or that indeed the value of the underlying assets has increased. To distinguish between these two hypotheses we calibrate the model twice, before the announcement (10/10/08) and after the announcement (10/14/08). As in Section 2.1 and 2.2, we control for news between the two dates by exploiting the estimation results in 2.1 and 2.2 and using the adjusted increase in equity and bond values for the calibration at the later date. Table 12 reports the results.

Several factors are worth mentioning. First, the model is able to mimic very well the change in the value of the underlying assets, with a mean squared error of only 5%. Second, the volatility of the underlying assets does not seem to have changed a lot over the long week-end, but the probability of a bank run did. Before the announcement of the plan was on average 1.4%, after the announcement dropped to 0.9%. The biggest beneficiary was Morgan Stanley, for whom the probability of a run went from 5.7% to 3.2%. Finally, the model estimates that the recovery rate in case of a run did not change before and after the announcement. This validates the assumption we made in section 3.7.

5. Valuations of Alternative Plans

Our analysis shows that the Paulson' Plan was able to add substantial value (roughly $130bn) to the banking sector, at a cost of $84-$107bn to the taxpayers. Even factoring in the deadweight cost of taxation (see Table 8), the net value added of the plan is positive. Therefore, the intervention has an economic rationale, even if we ignore the likely systemic effects of this plan (the stock market surged by 11% over those two days). What our analysis so far does not address, however, is whether this goal was achieved in the most cost effective way. This trade off has been analyzed from a theoretical point of view by Phillipon and Schnabel (2009). Here we want to perform this analysis from an empirical point of view. This exercise is clearly speculative, since the counterfactuals are difficult to assess. Nevertheless, the extended Merton model we used has been very successful in matching the observed variations, thus we feel reasonably confident to use it as a benchmark to evaluate the counterfactuals.

To evaluate these counterfactuals we need to impose one constraint and make one assumption. The constraint is that we only consider plans that achieve the same goal as the Paulson Plan. Since Paulson's Plan's objective was to recapitalize the banking system so that the risk of default of a financial institution became sufficiently low, we evaluate alternative plans with the constraint that they reach this objective: i.e., a reduction in the CDS rates of each bank equivalent to the one observed in the data (see Table 3). Since there are multiple CDS rates, depending on the maturity, we impose in particular that the alternative matches the drop in the one-year CDS rates, since these are the ones that indicate the imminent risk of a run, and the five-year CDS rates, which instead mainly depends on the current value of assets *A(0)*.

As in the event study, we want to consider the direct impact on the plan on CDS, and not the systemic effect. For this reason, Table 3 reports two declines in CDS rates: the actual decline and the adjusted decline, where the latter is adjusted for the decline in GE Capital CDS rates. Since we do not know whether the general decline, captured in the decline of GE Capital CDS rates, is due to the plan or to the other events, for completeness we consider two possibilities: that the plan achieves the adjusted decline in CDS or that the plan achieves the unadjusted decline in CDS. Clearly, the second hypothesis puts a much higher hurdle to the plan.

Conditional on achieving this objective, we rate the different plans along several dimensions, which are important both economically and politically: the investment required, the net cost, the value at risk, and the percentage of bank's equity capital the Government will end up owning. The need to evaluate the amount of funds required separately from the net cost arises from two considerations. First, there are some political constraints on the amount of funds employed, regardless of whether they are invested or given away as subsidies, as shown by the fact that the entire debate on the original Paulson Plan (to buy distressed assets from banks) was about the amount of money invested, not on the actual cost for taxpayers of this investment. Second, the expected cost of debt guarantee does not appear in the Government budget as a cost simply because of the way Government accounting is done. The need to calculate the value at risk derives from the fact that very large losses may have disproportionate negative effects, undermining the credibility of the U.S. Government and the dollar. Finally, the percentage ownership of the large banks acquired by the U.S. government has both political and economic consequences in the short and the long run.

For comparison in the first column of Table 13 we report the values of these criteria for the revised Paulson Plan analyzed so far. The only two parameters we have not discussed yet are the value at risk and the overall government ownership of banks.

The 5% value at risk is close to $100bn.[14] A more interesting dimension is the percentage of ownership acquired by the Government. We compute this as the amount of money invested divided by the sum of the market capitalization of the common equity and the preferred equity before the plan is announced (i.e., the 10/10/2008) plus the amount of money invested. This is the fraction of equity the Government should have taken, not necessarily what it will take since the warrant will be priced at the moment of the infusion. With this plan the Government would own on average 20% of the top ten banks, with a maximum of 48% ownership in Morgan Stanley.

We are now in the position to compare the revised Paulson Plan with some alternatives. The first one we analyze is the original Paulson plan, with no overpayment. The idea of this plan was to substitute risky assets of dubious value with assets of certain value (cash) on the banks' balance sheet. Even if these transactions occurred at market prices, this plan would have reduced the riskiness of banks' underlying assets and in so doing reduced their risk of default.

By using the model described above, we calculate that it would have been necessary to purchase $3.1trillion of banks' assets to achieve the same adjusted drop in CDS rates achieved by the revised Paulson plan (see Table 13A). If we want to achieve the same unadjusted drop, we would need $4.6 trillion. This is clearly a theoretical exercise since purchases of this entity would certainly alter market prices. Nevertheless, it gives a sense of the order of magnitude of the intervention required to achieve the stated goal only with asset purchase. The magnitudes involved suggest that even if it were possible not to overpay for the assets, it would have been unfeasible to reach the objective with the money requested under TARP.

Since by definition these transactions are done at the fair value, the expected cost of this strategy is zero. Nevertheless, it subjects taxpayers to an enormous risk. For this reason, we compute the value at risk. In Panel A the 5% value at risk for this alternative is $127bn, while the corresponding figure in Panel B is $203 billion. The main benefit of this approach is that it does not require any government ownership of banks.

[14] If we assume that the effect of the plan is to reduce not just the adjusted CDS, but also the raw CDS rates (Table 13b), the 5% VaR is slightly lower, because the initial value of the assets is higher, to match the higher value of debt. Appendix C elaborates on the methodologies we use to calculate the VaR under the various alternative plans.

The second alternative plan we consider is a variation of the original Paulson Plan, with the difference that the Government has an explicit mandate to overpay. We fix this overpayment at 20%. This overpayment could be the result of an explicit government decision or the result of a surge in prices due to the massive purchases made by the Government under this plan.

In this case the amount of investment needed decreases significantly: $953 billion if we target the adjusted reduction in CDS rates, $1.7 trillion if we target the raw reduction. Note that the amount necessary to achieve the required reduction in adjusted CDS is similar to, but falls short of the amount Secretary Paulson requested to buy toxic assets. This reduction in the funds needed comes at a high price for the taxpayers: they have to pay $191bn up front. The value at risk, however, is significantly lower: only $49 bn. Once again, one benefit of this approach is that the government does not end up owning any share in the banking sector.

The third hypothesis we consider is a pure equity infusion, with no debt guarantee. This is the proposal advanced by several economists (Diamond et al., 2008, Stiglitz, 2008). If the goal is simply to achieve the adjusted reduction in the CDS rates, the preferred equity infusion achieves it at twice the upfront investment of the revised Paulson plan: $261bn vs $125. The cost of this option, $65bn, is represented by the transfer in value from equityholders to debtholders that occurs when equity is injected in a very highly levered firm. We attribute this share to the government in proportion to the equity acquired at the price before the announcement. Clearly, the government could have been imposed all these costs on the existing equityholders buying at a lower price, but this would have required a forced recapitalization, not a voluntary one. The VaR would also have been significantly higher than the Revised Paulson Plan: $211bn.

This approach would have had very adverse effects in terms of government ownership of banks. On average the government would have ended up owning 40% of the top ten banks. This ownership would have been very unequally distributed. As Figure 6 shows, the equity infusion plan will concentrate the investment in the three former investment banks and Citigroup. Such investment would have given the Government 61% of Citigroup, 50% of Morgan Stanley and 39% of Goldman Sachs.

The scenario is worse if we want to target the raw reduction in CDS rates. In this case the equity infusion required would be \$495bn, with a cost for the taxpayers of \$139bn and a Government ownership of banks of 52%.

This analysis suggests that the original Paulson Plan not only would have been extremely costly for taxpayers, but it would have also been unfeasible in the terms proposed by Paulson. Even ignoring the fact that it would have been difficult to limit the purchase of assets from banks alone and assuming a generous overpayment (20%), the entire TARP money would have not been sufficient to rescue the ten largest banks alone.

By contrast, the revised Paulson plan seems to perform the best, among the options considered at the time and analyzed by Philippon and Schnabel (2009). It has the lowest up-front investment need, the lowest up-front cost, which more than compensate for the higher 5% VaR. This advantage stems from the cost effectiveness of the debt guarantee. A debt guarantee on unsecured debt provides the necessary access to funds in a crucial moment, making all the debt safer, while not guaranteeing it all. The only drawback of the revised Paulson Plan vis-à-vis alternatives is the higher government ownership of banks it generates.

While the revised Paulson plan performs best within this set of options, it is clearly dominated by a debt for equity swap along the lines of what proposed by Zingales (2008a and b). The idea aims at eliminating the threat of default by converting long term debt into equity. To protect the value of the existing equityholders, such a plan would grant them the option to buy back their claim from the old debtholders (now transformed in equityholders) at the face value of debt. The beauty of this scheme, first devised by Bebchuck (1988), is that is that it does not require any valuation of the existing assets, which is the biggest problem any plan is facing given the uncertainty in the value of the underlying assets. Since this plan does not involve any Government money, all the entries are obviously zero. We did compute, however, whether the conversion of the long term debt would have been sufficient to achieve the stated goals. In fact, it is more than sufficient. Converting the long term debt insure a dramatic drop of the CDS rates to 7-8 basis points, the level most banks had at the beginning of 2007. So this plan was economically feasible, but it would have required new legislation to be implemented (Swagel, 2009).

6. Conclusions

We analyze the market response to the revised Paulson plan and show that, systemic effects aside, this plan adds $132bn to the banking sector at a taxpayers cost of between $15 and $47bn, with a net benefit between $84 bn and $107bn. By looking at the limited cross section we can infer that this net benefit is the combination of two factors. On the one hand, a government intervention reduces the enterprise value by 2.5%, possibly due to the inefficient restrictions the government will impose. On the other hand, the government money infusion reduces the probability of bankruptcy, which – we estimate—could cause a dissipation of 22% of the enterprise value.

We then study the cost of alternative plans that would have achieved the same effects in terms of reduction of the default risk of existing banks. The revised Paulson plan vastly dominates the original Paulson Plan and performs better than the most popular alternatives advanced at the time. Only a debt-for-equity swap would have done better, but this would have required specific legislation to be implemented.

Appendix A. Bootstrapping Risk Neutral Default Probabilities from CDS rates

Denote by $r(\tau)$ the riskless rate at time τ and by $p(\tau)$ the risk neutral default intensity for time τ. We assume for simplicity that both $r(\tau)$ and $p(\tau)$ are simple deterministic functions of time. Assuming continuous payments, the no-arbitrage formula for a CDS rate on a contract with maturity T is given by

(A1) $$CDS(T) = \frac{(1-\delta)\int_0^T p(\tau) e^{-\int_0^\tau r(u)+p(u)du} d\tau}{\int_0^T e^{-\int_0^\tau r(u)+p(u)du} d\tau}$$

where δ is the recovery rate. Note that if the default intensity $p(\tau)=p$ is constant, then $CDS(T)=p(1-\delta)$. When $p(\tau)$ is not constant, we can use CDS rates for various maturities T to bootstrap out $p(\tau)$ for every τ. For simplicity, we assume that $p(\tau)$ is a step functions with one year step size. To implement the procedure we need the spot rates $r(\tau)$, which we bootstrap out from plain-vanilla swap rates data, available on the Federal Reserve Board web site. Fixed for floating swap rates implicitly embed the LIBOR discount curve, which is used by dealers to price CDS contracts and other derivatives. The LIBOR curve implicitly embeds the risk of default of derivative security dealers. In this bootstrap procedure, we assume a recovery rate δ=40%, which is the standard assumption in the pricing of CDS (see e.g. Bloomberg description of CDS).

Given intensities $p(\tau)$ we can finally compute the probability to survive up to time T as:

(A2) $$Q(T) = e^{-\int_0^T p(\tau)d\tau}$$

The conditional probability of defaulting in year *n* conditional on not defaulting earlier, *P(n)=Prob(Default in year n | No Default before year n)*, can be computed from $Q(t)$ from Bayes' rule:

(A3) $$P(n) = \frac{Q(n-1)-Q(n)}{Q(n-1)}$$

where $Q(0)=1$.

Appendix B: The Merton Model of Equity as an Option

In order to take into account the possibility of a short term default, we modify the Merton's model to consider two possible maturities of debt, short term (ST) and long term (LT). Consider a bank with an amount $A(0)$ of assets at time 0. To illustrate the simple model, assume for simplicity that the principal on ST debt and LT debt is the same, $D_L=D_S$, that debt carries no coupon payments, and that short-term debt is senior to long-term debt. The value of $A(t)$ changes over time, due to cash inflows and outflows, as well as the willingness of market participants to purchase such assets. For instance, if some of these assets are Mortgage Backed Securities, then their market value may decrease in price if market participants expect higher mortgage defaults in the future.

In this simplified setting, consider the bank now at maturity of the short-term debt T_S. In order to cover its liabilities, the bank has to sell some of its assets $A(T_S)$, or, equivalently, roll-over ST debt. To take into account the possibility of a bank run or a liquidity shock, we assume that at time T_S there is a risk neutral probability p that the market value of assets drops by $x\%$. If $A(T_S) < D_S$, the bank defaults, equity and LT debt holders are wiped out and ST debt holders seize the remaining assets $A(T_S)$. If $A(T_S) > D_S$, the bank pays D_S and proceeds on with its operations. At maturity of the long-term debt T_L, the situation is similar. If assets $A(T_L) < D_L$, the bank defaults, equity holders receive nothing, and debt holders receive the assets $A(T_L)$. Otherwise, debt holders receive their principal D_L and equity holders obtain the remaining assets $A(T_L) - D_L$.

Figure 4 illustrates the model: the two vertical dotted lines correspond to the maturities of the short-term and long-term debt. The solid curved line represents one hypothetical path of assets over time, while the shaded areas correspond to possible asset values at T_S and T_L from the perspective of a market participant at time 0. The solid curved line represents the case in which no default on long-term debt takes place, neither at T_S nor at T_L. In contrast, the dashed line that starts at T_S represents a hypothetical path leading to default of the bank: at T_L the bank does not have enough to pay in full its obligations to debt holders.

More specifically, now, consider a bank at time 0, with assets $A(0)$, financed by short term deposit *Dep*, unsecured and secured short term debt, denoted by D_S and D_S^{Sec}, respectively, and long term debt D_L. We make the simplifying assumption that deposit, short term debt and long term debt are all zero coupon instruments, maturing at T_S (deposits and short term debt) and at T_L (long term debt). The balance sheet also reports "other liabilities" among the long term liabilities. We assume that these liabilities also mature at T_L, and are senior to long term debt. Finally, we assume secured short term debt is senior to everything else, including deposits (which are instead partly insured by the FDIC).

As in Black and Scholes (1973) and Merton (1974), the market value of assets $A(t)$ follows a geometric Brownian motion. Under the pricing probability distribution, we then have that

$$\log(A(T_{S-})) \sim N(\log(A(0)) + (r-0.5\sigma_A^2)T_S,\ \sigma_A^2 T_S),$$

where r is the riskless rate. At T_S, there is a (risk neutral) probability p that the asset value will drop to $A(T_S)=xA(T_{S-})$. Because deposits are senior to unsecured short term debt holders (and are insured by FDIC), the payoff to short term debt holders at T_S is

$$ST\ Deb\ Payoff = \max(A(T_S) - (Dep+D_S^{Sec}),0) - \max(A(T_S) - (Dep+ D_S^{Sec} + D_S),0)$$

That is, the payoff is zero if $A(T_S)<Dep+ D_S^{Sec}$, while it is $A(T_S)-(Dep+ D_S^{Sec})$ if $A(T_S)>Dep+ D_S^{Sec}$ but $A(T_S)<Dep+ D_S^{Sec} +D_S$, and it is finally equal to D_S if $A(T_S)>(Dep+ D_S^{Sec} +D_S)$. Note that in the former two cases, equity holders and debt holders get zero. It follows that by the usual option pricing arguments, the value of short term debt under the two scenarios of no liquidity shock or with a liquidity shock at T_S are

$$V^S(A(0)|no\ shock\ at\ T_S) = BSC(A(0), Dep+ D_S^{Sec}, \sigma_A, r, T_S) - BSC(A(0), Dep+ D_S^{Sec} + D_S, \sigma_A, r, T_S)$$

$$V^S(A(0)|shock\ at\ T_S) = BSC(A(0)x, Dep+D_S^{Sec}, \sigma_A, r, T_S) - BSC(A(0)x, Dep+ D_S^{Sec} + D_S, \sigma_A, r, T_S)$$

where BSC denotes the Black and Scholes option pricing formula. Thus, the value of short term debt is

$$V^S(A(0)) = V^S(A(0)|no\ shock\ at\ T_S)\ (1\text{-}p) + V^S(A(0)|shock\ at\ T_S)\ p$$

Conditional on the bank surviving at T_S, we can compute then the value of long term claims. In particular, if the firm survives at T_S, its assets will be reset at

$$A^*(T_S) = A(T_S) - (Dep+ D_S^{Sec} + D_S)$$

For simplicity, after paying the short term liabilities, we assume that assets are still log-normally distributed going forward. In particular, conditioning on a given $A(T_S)>Dep+ D_S^{Sec} + D_S$, we assume

$$log(A^*(T_L))\ |_{A(Ts)} \sim N(log(A^*(T_s) + (r\text{-}0.5\ \sigma_A^2)(T_L\text{-}T_S)\ ,\ \sigma_A^2(T_L\text{-}T_S)\ )$$

Given this, we can value the equity at T_S conditional on $A(TS)> Dep+ D_S^{Sec} + Ds$ again by Black and Scholes formula. In particular, under this condition the payoff to equity is given by

$$Equity\ Payoff = max(A^*(T_L) - (D_L + D_O),0)$$

where D_O are the other liabilities in the balance sheet, and D_L is the face value of long-term debt, computed in such a way to make the value of the zero coupon bond equal to the estimated market value of debt of the bank (see below). Assuming the other liabilities are senior to long term debt, the payoff to long term debt holders is then

$$LT\ Debt\ Payoff = max(A^*(T_L) - D_O,0)\ -\ max(A^*(T_L) - (D_L + D_O),0)$$

It follows that conditional on $A(T_S)> Dep+ D_S^{Sec} + Ds$, the value at T_S of equity and LT debt are, respectively:

$$V^E(A^*(T_S)) = BSC(A^*(T_S), D_L+D_O, \sigma_A, r, T_S - T_L)$$

$$V^{LT}(A^*(T_S)) = BSC(A^*(T_S), D_O, \sigma_A, r, T_S - T_L) - BSC(A^*(T_S), D_L+D_O, \sigma_A, r, T_S - T_L)$$

If $A(T_S) < Dep+ D_S^{Sec} + D_S$, instead, the value of both equity and LT debt is zero. In order to compute the value today (i.e. 0) for LT debt and equity, we must take their discounted expected value of the payoff at T_S, under the pricing probability distribution. Given the log normality assumption, we therefore obtain

$$V^E(A(0)) = \int_{Dep+D_S^{Sec}+D_S}^{\infty} e^{-rT_S} V^E(A-(Dep+D_S^{Sec}+D_S)) f(A) dA$$

$$V^{LT}(A(0)) = \int_{Dep+D_S^{Sec}+D_S}^{\infty} e^{-rT_S} V^{LT}(A-(Dep+D_S^{Sec}+D_S)) f(A) dA$$

where $f(A)$ is a mixture of lognormal distributions, weighted by the probabilities p and $(1-p)$ that a liquidity shock occurs at T_S.

Finally, the calculations above also allow us to compute the value of the FDIC deposit guarantee. Let $Dep^{Ins} < Dep$ be the total amount of deposits that are insured by FDIC. The same argument as above implies that the cost of the guarantee is given by the spread put option

$$V^G(A(0)) = V^G(A(0)|\text{no shock at } T_S)(1-p) + V^G(A(0)|\text{shock at } T_S)\, p$$

where

$$V^G(A(0)|\text{no shock at } T_S) = BSP(A(0), Dep+D_S^{Sec}, \sigma_A, r, T_S) - BSP(A(0), Dep+D_S^{Sec} - Dep^{Ins}, \sigma_A, r, T_S)$$

$$V^G(A(0)|\text{shock at } T_S) = BSP(A(0)x, Dep+D_S^{Sec}, \sigma_A, r, T_S) - BSP(A(0)x, Dep+D_S^{Sec} - Dep^{Ins}, \sigma_A, r, T_S)$$

There are four unobservable entries in these formulas: the value of assets today $A(0)$, the volatility of assets σ_A, the probability of a liquidity shock p, and the loss in case of a shock x. We choose these quantities to match four observables: the market capitalization of each bank on Oct 10th, 2008, the volatility of equity, as well as an estimate of market values of ST debt and LT debt on the same day. The estimated market value of debt is computed from CDS rates. First, we compute the average coupon and average maturity of debt, using data from Bloomberg. Second, we compute the present value of future (average) coupons and principal up to the (average) maturity, discounting them at the CDS implied yield

$$\text{Yield} = \text{Risk Free Rate} + \text{CDS Rate}$$

Given the value of LT debt, we compute the principal value of an equivalent zero coupon bond with five year to maturity (the maturity of CDS) as

$$D_L = \text{Value of Debt} * (1+\text{Yield})^5$$

For ST debt we apply the same methodology, although we do not have coupons in this case. Since we are interested in very short term probability of default, we considered a maturity of only three months in the calibration, and used the shortest maturity CDS (1 year) to compute the implied yield.

It is worth pointing out that the CDS implied yields under-estimates the true yield of bonds (see e.g. Longstaff et. all (2004)) and thus we over-estimate the value of debt in this case. We also computed the value of debt and implied transfers by treating the principal value as a zero coupon bond itself, thereby grossly under-estimating the value of debt. The transfers from equity holders to debt holders were very similar.

For the calibration after the announcement, on 10/14/2008, we control for other confounding news between 10/10/2008 and 10/14/2008 by exploiting the estimation results in Sections 2.1 and 2.2, which provide the increase in the values of equity and debt that control for the market variation and the variation in GE capital, respectively. In particular, we impose that the values of equity and debt on 10/14/2008 are equal to the respective values at 10/10/2008 plus the adjusted values. Because these adjustments do not regard the value of short-term debt, we perform a similar adjustment to the 1-year CDS rates of banks on 10/14/2008, in which we control for the percentage decline in the CDS rate of GE capital. The remaining part of the calibration on 10/14/2008 is the same as at the previous date.

Appendix C. Taxpayers VAR Calculations

For the Revised Paulson Plan, we compute the VaR from the perspective of tax payers as follows: First, we estimate the correlation structure of banks assets from the correlation of changes of short-term and long-term CDS rates. Second, we use these correlation structures to simulate the joint "liquidity shock" at T_S as well as the joint assets realization at $T=3$. More specifically, we compute the liquidity shock at T_S as follows: For each bank i, given a probability p_i of a liquidity shock, we compute a cutoff level $e_i=N^{-1}(p_i)$, where $N(.)$ denotes the cumulative standard normal distribution. We then simulate a vector $\varepsilon \sim \varphi(0,R)$, where $\varphi(0,R)$ denotes the multivariate normal density with correlation matrix R. A liquidity shock for bank i is declared if $\varepsilon_i<e_i$. The correlation structure for liquidity shocks R is obtained from the variance covariance of the changes in short-term CDS rates. We simulate the value of assets $A^*(T) = (A_1^*(T),\ldots, A_n^*(T))$ at T jointly according to the model

$$\log(A^*(T)) \mid_{A(Ts)} \sim N(\log(A^*(T_s) + (\mu-0.5\,\sigma_A^2)(T-T_S)\,,\, \Sigma_A(T-T_S)\ )$$

where Σ_A s the joint covariance matrix obtained from the correlation of CDS rate changes and the calibrated asset volatilities σ_A, and μ is the risk natural drift rate of assets, discussed further below. In this formula, for each bank i we have that its assets at T_S are given by

$$A_i^*(T_S)=\max(A_i(T_S)+ D_{Si} *1.25-(Dep_i+D_{Si}+D_{Si}^{Sec}),0)$$

To explain this formula, $A_i(T_S)$ denotes the amount of assets at TS, when the short term liabilities become "due". This is given by $A_i(T_S)= x_i A_i(T_{S-})$ with a probability π_i and $A_i(T_S)= A_i(T_{S-})$ with probability $(1-\pi_i)$, where π_i denotes the risk natural probability of a shock, discussed below. To compute the 3-year VaR we need to take into account the ability of banks to issue new debt, therefore we augment the asset value by the amount that the bank can issue at T_S minus the total liabilities that become due at TS, according to the model, namely, deposits Dep, unsecured ST debt D_S and secured ST debt D_{Si}^{Sec}. If the bank total net assets at TS are smaller than 0, the bank fails. As before, we simulate the vector $A(T_S)=(A_1(T_S),\ldots, A_n(T_S))$ jointly according to the model

$$log(A(T_S)) \sim N(log(A(0) + (\mu_0-0.5\ \sigma_A^2)T_S\ ,\ \Sigma_A T_S\ )$$

where μ_0 is the drift rate of assets before T*S* discussed further below.

For each bank *i* we then compute the Government disbursement at $T=3$ as the difference between $D - A(T)$, if any, where D equals the total LT debt maturing by T plus the new guaranteed debt D_S*1.25 issued at T_S, capitalized at the risk free rate to T (because it is government guaranteed), up to the maximum guarantee debt. To be conservative, we do not include "other liabilities" in D. On top of this, we compute the value of the investment in equity for the government, by using the Black and Scholes option pricing formula to compute the value of equity defined on the simulated assets at time T, minus of course the maturing guaranteed debt $D_S*1.25$, capitalized at the risk free rate to T. This approach ensures the correct correlation between losses from the guarantee and equity investment, as if a bank needs a government intervention because of losses on assets, its equity value ought to small as well, implying a double loss for the government. The potential losses are given by the sum of losses from the guarantee and from the equity position.

We compute the VaR for the other three cases (purchase of assets with and without overpayment, and pure capital infusion without guarantee) in an analogous manner. In particular consider the scenario in which the government purchases the banks' assets (with or without overpayment). Let $A_i(0)$ the amount purchased from bank *i*. We then simulate the value at $T=3$ of these assets $A_i(T)$ as above. For symmetry, we consider the also in this case a shock at T_S for the value of assets held by the government. In particular, we define the after-shock value of assets as $A_i^*(T_s)= A_i(T_S)$ if no shock occurs, and $A_i^*(T_s)= xA_i(T_S)$ if a shock occurs. The remaining calculations are the same, noting that in this case there is no guarantee in place, and thus all of the VaR is coming from the devaluation of the assets purchased.

Finally, for the case of a pure capital infusion we follow the same approach of simulating the value of assets at T=3. From the calibration we obtain the capital infusion necessary at 0 to yield a reduction in the value of CDS rates comparable to the ones in the data. From the capital infusion, we then obtain the percentage of government ownership of the bank and the value of initial assets of the bank (equal to old assets plus additional capital). We then simulate the value of assets at T as in the previous cases, taking into account that at TS the bank can fail if its assets are below the total amount of short term liabilities D. Recall that there is no guarantee in this case. At T, we compute the value of equity using the Black and Scholes formula for equity, and compute the profits/loss for the government as the difference from the initial capital infusion. We obtain the VaR number from the distribution of profits/losses at T.

One final important issue in the simulation of the asset value of each bank i, $A_i(T)$, is how to move from the risk neutral dynamics to the risk natural (physical) dynamics, which is needed for VaR calculations. To move from risk neutral to risk natural probability measure, it suffices to make an assumption about the risk premium on traded assets. We assume that the market value of these assets has a relatively generous Sharpe ratio of 35%. Note that the higher the Sharpe ratio, the higher is the expected value of future assets and thus the lower is the VaR. Given the assumed Sharpe ratio λ=35%, the annual drift rate of assets after T_S is then given by

$$\text{drift rate of assets} = \mu = \text{risk free rate} + \lambda\ \sigma_A$$

where σ_A is the volatility of assets. This transformation must hold for $t>T_S$. At T_S there is also the liquidity shock, and thus the drift rate of assets before T_S must be adjusted to ensure that the ex-ante Sharpe ratio is consistent with the possible crash. In particular, we proceed as follows: Let π denote the risk natural probability of a drop at T_S. Then, we first require that the return on assets over TS must still be μ, that is $E[A(T_S)]=A(0)\exp(\mu T_S)$, which in turn implies

$$E[A(T_S)] = (1-\pi)A(0)\exp(\mu_0 T_S)+ \pi\, x\, A(0)\exp(\mu_0 T_S)= A(0)\exp(\mu T_S)$$

or

$$\mu_0(\pi) = \mu - \log((1-\pi) + \pi x)/T_S$$

That is, for given π we can compute the drift μ_0 which ensures the proper expected return. We can then pin down π by imposing a Sharpe ratio also on the ex-ante investment. In particular, we can compute the variance of $A(T_S)$. The second moment is

$$\begin{aligned} E[A(T_S)^2] &= [(1-\pi) + \pi x^2]\, E[A(T_S)^2] = [(1-\pi) + \pi x^2]\, E[A(T_S)^2] \\ &= [(1-\pi) + \pi x^2] A(0)^2 \exp((2\mu_0+\sigma_A^2)T_S) \end{aligned}$$

yielding

$$\begin{aligned} V(A(T_S)) &= E[A(T_S)^2] - E[A(T_S)]^2 = \\ &= [(1-\pi) + \pi x^2] A(0)^2 \exp((2\mu_0+\sigma_A^2)T_S) - [(1-\pi)+\pi x]^2 A(0)^2 \exp(2\mu_0 T_S) \\ &= \{[(1-\pi) + \pi x^2]\exp(\sigma_A^2 T_S) - [(1-\pi)+\pi x]^2\}\, A(0)^2 \exp(2\mu_0 T_S) \end{aligned}$$

The T_S Sharpe Ratio is then the expected excess return $E[A(T_S)/A(0)-\exp(r T_S)]$ divided by the standard deviation $STD(A(TS)/A(0)) = V(A(T_S)/A(0))^{½}$, that is

$$\begin{aligned} SR &= E[A(T_S)/A(0)-\exp(r T_S)] / STD(A(T_S)/A(0)) \\ &= [(1-\pi) + \pi x - \exp(-(\mu_0(\pi)-r) T_S)] / \{[(1-\pi) + \pi x^2]\exp(\sigma_A^2 T_S) - [(1-\pi)+\pi x]^2\}^{½} \end{aligned}$$

We obtain the probability π by imposing SR = 0.35 $\sqrt{T_S}$. [In random walk-type of models, the Sharpe ratio is increases as a square root of time, as the expected return at the numerator increases linearly, but the standard deviation increases as a square root of time].

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Figure 1: CDS Rates

All the rates are in basis points per year. Source: Datastream

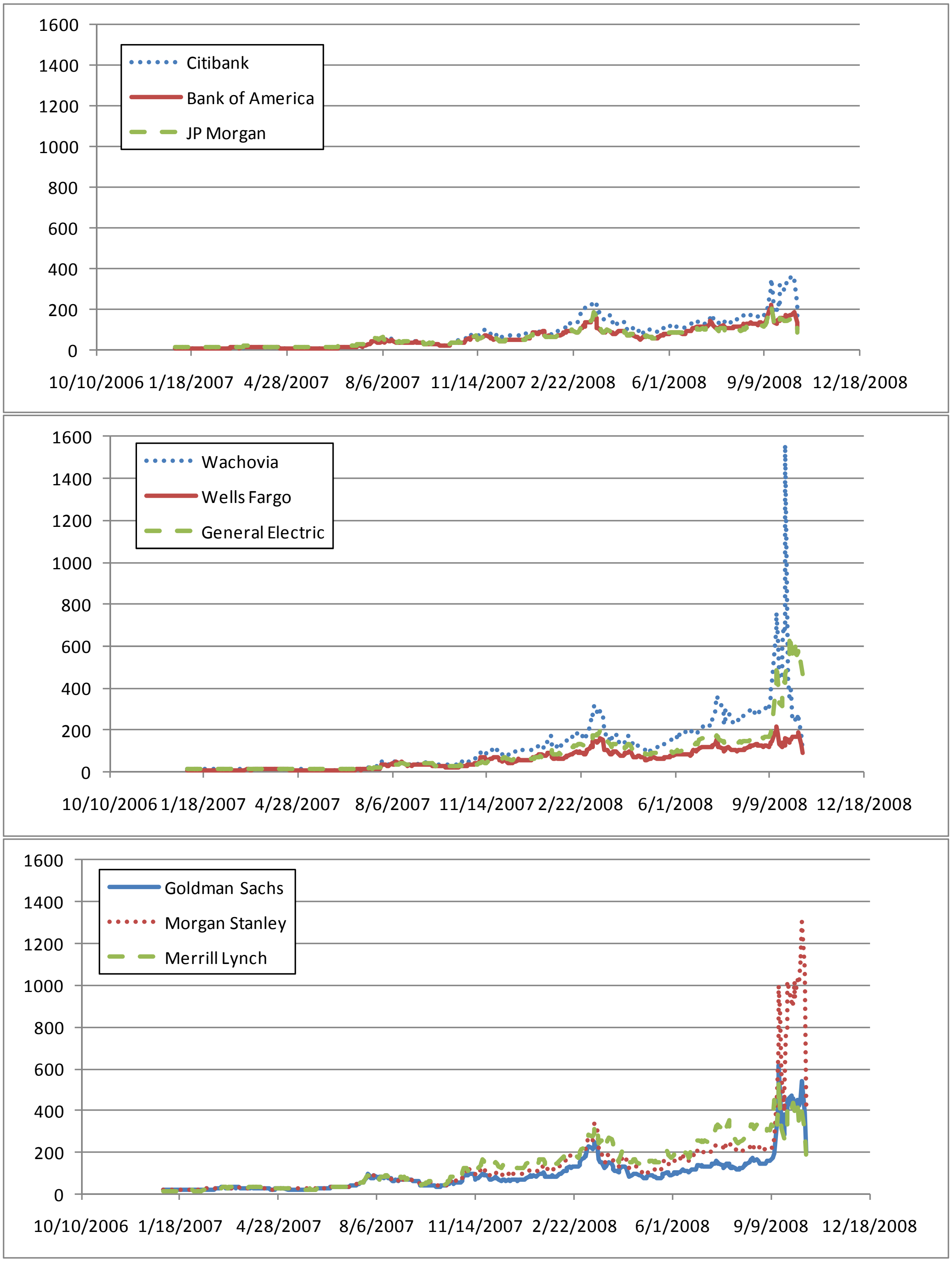


Figure 2: The Bank Run Index

The figure plots the difference $R_t = P_t(1) - P_t(2)$, where $P_t(n)$ is the conditional probability of default in year n after t, conditional on not defaulting before n. These conditional probabilities are inferred from the term structure of CDS rates.

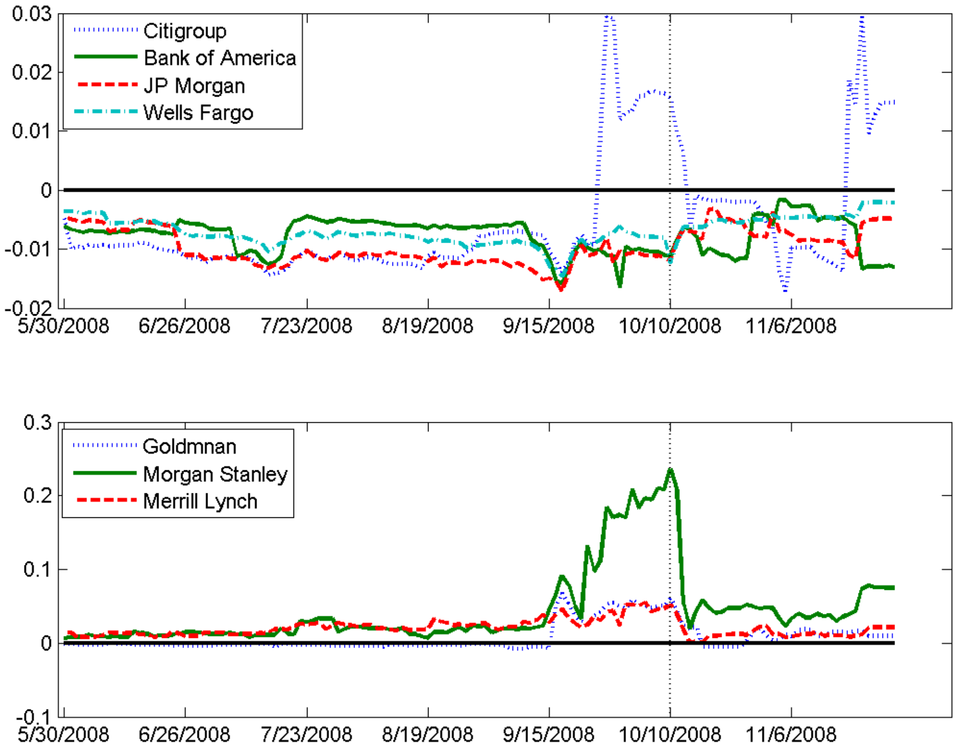


Figure 3: The Fear Index VIX

This figure plots the CBOE VIX index, the expected risk neutral volatility obtained from short term options. The vertical dotted line corresponds to the 10/10/2008.

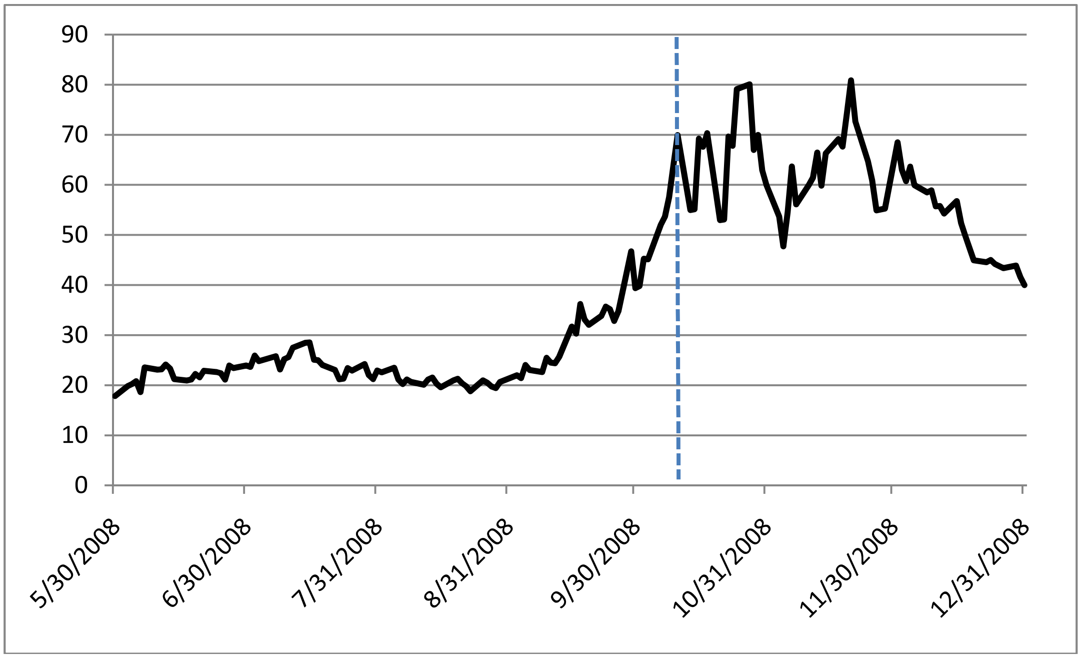


Figure 4: An Illustration of the Model

Assets *A(t)* move over time. At T_S there is the rollover of short term debt and deposits. However, at this time, there is also a probability *p* of a liquidity shock, which reduces the value of assets by *x*, that is, if the liquidity shock hits then $A(T_S)=x\,A(T_S-)$. If at T_S $A(T_S)<D_S$, there is default at T_S. In this case, equity and long term debt holders are wiped out, while short term bond holders receive $A(T_S)$. If $A(T_S)>D_S$, assets *A(t)* evolve according to a lognormal model until T_L. At T_L, default occurs if $A(T_L)<D_L$. In the computations we further divide the short term debt in deposits and short term debt, while long term debt include also other liabilities.

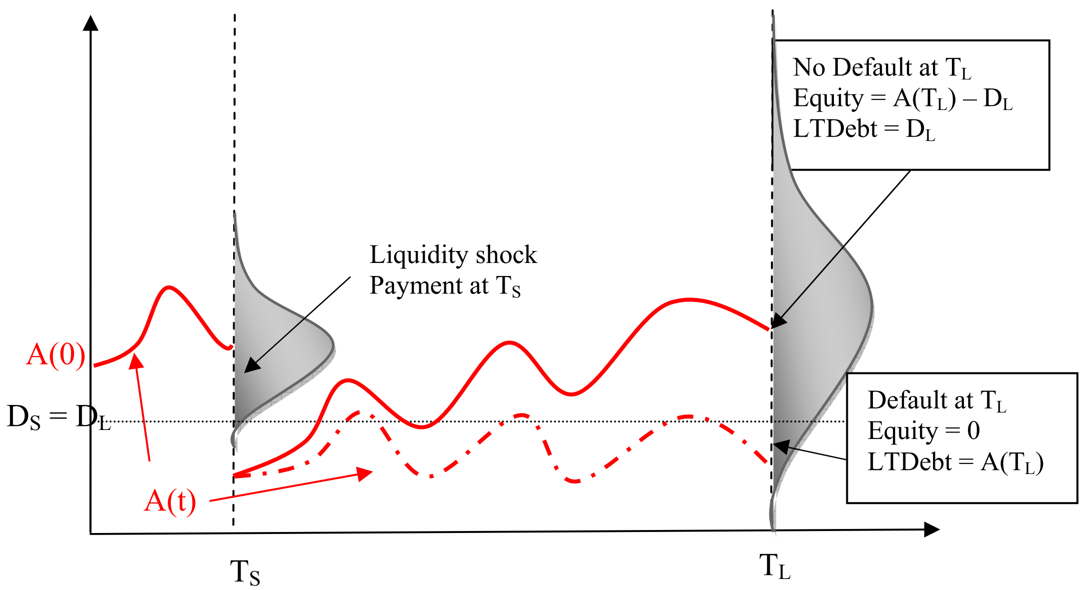
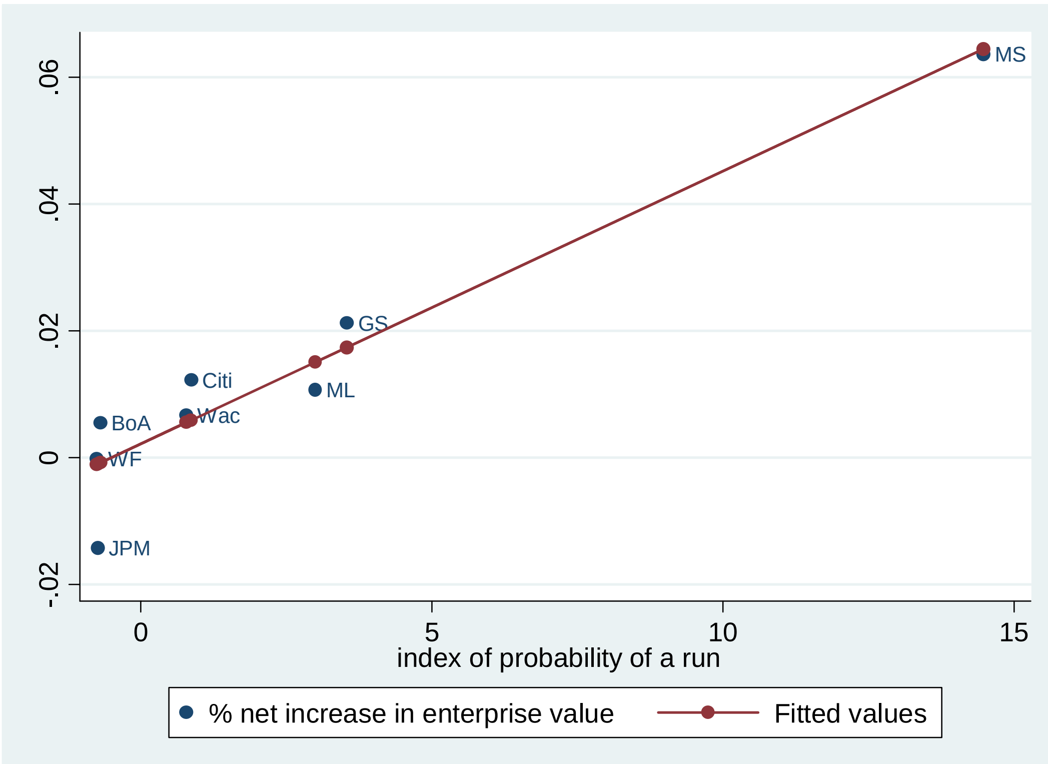


Figure 5: Predicting the size of the net value increase

Figure 5A plots the net percentage value increase at the announcement of the plan on the run index, i.e. the difference in the probability of default embedded in the 1-year CDS rates and in the 3-year CDS rates before the announcement. Figure 5b plots the net percentage value increase at the announcement of the plan on the equity market performance of the corresponding stock during the crisis, i.e. from 7/1/07 to 10/10/08.

5A: % Net Increase in Enterprise Value on Probability of Run



5B: % Net Increase in Enterprise Value on Previous Stock Market Performance

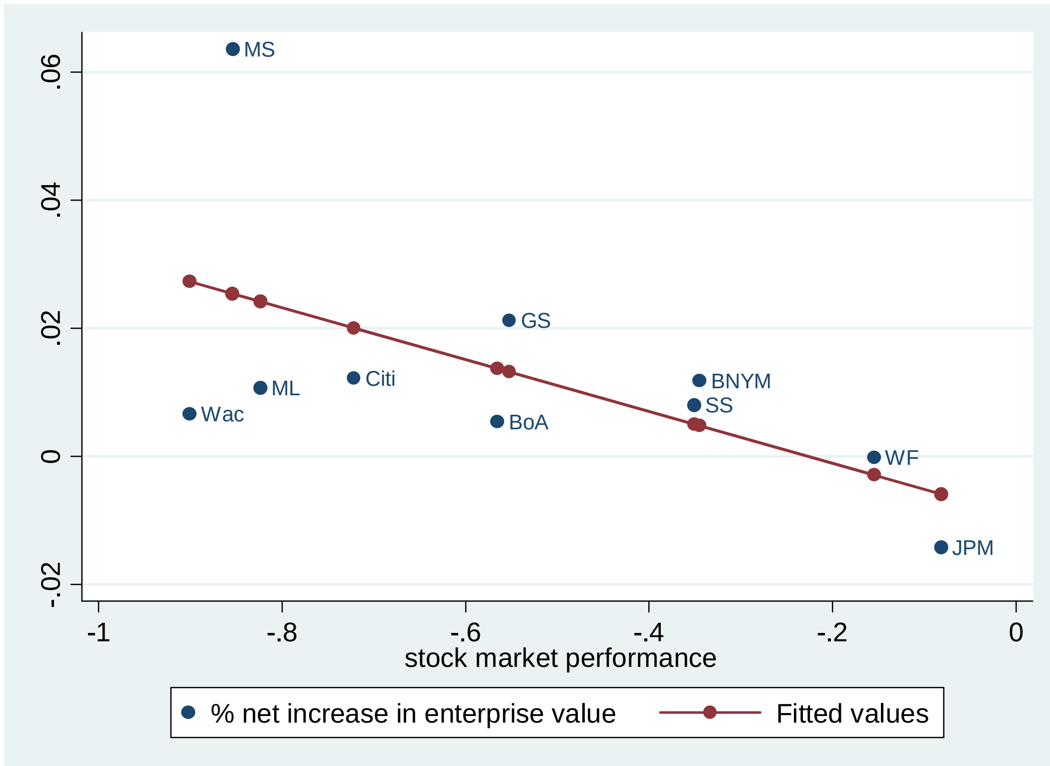


Figure 6: Difference in Equity Infusion

This figure compares the equity infusion under the Revised Paulson Plan and the equity infusion needed to match the observed adjusted reduction in the CDS rates observed after the announcement of the revised Paulson Plan (see Table 3). All the numbers are in billions of US$.

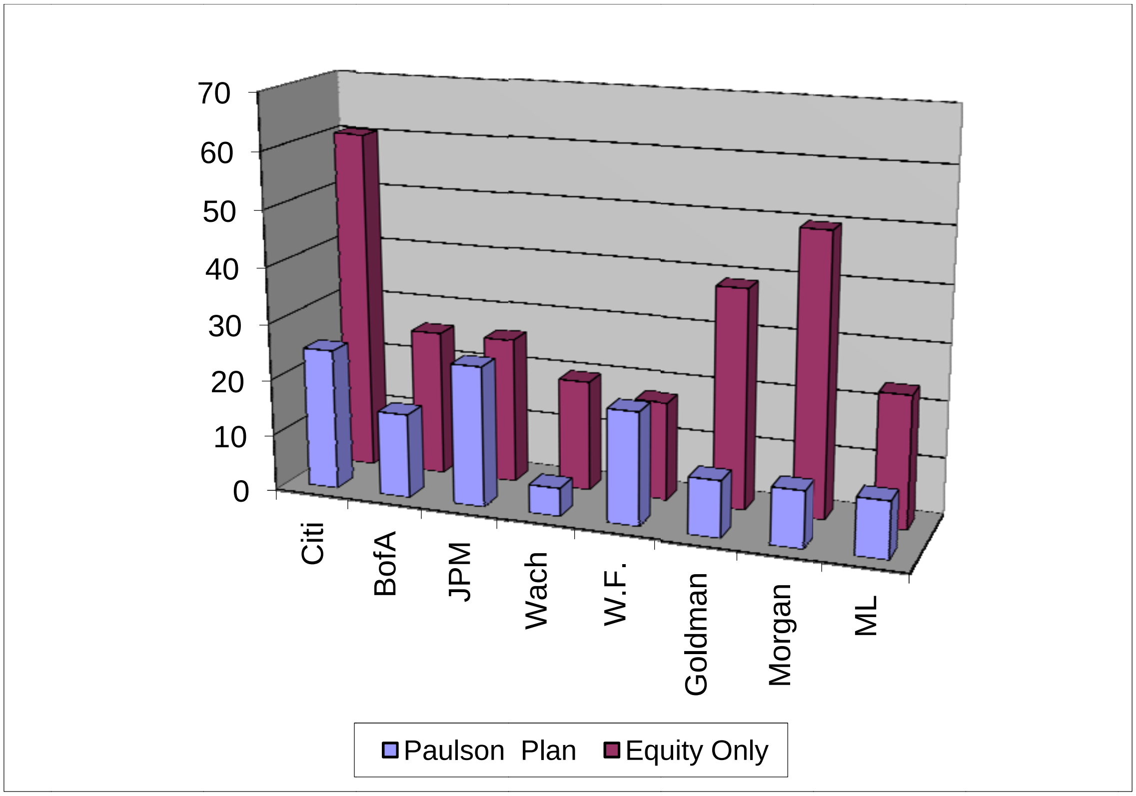


Table 1: The Revised Paulson Plan

Equity infusion is the amount of money (in billion of US$) the Government will invest in each of these banks according to the revised Paulson Plan. The price is the market value of common equity stock at closing on 10/14/2008. The number of shares (in billion) are as of 9/30/2008 as from the latest company filings. The number of warrants is 15% of the equity infusion divided by the price of common on 10/14/2008. The dilution factor, which is used to price the warrants, equal 1/(1+m/n), where m is the number of warrants and n the number of shares. The amount of guaranteed debt is 125% of the sum of the short term debt plus the long term debt maturing before June 30 2009.

	Equity infusion	Price 10/14/2008	# of outstanding shares	# of warrants	Dilution factor	Guaranteed debt
Citigroup	25	18.62	5.45	0.20	0.96	127.3
Bank of America	15	26.53	5.02	0.08	0.98	182.3
JP Morgan Chase	25	40.71	3.73	0.09	0.98	277.9
Wachovia	5	6.31	2.15	0.12	0.95	15.9
Wells Fargo	20	33.52	3.32	0.09	0.97	76.0
Bank of NY Mellon	3	34.76	1.15	0.01	0.99	3.6
State Street Corp	2	56.69	0.44	0.01	0.99	5.4
Goldman Sachs	10	122.9	0.43	0.01	0.97	80.9
Morgan Stanley	10	21.94	1.11	0.07	0.94	17.8
Merrill Lynch	10	18.24	1.60	0.08	0.95	32.1
Total	125.0					819.1

Table 2: Main Data on Banks Targeted by the Plan

Panel A reports balance sheet information for the banks targeted by the first phase of the plan. The information comes from the banks' 10Q filing as of 09/30/2008 (except Goldman Sachs and Morgan Stanley, whose data are as of 08/31/2008), which were the latest available on 10/10/2008. The data for the end of the third quarter are very similar. All figures in billions of US$. Panel B report some additional market information used in the analysis. Market capitalization is in billions of US$. The implied volatility is extracted from at-the-money call options on 10/10/2008 with the longest maturity available. Actual volatility is the annualized daily standard deviation of daily returns estimated during the period July-September 2008. The preferred yield is computed using the most recent preferred issue by each company that is trading. Dividend per share is obtained multiplying the last quarterly dividend times four.

Panel A: Balance Sheet data

	Deposits			Short Term Debt		Long				
		Non Interest	Percent			Term	Other	Total		Total
	Total	Bearing	Insured	Total	Unsecured	Debt	Liabilities	Liabilities	Equity	Assets
Citigroup	780.3	108.0	47.4	352.3	101.9	396.1	395.7	1,924.4	126.1	2,050.5
Bank of America	874.1	204.5	62.9	371.5	145.8	257.7	166.8	1,670.1	161.0	1,831.2
JP Morgan Chase	969.8	203.0	37.4	446.4	222.3	255.4	434.0	2,105.6	145.8	2,251.0
Wachovia	389.5	57.5	66.9	58.2	12.7	183.8	90.2	721.7	70.2	791.9
Wells Fargo	339.1	89.4	64.2	86.1	60.8	103.9	31.9	561.1	48.0	609.1
Bank of NY Mellon	174.2	81.7	3.1	20.3	2.9	15.5	30.0	240.0	27.5	267.5
State Street Corp	150.9	70.0	0.6	100.2	4.3	4.1	17.3	272.5	13.1	285.6
Goldman Sachs	29.1	0.0	14.3	443.5	64.7	176.4	387.2	1,036.2	45.6	1,081.8
Morgan Stanley	36.8	0.0	81.6	193.7	14.2	202.3	518.8	951.6	34.5	986.1
Merrill Lynch	90.0	0.0	85.3	242.9	25.7	232.5	272.0	837.4	38.4	875.8
Total	3,834			2,315		1,828	2,344	10,321	710	11,030

Panel B: Other Market Information

	Mkt. Cap	Implied	Actual	Preferred	Dividends
	10/14/08	Volatility	Volatility	yields	per share
Citigroup	101.5	77.59%	170.76%	12.46%	1.28
Bank of America	133.1	77.75%	193.52%	8.83%	2.56
JP Morgan Chase	151.7	57.37%	152.34%	8.84%	1.52
Wachovia	13.6	79.08%	696.48%	11.33%	0.20
Wells Fargo	111.3	56.48%	125.54%	8.73%	1.36
Bank of NY Mellon	40.0	85.79%	177.78%	8.16%	0.96
State Street Corp	24.7	67.00%	166.84%	7.25%	0.96
Goldman Sachs (a)	52.6	67.73%	90.50%	7.79%	1.40
Morgan Stanley (a)	24.3	88.57%	151.25%	11.16%	1.08
Merrill Lynch	29.2	82.23%	177.94%	11.55%	1.40
Average	68.2	73.96%	210.29%	9.61%	1.27
Total	681.9				

Table 3: Change in the Value of Long Term Debt around the Announcement of the Revised Paulson Plan

CDS rates refer to a five year debt instrument and are expressed in basis points per year. The source is Bloomberg. The probability of default is calculated as (1- CDS rate/100)/(1- Recovery rate), where we assume the recovery rate to be 20%. The adjusted gain is the present value of the reduction in insurance costs paid on all the debt outstanding, with the actual structure of maturity, as a result of a drop in the CDS rates, adjusted for the percentage reduction in GE cost. As a discount rate we use 3.5%. The debt and the adjusted gain data are in billion of US$.

	5 year	5 year			Long Term Debt			Net Derivative Payables		
	CDS spread	CDS spread	Raw	Adjusted	LT	GE Adj.	CDX Adj.	Amount	GE Adj.	CDX Adj.
	10/10/08	10/14/08	Decline	Decline	Debt	Gain	Gain	Net Deriv.	Gain	Gain
Citigroup	341.7	144.6	197.1	72.9	396.1	21.4	23.9	103.4	3.6	3.9
Bank of America	186.2	99.2	87.0	0.0	257.7	4.2	5.1	26.5	0.3	0.3
JP Morgan	162.5	88.0	74.5	0.0	255.4	3.6	4.2	85.8	0.8	0.9
Wachovia	267.5	109.2	158.3	34.1	183.8	7.5	8.4	13.4	0.4	0.4
Wells Fargo	186.7	89.8	96.9	0.0	103.9	1.6	1.8	10.8	0.1	0.1
Bank of NY Mellon					15.5					
StateStreet					4.1					
Goldman	540.0	201.7	338.3	214.1	176.4	17.6	19.0	103.9	6.7	7.1
Morgan Stanley	1300.9	427.1	873.8	749.6	202.3	51.6	54.4	68.4	11.8	12.5
Merrill Lynch	398.3	182.5	215.8	91.6	232.5	13.0	14.3	55.6	2.6	2.8
General Electric Capital	590.0	465.8	124.2							
CDX Index	213.0	176.8	36.2							
Total					1,828	120.5	131.3	467.8	26.3	28.0

Table 4: Change in the Value of Equity around the Announcement of the Revised Paulson Plan

Panel A refers to common equity, while Panel B to preferred equity. The market capitalization is price per share on 10/10/2008 times the number of shares outstanding. The betas are estimated from daily stock prices during the period 1/1/07-10/9/08. The daily prices are from Bloomberg. As a price for the preferred equity we use the most recently issued preferred of each company, assuming that all preferred of each bank have the same characteristics. The abnormal return equals raw return – beta * market return, where the market return (measures as S&P 500) increased by 11% over those two trading days. Value increase is the product of the initial market capitalization time the abnormal return. Market capitalizations and value increases are in billion of US$.

Panel A: Common Equity

	Market cap	Estimated	Raw	Abnormal return		Value increase	
	10/10/2008	Beta	return	Beta =1	Est. beta	Beta =1	Est. beta
Citigroup	76.89	1.97	0.32	0.21	0.10	16.1	7.9
Bank of America	104.71	2.08	0.27	0.16	0.04	16.9	4.4
JP Morgan Chase	155.19	1.77	-0.02	-0.13	-0.22	-20.5	-33.6
Wachovia	11.07	4.28	0.23	0.12	-0.24	1.3	-2.7
Wells Fargo	93.99	1.73	0.18	0.07	-0.01	7.0	-0.5
Bank of NY Mellon	30.48	1.85	0.31	0.20	0.11	6.2	3.3
State Street Corp	18.79	1.70	0.31	0.20	0.13	3.8	2.4
Goldman Sachs	38.01	1.60	0.38	0.27	0.21	10.4	7.9
Morgan Stanley	10.74	2.19	1.27	1.16	1.03	12.4	11.0
Merrill Lynch	25.20	2.47	0.16	0.05	-0.11	1.2	-2.8
Total	565.1					54.8	-2.8
Average		2.16	0.34	0.23	0.10		

Panel B: Preferred Equity

	Market cap	Estimated	Raw	Abnormal return		Value increase	
	10/10/2008	Beta	return	Beta =1	Est. beta	Beta =1	Est. beta
Citigroup	9.48	1.35	0.37	0.26	0.22	2.4	2.1
Bank of America	11.28	0.19	0.22	0.11	0.20	1.2	2.2
JP Morgan Chase	5.32	0.45	0.12	0.01	0.07	0.0	0.4
Wachovia	5.90	1.27	0.20	0.09	0.06	0.5	0.3
Wells Fargo	0.34	0.36	0.22	0.11	0.18	0.0	0.1
Bank of NY Mellon							
State Street Corp							
Goldman Sachs	0.74	0.50	0.21	0.10	0.15	0.1	0.1
Morgan Stanley	0.30	1.14	1.13	1.02	1.01	0.3	0.3
Merrill Lynch	4.50	1.03	0.39	0.28	0.28	1.3	1.2
Total	37.9					5.9	6.7
Average		0.79	0.36	0.25	0.27		

Table 5: Aggregate Effects of the Revised Paulson Plan

The changes in the value of common and preferred equity come respectively from Table 4a and Table 4b. The changes in the value of the debt and in net derivative payables come from Table 3. The total of change in derivative payables is equal to the sum of the individual components times 20%, to take into account collateralization and the fact that in aggregate most derivative transactions are between the large dealers. The total benefit is the sum of the three above components. The net cost of equity infusion comes from Table 6 and the net cost of the debt insurance from Table 7. The total cost is the sum of these two above components. The net benefit is the difference between the total benefit and the total cost. All figures are in billion of US$.

	Change in the value of common equity	Change in the value of preferred equity	Change in the value of debt	Change in value of derivative liabilities	Reduction in the cost of deposit insurance	Total	Net cost of equity infusion	Net cost of unsecured debt insurance	Cost of extendend deposit guarantee	Total	Net Benefit	% Net Benefit
Citigroup	7.9	2.1	21.4	0.7	1.1	33.3	4.8	3.0	0.4	8.2	25.1	1.2%
Bank of America	4.4	2.2	4.2	0.1	0.3	11.3	1.2	0.2	0.0	1.4	9.8	0.5%
JP Morgan Chase	-33.6	0.4	3.6	0.2	0.2	-29.4	1.8	0.6	0.3	2.7	-32.1	-1.4%
Wachovia	-2.7	0.3	7.5	0.1	0.7	5.9	0.7	0.2	0.0	0.9	5.0	0.7%
Wells Fargo	-0.5	0.1	1.6	0.0	0.2	1.3	1.5	0.0	0.0	1.5	-0.1	0.0%
Bank of NY Mellon	3.3	0.0			0.0	3.3	0.1		0.0	0.1	3.3	1.2%
State Street Corp	2.4	0.0			0.0	2.4	0.0		0.0	0.0	2.4	0.8%
Goldman Sachs	7.9	0.1	17.6	1.3	0.0	27.0	0.1	3.5	0.0	3.6	23.3	2.1%
Morgan Stanley	11.0	0.3	51.6	2.4	0.8	66.0	1.4	2.1	0.0	3.5	62.5	6.4%
Merrill Lynch	-2.8	1.2	13.0	0.5	0.4	12.3	1.7	1.3	0.0	2.9	9.4	1.1%
Total (pessimistic case	-2.8	6.7	120.5	5.3	3.7	133.3	35.8	10.8	0.7	47.3	86.0	0.8%
Total (oversight panel)	-2.8	6.7	120.5	5.3	3.7	133.3	28.4	10.8	0.7	39.9	93.4	0.8%
Total (optimistic case)	-2.8	6.7	120.5	5.3	3.7	133.3	13.2	10.8	0.7	24.8	108.6	1.0%
Without Morgan Stanley												
Total (pessimistic case	-13.8	6.4	68.9	2.9	2.9	67.3	32.7	8.7	0.7	42.2	25.2	0.2%
Total (oversight panel)	-13.8	6.4	68.9	2.9	2.9	67.3	24.2	8.7	0.7	33.6	33.7	0.3%
Total (optimistic case)	-13.8	6.4	68.9	2.9	2.9	67.3	11.8	8.7	0.7	21.3	46.1	0.4%

Table 6: Shareholders' Net Gain from the Government's Equity Infusion

This table provides two estimates of the present value of the claims the government is receiving in exchange for the equity infusion. In Panel A the present value of the preferred is computed using the yield to maturity of the bonds and the warrant is assumed to have a maturity of ten years. In Panel B the present value of the preferred is computed using the CAPM beta, while the warrant is assumed to have an effective maturity of 3 years since it is not protected against the payment of dividend after that date. Finally, the Congressional Oversight Report provided valuation of the same claims for all of our banks, except Merrill Lynch, Bank of NY Mellon and State Street. We impute their values using the average difference between our valuation the Report valuation for the common set of banks. In addition, Wachovia and Wells Fargo are reported jointly in the Report, and we split their values according to the equity infusion percentage in the second column.

Panel A: Optimistic

	Our calculations						Congr. Oversight Report	
	Equity Infusion	Theoretical Value of Preferred	Theoretical Value of Warrant	Total Theoretical Value Claim	Difference		Total Theoretical Value Claim	Difference
Citigroup	25	18.1	13.6	20.2	4.8		15.5	9.5
Bank of America	15	12.7	7.4	13.8	1.2		12.5	2.5
JP Morgan Chase	25	21.2	13.3	23.2	1.8		20.6	4.4
Wachovia	5	3.8	3.3	4.3	0.7		4.6	0.4
Wells Fargo	20	17.0	10.2	18.5	1.5		18.6	1.4
Bank of NY Mellon	3	2.6	2.2	2.9	0.1		2.6	0.4
State Street Corp	2	1.8	1.4	2.0	0.0		1.8	0.2
Goldman Sachs	10	8.9	7.0	9.9	0.1		7.5	2.5
Morgan Stanley	10	7.7	6.4	8.6	1.4		5.8	4.2
Merrill Lynch	10	7.5	5.4	8.3	1.7		7.2	2.8
Total	125.0	101.3	70.0	111.8	13.2		96.6	28.4

Panel B: Pessimistic

	Our calculations						Minimum between pessimistic and Congr. Oversight Report		
	Equity Infusion	Theoretical Value of Preferred	Theoretical Value of Warrant	Total Theoretical Value Claim	Difference		Value Claim	Difference	
Citigroup	25	16.5	10.1	18.0	7.0		15.5	9.5	
Bank of America	15	9.6	5.8	10.5	4.5		10.5	4.5	
JP Morgan Chase	25	17.3	8.4	18.6	6.4		18.6	6.4	
Wachovia	5	1.9	2.2	2.2	2.8		2.2	2.8	
Wells Fargo	20	14.0	6.5	15.0	5.0		15.0	5.0	
Bank of NY Mellon	3	2.0	1.5	2.3	0.7		2.3	0.7	
State Street Corp	2	1.4	0.8	1.5	0.5		1.5	0.5	
Goldman Sachs	10	7.2	4.3	7.9	2.1		7.5	2.5	
Morgan Stanley	10	6.2	4.7	6.9	3.1		5.8	4.2	
Merrill Lynch	10	5.8	4.1	6.4	3.6		6.4	3.6	
Total	125.0	81.9	48.4	89.2	35.8		85.3	39.7	

Table 7: Cost of the Bank Debt Guarantee Provided by the FDIC

The CDS rates, in basis points, are for a three year contract and are obtained from Datastream. All the balance sheet information is as of 09/30/08, apart from Goldman Sachs and Merrill Lynch whose values are as of 08/31/08. The total debt guaranteed is 125% of the short term unsecured debt. The total cost of the Government guarantee is discounted value of the difference between the value of this guarantee (CDS rate times the value of the debt guaranteed) minus the cost to the banks (75 basis points times the value of the debt guarantee) over the period of the guarantee (the next three years). All values in billions of US$, exception made for the CDS rates.

			Debt Insurance		Deposit Insurance		
	Unsecured Short term Debt	3-year CDS spread 10/14/2008	Total Guaranteed debt	Total Cost of Insurance	Uninsured Non-Int. bearing Deposits	Total Cost of Insurance	Savings from Deposit Guarantee
Citigroup	101.9	155.9	127.3	3.0	56.8	0.39	1.1
Bank of America	145.8	79.1	182.3	0.2	75.9	0.03	0.3
JP Morgan Chase	222.3	82.3	277.9	0.6	127.1	0.28	0.2
Wachovia	12.7	117.3	15.9	0.2	19.1	0.00	0.7
Wells Fargo	60.8	74.1	76.0	0.0	32.1	0.00	0.2
Bank of NY Mellon	2.9		3.6				
State Street Corp	4.3		5.4				
Goldman Sachs	64.7	227.7	80.9	3.5	0.0	0.00	0.0
Morgan Stanley	14.2	490.3	17.8	2.1	0.0	0.00	0.8
Merrill Lynch	25.7	213.5	32.1	1.3	0.0	0.00	0.4
Total	655.3		819.1	10.8	310.8	0.7	3.7

Table 8: Summary of Robustness Check Results

This table reports the final aggregate results from numerous robustness checks. Each column reports the final net benefit of the government intervention from Table 5. The four cases corresponds to the four assumptions we made in the calculations, namely optimistic / pessimistic in terms of the valuation of the securities the U.S. government received in exchange of the capital infusion (see Table 6) and with or without Morgan Stanley, whose price moved also because of the announcement of a capital infusion from Mitsubishi. Each row reports the parameter we changed compared to the base case, reported in the first row.

	With Morgan Stanley				**W/o Morgan Stanley**		
		Oversight				**Oversight**	
	Pessimistic	**Report**	**Optimistic**		**Pessimistic**	**Report**	**Optimistic**
Base Case	86.0	93.4	108.6		25.2	33.7	46.1
CDS recovery 0%	93.7	101.1	116.3		28.6	37.2	49.5
CDS recovery 40%	75.0	82.5	97.6		20.1	28.7	41.0
LIBOR discount	84.2	91.6	106.8		23.8	32.4	44.7
Control by CDX	97.5	105.0	120.1		33.8	42.4	54.7
Beta - 2 St. Err	96.3	103.7	118.9		35.3	43.8	56.2
Beta + 2 St. Err	77.0	84.4	99.6		16.4	25.0	37.3
100% Derivatives Exposure	107.8	115.2	119.3		37.5	57.1	58.4
50% Derivative Exposure	94.6	102.0	106.1		30.2	49.8	51.1
30% Deadweight Cost of Tax	72.7	82.4	91.0		13.4	35.6	40.6
54% Deadweight Cost of Tax	63.4	74.5	86.2		5.1	29.0	36.5
Average	86.2	94.2	106.4		24.5	37.7	46.9

Table 9: Implied Estimates of the Cost of Bankruptcy

This table estimates the value of bankruptcy costs implicit in the market response to the Paulson Plan. The first two columns report the total enterprise value (book value of debt and preferred plus market value of common equity) and the change in the market value of each of the banks involved in the Paulson Plan (all values are in billions of US$). The third and fourth columns report the risk neutral probability of bankruptcy embedded in the CDS rates before and after the announcement. Columns five and six report the implicit estimate of the bankruptcy costs calculated according to formula (8) in the text.

	Enterprise Value	Change in Enterprise Value	Prob of default 10-Oct	Prob of default 14-Oct	Estimated Bankrupcty Costs bn $	Estimated Bankrupcty Costs %
Citigroup	2,026	25	5.08	2.16	147	7.3%
Bank of America	1,803	10	1.43	0.76	100	5.5%
JP Morgan	2,257	-32	1.42	0.77		
Wachovia	735	5	4.05	1.66	34	4.6%
Wells Fargo	672	0	1.45	0.69		
Bank of NY Mellon	280	3				
StateStreet	297	2				
Goldman	1,089	23	9.74	3.72	93	8.5%
Morgan Stanley	976	62	30.33	8.26	162	16.6%
Merrill Lynch	867	9	7.69	3.26	65	7.5%
Total	11,002					
recovery rate	0.2					
discount rate	0.1					

Table 10: Value Transferred to Long Term Debt by Equity Infusion

This table estimates the changes in the value of equity due only to the infusion of equity. The first two columns report the value in the model of long term debt and equity before the equity infusion, columns 3 and 4 report the value of long term debt and equity after the equity infusion reported in column 5. Columns 6 and 7 report the difference in the value of debt and equity as a result of the equity infusion. The last column reports what fraction of the equity infusion goes to increase the value of the long term debt. All values in billions of US$, exception made for the fraction of equity infusion to debt.

	Enterprise Value	Change in Enterprise Value	Prob of default 10-Oct	Prob of default 14-Oct	Estimated Bankrupcty Costs bn $	Estimated Bankrupcty Costs %
Citigroup	2,026	25	5.08	2.16	147	7.3%
Bank of America	1,803	10	1.43	0.76	100	5.5%
JP Morgan	2,257	-32	1.42	0.77		
Wachovia	735	5	4.05	1.66	34	4.6%
Wells Fargo	672	0	1.45	0.69		
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StateStreet	297	2				
Goldman	1,089	23	9.74	3.72	93	8.5%
Morgan Stanley	976	62	30.33	8.26	162	16.6%
Merrill Lynch	867	9	7.69	3.26	65	7.5%
Total	11,002					
recovery rate	0.2					
discount rate	0.1					

Table 11: Explaining the Changes in the Market Value of Debt and Equity

This table confronts the changes in the value of debt (panel A) and equity (panel B) predicted by the model with the actual changes observed in the market place. The changes in the value of the debt should be the value transferred as a result of the equity infusion (first column) and of the debt guarantee (second column). The changes in the value of equity after the equity infusion is announced (but before it is executed) are the sum of the expected gain from the equity infusion due to the fact that the government pays more than what he receives (see Table 6) minus the transfer to the debtholders (Table 8). The previous to the last column reports the fraction of the debt guarantee that does appear to have been absorbed by debtholders (last column of Panel A). The last column is the difference between the market value changes (column IV), the total predicted value changes (column 3) and the residual benefit of debt guarantee (column 5). All the figures are in billions of US$.

Panel A: Changes in the Value of Debt

	Market changes	Model transfer from equity	Net insurance benefits	Total	Difference	Eliminate Liquidity Shock	Difference
Citigroup	21.4	9.4	3.0	12.4	9.0	3.5	5.5
Bank of America	4.2	3.3	0.2	3.5	0.7	0.6	0.1
JP Morgan Chase	3.6	4.2	0.6	4.8	-1.2	0.7	-1.9
Wachovia	7.5	2.5	0.2	2.7	4.8	0.9	3.9
Wells Fargo	1.6	2.6	0.0	2.6	-1.0	0.3	-1.3
Bank of NY Mellon		0.0		0.0			
State Street Corp		0.0		0.0			
Goldman Sachs	17.6	4.4	3.5	7.9	9.7	2.8	6.9
Morgan Stanley	51.6	6.8	2.1	8.9	42.6	7.2	35.4
Merrill Lynch	13.0	4.8	1.3	6.1	6.9	3.0	3.9
Total	120.5	38.0	10.8	48.9	71.6	19.1	52.5

Panel B: Changes in the Value of Equity

	Change in Market value		Net gain of equity: Net gain from equity infusion	Transfer to debt	Total
Citigroup	7.9		4.8	9.4	-4.6
Bank of America	4.4		1.2	3.3	-2.1
JP Morgan Chase	-33.6		1.8	4.2	-2.4
Wachovia	-2.7		0.7	2.5	-1.8
Wells Fargo	-0.5		1.5	2.6	-1.1
Bank of NY Mellon	3.3		0.1	0.0	0.1
State Street Corp	2.4		0.0	0.0	0.0
Goldman Sachs	7.9		0.1	4.4	-4.3
Morgan Stanley	11.0		1.4	6.8	-5.5
Merrill Lynch	-2.8		1.7	4.8	-3.2
Total	-2.8		13.2	38.0	-24.8

Table 12: Change in the value of assets implied by the model

In the extended Merton (1974) model described in Appendix B, we choose the four unobservable variables (value of assets today A(0), volatility of assets σA, probability of a liquidity shock p, and loss in case of a shock x) to match the four observables: the market capitalization of each bank, the volatility of equity, the estimated of market value of ST debt, and the estimated market value of LT debt. The estimated market value of debt is computed from CDS rates. The first four columns report the value estimated by using the October 10, 2008 data, while the second four columns the value estimated by using the October 14, 2008 data. The previous to the last column report the difference between the value of assets estimated the two days and the last column reports the change in the value of assets as derived in Table 5 (common equity, preferred equity, debt). All the $ figures are in billions of US $. The volatilities and the probabilities are in percentage terms. The recovery rate is the fraction of value recovered.

	Values estimated on 10/10/2008				Values estimated on 10/14/2008					Estimated	Actual
	Asset	Asset	Prob of	Recovery	Asset	Asset	Prob of	Recovery		changes in	changes in
	Volatility	Value	run	Rate	Volatility	Value	run	Rate		asset value	asset value
Citigroup	9.5	1,915	1.00	0.25	8.8	1,945	0.69	0.29		29.8	31.4
Bank of America	11.4	1,748	0.27	0.31	11.3	1,758	0.21	0.31		10.5	10.9
JP Morgan Chase	9.3	2,202	0.28	0.30	7.7	2,172	0.22	0.31		-30.0	-29.7
Wachovia	7.3	708	0.54	0.27	5.8	713	0.31	0.33		4.6	5.1
Wells Fargo	20.1	651	0.28	0.27	19.2	652	0.21	0.27		0.9	1.1
Bank of NY Mellon											
State Street Corp											
Goldman Sachs	8.0	999	1.91	0.23	7.2	1,024	1.25	0.26		24.6	25.6
Morgan Stanley	7.0	825	5.71	0.15	5.3	887	3.17	0.16		62.3	62.9
Merrill Lynch	7.8	803	1.50	0.24	6.2	813	1.04	0.28		10.3	11.4
Average	10.1		1.4	0.3	8.9		0.9	0.3			
Total		9,851				9,964				113	119

Table 13: Cost of Alternative Plans

This table measures the Revised Paulson Plan along four dimensions and compares it along these dimensions with four alternatives. The four dimensions are: the amount of funds required by the plan, the ex ante cost of the plan for taxpayers, the value at risk for taxpayers (5% probability of a loss in three years), and the percentage of ownership the Government would have acquired if it invested in straight equity. All the plans in Panel A are constrained to deliver a reduction in CDS rates at least as big as the adjusted decline reported in Table 3. All the plans in Panel B are constrained to deliver a reduction in CDS rates at least as big as the raw decline reported in Table 3. All the figures are in billions of US$.

Panel A: Target = adjusted reduction in CDS rates

	Revised Paulson Plan	Original Paulson Plan: Asset Purchase		Pure Equity Infusion	Long-term Debt for Equity Swap
		no over payment	20% over payment		
Investment required	125	3,084	953	261	0
Net cost to taxpayers	49	0	191	65	0
5% 3 year Value at Risk	98	127	49	211	0
% of banks owned by Government	20%	0	0	40%	0

Panel B: Target = raw reduction in CDS rates

	Revised Paulson Plan	Original Paulson Plan: Asset Purchase		Pure Equity Infusion	Long-term Debt for Equity Swap
		no over payment	20% over payment		
Investment required	125	4,585	1,654	495	0
Net cost to taxpayers	49	0	331	139	0
5% 3 year Value at Risk	93	203	88	363	0
% of banks owned by Government	20%	0	0	52%	0