Preliminary Draft

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 system. We estimate that the revised Paulson plan increased the value of banks' financial claims by $109 billion at a taxpayers' cost of $112 -135 billions, creating no value in the banking sector. We compare the cost of Paulson's plan with the costs of alternative solutions that would have achieved the same objective in term of solvency of the banking system. We find that the revised Paulson plan is the most expensive for the taxpayers, second only to the original Paulson plan. The biggest beneficiaries of this massive redistribution were the debtholders of financial institutions, especially those of the three former investment banks and of Citigroup. The equity holders just broke even.

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On Monday, October 13, 2008, U.S. Treasury Secretary Hank Paulson announced the largest U.S. government intervention into the financial sector in history. The plan included a $125bn 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 all new bank debt issues, which we estimate to be worth approximately $99`bn. Did this plan create any value? Who were the main beneficiaries?

Given the worldwide changes in financial markets occurring between Friday the 10th and Tuesday the 14th, 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) prices, 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 prices 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 $105bn. If we add to these changes, the abnormal variation in the market value of common equity (-$2.6bn) 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 $109bn.

This increase, however, came at a significant 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 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 $99bn. This brings the total taxpayers' cost at between $112bn and $135bn. Hence, in the banking sector the plan destroyed between $3bn and $26bn.

During the event window (Oct 10-14), however, Mitsubishi confirmed the $9bn investment in Morgan Stanley. Consequently, part of Morgan Stanley return may be attributed to this positive news. When we exclude Morgan Stanley from the calculations, we estimate the plan net benefit between \$4bn and -\$17. In other words, the Paulson's plan simply amounts to a redistribution of money from taxpayers to the investors in the major financial institutions. Possibly a costly redistribution, in fact, where a fraction of the money transferred was lost.

This result might not be surprising: the plan was enacted to benefit the economy, not the banking sector. Yet, it is hard to see how the former objective can be accomplished without the latter. If the goal of the plan was to stop a run on the banking sector, the enterprise value of banks, saved from inefficient runs, should have increased more than the money taxpayers put in them. Similarly, if the plan's goal was to alleviate the undercapitalization of the banking sector and in so doing regenerate the incentives for banks to lend to the economy, we should observe banks' enterprise value to increase unless the borrowers capture all the value of the new lending.[1] These results do not allow us to conclude that the plan was useless: it could have succeeded in helping the economy through other channels, for instance by stopping investors' panic.

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. This model estimates that in the absence of the debt guarantee the shareholders would have lost \$25bn and the debtholders would have gained \$39bn. By adding the value of the debt guarantee we are able to approximate fairly well the market value increase of the debt. By contrast, the model overestimates the negative impact of the plan on equityholders. The model predicts a loss of \$25bn when the actual loss from variation in market prices is only \$3bn. The difference could be due to the fact that part of the benefit of the debt insurance is captured by equity since the company has to pay less to finance the debt.

Finally, we try to evaluate whether the same objective could have been achieved at a lower cost to taxpayers. If the main goal was to make banks solvent, we assume that

[1] This would required that the banking sector is perfectly competitive, a hard assumption given the extremely high rate of return of equity enjoyed by banks in recent years.

the objective is to achieve a reduction in the CDS prices 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. We find that the revised Paulson plan is the most expensive for the taxpayers, but it limits the value at risk and the Government ownership of banks.

The rest of the paper proceeds as follows. Section 1 describes the plan announced by Paulson 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 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 Revised 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 11th-12th 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 Secretary Hank Paulson announced his 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 Paulson's intentions. 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 two parts. First, the Government injects $125 billion 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 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 equity infusion with a strike price equal to the average price of the stock in the twenty working days before the equity 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 bank debt until June 30, 2009.[2] The FDIC guarantee is for a maximum of 125% of the sum of the short-term debt and the long-term debt maturing between now and June 2009. The last column of Table 1 approximates this debt using all the short-term debt plus the long-term debt maturing in 2008 plus half of the long term debt maturing in 2009.

Table 2 provides some information of the capital structure of these banks before the announced deal.

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

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

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

2.1 An Event Study on Bonds

The credit default swap 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. In other words, a credit default swap is an insurance against the risk of default. The price of this insurance is quoted as basis points of premium per year per notional amount of $100.

The market for CDSs, barely existing in 1999, reached more than $40 trillion of notional amount by 2007. 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 prices 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 prices. 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

$$\text{(1)} \qquad B + PV(\text{Insurance Cost}) = GB.$$

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 price) 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:

$$\text{(2)} \qquad PV(\text{Insurance Cost}) = \sum_{t=0}^{T} \frac{(1-\pi)^t \frac{CDS}{10000} * D_t}{(1+r_f)^t}$$

We can infer the risk-neutral probability of default π from the CDS prices themselves by assuming an expected recovery rate:

$$\pi = \frac{\frac{CDS}{10000}}{1 - \text{recovery rate}}.$$

This probability is then assumed constant over the maturity of the bonds.

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 (1) 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

$$\Delta PV(CDS) = \sum_{t=0}^{T} \frac{(1-\pi_1)^t \frac{CDS_1}{10000} * D_t}{(1+r_f)^t} - \sum_{t=0}^{T} \frac{(1-\pi_0)^t \frac{CDS_0}{10000} * D_t}{(1+r_f)^t}, \tag{3}$$

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

2.1.2 Application

We looked for CDS prices (the most liquid) for each of the ten banks involved. Even restricting our analysis to the 5-year contracts (the most liquid), we were unable to find the CDS prices for the two smallest banks (Bank of New York and State Street). Given the small amount of outstanding debt they have, we can ignore them without much of an effect on the results. Figure 1 plots these prices for the eight banks for which they are available from 1/1/2007 to 10/12/2008. The numbers for the relevant dates are reported in Table 3. By assuming a recovery rate equal to 20%, the risk neutral probability of default before and after the announcement are the one reported in the third and fourth column of Table 3, respectively. [3] As a discount rate and we use the average between the three year and the ten year bonds, which turns out to be 3.5%.

[3] The historical average recovery rate of bonds is about 40%, but it declines to about 20% during recessions (see e.g. Chen (2008)). Our results become stronger if we assume 40% recovery.

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 prices between Friday, October 10 and Tuesday October 14 (see Table 3). We then apply formula (3) 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 prices before the week-end.

To identify the impact that other factors could have had on the CDS prices of financial firms we look at the CDS prices of the largest financial firm not involved in the intervention: GE Capital. Interestingly, the CDS price 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.[4]

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 (3) the percentage change in insurance costs of GE capital (our control) multiplied by the ex-ante cost of insurance of the bank:

[4] The Warren Buffett investment in General Electric had been announced on October 1st, so it could not have impacted the CDS prices between the 10th and the 14th.

$$(4) \qquad Adjusted\,\Delta PV(CDS) = \Delta PV(CDS) - PV_0(CDS) \times \frac{\Delta PV^{GE}(CDS)}{PV_0^{GE}(CDS)}$$

The results are in column 8 of Table 3. Overall, the bonds gained $105bn in value. The bonds of the three old investments banks gained the most from the plan. The adjusted gains of the three were $62bn. Among the old commercial banks Citigroup stood to gain the most, both in level, $22bn, and in percentage of outstanding debt, 5.3%. Since these results depend on the assumptions about recovery rate, assumed at 20% in our base case, we also compute the gain in bonds under other assumptions: For instance, a 0% recovery implies a total gain of $112bn, while a 40% recovery – the historic average in United States – implies a total gain of $93bn.[5]

A reasonable concern about our control is that General Electric Capital may have being affected by its own idiosyncratic shocks during the event window. As an additional robustness check we therefore also 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. One complication on performing the adjustment in expression (4) 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 (2)) 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 contained in the last columns of Table 4. They are very similar to the case in which GE Capital was used as a control. In particular, overall the bonds gained $107bn in value.

[5] As additional robustness check, we also computed the adjustment using a simpler approach in which we adjust the CDS itself by the change in CDS of GE: Adjusted $\Delta CDS = \Delta CDS - \Delta CDS^{GE}$. The resulting total gain of debt was $78bn with zero recovery, and much less with higher recovery rates. However, adjusting only the CDS spreads themselves does not take into account the full change in insurance costs, which also depend on the probability of default.

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 we know that the equity betas of firms close to default tend to 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 2.1. 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 (-$2.6bn). 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 the puzzle.

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, we choose to use as a reference price for all the preferred shares outstanding 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.[6] 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 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 were within the group of these ten banks. When we look at the list of derivative positions as reported by the Controller of the Currency, 97% are held by these players. Hence, the change in the value of these contracts can change the distribution, but not the overall value.

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 $105bn, the market value of preferred by $6.7bn, while the market value of equity dropped by $2.6bn. Overall, the total value of financial claims in the top ten banks increased by $109bn 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

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

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 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.[7] Note that Paulson's plan forbids banks from increasing dividends without authorization from the Treasury only for the

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[7] 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.

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 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.[8]

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 equity infusion cost taxpayers between $13 and $36bn.

3.2 Cost of the Debt Guarantee

The FDIC offered a government guarantee to all new issues of bank debt until June 2009 for three years. To measure the ex ante cost of this guarantee we will make use once again of the CDS prices, 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 debt which is guaranteed by the government. Thus, it is as if they save the cost of insuring their own new debt for three years. The price the FDIC charges for this is 75 basis points. Since this guarantee is limited to 125% of the existing 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 prices minus the 75 basis points. This is the annual cost. Discounted over three years at the 3.5% rate, this amounts to $99 bn.

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

The biggest beneficiaries of this guarantee are Morgan Stanley, $50bn; Goldman Sachs, $22bn; and Merrill Lynch, $13bn. Among the old commercial banks the biggest beneficiary is Citigroup with $11bn.

Some might argue that this is a hypothetical cost. If the Government ensures none of these banks fail, the realized cost of this guarantee is zero. 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 price 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 trillion, each additional 10 basis points on the CDS correspond to $10.5bn of additional cost for the taxpayers.

3.3 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 $109bn, but this goal was achieved at a cost that in the more optimistic valuation is $112bn and in the less optimistic one $135bn, with a net effect between -$3bn and -$26bn. Note that the FDIC guarantee on the new debt ($99bn) represents the vast majority of this cost, while the net cost of the equity infusion (between $13bn and $36bn) is relatively limited. .

These estimates are obtained attributing all the gains of Morgan Stanley to the revised Paulson plan. If we exclude Morgan Stanley from the analysis, the value increase is only $65bn, with a cost between $61 and $82, with a net benefit oscillating between $4bn and -$16bn.

Overall, we can say that the Paulson plan did not create any value in the banking sector, it was simply a redistribution of money from taxpayers to the investors in the major financial institutions, especially the debtholders. Since a lot of the debt was held by foreign institutions, the deal was a net loss from a U.S. taxpayers' point of view.

To be fair, the ultimate objective of the plan was not to help the banking sector but to help the economy. Since we are unable to measure the economy-wide effects because they are too intermingled with the many news (and lack of bad news) occurring during that weekend, we cannot conclude that the plan was useless.

However, several of the mechanisms through which the plan could have benefitted the economy do pass through an increase in the value of banks. If the plan was aimed at stopping banks' run, for instance, the biggest beneficiaries would have been the banks themselves, and these benefits should have materialized in a higher enterprise value net of 'Paulon's gift". We do no find that.

Similarly, another justification for the plan was that banks were not supplying loans efficiently and the economy suffered (Ivashina and Scharfstein, 2008). In other words, banks, burdened by a debt overhang, were passing up good investment opportunities. When companies emerge from a situation of severe debt overhang their enterprise value increases significantly, as Kroszner (2003) as shown. That we do not find this effect in our study is surprising. One possibility is that the banking sector is so perfectly competitive that all the financing is provided at cost, generating no value for the lending institution. Otherwise, we have to conclude that either banks were not in an inefficient debt overhang type of situation (an unlikely scenario given the evidence in Ivashina and Scharfstein, 2008) or the plan did not succeed in getting them out of this situation.

3.4 Defusing a Bank Run?

Did the Paulson plan help defuse a bank run? If the Paulson plan managed to defuse a bank run, we should find some independent evidence in the behavior of CDS rates of various maturities. In fact, a bank run implies that the bank is more likely to default in the nearest future than in the far future. This probability of default is embedded in CDS rates of various maturities. We obtain from Datastream data on CDS rates for contracts of 1 year, 3 years and 5 years to maturity, and interpolate the intermediate maturities of 2 and 4 years. Denote by $r(t;T)$ the riskless rate at t with maturity T, and by $p(t;T)$ the default intensity at t with maturity T. Assuming continuous payments, the CDS rate at time t with maturity T is given by

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

where δ is the recovery rate. Note that if the default intensity *p(t;τ)* is constant over maturity *τ*, we obtain CDS(t;T)=p(t)(1-δ). When *p(t;τ)* is not constant we can use CDS rates for various maturities T to bootstrap *p(t;τ)* for every *τ*. For simplicity, we assume that *p(t;τ)* is a step functions with one year step size. To implement the procedure we need the spot rates *r(t;τ)*. We obtain daily spot rates from plain vanilla swaps, whose rates are available from the Federal Reserve Board web site. In this exercise we assume a recovery rate δ=40%.

Given intensities *p(t;τ)* we can compute the survival probabilities $Q(t;T)=e^{-\int_0^T p(t;\tau)d\tau}$ as well the conditional probability of defaulting in year *n* conditional on not defaulting earlier. Denote this probability by *P(t;n)=Prob(Default in t+n | No Default before t+n)*, this is given by

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

where *Q(t;0)=1*. If we find that *P(t;1)>P(t;2)*, then it is likely that a bank run is taking place, as default is more likely in the first year than in the second year (conditional on surviving the first year). The Paulson plan can be deemed effective to defuse a bank run if the difference *D(t)=P(t;1)-P(t;2)* moved from positive to negative. Panel A of Figure 3 shows the difference *D(t)* on 10/10/2008 and 10/14/2008. As it can be seen, the banks with positive D(t) on the first date were Citigroup, the three investment banks, as well as GE Capital. On the second date, none of these banks have D(t) decline below zero. Figure 4 shows, however, that D(t) turned indeed negative at least for Citigroup for a few weeks, until mid November 2008, when Citigroup D(t) index turned sharply positive again, eliciting the second bailout, discussed in the next section. The investment banks' *D(t)* index never turned negative during the sample. Overall, the evidence from CDS suggests that the only banks subject to a possible bank run was Citigroup and the investment banks. The bailout was able to temporarily defuse Citigroup run, but only for a short while.

3.5 Citigroup Bailout 2

On November 23, 2008, just over a month from the first bailout, the U.S. Government announced a new large intervention targeted this time only to help Citigroup. From October 14, 2008 to November 21, 2008, Citigroup share price dropped from over $18/share to just $3.77/share. On that day, as the share price declined, Citigroup CDS price peaked at 492.1. The new government intervention has two parts: (i) A $20 billion capital infusion through the issuance of preferred equity to the US Treasury; and (ii) a partial guarantee on the losses incurred on a $306bn-worth portfolio of Citigroup's mortgage related assets. In this guarantee, the UST takes 90% of the losses over $29bn for a period of 10 years, for residential mortgages, and 5 years for non-residential mortgages. In exchange of the guarantee, Citigroup issues additional $7bn of preferred equity, and agrees to cut dividends to $.01/share per quarter for three years.

We compute the costs and benefits of the new bailout through a similar event-study analysis for the window 11/21/2008 – 11/24/2008. During the event window, Citigroup common stock price increased from $3.77 to $5.95, a 58% return, the value of last issued preferred equity increased by 38%, while the CDS price declined from 492.1 to 249.2. As before, we adjust Citigroup stock returns by the 6.47% aggregate market return during the event window. Similarly, we adjust the reduction in insurance costs by GE Capital percentage reduction, as in expression (4), or CDX price. Overall, common stocks increased by $9.3bn, preferred equity by $6.3bn, and bonds by $28.5bn, for a total increase in enterprise value of $44bn.

How much did the intervention cost to the U.S. Government? Preferred equity pays quarterly an 8% dividend, and it is redeemable by Citigroup at any time. Using the same yield as in the calculations in Table 4 – a conservative assumption given that Citigroup's share prices dropped since October 21th – and the same assumption that redemption will occur in five year we value the preferred equity between $15.2 and $16.7 billion. That is, there is a net loss of (at least) $3.3bn.

The largest cost of the intervention, however, comes from the guarantee on the losses on the $306bn portfolio. This guarantee is nothing more than a put option on the assets of this portfolio. This put option has a strike price of $277bn and a coefficient of 90%, as Citigroup covers the first $29bn losses and the US Government takes only 90% of additional losses. We assume a maturity of 5 years and an interest rate of 3.1%. The volatility of these assets is hard to measure. We proceed in two ways: first, we compute the volatility of an index of assets that are similar in nature, namely the ABX.AAA index, which is an index of the value of residential mortgages that were rated AAA at inception of the index. According to Bloomberg, the historical volatility of this index is 45%. Second, we use a Merton model, as explained in the next section, to compute the implicit volatility of assets, and obtain 41% volatility. To be conservative, since this is a cost, we use the latter number in the calculations. Since dividends are virtually zero, an application of Black and Scholes formula yields an insurance premium of $77.7bn. As mentioned, in exchange of this guarantee Citigroup issues an additional $7bn of preferred shares, whose value is $5.9bn, for a total net cost of insurance of $60.1bn. There are a few other items to consider, though. First, Citigroup also issued $2.7bn of exercisable value of warrants with strike price $10.61, whose value we calculate to be only $0.66bn. Second, the requirement of zero dividend increases the value of the warrants issued on October 24th in the first bailout. We calculate the increase in value of these warrants to be $2.5bn. Including these two items, the net cost of insurance is $57bn, for a total cost the intervention of $60.3bn. The total net benefit was $44bn, yielding a net benefit of – $16.3bn.

4. The Ex Ante Effects of the Plan

Given the extreme volatility of markets during this period, it is legitimate to ask whether these 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.

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. 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 2 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. The Appendix contains more details on the model, as well a discussion on how we treat various forms of liabilities.

Table 2 reports the 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. There are two key ingredients in the model that are not available: the market value of the firm's assets (the number in Table 1 is the book value) and the size of the shaded area in Figure 2, which depends on assets' volatility σ_A. For each bank, we estimate the market value of assets A(0) and the assets' volatility σ_A in order to match the market value of equity and an estimate of the market value of long-term debt. The appendix contains the details.

4.2 The Co-insurance Effect

Table 8 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 equity infusion. In particular, the $125bn equity infusion increases the overall value of the equity of these ten banks by only $85.1 bn, 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 $38.7bn (see column 6), equal to 30% 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 (73%), Merrill Lynch (52%), Goldman Sachs (48%), Wachovia (47%), and Citigroup (38%). It is smaller for JP Morgan and Bank of America (both around 17%) and very small both in absolute and relative size for all the other banks involved.

4.3 Explaining the Changes in the Market Value of Debt

Table 9 compares the model's prediction about the changes in market value of debt and equity to the actual changes in the market. In particular, in the absence of the debt guarantee, the model estimates that shareholders would have lost \$26bn (the net result of a gain of \$13bn from the equity infusion and a loss of \$39bn due to the value transferred to debt holders – see Table 9B, column 3) and the debtholders would have gained \$39bn (see Table 9A, column 1). By adding the value of the \$99bn of debt guarantee we are able to approximate fairly well the market value increase of the debt, especially for the commercial banks.

4.4 Explaining the Changes in the Market Value of Equity

By contrast, the model overestimates the negative impact of the plan on equityholders (Table 9B). The model predicts a loss of \$26bn, when the actual loss is only \$3bn. The difference could be due to the fact that part of the benefit of the debt guarantee is captured by equity, since the company has to pay less to finance the debt. If we add the component of the debt guarantee not absorbed by debt (i.e., the last column of Table 9A), the difference is smaller, although still significant. In particular, the model underpredicts the increase in equity value of Citigroup, while it overpredicts the increase of JP Morgan. One possible interpretation is the competitive effects of the plan. By rescuing Citigroup and Bank of America, the plan might have hurt its direct competitors, i.e. Morgan Stanley and JP Morgan, which now owns Bear Stearns.

5. Valuations of Alternative Plans

Now that we have shown that the model can do a reasonable job at explaining the changes in the market value of debt and equity, we can use it to evaluate the performance of alternative plans. If Paulson's objective was to recapitalize the banking system so that the risk of default of a financial institution became sufficiently low, we should evaluate alternative plans with the constraint that they reach this objective: i.e., a reduction in the CDS prices of each bank equivalent to the one observed in the data (see Table 3).

As in the event study, however, 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 prices: the actual decline and the adjusted decline, where the latter is adjusted for the decline in GE Capital CDS prices. Since we do not know whether the general decline, captured in the decline of GE Capital CDS prices, 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: 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 biggest cost of the revised Paulson Plan is the debt guarantee, which does not appear in the Government budget as a cost, simply because of the way Government accounting is done.

For comparison in the first column of Table 10 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 value at risk is close to \$250bn, which is more than the sum of the debt guarantee plus the entire amount of the equity infusion. The vast majority of the 250bn VaR figure comes from the possibility that the US government will in fact be called to guarantee the debt of one or more banks, rather than the potential loss from its initial \$125bn investment (See Appendix for details on the computation of VaR).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 $4.6 trillion of banks' assets to achieve the same adjusted drop in CDS prices achieved by the revised Paulson plan (see Table 10A). If we want to achieve the same unadjusted drop, we need twice as much: $8.8 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 purchases without any overpayment. 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 (loss which occurs with a 5% probability within three years). In Panel A the value at risk for this alternative is $538bn, while in Panel B $1 trillion. One potential benefit of this approach is that it does not require any government ownership of banks.

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%. Alternatively, this could be considered as the original Paulson Plan with a 20% increase in the price of assets due to the massive purchases made by the Government.

In this case the amount of investment decreases significantly: 1.1 trillion if we target the adjusted reduction in CDS prices, 7.6 trillion if we target the raw reduction. This reduction in the funds needed comes at a high price for the taxpayers: they have to pay $177 bn up front and they risk an additional loss of $119 bn in the cheap scenario, the cost skyrocket to $1.2 trillion with a potential additional loss of $856bn in the more expensive scenario. 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 prices, the equity infusion achieves it with only a slightly higher investment than the revised Paulson plan ($189bn vs $125). This amount, however, is distributed in a very different way. As Figure 3 shows, while the Revised Paulson Plan invested a similar amount in the major banks, the equity infusion plan will concentrate the investment in the three former investment banks and Citigroup. Such investment would have given the Government 88% of Morgan Stanley and 52% of Goldman Sachs.

While a pure equity infusion would have not required a much bigger investment, it would have implied a significantly lower cost for the taxpayers ($65bn). This cost represents the transfer in value from equityholders to debtholders. Since the value at risk is $163 bn (on top of the $65bn), this plan seems better in any dimension than the revised Paulson plan, except for the Government ownership of banks, which turns out to be 25% rather than 20%. The political trade off, however, seems very steep. To avoid an extra 5% ownership of banks by the Government, we waste an extra $72bn of taxpayers' money, roughly $700 per family.

The scenario is very different, however, if we want to target the raw reduction in CDS prices. In this case the equity infusion required would be $581bn, with a cost for the taxpayers of $132bn and a Government ownership of banks of 47%.

As a last alternative we consider 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 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 prices to 7-8 basis points, the level most banks had at the beginning of 2007.

6. Conclusions

We analyze the market response to the revised Paulson plan and show that, possible systemic effects aside, this plan does not create any value in the banking sector: it amounts to a massive redistribution from taxpayers to bondholders. While this finding does not reject the possibility that the plan could have been successful in helping the economy, it questions the channel through which this could have occurred.

We then study the cost of alternative plans that would have achieved the same systemic effects in terms of reduction of the default risk of existing banks. We find that the revised Paulson plan is the most expensive for the taxpayers, second only to the original Paulson plan. The only reason to prefer it to a simple equity infusion would be to reduce the Government's ownership of banks by five percentage points. But this goal cost taxpayers an extra $72bn, roughly $700 per family.

Appendix A: The Model of Equity as an Option

Consider a bank at time 0, with assets A(0), financed by short term deposit Dep, short term debt D_S, and long term debt D_L. We make the simplifying assumption that deposit, short term debt and long term debt are 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.

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. Because deposits are senior to short term debt holders (and are insured by FDIC), the payoff to short term debt holders at T_S is

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

That is, it is zero if $A(T_S)<Dep$, it is $A(T_S)-Dep$ if $A(T_S)>Dep$ but $A(T_S)<Dep+D_S$, and it is equal to D_S if $A(T_S)>(Dep+D_S)$. 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 is

$$V^S(A(0)) = BSC(A(0), Dep, \sigma_A, r, T_S) - BSC(A(0), Dep+D_S, \sigma_A, r, T_S)$$

where BSC denotes the Black and Scholes option pricing formula, and r is the riskless rate.

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

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

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 $A(T_S)>Dep+Ds$, we assume

$$\log(A^*(T_L)) \mid_{A(TS)} \sim N(\log(A^*(T_s) + (r-0.5\,\sigma_A^2)(T_L-T_S),\ \sigma_A^2(T_L-T_S))$$

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

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

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

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

It follows that conditional on $A(T_S) > Dep+Ds$, 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 $A(T_S) < Dep+D_S$, 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

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

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

where f(A) is the lognormal distribution.

Two key unobservable entries in these formulas are $A(0)$ and σ_A . We choose these two numbers to match the market capitalization of each bank on Oct 10th, 2008, as well as an estimated market value of debt on the same day. The estimated market value of debt is computed as follows: 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

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

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

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

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.

Appendix B. 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 in changes in CDS spreads. Second, we simulate joint assets realization at T=3 using this correlation structure in the joint density. For each bank we then compute the Government disbursement at T=3 as the difference between D – A(T), if any, where D equals the total debt maturing by T plus total deposit. To be conservative, we do not include at this point "Other Liabilities". 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 defined on the new simulated assets at time T (plus any moneys coming from the government).

In the simulation of the asset value of each bank i, $A_i(T)$, we assume that the market value of these assets has a relatively generous sharpe ratio of 35%. Given the assumed Sharpe ratio λ=35%, the annual drift rate of assets is then given by

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

where σ_A is the volatility of assets.

The VaR calculation for the Purchase of Assets, with or without overpayment, computes the possible losses on the assets during the period of three years. For simplicity, we consider the aggregate asset purchased by the government, $A(T) = A_1(T)+\ldots+A_n(T)$, as following a GBM with a sharpe ratio of 35%. This assumption seems appropriate, as the government intent was to purchase "troubled assets", which have a relative uniformity across firms. We use the average volatility of assets in order to compute the distribution at T.

Finally, the VaR calculation for the simple equity infusion is computed as a 3 year VaR on equity only. In this case, given the implied investment in each bank, we can compute the historic returns on this portfolio by using past equity returns of each bank. We then compute the volatility of the portfolio as the realized volatility using data in the previous year. The long data set is motivated by the empirical observation that volatility is mean reverting, and that it was at its highest level in the month preceding the announcement of the Paulson plan.

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Figure 1: CDS Spreads

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

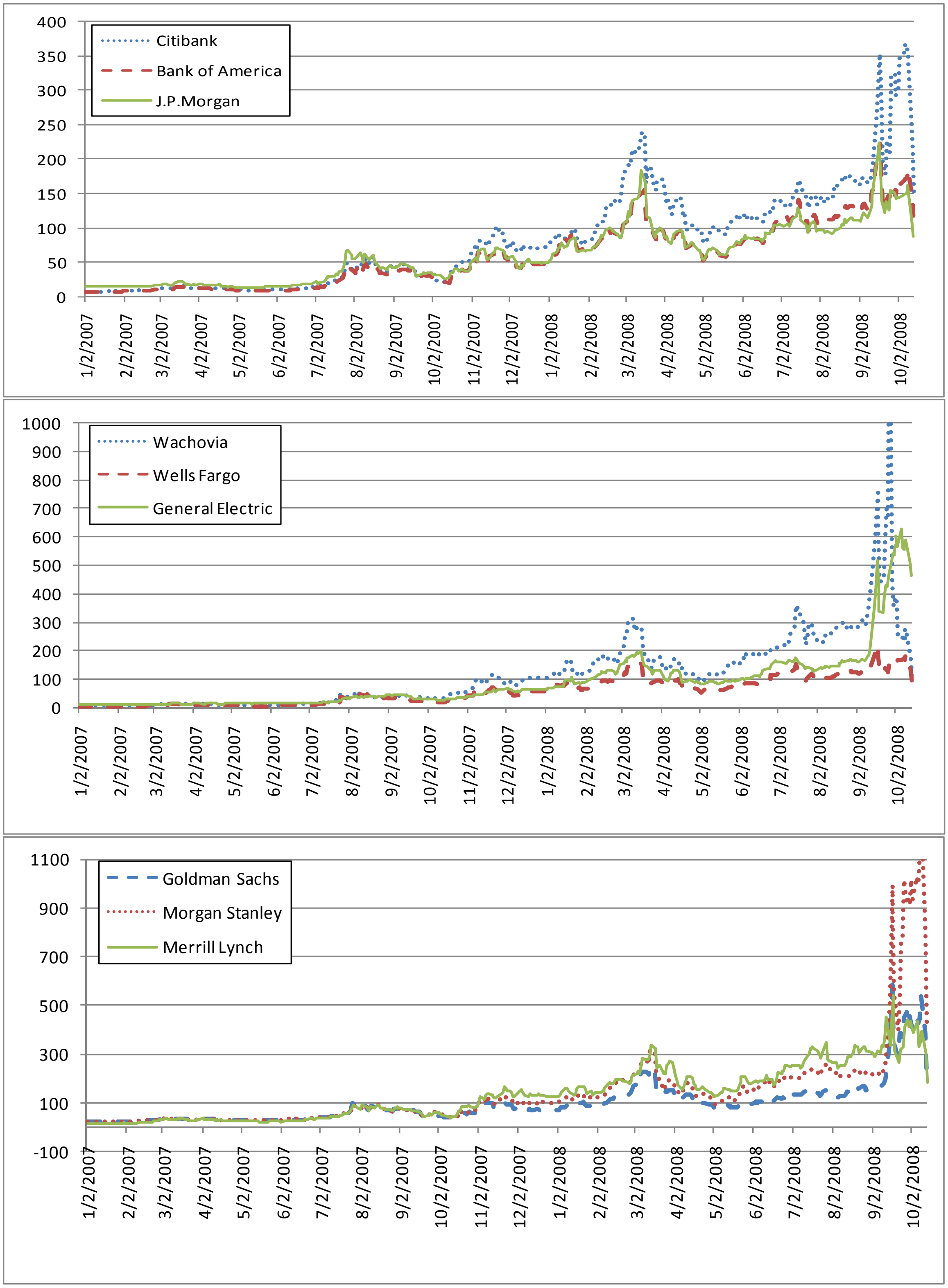


Figure 2: An Illustration of the Model

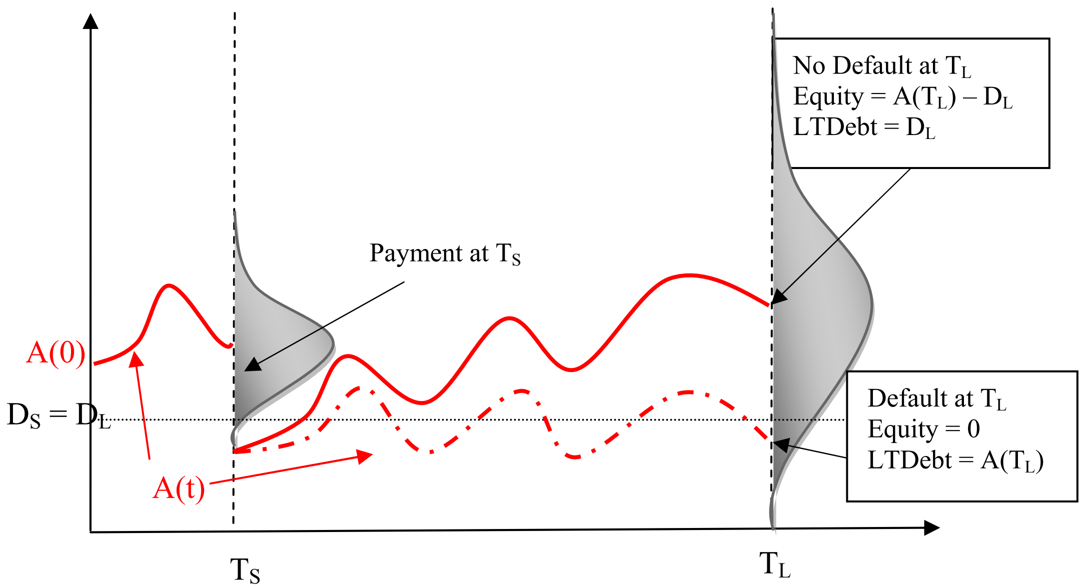
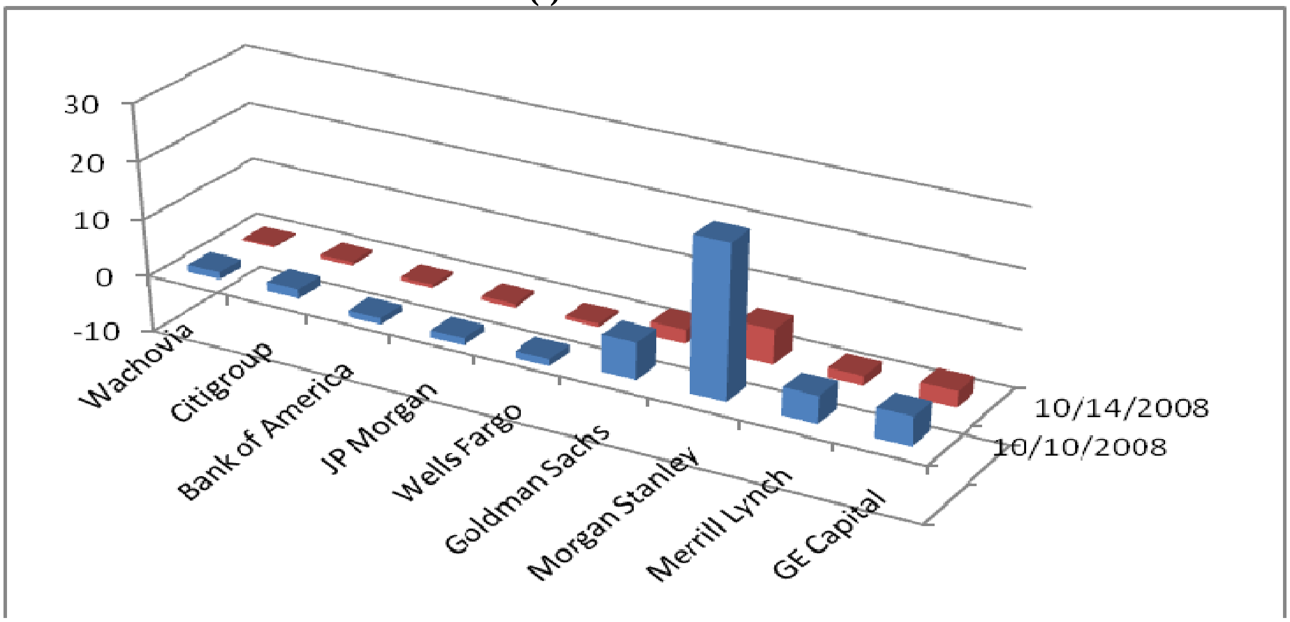


Figure 3: Bank Run

Panel A plots the difference *D(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*. Panel B uses a modified Merton model and computes the risk neutral probability that the bank's assets at T=1 suffer a crash in value (to 0), eliciting immediate default. The model is calibrated to short term and long term CDS spreads, as well as to equity value.

Panel A: Difference in Default Index D(t).



Panel B: Risk Neutral Probability of Default at T=1 according to Merton Model

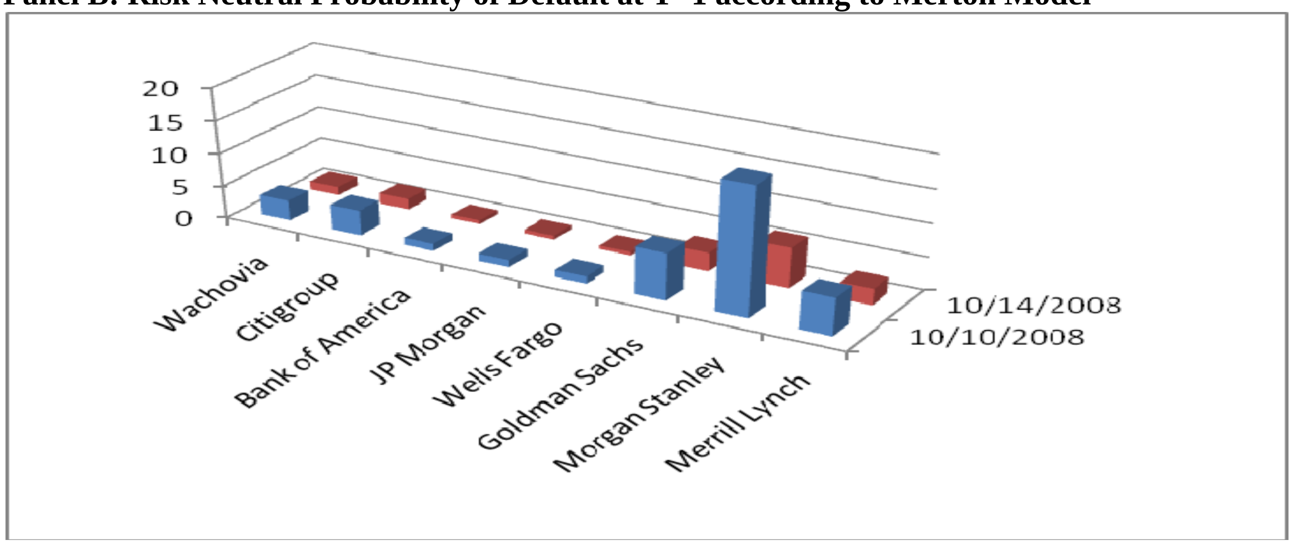


Figure 4. The time series of Default Difference Index D(t)

The figure plots the difference $D(t) = P(t;1) – P(t;2)$, where P(t;n) is the conditional probability of default in year n after t, conditional on not defaulting before n. A positive number indicates a possible bank run.

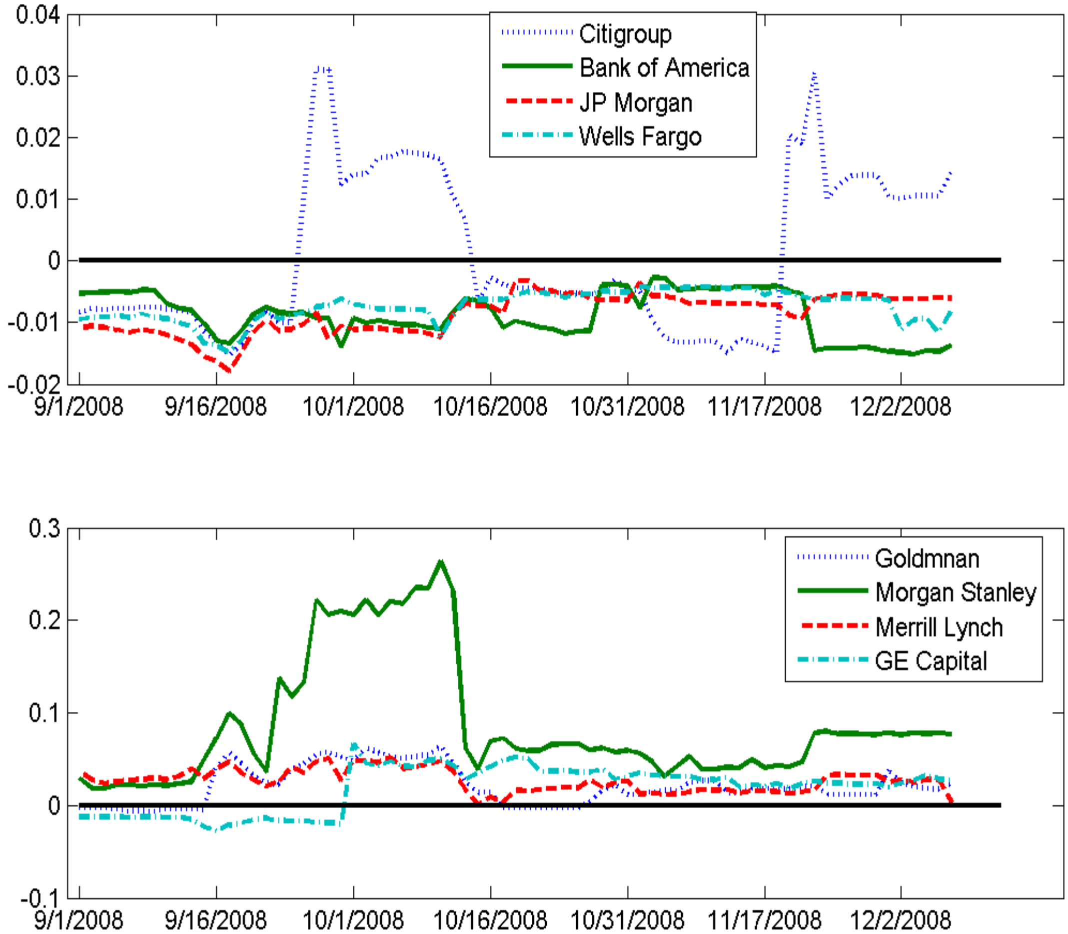


Figure 5: Difference in Equity Infusion

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 prices observed after the announcement of the revised Paulson Plan (see Table 3). All the numbers are in billions of US$.

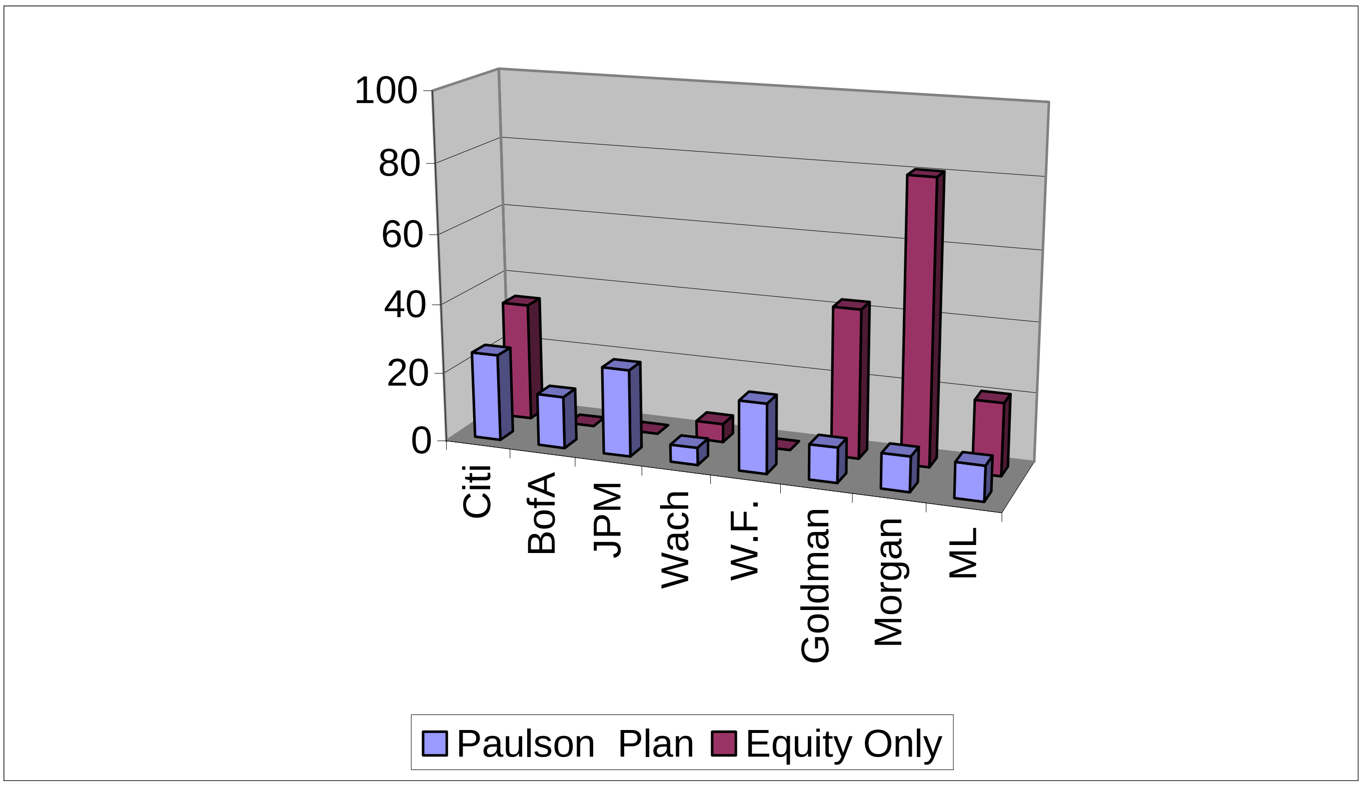


Table 1: The Revised Paulson Plan

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	491.3
Bank of America	15	26.53	5.02	0.08	0.98	589.8
JP Morgan Chase	25	40.71	3.73	0.09	0.98	378.2
Wachovia	5	6.31	2.15	0.12	0.95	113.0
Wells Fargo	20	33.52	3.32	0.09	0.97	124.6
Bank of NY Mellon	3	34.76	1.15	0.01	0.99	15.1
State Street Corp	2	56.69	0.44	0.01	0.99	29.1
Goldman Sachs	10	122.9	0.43	0.01	0.97	520.3
Morgan Stanley	10	21.94	1.11	0.07	0.94	428.6
Merrill Lynch	10	18.24	1.60	0.08	0.95	328.5
Total	125.0					3,018.6

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 06/30/2008 (except Goldman Sachs and Morgan Stanley, whose data are as of 05/31/2008), 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 Term Debt	Other	Tot liab.	Equity	Total assets
Citigroup	803.6	360.6	417.9	381.9	1,964.0	136.6	2,100.5
Bank of America	784.8	415.9	206.6	146.9	1,554.2	162.7	1,716.9
JP Morgan Chase	722.9	267.5	277.5	374.7	1,642.5	133.2	1,775.7
Wachovia	382.3	61.3	171.5	49.7	664.7	174.9	839.7
Wells Fargo	339.1	86.1	103.9	31.9	561.1	48.0	609.1
Bank of NY Mellon	127.2	2.5	17.1	25.9	172.7	28.6	201.2
State Street Corp	94.6	21.4	4.1	11.4	131.5	11.6	143.1
Goldman Sachs	29.5	396.9	208.0	408.9	1,043.3	45.1	1,088.5
Morgan Stanley	35.2	322.6	210.7	428.2	996.7	34.5	1,031.2
Merril Lynch	100.5	217.0	275.6	338.3	931.4	34.8	966.2
Total	3,419.8	2,151.7	1,892.9	2,197.8	9,662.1	809.9	10,472.1

Panel B: Other Market Information

	Cap 10/14/08	Implied Volatility	Actual Volatility	Preferred yields	Dividends per share
Citigroup	101.4	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
Merril Lynch	29.2	82.23%	177.94%	11.55%	1.40
Average	68.2	73.96%	210.29%	9.61%	1.27
Total	681.8				

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

CDS prices 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 price/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 prices, adjusted for the percentage reduction in GE cost (GE-labeled columns), or the CDX- implied insurance cost reduction (CDX labeled columns). As a discount rate we use 3.5%. The debt and the adjusted gain data are in billion of US$.

	Price of CDS 10/10/08	Price of CDS 10/14/08	Prob. of Default 10/10/08	Prob. of Default 10/14/08	Raw Decline	LT Debt 06/30/08	LT Debt 09/30/08	Adj. Gain (GE) 06/30/08	Adj. Gain(GE) 09/30/08	Adj. Gain (CDX) 06/30/08	Adj. Gain (CDX) 09/30/08
Citigroup	341.7	144.6	4.3%	1.8%	197.1	417.9	396.1	22.3	21.2	23.4	22.2
Bank of America	186.2	99.2	2.3%	1.2%	87.0	206.6	257.7	5.3	6.6	5.7	7.1
JP Morgan	162.5	88.0	2.0%	1.1%	74.5	277.5	277.5	5.5	5.5	5.8	5.8
Wachovia	267.5	109.2	3.3%	1.4%	158.3	171.5	183.8	6.9	7.4	7.2	7.8
Wells Fargo	186.7	89.8	2.3%	1.1%	96.9	103.9	103.9	2.5	2.5	2.6	2.6
Bank of NY Mellon						17.1	15.5				
StateStreet						4.1	4.1				
Goldman	540.0	201.7	6.8%	2.5%	338.3	208.0	202.0	18.0	17.5	18.4	17.9
Morgan Stanley	1300.9	427.1	16.3%	5.3%	873.8	210.7	202.3	32.5	31.2	32.4	31.1
Merrill Lynch	398.3	182.5	5.0%	2.3%	215.8	275.6	275.6	11.5	11.5	11.6	11.6
General Electric Capital	590.0	465.8	7.4%	5.8%	124.2						
CDX Index	213.0	176.8			36.2						
Total						1,893	1,919	104.5	103.3	107.2	106.1

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	76.83	1.96	0.32	0.21	0.10	16.1	8.0
Bank of America	104.71	2.07	0.27	0.16	0.04	16.9	4.5
JP Morgan Chase	155.19	1.77	-0.02	-0.13	-0.22	-20.5	-33.6
Wachovia	11.07	4.26	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	1.86	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	2.16	1.27	1.16	1.03	12.4	11.0
Merril Lynch	25.20	2.46	0.16	0.05	-0.11	1.2	-2.8
Total	565.0					54.7	-2.6
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
Merril 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 come from Table 3. 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$.

	Benefits				Costs			
	Change in the value of common equity	**Change in the value of preferred equity**	**Change in the value of debt**	**Total**	**Net cost of equity infusion**	**Net cost of debt insurance**	**Total**	**Net Benefit**
Citigroup	8.0	2.1	22.3	32.4	4.8	11.1	16.0	16.4
Bank of America	4.5	2.2	5.3	12.0	1.2	0.7	1.9	10.2
JP Morgan Chase	-33.6	0.4	5.5	-27.8	1.8	0.8	2.6	-30.4
Wachovia	-2.7	0.3	6.9	4.5	0.7	1.3	2.0	2.5
Wells Fargo	-0.5	0.1	2.5	2.0	1.5	0.0	1.5	0.6
Bank of NY Mellon	3.3	0.0		3.3	0.1			3.3
State Street Corp	2.4	0.0		2.4	0.0			2.4
Goldman Sachs	7.9	0.1	18.0	26.0	0.1	22.3	22.4	3.7
Morgan Stanley	11.0	0.3	32.5	43.8	1.4	49.9	51.2	-7.4
Merril Lynch	-2.8	1.2	11.5	9.9	1.7	12.7	14.4	-4.5
Total (optimistic case)	**-2.6**	**6.7**	**104.5**	**108.7**	**13.2**	**98.8**	**112.0**	**-3.3**
Total (pessimistic case)	**-2.6**	**6.7**	**104.5**	**108.7**	**35.8**	**98.8**	**134.6**	**-25.9**
Without Morgan Stanley								
Total (optimistic case)	-13.6	6.4	72.0	64.8	11.8	48.9	60.7	4.1
Total (pessimistic case)	-13.6	6.4	72.0	64.8	32.7	48.9	81.6	-16.8

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 assuming a beta of 1, 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

Panel A:

	Equity Infusion	Theoretical Value of Preferred	Theoretical Value of Warrant	Total Theoretical Value Claim	Difference
Citigroup	25	18.1	13.6	20.2	4.8
Bank of America	15	12.7	7.4	13.8	1.2
JP Morgan Chase	25	21.2	13.3	23.2	1.8
Wachovia	5	3.8	3.3	4.3	0.7
Wells Fargo	20	17.0	10.2	18.5	1.5
Bank of NY Mellon	3	2.6	2.2	2.9	0.1
State Street Corp	2	1.8	1.4	2.0	0.0
Goldman Sachs	10	8.9	7.0	9.9	0.1
Morgan Stanley	10	7.7	6.4	8.6	1.4
Merril Lynch	10	7.5	5.4	8.3	1.7
Total	125.0	101.3	70.0	111.8	13.2

Panel B:

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

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

The CDS prices, in basis pints, are for a three year debt instrument. They come from Bloomberg. All the balance sheet information is as of 06/30/08, apart from Goldman Sachs and Merrill Lynch whose values are as of 05/31/08. The total debt guaranteed is 125% of the sum of the short term debt plus the long term debt maturing before June 30 2009. The total cost of the Government guarantee is discounted value of the difference between the value of this guarantee (CDS price time the value of the debt guaranteed) minus the cost to the banks (75 basis points time 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 price of CDS.

	Short term	Long term maturing in 2008	Long term maturing in 2009	Price of 3 yr CDS 10/14/2008	Total Guaranteed debt	Total cost of insurance
Citigroup	360.6	11.8	41.5	155.9	491.3	11.1
Bank of America	415.9	32.3	47.4	79.1	589.8	0.7
JP Morgan Chase	267.5	10.9	48.4	82.3	378.2	0.8
Wachovia	61.3	11.0	36.3	117.3	113.0	1.3
Wells Fargo	86.1	4.9	17.2	74.5	124.6	0.0
Bank of NY Mellon	2.5	5.2	8.8		15.1	
State Street Corp	21.4	0.5	2.8		29.1	
Goldman Sachs	396.9	6.6	25.3	227.7	520.3	22.3
Morgan Stanley	322.6	10.0	20.6	490.3	428.6	49.9
Merrill Lynch	217.0	14.0	63.5	213.5	328.5	12.7
Total	2,151.7	107.2	311.8		3,018.6	98.8

Table 8: 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.

	Value Before Equity Infusion Announc.		Value After Equity Infusion Announc.		Amount of Equity Infusion	Difference		Fraction of equity infusion to debt
	LT Bonds	Equity	LT Bonds	Equity		LT Bonds	Equity	
Citigroup	365.4	86.4	375.0	101.7	25	9.6	15.3	0.38
Bank of America	192.5	116.0	195.2	128.2	15	2.7	12.2	0.18
JP Morgan Chase	265.9	160.5	270.0	181.3	25	4.1	20.8	0.16
Wachovia	152.9	17.0	155.3	19.6	5	2.4	2.6	0.47
Wells Fargo	103.0	94.3	105.3	111.9	20	2.3	17.6	0.12
Bank of NY Mellon	14.5	30.5	14.8	33.1	3	0.3	2.6	0.10
State Street Corp	3.0	18.8	3.1	20.6	2	0.1	1.8	0.04
Goldman Sachs	171.9	38.7	176.7	43.9	10	4.8	5.1	0.48
Morgan Stanley	127.9	11.0	135.2	13.3	10	7.3	2.3	0.73
Merril Lynch	235.8	29.7	241.0	34.4	10	5.2	4.7	0.52
Total	1632.9	602.9	1671.6	688.0	125.0	38.7	85.1	0.30

Table 9: 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

	Transfer from equity	Net insurance benefits	Total	Market changes	Difference
Citigroup	9.6	11.1	20.7	22.3	-1.6
Bank of America	2.7	0.7	3.4	5.3	-1.9
JP Morgan Chase	4.1	0.8	4.9	5.5	-0.6
Wachovia	2.4	1.3	3.7	6.9	-3.2
Wells Fargo	2.3	0.0	2.3	2.5	-0.2
Bank of NY Mellon	0.3		0.3		
State Street Corp	0.1		0.1		
Goldman Sachs	4.8	22.3	27.0	18.0	9.0
Morgan Stanley	7.3	49.9	57.1	32.5	24.7
Merrill Lynch	5.2	12.7	18.0	11.5	6.5
Total	38.7	98.8	137.5	104.5	32.6

Panel B: Changes in the Value of Equity

	Net gain from equity infusion	Transfer to debt	Total	Change in Market value	Equity share of debt guarantee	Difference
Citigroup	4.8	9.6	-4.8	8.0	0.0	12.7
Bank of America	1.2	2.7	-1.5	4.5	0.0	6.0
JP Morgan Chase	1.8	4.1	-2.2	-33.6	0.0	-31.4
Wachovia	0.7	2.4	-1.7	-2.7	0.0	-1.0
Wells Fargo	1.5	2.3	-0.8	-0.5	0.0	0.3
Bank of NY Mellon	0.1	0.3	-0.2	3.3	0.0	3.5
State Street Corp	0.0	0.1	-0.1	2.4	0.0	2.5
Goldman Sachs	0.1	4.8	-4.7	7.9	9.0	3.6
Morgan Stanley	1.4	7.3	-5.9	11.0	24.7	-7.7
Merrill Lynch	1.7	5.2	-3.6	-2.8	6.5	-5.7
Total	13.2	38.7	-25.5	-2.6	40.2	-17.2

Table 10: 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 one year), 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 prices 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 prices 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 prices

	Revised Paulson Plan	Original Paulson Plan: Purchase of assets for cash		Pure Equity Infusion	Long-term Debt for Equity Swap
		no over payment	20% over payment		
Investment required	125	4,521	1,061	189	0
Net cost to taxpayers	137	0	177	65	0
5% 3 year Value at Risk	172	534	119	163	0
% of banks owned by Government	20%	0	0	25%	0

Panel B: Target = raw reduction in CDS prices

	Revised Paulson Plan	Original Paulson Plan: Purchase of assets for cash		Pure Equity Infusion	Long-term Debt for Equity Swap
		no over payment	20% over payment		
Investment required	125	8,782	7,643	581	0
Net cost to taxpayers	137	0	1,274	132	0
5% 3 year Value at Risk	172	1,038	856	499	0
% of banks owned by Government	20%	0	0	47%	0