Saving a Bank?
Cracking the Case of the Fortis Bank?

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Abstract

This paper presents a simple experimental System Dynamics model of the underlying value and stock market value of a bank to analyze a loss of trust the a bank. The System Dynamics model was developed on 28 September 2008 –the day the governments of the Benelux countries met in a great hurry to rescue the Fortis bank– in order to gain a better understanding of the potential dynamics of bank crises and to test policies for keeping banks from collapsing. The System Dynamics model and an even simpler exam case based on it are interesting because of the actuality and importance of the topic, their small size and simplicity, their potential to generate different dynamic behaviors, and their usefulness for quick fostering of understanding and rough-cut policy exploration.

Keywords: Financial Crisis, Collapse, System Dynamics, Fortis Bank, Credit Crunch

1 Introduction

The recent US sub-prime mortgage crisis and worldwide credit crunch brought many European banks in serious problems. One of the biggest banks of the Benelux[1], the Fortis Bank, almost went bankrupt because of a combination of events and mistakes: (i) the difficulty to raise an additional €8.3 10^9 to finance the integration of their share of the ABN-AMRO bank, taken over just before the credit crunch at too high price, (ii) its losses on its American positions (Lehman Brothers and sub-prime debt) (iii) rumors in combination with a disastrous communication strategy and a resulting loss of trust in the management of the bank (see section 4 for an account of events). Near the end of September, the Fortis share price collapses: in two days time it loses 35% of its value (71% from 1 January 2008). The governments of the three countries met in a great hurry on 28 September 2008 to keep the Fortis Bank from collapsing. The main reason for wanting to rescue the bank at all cost is that the Fortis Bank is a system bank (especially in Belgium), which means that it performs many systems functions and/or that its collapse could lead to a collapse of the financial system.

That same day, a simple, high-level, exploratory System Dynamics model was developed, firstly to quickly foster understanding about mechanisms and possible dynamics of bank crises, and secondly to explore and test high-level policies to prevent banks, like the Fortis Bank, from collapsing. Later on, the model was slightly extended in order to make it less abstract and closer to the policy reality of the financial world. The resulting model is simple and small. It has value as an introduction to the problem. However, bank structures, dynamics and regulatory banking policies are more complex than this picture: the model does not focus on liquidity problems as is done in (Rafferty 2008), nor on explicit stocks and flows of money through the bank –and the underlying bank's net worth– as is done in (MacDonald and Dowling 1993), nor on detailed operations and decisions of

[1] Belgium, the Netherlands and Luxembourg

a commercial bank as is done in (MacDonald 2002). It mainly focuses on the link between the net worth of the bank and its share price, and in second instance its capital adequacy. The simple structures included in the current version of the model already allow to generate different possible families of dynamic behavior that are revealing for the issue at hand. The model presented in section 2 could be extended to deal with bank liquidity and money flows.

The (initial) model was also turned into a 'hot' testing/teaching case (see section 3.3). On 23 October, 36 MSc students had to solve this case for their exam of the Introductory System Dynamics course at the Faculty of Technology, Policy and Management of Delft University of Technology.

The model is first of all presented and discussed in section 2. After a short introduction in subsection 2.1, the System Dynamics model itself is presented in subsection 2.2. The behavior of the basic model is explored in subsection 2.3. Some policies to prevent a collapse from happening are tested in section 2.4.

The Fortis Bank hot testing & teaching case is presented and discussed in section 3. After a short introduction about 'hot' teaching & testing cases used at Delft University of Technology in subsection 3.1, the testing case description is given in subsection 3.2, and the case questions in subsection 3.3. The 'hot' teaching & testing case model is presented in subsection 3.4. Its behavior is discussed in subsection 3.5. Uncertainty and sensitivity analyses are discussed in subsection 3.6. An aggregated causal loop diagram for communicating the dynamics of the worst case scenario –a collapse of the bank– is presented in section 3.7. In subsection 3.8, a potential policy to prevent the worst case scenario from happening is tested (for illustrative purposes only).

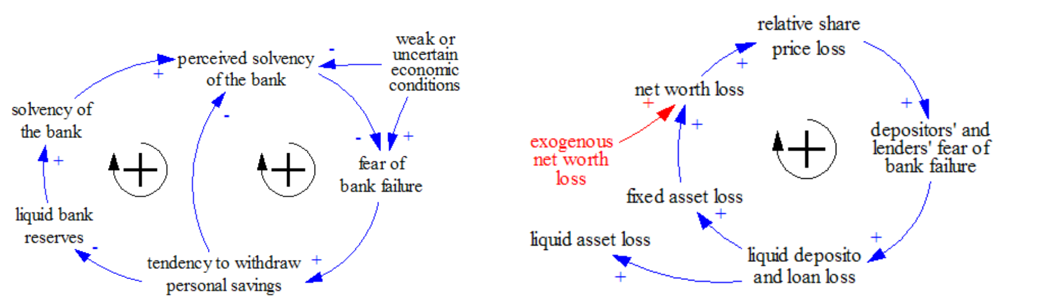
What really happened to the Fortis Bank is summarised in section 4. And some concluding remarks are formulated in section 5.

2 A High-Level System Dynamics Simulation Model

2.1 Run on a Bank? Or Not?

It should be clear, from the outset, that the goal of this paper is to present highly aggregated and extremely simple models of a bank crisis –not a precise/detailed model of the real Fortis Bank crisis– in order to generate more insight into the potential dynamics of bank crises. The perils of the Fortis Bank simply gave the initial impetus towards building the models.

The Fortis Bank lost a serious share of its underlying value in the American sub-prime mortgage crisis. After communicating those losses, its share price plummeted, and any banker's worst nightmare scenario –a run on the bank– started to loom.



(a) Causal loop diagram of a traditional bank run, based on (Richardson, 1991; MacDonald, 2002)

(b) Right: Causal loop diagram of the bank crisis as modeled in this paper

Figure 1: Causal loop diagrams of alternative, complementary bank run hypotheses/models

The left hand side Causal loop diagram in Figure 1 (based on (Richardson 1991) and (MacDonald 2002, p67-77)) corresponds to a traditional bank run, whereas the right hand side Causal loop diagram corresponds to the alternative bank run modeled in this paper. The traditional 'liquidity-solvency' model and the alternative 'net worth-share price' model are complementary and may also be combined.

An alternative 'net worth-share price' bank run (as in the case of the Fortis Bank) may look as follows: a serious exogenous net worth loss leads to a share price loss. A strongly decreasing share price increases depositors' and lenders' fear of bank failure, who start to withdraw (unguaranteed) liquid deposits and loans causing liquid deposit and loan losses, causing the bank's assets to decrease, first the liquid assets and after depleting the liquid assets also the fixed assets (that need to be sold to generate liquid assets). Liquidating (fixed) assets at a cost (illequidity premium), leads to further net worth losses, and so on. This reinforcing loop –if fast and strong enough– is hard to stop before hitting the bottom.

Whether such a collapse actually takes place or not may depend on the strength of the reinforcing loop, but also on uncertain factors such as fear and uncertainty, the stickiness of the bank's deposits and loans, the liquidity of the asset base, and the percentage loss when liquidating fixed assets (illiquidity premium).

The alternative 'bank run' is modeled here because:

- The Fortis Bank was not a traditional savings and loans bank but a multi-purpose bank listed on the stock market. Hence, the interaction between the (estimated) underlying value and the stock market value needed to be taken into account.
- During the crisis, the Fortis management kept on communicating that the Fortis Bank had a solid asset base and did not have any solvency problems. However, it was not clear whether that would still be the case after liquidating assets at a loss.
- The Fortis Bank was a real system bank, and it was clear that the Benelux governments would support system banks through temporary liquidity problems. However, it was questionable whether the Benelux governments and shareholders would be willing to support the system bank through combined liquidity and net worth problems.

Since the main goals of developing the models were to model and simulate possible structural explanations of a 'dump and run on a bank' and to develop robust policies to prevent it from collapsing, the model structure should allow to generate different families of behaviors among which a collapse.

2.2 A System Dynamics Simulation Model

The basic model structure is visualised in the Stock-Flow structure depicted in Figure 2. The model is highly aggregated and simplified. Data/numbers used in this paper are fictitious, used for illustrative purposes only.

The following is assumed.

The *share price* of the bank is modeled as a stock variable because we are interested in the overall behavior, not in minute changes. The *share price loss* outflow equals the relative *perceived overvaluation* times the *share price* divided by a *share price loss delay* of 1 day. The *share price rise* inflow equals the relative *perceived undervaluation* times the *share price* divided by a *share price rise delay* of 1 week. Hence, the share price adjusts faster downwards than upwards. The initial stock market value of the bank –just before the critical week, week two of the simulation– is assumed to amount to €10.

The *perceived overvaluation* –in relative terms, thus expressed in percentages– is assumed to be the difference between the *share price* and the *estimated net worth per share*, divided by the *share price*. The perceived undervaluation –in relative terms, thus expressed as a percentage– is modeled as the difference between the *estimated net worth per share* and *share price*, divided by the *share price*.

The *estimated net worth per share* is simply the *estimated net worth* divided by the *total number of shares*. The *estimated net worth* equals *total assets* minus *total deposits and loans*.

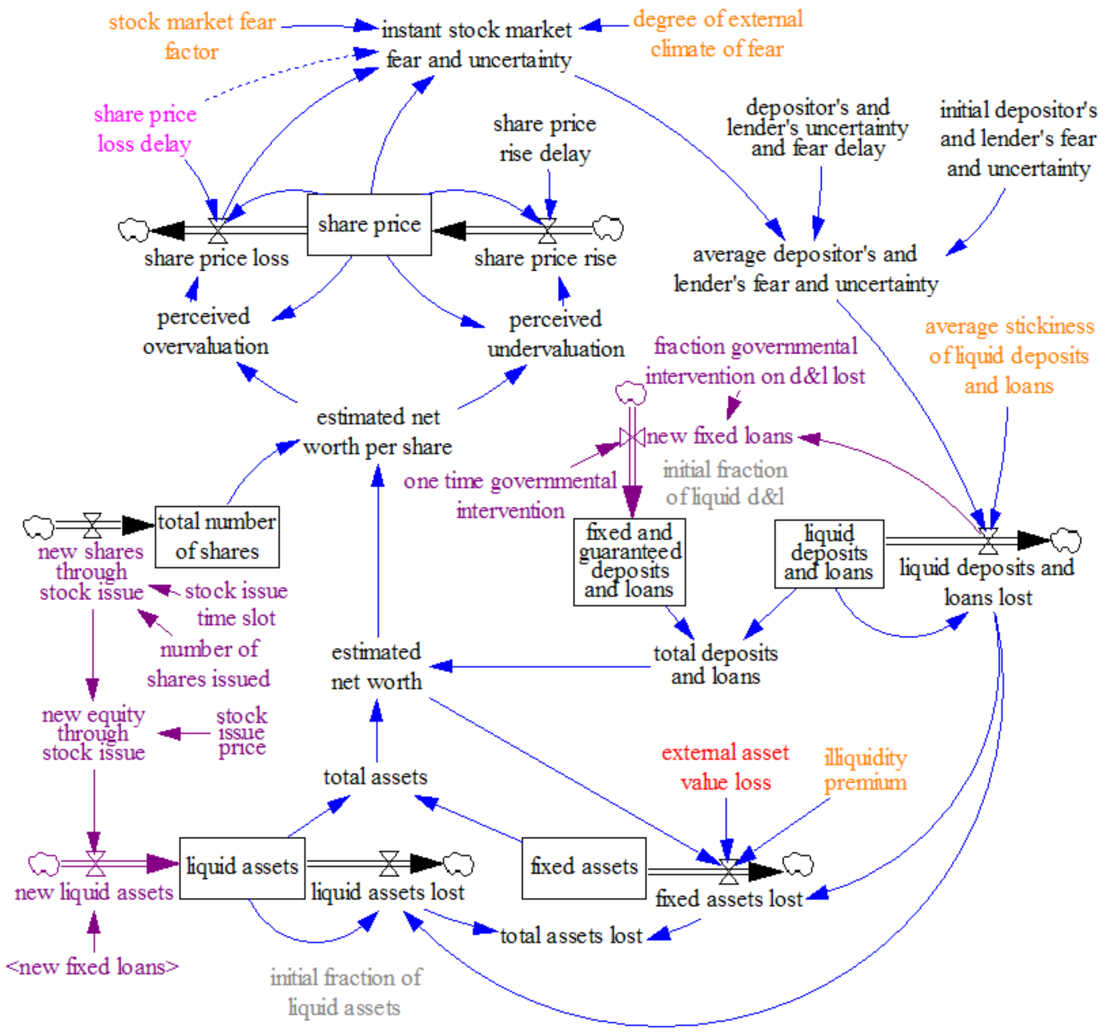


Figure 2: Stock/Flow Diagram of the System Dynamics simulation model – policy structures in purple

Total assets are the sum of the *liquid assets* and the *fixed assets*. Initially, the amount of *total assets* is assumed to equal the sum of the *total deposits and loans* and the total stock market value (the *share price* times the *total number of shares*). An *initial fraction of liquid assets* of 10% is assumed.

In this simplistic short-term crisis model, *liquid assets* can only increase by means of *new liquid assets* which are raised by means of *new equity through stock issue* or *new fixed loans*. It is assumed that unguaranteed *liquid deposits and loans* are impossible to obtain by banks in crisis, but that state aid in the form of *fixed loans* may be obtained. Stock issues of course also raise the number of shares, and *new fixed loans* of course also increase the *fixed and guaranteed deposits and loans*. *Liquid assets* are *lost* at the same rate *liquid deposits and loans* are *lost*. After depletion of the *liquid assets*, *fixed assets* are *lost* at the same rate *liquid deposits and loans* are lost times an *illiquidity premium* (the percentage cost of having to sell fixed assets in times of crisis).

The *illiquidity premium* remains constant, in the Base Case at 0%, although it could be argued that this *illiquidity premium* depends on the *degree of external climate of fear* and that it should increase the more fixed assets (with ever lower liquidity) are actually sold. Except for this shift, there are in this simplistic short-term crisis model no shifts between fixed and liquid assets. The variable *external real value loss shock* is used to model and simulate an asset shock as a percentage of the estimated underlying value (without *illiquidity premium*). It amounts to 35% of the *estimated net worth* in week 2.

The variable *total deposits and loans* sums the *fixed and guaranteed deposits and loans* and the *liquid deposits and loans* (*liquid deposits and loans* not guaranteed by the government). Here too, there is no interaction between the *fixed and guaranteed deposits and loans* and the *liquid deposits and loans* because of the short-term focus of the model. The *initial fraction of liquid deposits and loans* is assumed to amount to 50%.

Liquid deposits and loans are *lost* when depositor's and lender's withdraw their money. The flow *liquid deposits and loans lost* is modeled as the *average depositor's and lender's fear and uncertainty* times the *liquid deposits and loans* divided by the *average stickiness of liquid deposits and loans*. The real *average stickiness of liquid deposits and loans* is unknown: in the Base Case simulation, it is assumed to equal 1 week. The *average depositor's and lender's fear and uncertainty* smoothes the *instant stock market fear and uncertainty.* It is modeled as a third order delay of the *instant stock market fear and uncertainty* with a *depositor's and lender's uncertainty and fear delay* of 1 week. In the Base Case, the *average depositor's and lender's fear and uncertainty* initially equals 0%. The *instant stock market fear and uncertainty* is modeled as:

$$\frac{\text{degree of external climate of fear} * \text{stock market value loss}}{\text{stock market value/market loss delay} * \text{stock market fear factor}}$$

The *instant stock market fear and uncertainty* remains between 0% (absence of uncertainty and fear) and 100% (total uncertainty and fear). In the base model, the *stock market fear factor* is assumed to amount to 25%. This factor is used to put the *share price loss* into perspective – that is to say, relative to the *share price*: 25% means that traders and shareholders freak out completely if the *share price* drops 25% of its value during the *market loss delay* period of 1 day. Since the general climate is one of uncertainty and fear, the *degree of external climate of fear* is assumed –in the base model– to be rather high, twice as high as before the crisis or 200%.

Structures modeled to simulate policies are displayed in purple. Two policies focussed on increasing the *fixed and guaranteed deposits and loans* –and hence the *liquid assets*– are a discrete *one time governmental intervention* and a continuous *fraction of governmental intervention on deposits and loans lost.* A policy focussed on reducing the amount of *liquid deposits and loans lost* by increasing governmental guarantees is not modeled explicitly, but could be simulated by changing the *initial fraction of liquid deposits and loans.* Finally, a policy focussed on increasing *liquid assets* by means of stock issues (and if bought by governments, a (partial) nationalisation) is modeled in the bottom left corner of Figure 2.

As already mentioned, this model contains important simplifications and assumptions. It is implicitly assumed that the estimated net worth equals the real net worth. That may not be the case in reality, and could be dealt with in the model. In this version of the model, it is also assumed that there is no bandwagon effect nor speculation on the stock market (which may be an interesting extension). Since the model is a short-term crisis model, it is assumed (i) that there is no change in assets due to profits, (ii) that *fixed and guaranteed deposits and loans* do not come at their end, (iii) that there are no shifts between liquid and fixed assets, and (iii) that there are no shifts between liquid and fixed deposits and loans. Furthermore, it is assumed that the *average stickiness of liquid deposits and loans* is constant instead of dependent on the *average depositor's and lender's fear and uncertainty* or the *liquid assets* (bank reserves). Again, that may be an interesting extension of the model.

2.3 Behavior of the Base Model

The model allows to generate the different types of behaviors it should be able to generate after a 35% fixed asset loss:

- A minor bank run (green lines in Figure 3) buffered by liquid assets alone, without impacting fixed assets and net worth, is generated by the BaseCase scenario with an *average stickiness of liquid deposits and loans* of 4 weeks and an *illiquidity premium* of 0%.
- A sizeable bank run (red lines in Figure 3) draining the liquid assets and part of the fixed assets, and hence, part of the net worth, is generated by the BadCase scenario with an *average stickiness of liquid deposits and loans* of 1 week and an *illiquidity premium* of 10%.
- A major bank run (blue lines in Figure 3) draining both liquid and fixed assets, and hence, the entire net worth is generated by the WorstCase scenario with an *average stickiness of liquid deposits and loans* of 1 week and an *illiquidity premium* of 20% generates such a major bank run.

The *fixed asset loss* (35% of the net worth) in the second week Figure 3

2.4 Policy Analysis

Three types of policies are tested in this subsection: stock issues, gradually provided loans, and one-time loans. The stock issue and one-time loan policies are modeled as almost immediate interventions, provided in week 3 (the week following the 35% loss).

Following stock issue policies are tested:

- `WorstCasePol100Equity10Euro`: starting from the WorstCase scenario, 100 10^6 shares are issued (and sold to the government) at a price of €10/share (total €10^9);
- `WorstCasePol133Equity7Euro50`: starting from the WorstCase scenario, 133 10^6 shares are issued (and sold to the government) at a price of €7.5/share (total €10^9);
- `WorstCasePol163Equity6Euro`: starting from the WorstCase scenario, 164 10^6 shares are issued (and sold to the government) at a price of €6.1/share (total €10^9).

Following adaptive loan policies are tested:

- `WorstCasePolAdaptiveLoan20percent`: starting from the WorstCase scenario, the government (or central bank) gradually provides a loan a 20% of the *deposits and loans lost*;
- `WorstCasePolAdaptiveLoan25percent`: starting from the WorstCase scenario, the government (or central bank) gradually provides a loan a 25% of the *deposits and loans lost.*

Following one-time loan policies are tested:

- `WorstCasePol1TimeGovLoan1000`: starting from the WorstCase scenario, the government (or central bank) provides a one-time loan of €10^9 in week 3;
- `WorstCasePol1TimeGovLoan500`: starting from the WorstCase scenario, the government (or central bank) provides a one-time loan of €0.5 10^9 in week 3.

The behavior of these policies is displayed in Figure 4:

- The *share price* (upper left corner) improves only in case of a stock issue above the market price (`WorstCasePol100Equity10Euro`), but implies a serious direct loss for the government or central bank. Weak interventions (`WorstCasePolAdaptiveLoan20percent` and `WorstCasePol1TimeGovLoan500`) do not result in a stabilisation of the share price and are therefore not to preferable. Equity issued at or slightly below the share price, or sufficiently high (one-time or gradual) loans may stabilise the share price at different price levels (in descending order: `WorstCasePol133Equity7Euro50`, `WorstCasePol1TimeGovLoan1000`, `WorstCasePol163Equity6Euro`, `WorstCasePolAdaptiveLoan25percent`). Partial stock issue interventions (partial nationalizations) may also be problematic if share prices keep on falling afterwards. Falling share prices are not an issue (for an intervening government or central bank) in case of loans or full nationalizations.

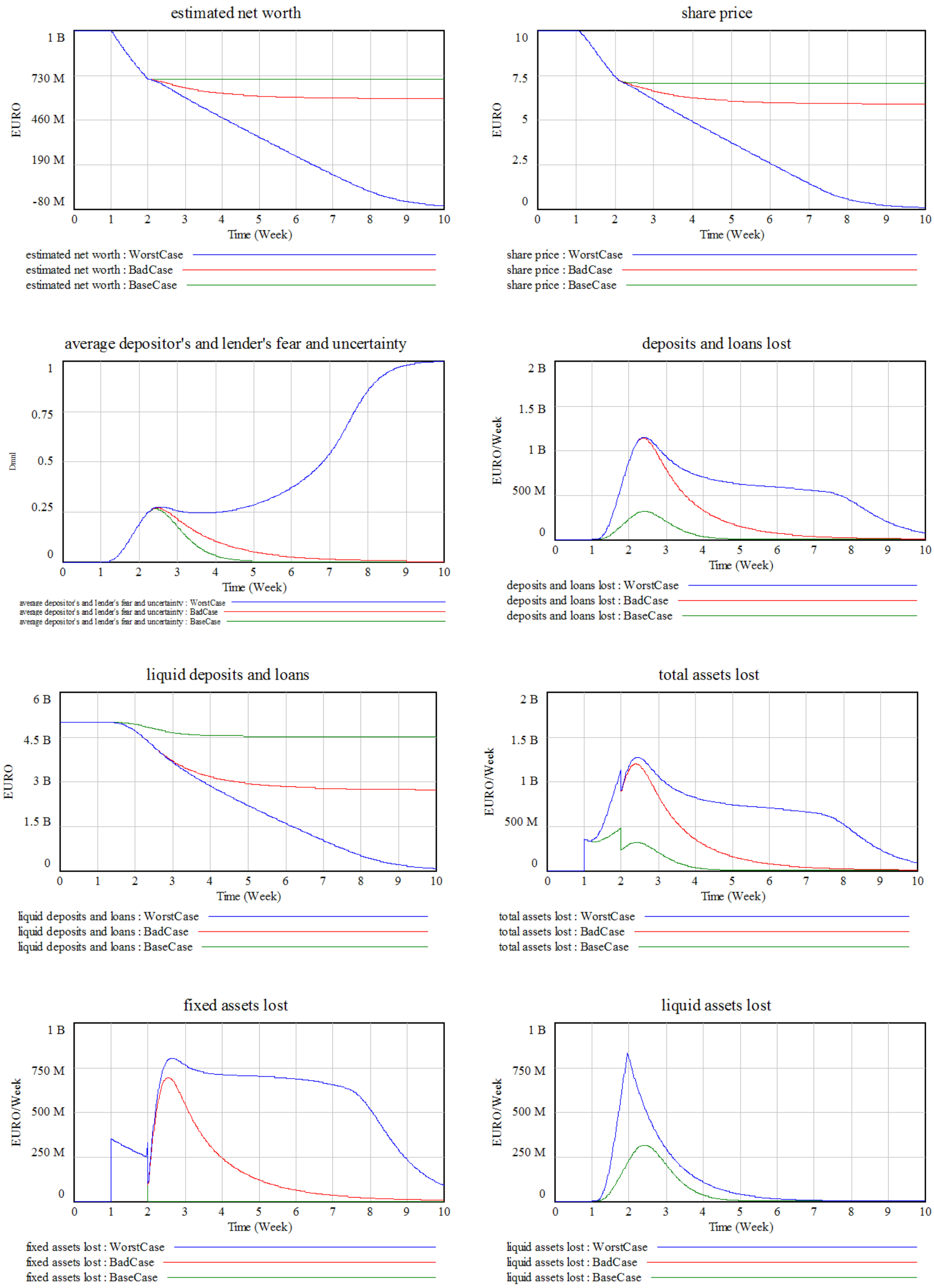


Figure 3: Behavior of the BaseCase, BadCase and WorstCase scenarios, more precisely in terms of the stock market value, underlying asset loss, instant stock market fear and uncertainty, and smoothed market fear and uncertainty.

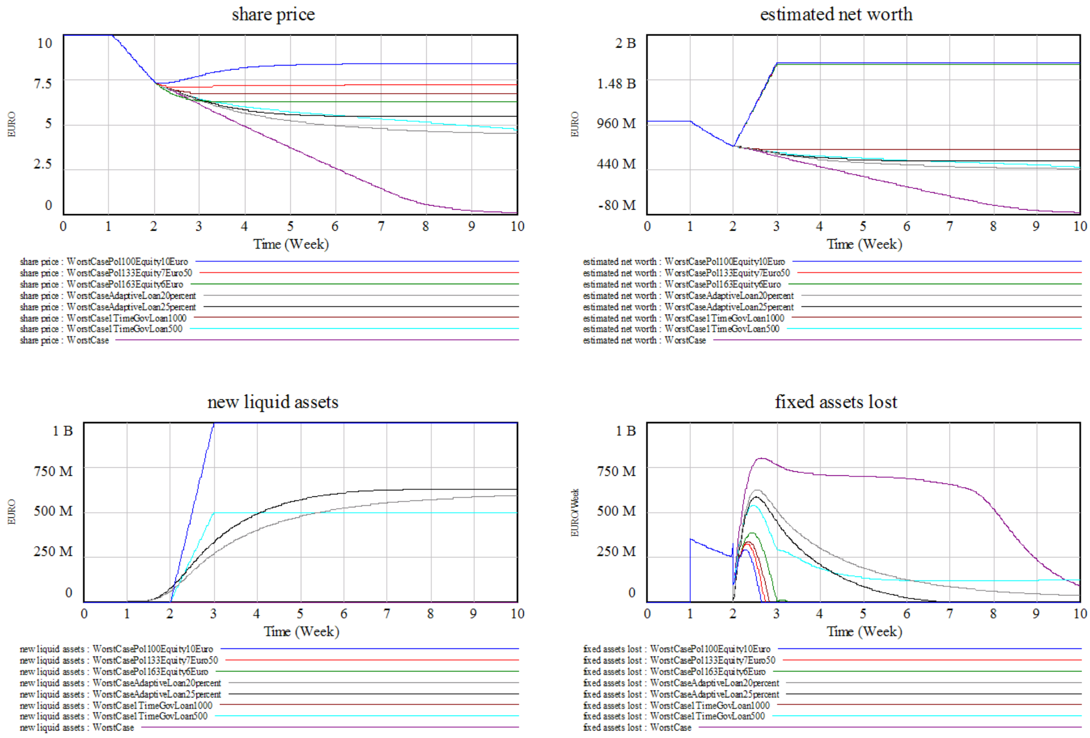


Figure 4: Behavior of the policies on a set of key variables, more precisely the *share price*, *estimated net worth*, *new liquid assets* (∼ injection by government or central bank), *fixed assets lost*

- Stock issues increase the *estimated net worth* with the amount of money injected but also the number of shares. Issue prices at or above the share price (`WorstCasePol100Equity10Euro` and `WorstCasePol133Equity7Euro50`) increase the *estimated net worth per share*. Issue prices below the share price (`WorstCasePol163Equity6Euro`) actually drag the *estimated net worth per share* down. The evolutions of net worth of the other policies (`WorstCasePolAdaptiveLoan20percent`, `WorstCasePolAdaptiveLoan25percent`, `WorstCasePol1TimeGovLoan1000`, `WorstCasePol1TimeGovLoan500`) are simply inversely proportional to the cumulative *fixed assets lost*.

- Amounts of *new liquid assets* –which correspond in fact to financial injections by governments or central banks– that allow to stabilise share prices are lowest for a sufficiently high gradual loan (`WorstCasePolAdaptiveLoan25percent`).

- The amount of *fixed assets lost* –which is proportional to initial net worth lost– is lower for stock issues at high issue prices (`WorstCasePol100Equity10Euro` and `WorstCasePol133Equity7Euro50`) and sufficiently high one-time loans (`WorstCasePol1TimeGovLoan1000`). Even the high gradual lending policies leads to a serious amount of *fixed assets lost* (`WorstCasePolAdaptiveLoan25percent`). Insufficiently high loans (`WorstCasePol1TimeGovLoan500` and `WorstCasePolAdaptiveLoan20percent`) lead to continued *fixed assets losses* and are therefore not effective.

From these graphs, it could be concluded that:

- Both shareholders interested in maximizing share prices and management interested in minimizing asset losses would prefer equity-oriented policies at a high issue price or high one-time loans: `Pol100Equity10Euro` ≻ `Pol133Equity7Euro50` ≻ `Pol1TimeGovLoan1000`.

- Governments and central banks interested in stopping vicious cycles without spending more than necessary [new liquid assets] would prefer sufficiently high adaptive loans, sufficiently high one-time loans (which will be repaid), or rightly-priced equity-oriented policies (not if the share price keeps on falling afterwards): `AdaptiveLoan25percent` ≻ `Pol1TimeGovLoan1000` ≻ `Pol133Equity7Euro50` ≻ `Pol163Equity6Euro`.

The most appropriate compromise strategy therefore seems to be:

- at first a firm governmental guarantee hoping that it will stabilise the market (because it only has financial implications in case of a collapse),
- if the firm governmental guarantee does not work, then a sufficiently high loan (`WorstCasePol1-TimeGovLoan1000`) or a rightly-priced partial nationalisation (`Pol133Equity7Euro50`)
- and if that does not work, a full nationalisation of the system bank.

3 The Fortis Bank Case

3.1 Hot Teaching/Testing Cases

The use of 'hot' issues for testing/teaching is one of several recent innovations in the Introductory System Dynamics course at Delft University of Technology (see (Pruyt et al. 2009)). For a discussion of 'hot' testing/teaching case and more examples of 'hot' cases, see (Pruyt 2009c). Two other recent 'hot' teaching and testing cases are discussed in (Pruyt 2009b) and (Pruyt 2009a).

The Fortis Bank case (see 3.2 and 3.3) was given to first-year master students during their time-constrained 'Introduction to System Dynamics' exam at Delft University of Technology on 23 October 2008. Most students were able to build the model and about half of the students managed to use the model for policy analysis purposes. A minority of students had major difficulties with the level of aggregation/abstractness of the model.

3.2 Case Description – Saving One Bank to Save the Banking System

> The recent credit crunch, which started as a subprime mortgage crisis in the United States, also caused serious problems for many European banks. One of the biggest banks of the Benelux (Belgium, the Netherlands and Luxembourg), the Fortis Bank, almost went bankrupt. The governments of the three countries met in a great hurry in the weekend of September 27-28 2008 to rescue the Fortis Bank. The reason for rescuing the bank at all cost is that the Fortis Bank is a system bank, which means that its collapse leads to a collapse of the rest of the financial system.
>
> *So let us go back to the weekend of September 27-28, let us ignore what happened afterwards, and assume that*[2]*:* In spite of the fact that you are not a financial specialist, you are asked by the three ministers of finance (probably because of your excellent System Dynamics Modeling skills) to help them really understand the issue at hand and help them design an appropriate policy to prevent the Fortis Bank from going bankrupt. Several top-level financial/banking experts and government officials are able to provide you with some general, high-level information, and more specific details concerning the Fortis Bank.
>
> The *stock market value* of the Fortis company can only increase by means of an inflow –the *stock market value increase*– and can only decrease by means of an outflow –the *stock market value loss*. Generally speaking, the *stock market value loss* equals the relative *perceived overvaluation* times the *stock market value* divided by the *market*

[2]Note that values used in this case description are fictitious, used for illustrative purposes.

loss delay of about 1 week. And the *stock market value increase* equals the *perceived market opportunity* times the *stock market value* divided by a *market increase delay* of about 4 weeks. Suppose that the *initial stock market value* of the Fortis Bank, some 10 weeks before the critical week, amounted to €24.6.

The *perceived overvaluation* –in relative terms, thus expressed in percentages– is then nothing but the difference between the *stock market value* and the *estimated underlying value*, divided by the *stock market value*. One of the financial experts advices you to model the *perceived market opportunity* as: (100% - *instant market fear and uncertainty*) ∗ *perceived undervaluation*. The *perceived undervaluation* –in relative terms, thus expressed as a percentage– is then nothing but the difference between the *estimated underlying asset value* and the *stock market value*, divided by the *stock market value*.

Suppose that the *estimated underlying value* (per stock) of the Fortis Bank amounted initially, some 10 weeks before the catastrophic week, to €25. The *estimated underlying value* can increase by means of *underlying asset increase*s and can decrease by means of *underlying asset loss*es (e.g. in case of a run on the bank, loss of unsecured assets, et cetera). The *underlying asset increase* could be simplified as the *average profitability* on the underlying assets times the *estimated underlying asset value*. The *average profitability* of the assets amounts to 0.2% per week. The financial advisors agree that the *underlying asset loss* should best be modeled as:

underlying asset loss = *external real value loss shock* ∗ *estimated underlying value* + (*average bank client's fear and uncertainty* ∗ 1/*stickiness assets*) ∗ *estimated underlying value*.

The *external real value loss shock* should be used to model and simulate the asset shock as a percentage of the *estimated underlying value*. This *external real value loss shock* amounted in week 10 to 35% in this 1 week time[3]... The exact *average stickiness of the assets* of the Fortis Bank is unknown: it could lie anywhere between 4 weeks and 52 weeks. Just take the average value of 28 weeks for a start. The *average bank client's fear and uncertainty* follows the *market fear and uncertainty*, but then smoothed. Model the *average bank client's fear and uncertainty* therefore as a third order delay of the *instant market fear and uncertainty* with an *uncertainty and fear delay* of 2 weeks. Initially, the *average bank client's fear and uncertainty* is equal to 0%.

The *instant market fear and uncertainty* could be modeled as:

instant market fear and uncertainty = *degree of external climate of fear* ∗ *stock market value loss* / (*stock market value* / *market loss delay* ∗ *stock market fear factor*).

The *instant market fear and uncertainty* should also remain between 0% (absence of uncertainty and fear) and 100% (complete uncertainty and fear). The *stock market fear factor* is assumed to be some 25%. This factor is used to put the loss into perspective – that is to say, relative to the share price: the 25% means that people freak out completely if the share price drops 25% of its initial value during the *market loss delay* period of one week. Since the general climate is one of uncertainty and fear, the *degree of external climate of fear* could be assumed to be rather high, for example twice as high as before the crisis, thus 200%.

3.3 Case Questions

1. (/6) Make a System Dynamics simulation model of this issue on your computer. Save the model using your family name or student number and the version of the model.

[3]Hint: you can model this for example by means of two step functions.

2. (/2) Verify the model very briefly. Include the necessary formulas/code/structures that ensure that variables that cannot become negative indeed remain greater or equal to zero. Examples are: the *perceived overvaluation*, the *perceived undervaluation*, and the *underlying asset loss*. Why do these variables always need to be greater than 0?
3. (/1) Validate the model extremely briefly. Use maximum 2 very simple tests. Do not perform any extensive validation tests or sensitivity analyses here. Briefly describe the tests used.
4. (/1) Simulate the model for a period of 52 weeks. Make graphs for following variables: *underlying asset loss*, *underlying asset value*, *stock market value*, *underlying asset loss*, *instant market fear and uncertainty*, and *smoothed market fear and uncertainty*. Sketch them on this exam copy too.
5. (/2) Three variables are particularly uncertain, simply because they are unknown: the *stock market fear factor*, the *average stickiness of assets*, and the *degree of external climate of fear*. Test the sensitivity of your model (manually) to changes in these variables. Keep it simple! What can you conclude regarding the sensitivity of your model?
6. (/2) Sketch the dynamics of the *stock market value* and the *smoothed market fear and uncertainty* for the worst case and best case scenarios in just two graphs on your exam copy (use different colors except red):
   - a *stock market fear factor* of 25%, an *average stickiness of assets* of only 4 weeks, and a *degree of external climate of fear* of 200%.
   - a *stock market fear factor* of 100%, an *average stickiness of assets* of only 52 weeks, and a *degree of external climate of fear* of 100%.
7. (/4) Draw an extremely aggregated/simple *causal loop diagram* of the system to help you communicate the main feedback effects responsible for the *worst case* system behavior.
8. (/1) Explain the link between structure & behavior briefly for the worst case scenario only.
9. (/1) Save your model under another name and add a simple closed loop policy (in color) that prevents the bank from collapsing, no matter which of the scenarios actually materialises. Name or describe the policy briefly. Test the policy at least in case of the worst case scenario and sketch the resulting dynamics on your exam sheet.

Answers to most of these questions are provided in the following subsections.

3.4 The Case Model

Answering the case question 1, students have to develop the simulation model displayed in Figure 5. Answering case question 4, students need to fine-tune some formulations.

3.5 Behavior of the Base Model

This subsection contains the answer to the fourth case question. Figure 6 displays the behavior of the base model over a period of 52 weeks for a selection of variables for the base model and the parameter values discussed above. The underlying (asset) value loss of 35% leads to an increase of the instant market fear and uncertainty from 0% to 100% (∼panick), an increase –but less pronounced– of the smoothed market fear and uncertainty, which in turn leads to an additional –but smaller– underlying asset loss, and a further decrease of the stock market value. However, the additional decrease is not dramatic: in other words, the bank does not collapse in the base case simulation.

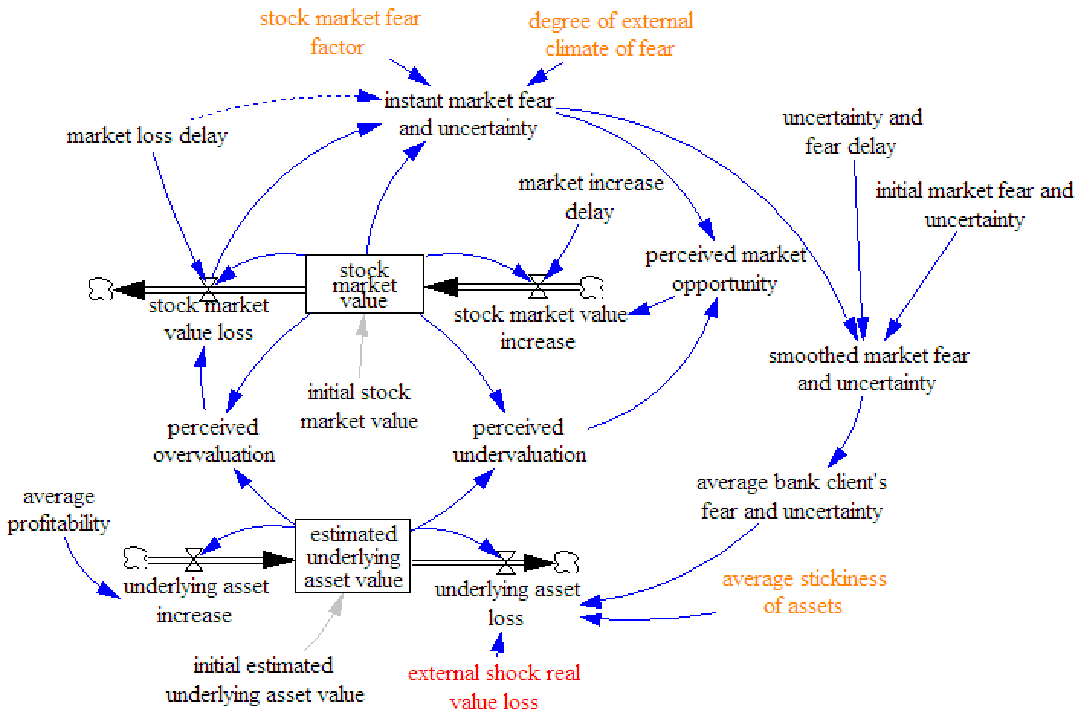


Figure 5: Stock/Flow Diagram of the System Dynamics simulation model

3.6 Sensitivity, Uncertainty and Scenario Analysis

In the fifth case question, students need to address the sensitivity of the model to changes in three uncertain (exogenous) variables/constants.

The model is mostly not behaviorally sensitive, except when the stock market fear factor is very high *and* the average stickiness of assets is very low *and* the degree of external climate of fear is very high. In that case, the bank goes bankrupt. There is a clear bifurcation point. Hence, the behavior of the model is behaviorally sensitive to a really heavy crisis...

Three variables are particularly uncertain: the stock market fear factor, the average stickiness of assets, and the degree of external climate of fear. However, the model is not sensitive to any of these uncertain parameters in isolation.

But the model is behaviorally sensitive for simultaneous changes in the three variables. This may be illustrated by means of scenarios. Figure 7 displays the dynamics of three scenarios: a worst case scenario, a base case scenario, and a best case scenario. The scenario combining a stock market fear factor of 25%, an average stickiness of assets of only 4 weeks, and a degree of external climate of fear of 200% leads to a collapse and may rightly be called the 'worst case scenario'. A scenario with a stock market fear factor of 100%, an average stickiness of assets of only 52 weeks, and a degree of external climate of fear of 100% does not lead to a collapse and may rightly be called the 'best case scenario'. The base case scenario was already defined above.

Further investigation by means of comprehensive Multi-Variate Sensitivity Analysis and/or Exploratory Modeling and Analysis (EMA) as discussed by Pruyt (2007) and Lempert, Popper, and Bankes (2003) leads to the conclusion that only few combinations really lead to a run on the bank. These combinations nevertheless justify proactive governmental policies, needed to prevent a collapse of the bank but only in exceptional circumstances. Preferably, these policies should in fact only be activated and cost money in case of major crises.

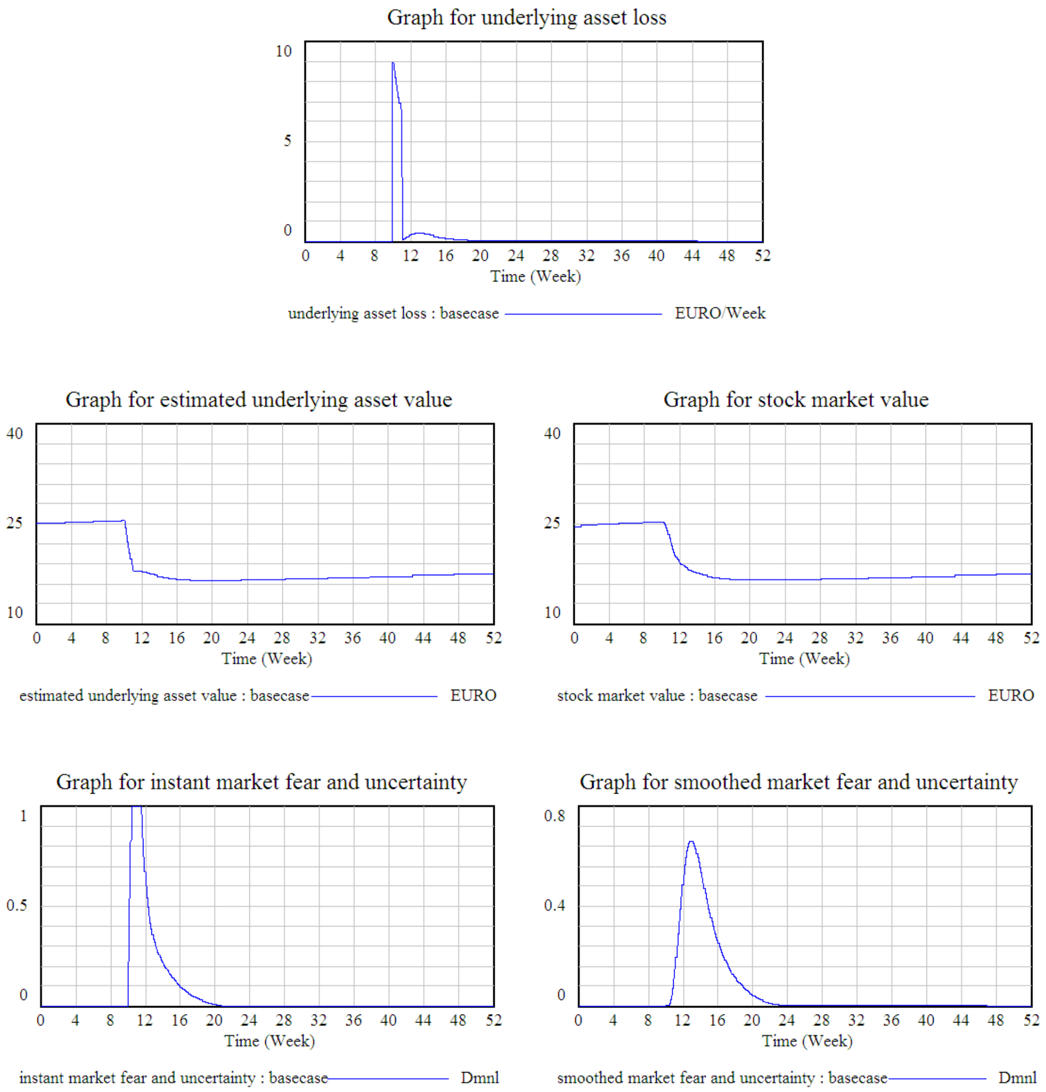


Figure 6: Behavior of the Base Model, more precisely the stock market value, underlying asset loss, instant market fear and uncertainty, and smoothed market fear and uncertainty.

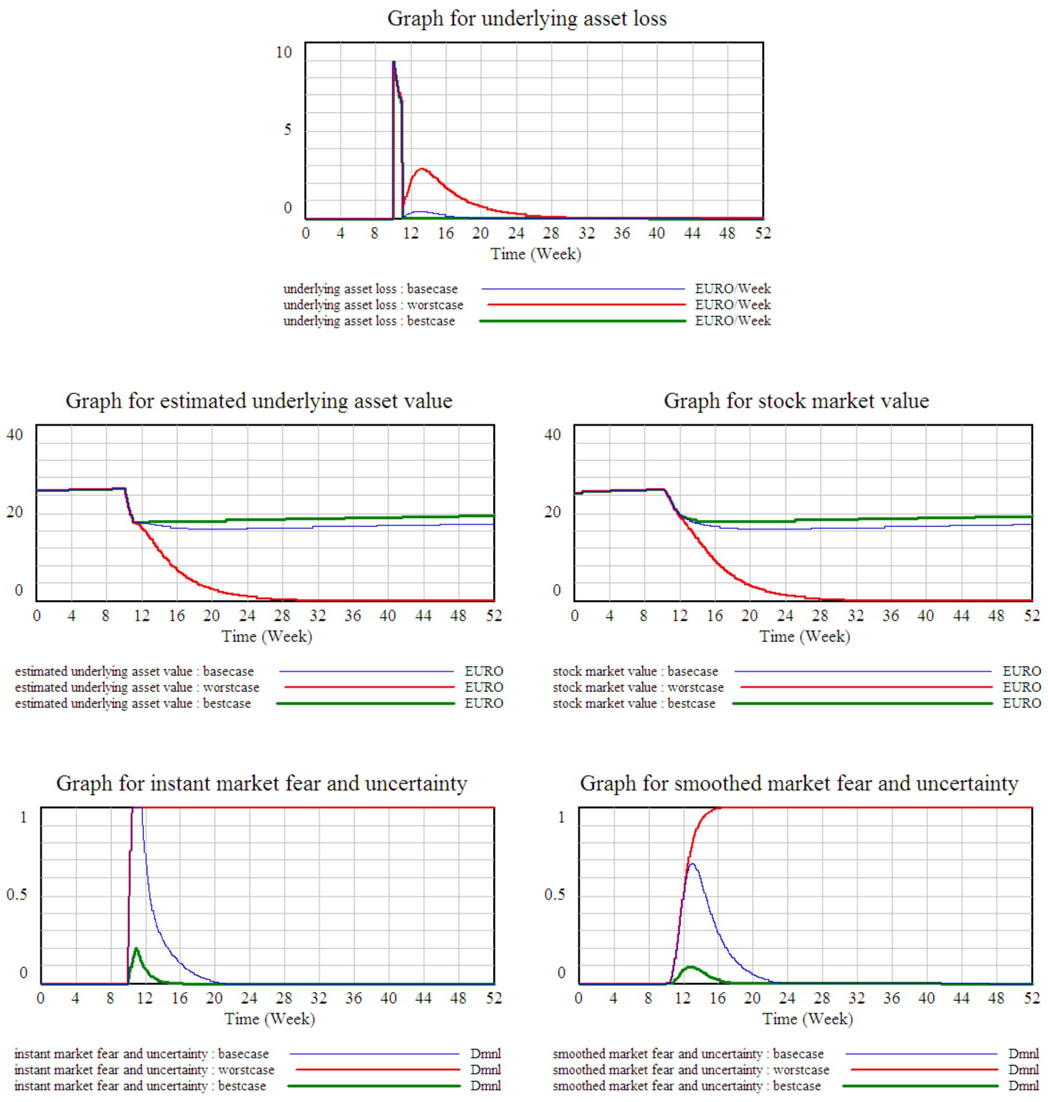


Figure 7: Dynamics for a worst case, base case scenario, and best case scenario

3.7 Causal Loop Diagram for the Worst Case Scenario

The worst case scenario, the run on the bank, is therefore the scenario of interest. Figure 8 shows an aggregated causal loop diagram of the simulation model explaining the main feedback effects responsible for the worst case system behavior. Students have to draw a similar causal loop diagram to answer case question 8.

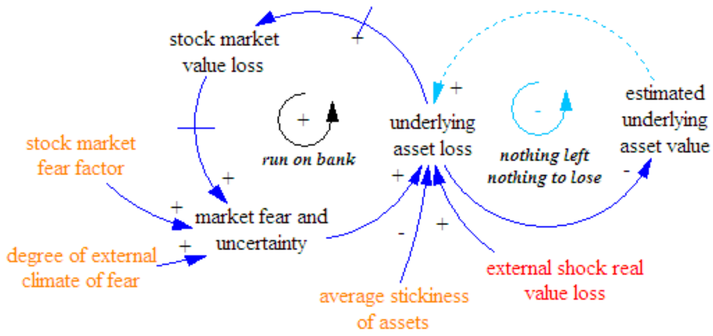


Figure 8: Aggregated *causal loop diagram* of the system explaining the main feedback effects responsible for the worst case system behavior

This causal loop diagram could then be used to explain the link between structure and behavior for the worst case scenario: a strongly decreasing stock market value leads to fear and uncertainty, which incites people to empty their bank accounts, causing the stock market value to even fall further, etc. This positive feedback effect –if fast and strong– is hard to stop before hitting the bottom. . .

3.8 Policy Analysis

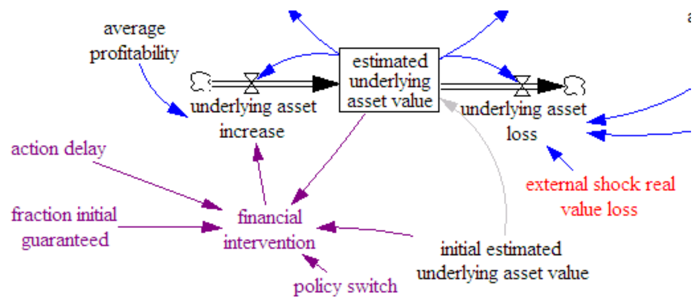


Figure 9: Stock-Flow structure of a 50% guarantee of the underlying value

In this section, one policy that might possibly prevent the bank from collapsing no matter which of the scenarios actually materialises, is tested using the simple simulation model. The simple closed loop policy tested here is a government guarantee –of say 50%– of the initial underlying value (more precisely of the deposits and loans), no matter the loss. . .

The additional Stock-Flow structure of that policy is displayed in Figure 9. The consequence is that the government only needs to pay in the exceptional case of a really heavy crisis and subsequent run on the bank (see Figure 10). In all other cases, this policy does not cost any money (see for example the base case where no intervention is needed).

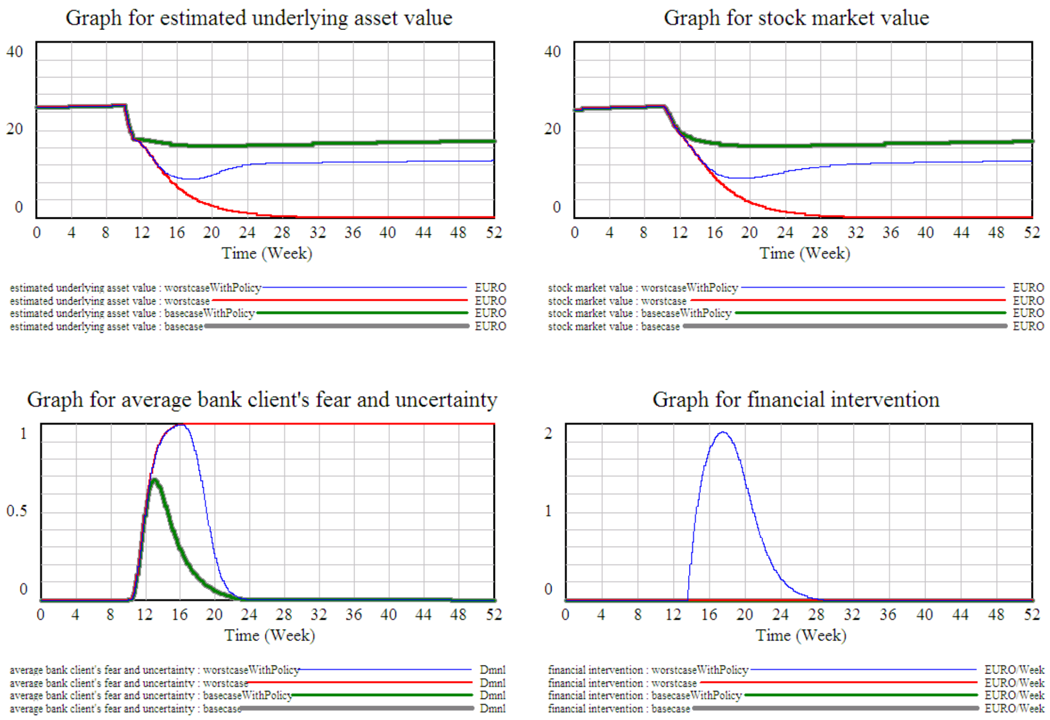


Figure 10: Worst case and base case runs with/without a 50% guarantee of the underlying value

4 Postscript: What Really Happened – The Fall of the Fortis Holding

The storyline of this section is mainly based on newspaper articles, web articles, and the vkwmetena website[4].

In October 2007, a consortium of Royal Bank of Scotland, Fortis Holding, and Banco Santander bought ABN-Amro for the (with hindsight excessive) sum of €72 10^9. Fortis' share in the world's biggest financial takeover amounted to €24 10^9. In order replenish its capital and to finance the integrating of the retail operations following the takeover, the Fortis Holding needed to raise €8 10^9, sell assets, and cancel the payment of an interim dividend of €1.3 10^9 right in the middle of the credit crunch. Decreasing share prices reflected concerns about the feasibility of the takeover and rumors about an additional issue at historically low prices.

After the collapse of Lehman Brothers, it became increasingly clear that Fortis was seriously exposed to the American merchant bank and to sub-prime debt. Subsequently, shareholders started to dump their Fortis shares. Rock bottom share prices led to uncertainty about the bank's liquidity and solvency which induced savers to empty their deposits. Vague and overoptimistic communication only reinforced the climate of uncertainty and distrust.

In the week prior to September 28 2008, Fortis shares prices collapsed: Fortis Holding was hit by a 35 % drop of its share price in only two days –one of the biggest trading falls– after rumors and denials about a possible intervention or sale its stake in ABN-AMRO. The reinforced downward spiral could not be stopped without governmental intervention. On 27 and 28 September, the governments of the BeNeLux countries met in a great hurry to rescue the Fortis Holding: it was decided that Fortis would receive a €11.2 10^9 rescue/bail-out package from the BeNeLux governments and would partly be nationalised (49%). However, Fortis continued to face liquidity

[4] `http://polsslag.vkwmetena.be/index.php/belgische-context/48-de-val-van-fortis`

problems, and big clients continued to withdraw their money (€35.9 10^9 between 29 September and 3 October). On 2 January 2009, Belgian newspapers reported that the cumulative amount of loans provided by the Belgian Central Bank in order to prevent the Fortis Bank from going bust amounted to €29 10^9 and increased to €90 10^9 in the following four days.

What happened afterwards: When it became clear that €12.6 10^9 debt needed to be refinanced in the third quarter, more drastic measures were taken unilaterally: on 3 October the Dutch government broke its part of the promise and nationalized the Fortis Bank Nederland, ABN Amro, and the insurance branch for the total sum of €16.8 10^9. he Dutch minister of finance, Wouter Bos, argued that he needed 'to isolate the good from the contaminated parts'. That statement pushed the share price of the remaining part of the Fortis Holding even deeper down. The Belgian government subsequently decided on 4-5 October to nationalize the remaining part, and to sell 75% of the part BNP Paribas was 'willing' to buy[5] to BNP Paribas for only €1.6 per share. In order to 'convince' BNP Paribas, the Belgian government had to lend another €3 10^9 to the Fortis-holding. This deal was subsequently challenged several times by shareholders (both in court and shareholders' meetings) and renegotiated (30 January 2009 and 6 March 2009). More than €25 10^9 of net worth was lost...

5 Concluding Remarks

This paper presents a simple, experimental System Dynamics model of an important issue which generates interesting dynamic behaviors and has a strong intuitive appeal.

Many banks had to be rescued from collapsing in 2008-2009. This exploratory study suggested a possible mechanism of the collapse of a bank in which the share price has an important signalling function, and a policy to prevent a collapse from happening. That policy looks like a sequential experiment:

- at first a firm governmental guarantee needs to be provided, hoping that it will stabilise the market (because it only has financial implications in case of a collapse),
- if the firm governmental guarantee does not work, then a sufficiently high loan seems to be needed, or a rightly-priced partial nationalisation (if a 'right' price can be determined in such a market environment)
- and if that does not work, a full nationalisation (without immediate resale at rock-bottom price) seems to be the final step.

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[5] BNP Paribas refused to take over €0.1 10^9 liquid assets, the international insurance branch (estimated worth of €2.5 10^9), and a whole lot of 'structured asset-backed securities' (mainly sub-prime debt).

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