Complexity Research Initiative for Systemic Instabilities

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Complexity Research Initiative for Systemic InstabilitieS
FP7-ICT-2011-7-288501-CRISIS

Deliverable D5.1
Game Architecture: Online Multiplayer Economic Game

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Abstract	This document reports on the work in WP5 which aims at creating the CRISIS Game, an online multiplayer economic game. The CRISIS Game is a simulation of a market economy, with households, firms and banks. Households provide the workforce, as well as the market demand for consumer products. They are also clients of banks, depositing their savings and shopping for interest gains. Firms are the employers on the labor market, the providers of goods and clients of banks seeking loans to scale up their production to meet market demand. Banks collect deposits from households (or firms), give loans to firms and invest in firms by trading in the shares of them. Banks also participate in the interbank market, seeking and offering loans to one another. In the online game, banks will be impersonated by human players while firms and banks behaviors will be generated by the underlying Agent Based Model. This document starts from the above description and guides the reader through various steps of game definition. After a brief overview of how games are designed in the gaming industry, a first, high-level description is provided. This is followed by a discussion of the elements of the gameplay, providing details on the main actors of the economic simulation, from banks to households/firms and markets. A detailed description of the game mechanics augments this, offering details about the operation of the underlying core economic simulator (mainly based on the Mark I version of the Macroeconomic ABM, from the book of Delli Gatti et al. [1]). In addition to these, additional considerations are given to exogenous events as a possible source of scripting in the simulated economy. These sections are followed by design issues that are specific to the process of turning a scientific economic simulator into a multiplayer economic game. Finally, brief comparisons of our plans to related endeavors (i.e., similar economic simulator games) are given, as well as a discussion about the relationship of this work to the work carried out in other work packages of the CRISIS project.

Distribution level	Publicl	**Status**	Final	**Version**	01
Contractual delivery date	30/04/2012	**Actual delivery date**		30/04/2012	

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1 Introduction

This document describes the computer game that is to be developed in the CRISIS project, the *CRISIS game.* The game will be based on a unified agent-based macro and financial model which is also developed by the partners in the project, the *CRISIS model*. Our final goal, therefore, is to ground the *CRISIS game* in the *CRISIS (integrated) Agent Based Model.*

The goal of the game is multifold. Being an on-line accessible game, it is going to be one of the main dissemination vehicles of the project targeting a broader non-scientific audience. The game factor will help us to engage people in the topic, and playing the game will improve their education in economics. During the game, we can observe the players' reactions in different situations, and the recorded data will help us to calibrate the underlying models. Finally, a local version of the on-line game will target policy makers by offering a serious-gaming environment for internal training purposes. To achieve the above four goals, we need to find a delicate balance between designing a game that is fun to play, and one that is based on sound scientific results. This document describes a game that, we believe, fulfills this requirement.

In fact, we propose to develop multiple versions of the game. All versions would share the same simulation engine, of course, but they would differ in how the game is set up, and how it is played. In the project plan (DoW) there are basically two games described: an on-line game, and one that is played by people in the same geographic location. We believe that the on-line game should be developed for a more general audience, playing in a casual style, not assuming deep economic knowledge. In contrast, the game for players at the same geographical location could assume players that can talk to each other, provide an intensive game play, and assume a deeper economic knowledge. In this document, we describe the overall architecture of the game, which is the same for both kinds of games, and we discuss those game features that are different. Specifically, in Section 2.7, we describe three settings that each provides a different version of the game.

In the following section, we discuss the procedures we apply in developing the game. We introduce the normal way in which games are developed, and then we present how we apply this in the CRISIS project.

1.1 The development process

To achieve our goal to develop a fun game on a scientific base, we had to tweak the quasi industry standard processes of computer game development. Normally, the development of a computer game is an involved process that progresses through several stages. During the CRISIS project not all stages will be implemented as not all stages are applicable. In the following paragraphs we first summarize the general game development process, and then we describe how we are going to implement it.

Game production is normally divided into the following three phases: pre-production, production, and post-production. The goal of the pre-production phase is to convince a publisher to fund the development of the game. The designers first describe the ‘High concept’ in a few lines, which is then developed into a ‘Pitch’ document. The pitch is a short summary document intended to present the game's selling points and detail why the game would be profitable to develop. Then a ‘Concept’ document is developed that includes the high concept, the game's genre, the game-play description, the game’s features and setting, the story, the target audience, the targeted hardware platforms, an estimated schedule, a marketing analysis, as well as team requirements, and risk analysis. This is the base of the ‘Game Design’ document, which is a living document continuously updated during the development. The game design document includes everything about the game; it describes aspects like the story, characters, level/environment design, game play, art, sound/music, user interface, game controls, etc. In addition to these documents, it is not uncommon to even produce a prototype in the pre-production phase to help defining the major game-play elements.

Prototyping and development of the design continue in the development phase. These activities last until the end of the project, meaning that the game design continuously changes as the product is developed. Trying out ideas in prototypes and testing the final implementation of features spawn new ideas that are prototyped and tested again. This iterative process works throughout the project and results in a game with well thought-out and fine tuned features. However, these are often rather different from what is described in the original game design.

The post-production phase usually consists of maintenance and other commercial activities. In case of an on-line game, maintenance means the operation of the game servers, but also releases of bug fixes, and sometimes even new levels/worlds or new features. From a non-technical point of view, the post-production phase consists of marketing and sales activities, as well as user-group organization and user-feedback collection. In general, in the post-production phase the emphasis shifts from development tasks to commercial and social tasks.

In the CRISIS project, the three phases of game development are implemented with a little modification. Instead of undertaking the pre-production phase with its original goal (to convince a publisher to fund the development), we extended it to consider the economic models running in the background of the game engine. The results are summarized in the present document, which is a more detailed account than what is usually produced by initial game design. Here we go into details on how the world is simulated by the economic simulator developed in the project. Furthermore, we analyze a series of issues that have to be solved during the development of the game. These are discussed in Section 5, and will be solved by prototyping during the beginning of the production phase. Prototyping, implementing and testing will mostly take part in the second phase, as usual, with art and level production getting an emphasis towards the end. From the post-development phase, user-group organization and user-feedback collection is planned within the project, while marketing, sales and technical maintenance are post-project activities. Clearly, most of normal post-development activities are out of the scope of an FP7 project. Nonetheless, activities aiming at increasing the visibility of

the game, and thus attracting users (players) to it, will be needed for the game to fulfill its goal within the CRISIS project.

The next section introduces the CRISIS Game, to be implemented in the project.

2 The CRISIS Game

This section provides an overall description of the proposed game. In addition, we also describe the basic information, like the genre of the game and the software platform it will be developed for. Brief discussions of game modes and the world of the game are also provided.

2.1 Game Description

The CRISIS Game is a simulation of a market economy, with households, firms and banks. Households provide the workforce, as well as the market demand for consumer products. They are also clients of banks, depositing their savings and shopping for interest gains. Firms are the employers on the labor market, the providers of goods and clients of banks seeking loans to scale up their production to meet market demand. Banks collect deposits from households (or firms), give loans to firms and invest in firms by trading in the shares of them. Banks also participate in the interbank market, seeking and offering loans to one another.

The behavior of the simulated market is anchored in the agent-based models developed in WP2 and WP3. In particular, the core of the game engine is based on the macroeconomic agent-based model (MABM) of WP3. More specifically, it is based on its first version, called MARK I (MABM-1), which follows the model described in Delli Gatti et al. [1] This will be extended by the financial agent-based model (FABM) of WP2.

The players of the game get to control the banks, while the actions of the other type of actors are simulated by artificial agents (governed by the combined models of MABM and FABM). Players receive information (news events, statistics, “expert” analysis by simulated players, etc.) and get the opportunity to make decisions about the market policy of the controlled bank (set interest rates, form the policies regarding loans to firms, and decide on events and actions on the interbank market).

Depending on the configurations, the game engine can offer a variety of game experiences, ranging from the “normal” state of the economy, via scenarios spotted by a few extreme events (like natural disasters or local political upheavals), to a full-blown economics crisis. These scenarios can be static or dynamic, and in the latter case, can be fully scripted or dynamically controlled (i.e., supervised by game makers). In all cases, the behavior of the “world economy” is governed by the appropriate parameter settings of the underlying economic models, capable of producing a rich set of behaviors.

2.2 Genre

The game developed in the project will be a browser game (i.e., played in web browsers), using Flash and Java technologies. [3] [4] It will feature multiple simultaneous players, thus it will belong to the multiplayer economic simulator category.

2.3 Platform

At the technical level, we intend to support normal PC computers, running Windows, Mac OS X, or Linux operating systems. The game will not support specific game hardware (like Playstation, Xbox, etc.) and no specific support for handheld devices (i.e., like smart phones) will be provided. (Nonetheless, the game may be playable on some smart phone platforms via standard web browsers. However, no specific efforts will be committed to guarantee this.)

2.4 Key Features

In the following we provide a list and summary of the key features of the CRISIS Game:

- **Competitive multiplayer game:** In a word full of opportunities, the player can step higher and higher on the ladder. However, the delicate balance can go wrong in the blink of an eye. Players compete for resources and for achievements: their performance is summarized in their position on the high score table or for the fulfillment of other in game goals.
- **Character Leveling:** Players will typically participate in a series of different games (simulation runs). As they play more and more, their virtual character gets better and better – both due to the experiences the human player collects and because of the character ability development system.
- **Real-Life Economy Models:** Under the hood, a simplified agent based model of the economy is running.
- **Entertaining and Tutoring Gameplay:** The goal of the game is to provide an entertaining game that also educates players. Players need not be experts to understand the challenges of the game, the charts and data tables and the set of actions they need to choose from. The tutoring feature is one of our most important objectives. After a short period, players are expected to understand the basic economic background of the game.
- **Achievements:** Individual games (simulation runs) may pose specific challenges for players. In addition, specific targets may be set for additional bonuses (i.e., achievements). These targets can range, for example, from being the most profitable bank, to a bonus for being able to maintain a 10% increase of profits over 20 time periods of the game, or to finding a specific player in the game, etc.

2.5 World Instances

Depending on the number of players interested, there can be several, parallel game worlds. Each world offers a different economy: with different initial state, different game (simulator) settings, etc. This provides a more diverse gameplay for the players, who can choose which world they want to join.

2.6 Global Settings

Games or world instances when started are initialized by various parameters. These parameters govern the behavior of the underlying model, as well as they influence the exogenous events (scripts) of the game.

2.6.1 Banking Regulations

A particularly important set of global settings are the banking regulations. The game engine allows for a customizable regulatory environment, providing a set of predefined settings, like:

- Basel II regulations,
- Basel III regulations, or
- An economy without these laws.

As it is well-known, the Basel regulations control how much capital banks need to put aside to guard against financial and operational risks. The settings contain risk and capital management requirements designed to ensure that a bank has adequate capital for the risks it exposes itself to through its lending and investment practices.

2.6.2 Global Events

Changes in the economic climate are reflected through global events that affect the entire world. An oil price crisis, a disaster, a war, terrorism activities, diseases, or a new discovery can all have global economic consequences. These are modeled in the game engine by external changes in the simulator's settings.

The hosts of the game can pre-program (script) these changes in simulator settings or can manipulate them in a more dynamic, supervised fashion. Changes in the global settings are communicated towards players as specific news items, describing an imaginary event (that reflects and motivates the effect of the changes in the parameter settings).

2.7 Game Modes

In order to accommodate players with different economical knowledge, enthusiasm, and time to spend in the game, we decided to create multiple game modes. The essence of the game stays unchanged, but the target audience, the play style and the game experience changes from mode to mode. The following three game modes are considered.

2.7.1 Online Game

In this game mode, the players can play an open ended game with a relatively stable environment. The game is slow paced to allow for a casual play style. The simulation update

cycle takes several hours in order to require only a few minutes every day from the players. Financial events, such as bankruptcies, can be caused by the players, or by exogenous events controlled by game hosts (possibly via the introduction of specifically programmed artificial agents).

2.7.2 Challenge Game

The Challenge Game is also played online via the website, but instead of joining an already ongoing game, in challenge games, players are set in a predefined situation. The initial state is defined by the game parameters set by the administrator on the website. The game is played real-time, and the length of the session is fixed or bound to objectives. However, it never takes more than a couple of hours. The number of human participants is limited to 1-5, but teams of players are allowed.

This is an intense game mode, with a fast pace close to real-time updates. It offers no chance to pause or stop the game, thus requiring serious efforts from the players.

2.7.3 War Game

The War Game is a special game mode for experts or students who are interested in the financial economy. A super user, the host, can set up the game, and other players could join. The host has the capability to configure the initial state of the world, set the game length and other simulator parameters. For educational purposes, the host can also pause and restart the game anytime.

This mode is similar to the Challenge Game, except that here the players can set up the game for themselves, while Challenge Games are set up by the central administrator. The War Game mode also offers additional features to the players, such as the ability to pause and restart the game, etc.

In the next section we outline the game actors and their behavior.

3 Gameplay Elements

This section provides a detailed outline of the game's actors and their behavior, as well as, the four markets connecting them.

3.1 Actors

Figure 1 provides an overview of MABM-1 (see [1]). The major components (actors) of the model underlying the game are essentially those of MABM-1 as represented in the figure augmented by a Stock market for shares issued by firms and by an interbank market.

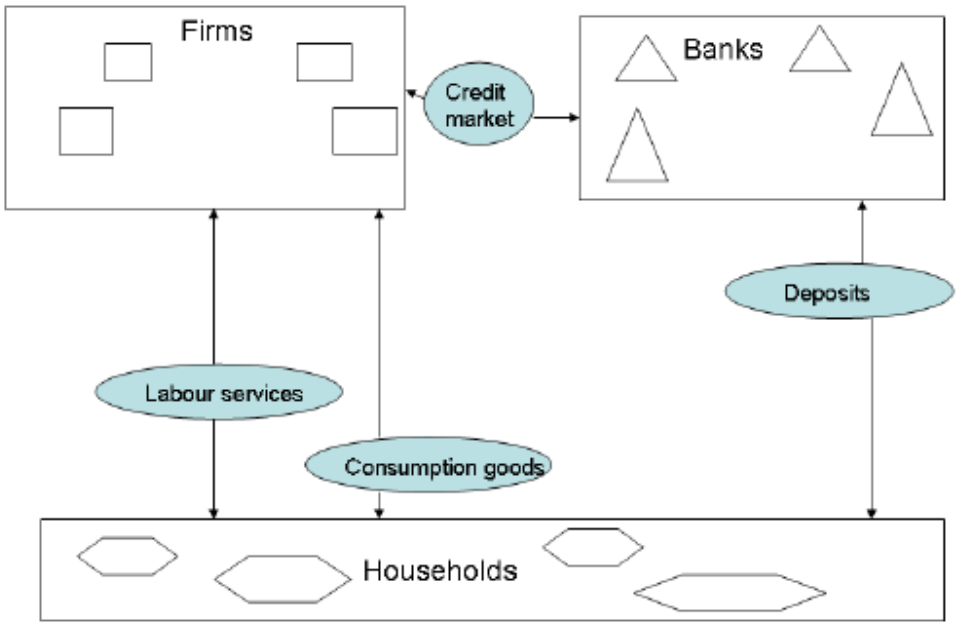

Figure 1 - Overview of the Mark I Model

There are three kinds of roles interacting in the game: banks, households, and firms. From these three, only the bank role is playable by human players, the remaining two are controlled by artificial software agents. All programmed agents can be fine tuned or can be tweaked during the sessions. This option will be very useful in the War Game mode, where the goal is to demonstrate or test a unique situation.

In the following sections, we describe the different actors, including the banks controlled by players.

3.1.1 Banks

The banks are the playable characters in the game. Their main purpose is to gain as much profit as possible by collecting deposits from households and firms, providing loans to firms, owning and trading the stocks of firms, and participating in the interbank money market. The players control these activities by adjusting loan and deposit rates for banks, firms and households, and by buying and selling assets. Players have to consider the exposure of the firms or banks they provide loans to, the risk of owning stocks, and they have to decide when they need to ask for a loan to meet their reserve requirements or to lend to other banks to make extra profit. To make a decision, players can look at various statistics, they receive news from the simulated world, and they can interact with each other via chat and mails.

3.1.1.1 Adjusting Deposit Rates (Deposit Market)

To collect deposits, banks have to set the interest rate they pay to depositors (households and firms). Since deposits provide liquidity the bank can use to invest in assets, the player may have an incentive to collect as much deposit as possible. Competing for depositors, however, pushes up the interest rates offered by the banks so that players have to consider the extra cost of paying higher interest rates associated with the effort to increase the deposit base.

3.1.1.2 Adjusting Loan Rates for Firms (Loan Market)

Similarly to deposits, banks may have an incentive to extend as many loans as possible. When firms ask for credit, however, banks must consider the risk of the firm as well as their exposure (assets, deposits and loans). They classify the firms into a risky or safe classes. Once the firms are classified, players have only to decide what interest rates to offer, and what amount they are willing to lend.

In a second version of the game, which would employ a more advanced model of the economy, banks could ask for collateral, and quotes for loan requests would include the requested collateral, too. Another possible improvement would be to consider more than two risk classes for the firms.

3.1.1.3 Trading Shares of Companies

The banks can own shares in the firms, which they are allowed to trade with each other. Each firm has issued shares that pay dividends when the firm makes a profit. The only owners of the shares are the banks. (This replaces the “rentier” in the Mark I model by merging it into the banks.) Thus, if a bank owns shares in a given firm and that firm pays a dividend the bank receives the dividend as profit.

Trading shares will be accomplished in a over the counter market. Banks that wish to sell shares can place their offers on a bulletin board. Banks that wish to buy shares can look up bids on the bulletin board and decide to take it or leave it. Additionally, banks can send alternative offers to the other bank selling the shares. This alternative offer is then either accepted by the other bank and the deal is made, or it is rejected and no deal is made.

3.1.1.4 Giving and Taking Interbank Loans (Money Market)

Banks may sometimes find themselves under financial stress, resulting in a need to borrow money. Similarly, a bank may find itself with excess unutilized capital and thus, with the wish to lend to other banks. Banks that need to borrow, and banks that want to offer loans can find each other by a mechanism similar to how firms find a bank for a loan. That is, a bank who wants to borrow posts her request to other banks. A bank who wants to lend money classifies the requesting banks into a lower and a higher risk category, assign different interest rates to the two classes, and divide the maximum allowed credit between the two classes. The requesting banks then review the offers, and select the best one. If this does not satisfy all their needs, then they take the second best, and so on.

3.1.2 Banks Governed by Artificial Agents

In some situations, it is beneficial to have banks controlled by artificial agents. While it is certainly a demanding task to design and implement such agents, they can improve the game experience by providing an enriched market environment. Besides being able to trade with artificial banks, human players can utilize programmed bank agents to provide suggestions or default actions in any given situation. This enables the players to operate their banks at a higher pace, to perform more actions than it would be possible otherwise. Additionally, employing artificial banks can fundamentally change the markets human players are active on, as they decrease the influence of the individual players on the market. Finally, automated banks can play an important role in the starting phase of a game. When there are no players in the beginning (of the on-line game, for example), or the players make no actions, artificial banks can still generate actions, and thereby put the markets in motion.

Artificial banks have the same decisions to make than human-controlled banks. They have to set deposit rates, quote interest rates for firms of different risk levels, decide which companies' shares to sell and buy, and decide whether to give or to take loans to and from other banks.

3.1.3 Households

Households are virtual characters in the game. They supply labor for firms, buy the consumption good from firms, collect wages and hold deposits in banks. The number of households is much larger than the number of banks or firms.

3.1.4 Firms

Firms are non-playable characters, too. Each firm employs households’labour to produce goods. For simplicity there is only one consumption good but, due to high uncertainty and transaction costs, each firm is able to differentiate its product/market. The firms must decide how much to produce, how many employees to hire or fire, and what price to charge for their good. If the firm is unable to pay its employees with internally generated funds, it must borrow from a bank; if it is unable to reimburse debt, it will go bankrupt.

In the first version of the game we have perishable goods. Indeed, goods expire in one turn of the hiring-producing-selling cycle of the firms. In a second version, the underlying model will be improved to handle durable goods. This will also have an influence on the game, as the firms will change their behavior, and thereby the whole economy will change.

3.2 Markets

The three roles in the game interact via several markets. Households and firms are connected by the labour market, households and firms are connected to banks by the deposit market. Firms and banks interact through the loan market, and banks interact by trading shares in the firms and by lending to each other in the interbank market. A short description of these markets are provided in the following sections.

3.2.1 Labour Market

On the labour market, households and firms -- thus only non-playable characters -- interact. This market is mainly hidden from the players, who are informed about the state of the job market only by the news and statistics.

Firms know their operative workforce. First, all firms with surplus workforce fire unnecessary workers randomly. On the other hand, if the desired scale of production implies greater labour demand, the firms hire from the currently available unemployed workers. Workers choose firms based on the wages they offer, and thus a firm may or may not satisfy its hiring needs. When it fails to satisfy its needs its output on the next time step is correspondingly reduced.

Once the matching has been completed, the firm computes the wage bill and the financing gap, which has to be filled by means of loans.

3.2.2 Loan Market

When firms find that they need extra funds to support their scale of production, they ask for loans. They randomly select a set of banks, and submit their request. The banks classify the received requests and allocate a certain amount of the available credit to each request. When the firms receive the answers from the banks, they rank them by the offered interest rate, and take the best offer. If that loan does not satisfy their needs, they take the second best, and so on, until they can cover all their costs, or they run out of offers.

3.2.3 Interbank Market

Due to the high fluctuation of the banks' liquidity, they may need to take interbank loans. Banks with liquidity deficits and banks with surpluses find each other by submitting request and offers to a bulletin board. When a matching is made, and loans are granted, the banks can reconsider their positions, and submit new requests and offers as needed.

3.2.4 Deposit Market

To obtain funds, banks compete for the deposits of households and firms. They offer different interest rates, and firms and households reconsider their commitment to their bank from time to time. When this happens they simply choose the bank offering the highest interest rate.

In this section, we provided an overview of the actors of the game, together with a brief description of their behavior. The four markets connecting these actors were also outlined. The next section will continue by discussing the technical, implementation details of the above described components.

4 Game Mechanics

In this section we provide a more detailed, technical description of the behavior of the actors, as well as the schedule of the simulation events (i.e., the implementation of the core simulation cycle of the economic model). These descriptions follow closely the definition of the Mark I model (of MABM, see WP2), as discussed in Delli Gatti et al. [1]

4.1 Agents & Actions

Agents in the simulation backing the game engine are actors in an artificial economic environment. Some of the agents are artificial, while others are controlled by human players. Such simulations, while not wide spread, are technologically possible and plausible. They have been created before, mainly for controlled economic experiments. Nonetheless, some of these previous efforts where used to create online, web-based games. [8] [9]

This section introduces the automated players: the households and the firms, as well as describes the framework for banks.

4.1.1 Households

Households have the following properties:

- Earned wages
- Household personal assets
- Employment status

In addition, Households also have a series of actions they perform. These will be discussed next.

4.1.1.1 Searching for a Job

- **Input** The ordered sequence of randomly chosen *M* firms based on the wage they offer, and the one which has been the previous employer.
- **Action** The labour contract of a worker expires after a finite number of periods. A worker whose contract has expired applies first to the firm which has been the previous employer. If the previous employer is not in the need of additional workforce at the time, the worker becomes unemployed. An unemployed worker contacts a finite number *M* of randomly chosen firms to get a job, starting from the one which offers the highest wage.
- **Output** Once employed the worker receives a wage for the entire duration of the labour contracts. The j^{th} worker (*j = 1, 2..., J*) supplies inelastically one unit of labour for the employing firm.

4.1.1.2 Consumption and Deposit of Savings

- **Input** The wage the individual receives.
- **Action** Income (wage) is spent in part on consumption goods (produced by the firms). The surplus money (savings) are deposited at the worker's bank. The propensity to consume is a nonlinear decreasing function of accumulated savings (wealth). The worker visits a finite number Z of firms to ascertain the selling prices. Then buys first from the lowest price selling firm. If the most preferred firm is in short supply, the worker can resort to the remaining (Z-1) firms. If the worker does not succeed in satisfying its consumption plan, it saves involuntarily.
- **Output** Households deposit their savings (wage minus the amount spent on the good) in their banks.

4.1.2 Firms

Firms have the following properties:

- Firm equity
- Prices
- Current production, stocks
- Past production
- Current credit demand
- Sales
- Bid interest rates
- Current employees
- Firm profits
- Expected demand
- Job vacancies
- Firm debts
- Firm liquidity resources (in a bank account)

In addition to the properties above, Firms also have a set of actions they perform. These will be discussed next.

4.1.2.1 Production

- **Input** The only input is the available labour for the given firm.
- **Action** The i^{th} firm (*i=1, 2..., I*) produces a consumption good using only labour at the t*th* time step. Technology is strictly linear ($Y_{it} = \alpha L_{it}$, where Y_{it} is the level of production, α is the labour productivity, L_{it} is the labour).
- **Output** The i^{th} firm (*i=1, 2..., I*) knows the *status quo* in the t^{th} time step, $A_{it} = (P_{it}, Y_{it})$. At the price P_{it}, given the average price P_t, demand D_{it} for the products of the firm can be different from production Y_{it}. Hence the difference (if positive) yields inventories: $S_{it} = Y_{it} - D_{it}$.

4.1.2.2 Updating Price

- **Input** The current *status quo*: $A_{it} = (P_{it}, Y_{it})$.
- **Action** Based on the *status quo*, the firm decides to change the price as follows, where η_{it} is a random positive value between [0,1]:

$$P_{it+1} = \begin{cases} P_{it}\left(1+\eta_{it+1}\right) & if \quad S_{it} = 0 \quad and \quad P_{it} < P_t \\ P_{it}\left(1-\eta_{it+1}\right) & if \quad S_{it} > 0 \quad and \quad P_{it} \geq P_{t-1} \end{cases} \tag{1}$$

- **Output** The price the firm uses in the next time step.

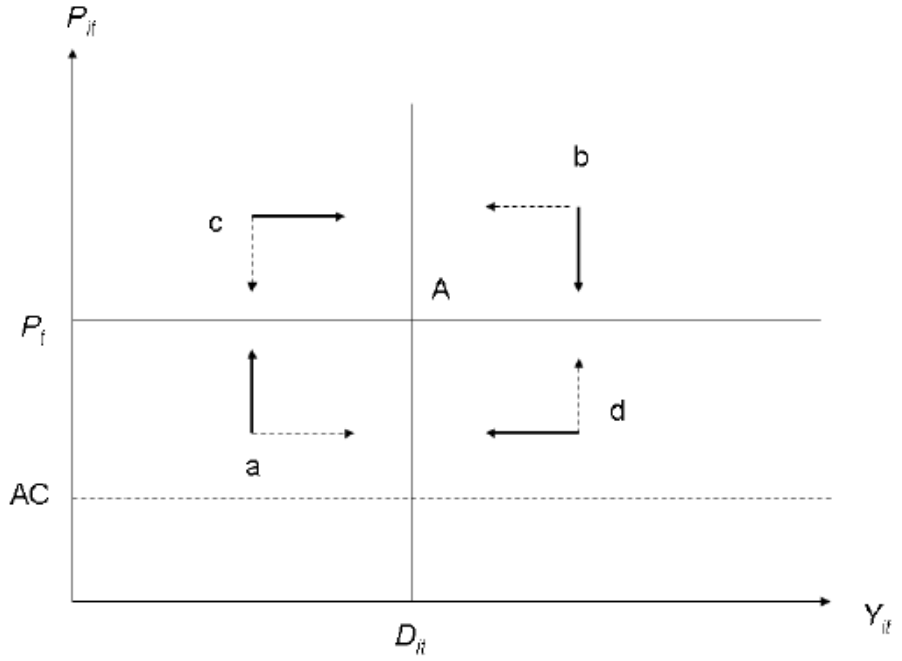

Figure 2: Price and quantity adjustments for the i^{th} firm

4.1.2.3 Updating Future Demand

- **Input** The current average price.
- **Action** The i^{th} firm decides to update the expectation of future demand and therefore the desired scale of activity Y_{it+1}^{d} as follows (where ρ_{it} is a random positive value between [0,1]):

$$Y_{it+1}^{d} = D_{it+1}^{e} = \begin{cases} Y_{it}\left(1+\rho_{it+1}\right) & if \quad S_{it} = 0 \quad and \quad P_{it} \geq P_t \\ Y_{it}\left(1-\rho_{it+1}\right) & if \quad S_{it} > 0 \quad and \quad P_{it} < P_t \end{cases} \tag{2}$$

The action is illustrated in Figure 2.

- **Output** The decision on the "desired" scale of production Y_{it}^d, determines the demand for labour $L_{it}^d = Y_{it}^d / \alpha$.

4.1.2.4 Posting Job Vacancies

- **Input** The operating workforce L_{it}^o.
- **Action** Firms post labour vacancies if the demand for labour to reach the desired scale of production is greater than the operating workforce.

$$V_{it} = \max\left(L_{it}^d - L_{it}^o, 0\right) \tag{3}$$

- **Output** The wage offered is:

$$w_{it} = \begin{cases} \max\left(\hat{w}_t, w_{it-1}\right) & \text{if } V_{it} = 0 \\ \max\left(\hat{w}_t, w_{it-1}\left(1 + \xi_{it}\right)\right) & \text{if } V_{it} > 0 \end{cases} \tag{4}$$

where $\underline{w}_t$ is the minimum wage, ξ_{it} is an exogenous percent increase. The minimum wage is periodically revised upward, in order to catch up with inflation.

4.1.2.5 Requesting Loans

- **Input** If internal financial resources (net worth: A_{it}) are in short supply with respect to the wage bill $w_{it}L_{it}$ - i.e. if there is a financing gap - the firm asks for a bank loan B_{it}:

$$B_{it} = \max\left(w_{it} L_{it} - A_{it}; 0\right) \tag{5}$$

For an illustration, see Figure 3.

- **Action** Borrowing firms contact a given number H of randomly chosen banks to get a loan, starting from the one which charges the lowest interest rate. If the most preferred bank is in short credit supply, the firm can resort to the remaining H-1 banks.

- **Output** If funds $B_{it}^s + A_{it}$ are still not sufficient to pay for the wage bill (*credit rationing*), the firm will fire redundant workers. If the firm ends up with excess supply, it gets rid of the unsold (non durable) goods (at zero costs).

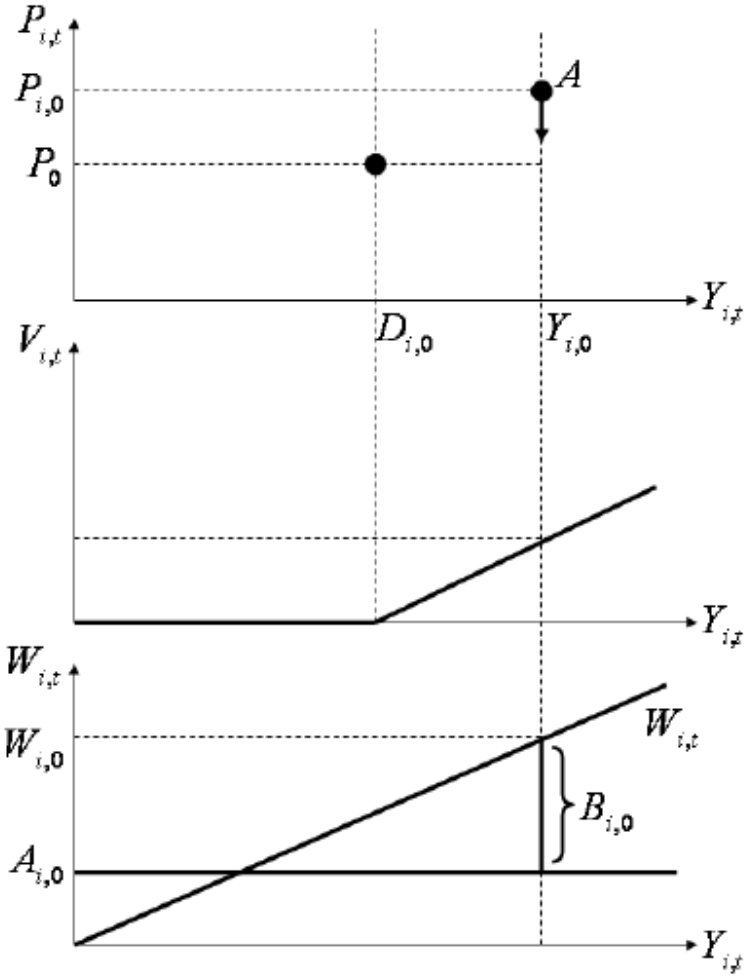

Figure 3: Loan calculations by the i^{th} firm

4.1.3 Banks

Banks are the agents human players can control. In this section we describe what the players can observe from their banks, and the possible actions they can perform. The same description also applies to the artificial agents that, in certain versions of the game, may potentially control some banks. The definitions provided below form the framework for the behavior implemented by the artificial agents.

Banks have the following properties:

- Portfolio of shares in firms
- Outstanding loans (both to firms and other banks)
- Deposits
- Cash

In addition to the above properties, banks also have a set of activities to perform. These will be discussed next.

4.1.3.1 Banks as Shareholders

- **Input** List of firms in which the i^{th} bank has a share.
- **Action** The bank receives dividends as owner of the firms.
- **Output** This income is added to the bank's resources.

4.1.3.2 Quote Loan Interest Rate and Quantities

- **Input** Historical data on the amount of loans the firms take and at what rate.
- **Action** Quote the interest rate and the maximum quantities for loans for a fixed term.
- **Output** The list of clients (firms) that could borrow money with the new terms and conditions.

4.1.3.3 Quote Deposit Rate

- **Input** Historical data on the amount of deposits the firms and households place and at what rate.
- **Action** Quote the interest rate for deposits for a fixed term. There is no maximum deposit amount: all deposits are accepted by the bank.
- **Output** The list of clients (firms, households) that could deposit money with the new terms and conditions.

4.1.3.4 Give Interbank Loans

- **Input** List of pending interbank loan requests.
- **Action** The player chooses a loan request according to his/her personal preferences.
- **Output** Each player's balance sheet is updated, the borrower gets the liquid money but he/she must pay it back according to the terms and conditions.

4.1.3.5 Place Interbank Loan Requests

- **Input** List of pending interbank loan requests.
- **Action** The player fills in the loan request parameters (interest rate, quantity and expiration date) and puts the request up at the bulletin board.
- **Output** After a few minutes the request is made visible to other players.

4.2 Turn Phases: Market Processes

This section describes how the artificial markets are cleared and updated.

Markets are fully decentralized and characterized by a continuous search and matching process. There are three different markets: the labour (*homogeneous*), the consumption good (*homogeneous, non durable*) and the credit market.

The scenario of a turn in the model is the following:

1. At time t, each firm i computes net worth:

$$A_{it} = A_{it-1} + (1 - \delta)\,\pi_{it} \tag{6}$$

   where π_{it} are profits and δ is the dividend payout ratio. If $A_{it} < 0$, the firm goes bankrupt and exits. If $A_{it} > 0$, the firm survives and proceeds to the next step.
2. Starting from the status quo, the firm decides (adaptively) the quantity to be produced (hence the demand for labour) and the price to be charged.
3. The labour market opens:
   a. Firms post vacancies (if any) at a certain offer wage.
   b. Each unemployed worker contacts a given number of randomly chosen firms to get a job, starting from the one which offers the highest wage.
   c. Once the matching has been completed, the firm computes the wage bill and the financing gap, which has to be filled by means of loans.
4. The credit market opens:
   a. Banks post credit vacancies (supply of loans) at a certain offer interest rate.
   b. Each firm contacts a given number of randomly chosen banks (possibly to all banks) to get a loan, starting from the one which offers the lowest interest rate.
   c. Once the matching has been completed, the firm assesses whether financial resources are enough to pay for the wage bill. If not - i.e. in case of credit rationing - some workers will be fired.
   d. Production is assumed to take the entire time step (i.e., goods will become available at the end of the t^{th} time step).
5. Market for the consumption goods opens:
   a. Firms post their offer price.
   b. Each worker/consumer contacts a given number of randomly chosen firms to buy consumption goods, starting from the one which offers the lowest price.
   c. Once the matching has been completed, the firm assesses whether there is sufficient demand to sell its goods. If not – i.e., in case of excess supply (inventories) - it gets rid of the unsold goods (at zero costs) because they are non durable. In an extension of the game, durable goods may also be introduced.
6. Accounting and surviving:
   a. At the end of the period, firms collect revenues and calculate gross profits (EBIT).
   b. If gross profits are big enough, the firm pays back its financial dues.
   c. Earnings after interest payments and dividends are retained profits, which are used to update net worth.
7. The cycle starts again with a next turn (t+1).

4.2.1 Bankruptcy

If the i^{th} firm goes bankrupt there is a negative demand spillover due to the loss of employment. Other firms will experience a reduction of demand. Moreover, the bank will record a non performing loan, which will affect the bank's net worth and therefore, through capital regulation, also the total amount of credit extended: $C_{kt} = E_{kt} / v$. Credit extended to other firms will be curtailed.

4.3 Exogenous Events

As discussed earlier, certain events of the simulated world originate outside the simulated economy. In particular, this is the case when extreme, one-time events occur, providing external shocks to the economy. The occurrence of these external events makes the game more interesting, allows for a richer game experience for the players and provides an opportunity for the CRISIS team to set up different experimental settings.

External events may take the form of natural catastrophes, or can be economic in nature. To facilitate such meddling with the game, we have three devices. First, we can influence the news series of the game. This allows us to communicate certain changes in the economy to the players. Second, global simulator settings (parameters) can be altered, thus changing the economic environment. For instance, the required reserve ratio for banks may be increased. Communication via the news system also plays a role here, since the players should receive a plausible explanation for the sudden change of the underlying economic conditions. Third, some agent-level parameters can also be changed on a per-agent basis (in case of the artificial agents). This will result in an altered behavior for a subset of the agents (e.g. some of the firms could start being overly optimistic about their future sales prospects).

In the following sections, we describe a few proposals for such exogenous events.

4.3.1 Natural Catastrophe

In case of a natural catastrophe, some of the firms could be artificially disabled. This way, they would fall out of production and borrowing for some time. This would cause a part of the households to be inactive, too. Such an event can be communicated to the users in the news, and the only necessary modification to the game is that, for a set of firms, the amount of produced goods is programmatically set to zero.

4.3.2 Dot-com Bubble

Some (or all) of the firms can be tweaked to be overly optimistic about their future sales, while the households can be made less eager to spend, and more eager to save. This could make a part of the economy collapse and cause problems in the banks. Technically, this can be

achieved by changing the forecasting of firms that determines the amount of production for the next phase.

In this section we have introduced the technical, implementation level details of the main type of actors of the simulation (game), together with the mechanics of the markets connecting them. In the next section we continue by discussing specific questions that are above the modeling level and that are related to the issue of transforming a scientific economic simulator into a multi-player economic game.

5 Design Issues

There are several issues that have to be considered when designing the game. These are related to issues arising when transforming a scientific simulation of the economy to a multiplayer economic game.

In the following sections we explain the issues we had to face, and describe our proposed solution, if any.

5.1 Target Audience / Levels of Play

When designing a game, one should identify the target audience (i.e., the envisaged players). In particular, in case of an economic game, the players' average economic expertise must be assessed. Since we want to allow players with close to zero experience, we need a simple UI with a limited number of options. On the other hand, if we decrease the complexity too much, the game would be boring. Therefore, we need to find the appropriate balance between experts and naïve, untrained players. One possible solution is to create tutorials to eliminate the difference, but that would perhaps require too much investment from casual players.

To solve this issue, we propose to have multiple variations of the game. The Online Game would fit the casual players more, while the War Game is tailored to experts in the field.

5.2 Synchronization

The game simulation can be arranged in two different ways with respect to how the actors in the world perform their actions. These are the *synchronous* and the *asynchronous* activation strategies. In a synchronous simulation, the agents perform their actions in turns. Time elapses by discrete steps and at each time step agents get to make their moves in a random order. In contrast, in asynchronous simulations agents perform their actions according to their own independent schedules. This way the actions are uncoordinated, agents do not have to 'wait' for each other.

The advantage of a synchronous simulation is that agents have equal chances of action. In particular, the players controlling banks can take their time to make decisions about the next move. When a simulation turn takes a longer period of time (e.g. 4 hours), it does not matter whether a player decided on the next move immediately after the new state of the world is revealed (at the beginning of the turn), or just before the end of the turn. In an Online Game, players can connect to the game any time in a turn, quickly make their moves and then disconnect until the next turn. This allows a more leisurely play-style, and fits players with little time for gaming.

The advantage of an asynchronous simulation is that its behavior is closer to reality. Agents can act on a virtually continuous time horizon, and they can immediately observe the effects of their actions. This operation mode favours the quick responder. That is, players who spend more time in the game can capitalize on their investment and exploit less frequently acting players. This can be an advantage in a war-game scenario, but it is a clear disadvantage in a long running casual game.

Additionally, it is also possible to create a hybrid simulation, in which some agents perform actions asynchronously, while others act in turns. For example, artificial household and firm agents could act asynchronously, but (human or possibly also artificial) banks can be constrained to synchronous operation. This has the advantage that the environment changes continuously, but the casual players are not differentiated on how much time they can spend in the game. The disadvantage is that enthusiastic players staying in the game longer, watching the economy change can get frustrated as they cannot react on what they see, but they are deemed to wait until the end of the turn to have their actions effected.

Our answer to this issue again is to create multiple variations. The Online Game designed for the casual players will employ a synchronous game mode, while the Challenge Game and War Game modes will run in the asynchronous operation mode.

5.3 Initialization

The initialization of the game is a crucial aspect that has direct influence on the whole game. Several possibilities might be useful and should be considered.

5.3.1 Initialization of the Mark I Model

The original model, on which the current game proposal is based on ([1]) solves this issue by simply using dummy data (e.g., fill up all the historical data which influence the decision of the actors in the model by zeros/ones).

In the current context, this would not be a valid approach. Players having the experience of several played games might speculate with this initial setup, and that might result in inherently distorted simulations (and results).

On the other hand, running the simulation until a “stable point” from such a state might help us identify an state that is free from wild oscillations in the beginning (of course, this is highly depending on the values of the used parameter settings of the underlying model). Once such a state is found, the game with human players could commence.

5.3.2 Default Initialization

There is a possibility to initialize all of the actors in the model with exactly the same amount of assets. This approach results in a highly controlled initial actor population, in which there is no heterogeneity.

5.3.3 Random Initialization

An alternative is to initialize all actors with random assets. This approach results in a more diverse initial actor population, but may provide unfavourable advantages to certain players.

5.3.4 User Initialized Assets

Allowing users to define their own set of initial assets (in a Challenge Game, for example) would result in a richer simulation activity at the beginning compared to the static, homogeneous distribution of assets. It is also possible to base the initial amount of money allocated to the users on experience points. This money can be spent by the player on buying assets at the beginning of the game. This way the initial assets are indirectly allocated based on how good the players performed in the previous (set) of games.

This slight difference in initial distribution of goods might result in a more heterogeneous player activity, and it also motivates the players to replay the game, thus increasing its replay value.

The best way to initialize a game is hard to tell beforehand. This issue will be resolved by prototyping and testing during the development phase of the game.

5.4 Joining the Game

The methods to be allowed for new players to join a running game are highly dependent on the time scale of a game simulation.

- If the game is to be run continuously, from week to week, for a longer time without interruption (i.e., the Online Game), it should be open for any player to register and join at any time. New firms, households and banks might appear in real life as well. Similarly, new banks controlled by new players could appear in the game at any point in time.
- If one full game simulation is played within a day (either in business hours or in the evening), new players with default assets would introduce an undesired noise in the game. Therefore, in short, real time games (i.e., the Challenge and War Games), new players should not be allowed to join running games.

Independently from the time scale, new players should be able to find a game and join, before the game starts. In the Online and Challenge Games, this could be facilitated by the web portal that handles the registration of users, provides a forum for game-related discussions, presents current high scores tables, and lists already created but not yet started games. It should be possible to search the list of games, to browse it and group it by various properties, like creation time, scheduled start, creator, etc. The portal could also maintain the network of gamers (users who played together in the past), and allow the users to quickly find games created by their fellow gamers.

5.5 Abandoning the Game

A problem similar to new players joining a running game is players leaving the game. There are two different ways a user might leave the game. The first is that the bank controlled by the user defaults. This is a controlled situation, the assets of the bank are sold according to predefined rules, creditors are paid back, and the player looses the bank to control (he might be able to stay in game to watch the others). The second case is when the user decides to leave the game, and he/she does not make any actions further on. This will eventually bring the bank left uncontrolled to default even without a crisis situation. This is undesired behavior and this can seriously affect the game experience of other players.

To avoid banks going bankrupt for lack of control, we could have an artificial player assigned even to banks controlled by human players. These software players could generate actions based on the perceived situation, which could be taken as suggestions for the human players. If the human player is active, he can decide to actuate or to cancel the actions proposed by the artificial agent. If the human player is inactive, the actions of the software agent are performed automatically. This way, human-controlled banks would behave as artificial banks, should the human abandon the game. Please note, that this approach fits long running, casual games more than short and intense real-time games, and that it assumes the existence of artificial actors for banks. In case of real-time game modes, we might decide not to deal with this problem, as abandoning such a game is less likely, and at the same time, dealing with the suggestions of the software could take too much time of the human player, thereby providing a less preferable game experience.

A third solution option is to monitor the players for inactivity. When inactivity is detected by a watchdog service, or when the player explicitly leaves the game, the game the bank is sold in an auction. Players remaining in the game may bid for its assets. The successful buyer gets everything – the loans, the deposits, the shares. Possibly, before initiating the final sell-out auction, reminders and warnings may be sent to the inactive user (by e-mail or by SMS).

5.6 Rejoining the Game

If a player falls out of a long running (never ending) game, it should be possible to rejoin the game controlling a different bank. Rejoining players should be handled similarly to new players, but we should disadvantage, or even ban players with a history of bankruptcies. To avoid intentionally ruining the game, players with earlier bankruptcies could start from a worse position (start with a bank in a worse position), and/or after a fixed amount of bankruptcies, the player would not be allowed to join the game anymore.

5.7 End of the Game

This is one of the most crucial points to define. The length of the game is tightly connected to other issues.

5.7.1 Fixed End Point

One possibility is to end the game after a predefined number of turns or alternatively, after a certain period of time. However, the impending end of world cause an “endgame effect”, where the players sell and buy everything, they try to increase their points or the value what helps them win the session or helps them achieve a better position/rank. Midsession joining of the game is not supported very well either, since players entering the game lately start with a clear disadvantage.

5.7.2 Random Ending

Another option is to close the game at a random point in time (perhaps after a minimum number of turns or after a minimum length of time). This solves the previously mentioned problem (endgame effect), provided that the value of long term investments can be calculated before their maturity at the end and their value can be accounted for in the ranking. However, the thought that any turn can be the last turn may be de-motivating for some players.

5.7.3 Last Man Standing

According to this option, the game lasts until there are at least two human players competing (i.e., who did not go bankrupt). However, it is likely that this setting would freeze the interbank market, since players who know that the last survivor will win are less likely to lend each other on the interbank market. Therefore, this stopping rule may induce unrealistic behavior. Also, since the game length will be unpredictable and midsession joining of the game cannot be realistically supported.

5.7.4 Open Ending

The Open Ended game has many advantages, but also some disadvantages. Midsession joining is easily supported, because latecomers have endless time to catch up. Also, players” behavior will not be affected by the approaching end. However, the opportunity to experiment with the simulator’s starting parameters would be lost. That is because in this case, successfully running several world instances (games) is very unlikely, since games compete for the same pool of users.

As the Online Game (for casual players) is planned to be open ended, the length of the game is not an issue in this case. In the Challenge Game and War Game modes, however, we should still decide to follow one of the above options. This decision will be the result of experimentation with the game during the development phase.

5.8 Cycle Time / Simulation-Time Resolution

In synchronous simulations, a difficult issue is the *cycle time*, that is, the time between synchronized updates. A related issue is the meaning of this time period in the simulated world.

E.g., one turn might mean one month in the simulation, but smaller values (weeks, days) are also possible.

The smaller this value is set, the more control we acquire over the events. The problem with short turns is that the difference between the turns could be so small, that the players (who control banks) will not perceive any change. They will observe a rather similar world turn-by-turn, which will not provide enough ground to make decisions. If we set the cycle time too long, the players will not get a chance to influence the economy, and the course of events will pass by without the players intervening. Finding the proper value takes careful balancing and will, again, be resolved by prototyping and experimentation during the development phase.

In this section we outlined matters arising from transforming a scientific economic simulator into a multiplayer economic game. Following the discussion of these design issues, we turn our attention in the next section to games similar to the one planned in this project.

6 Similar Games

In this section we briefly overview three existing online games similar in spirit and content to the one planned in the CRISIS project,

6.1 €conomia The Monetary Policy Game:

This game is an educational game sponsored by the European Central Bank. [5] Here players can play with the key interest rate and experience how the system oscillates from the changes and latency.

Similarities:

- The visualization and the style of game are very similar to what we envision.
- A similar simplicity and intuitiveness of the user interface is expected in the case of our game, too.

Differences:

- In €conomia the exogenous events are triggered randomly. In contrast, we want a more controllable, scripted or predefined series of these events.
- In the CRISIS Game, the players can't control the Central Bank. Instead, they are in control of a commercial bank.
- In our game, more options are provided for the players, not only the changing of the key interest rate.
- Unfortunately, information about the core economic model working under the hood of the €conomia game is not available to us, but the agent-based solution is very unlikely. In contrast, one of the main design goals of the CRISIS Game is an agent-based code.

Link to the game: http://www.ecb.int/ecb/educational/economia/html/index.en.html

6.2 The Banking Game

The Banking Game is a web-based environment simulating bank liquidity management in competitive market conditions. Unfortunately, we were unable to contact the developers of this project, so all information below is based on the homepage of the game. [6]

Similarities:

- In both games, the player controls a commercial bank.
- Both games feature a competitive multiplayer environment, where players compete with each other for more profitable opportunities in different markets.
- The Banking Game and the Crisis Game are both web based economic simulator games.

- The dynamic real-time approach of this game is similar to two of the proposed game modes (War Game and Challenge Game modes, see Section 2.7). On the other hand, the proposed Online Game mode will be a different approach.
- The target audience is somewhat similar, but in our case we would like to be able to reach out to players with lower expertise levels, i.e., to average citizens, too.

Differences:

- In our game, the players control the banks alone, not as members of a team of players like in the Banking Game.
- Unfortunately, we don't have information about the core economic model working under the hood of the Banking Game, but an agent-based solution is unlikely. In our case, the agent-base modeling approach is a main objective, thus we get a more living economy.

Link to the game: http://www.bankinggame.net/

6.3 eRepulik:

This game has a wider perspective than the models discussed so far. In the eRepublik game, economy is but one aspect of the game, although arguably, one of the most important ones. There are a host of other aspects of the game (e.g. fighting for territories, diplomacy, etc.), but the true depth is given by the market economy. The dynamics of the markets is, at least believable, thanks to the number of people playing this game. [7]

Similarities:

- Both games have a Job Market, a Money Market, etc.
- Character development can be found in both games.

Differences:

- In eRepublik, every agent is controlled by human players. In the CRISIS Game, households and firms are artificial agents.
- For simplicity, in our model there is only one type of goods. In eRepublik there are several types of goods (food, weapons, buildings, raw materials, etc.).
- We didn't want to involve the currency market in the game so there is only one currency. In contrast, in eRepublik every country has its different currency (i.e., no common currency like Euro or the US dollar).

Link to the game: http://www.erepublik.com

In this section we have provided a quick glance at a few online games similar to the planned CRISIS Game. In the next section, we place our efforts within the CRISIS project and outline the connections of this effort to those performed in other work packages of the project.

7 Relation to Other Work Packages

The CRISIS Game is fundamentally based on the economic simulation models developed by the partners within the project. As such, it takes direct input from 'WP8 Integration and synthesis of Financial Market and Macro ABM'. Indirectly, the game uses the output of 'WP2 Agent-based network model of the financial system' and 'WP3 Agent-based model of the macro economy'. 'WP4 Laboratory experiments with human subjects' plays a role in calibrating the models supplied by WP2 and WP3. The relation of these work-packages from the game point of view is illustrated in Figure 4. below.

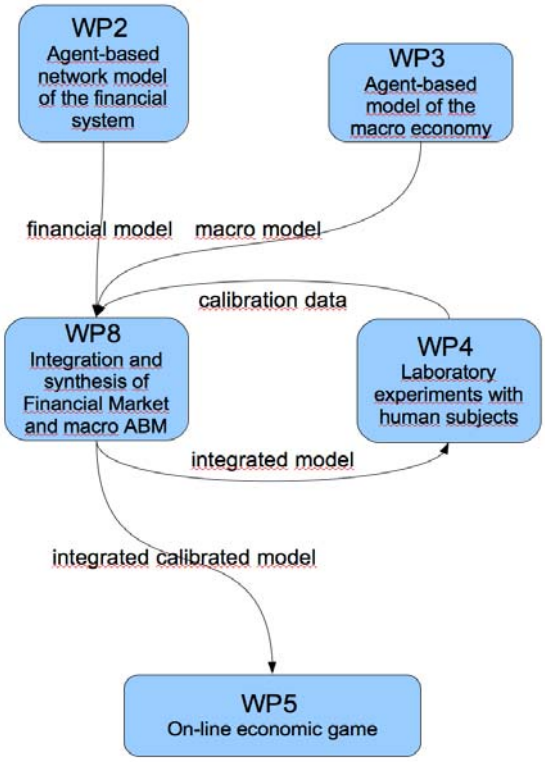

Figure 4: WP5 inputs

This section explained how the CRISIS Game discussed in this document fits into the larger scale efforts of the CRISIS project. In particular, connections to other work packages, in particular to WP2, WP3, WP4 and WP8 were discussed.

8 Conclusions

This document discussed the CRISIS Game, the online multiplayer economic simulator to be developed in the CRISIS project. While economic simulator games have been created before, even for the online, web-based genre, the enterprise described in this document is novel and somewhat unique in that it attempts to base a fun game on advanced, state of the art models of the economy and the financial system. In addition, these state of the art models will follow the agent-based paradigm, thus our CRISIS Game will be agent-based both in nature and implementation. An additional challenge stems from the fact that we intend to create a game that is educational in style, but, being one of the key dissemination vehicles of the project reaching out to wider audiences, that is also a game that provides an interesting, enjoyable gaming experience.

The report in this document started from the above goals and guided the reader through various steps of game definition. After a brief overview of how games are designed in the gaming industry, a first, high-level description was provided. This amounted to the discussion of the game's genre and the targeted platforms, as well as a series of high-level settings, including the very important differences between the possible game modes. In the next section the elements of the gameplay were discussed, providing details on the main actors of the economic simulation, from banks to households and markets. This was augmented by a detailed descriptions of the game mechanics, providing details about the operation of the underlying core economic simulator (mainly based on MABM-1). In addition to these, additional considerations were given to exogenous events as a possible source of scripting in the simulated economy. These discussions were followed by design issues that are specific to the process of turning a scientific economic simulator into a multiplayer economic game. This section listed decisions to be made on, among others, the target audience, synchronization, joining, rejoining and leaving a game, and the rule for terminating the game. In addition to listing possible solutions to these issues, our proposed solution to each of these issues was also pointed out. We briefly discussed related endeavors (i.e., similar economic simulator games) and placed our work in the context of the CRISIS project, outlining connections to other work packages.

This document is the first result of a longer effort aimed at creating a successful and enjoyable CRISIS Game. Further work will include a detailed discussion on the integration between the game and the underlying economic models, as well as the implementation of several versions of the planned game. The results of these efforts will be reported in separate deliverables.

9 References

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Appendix 1: Common Questions

In this section, we discuss a few questions that are typically asked when a new game is introduced. We provide the questions and the answers in the hope that they will help the reader in understanding the CRISIS Game that is developed in the project.

- **What is the game?**
  This is an on-line economic-simulator game about the economy and the financial system. Players can control banks, and they have to avoid or reduce the impact of a crisis while reaching their personal goals, which is normally to make money. Of course, if you fight the fire all the time, you can't collect enough wealth. However, if you are too greedy, you risk the health of the economy and you can lose much more in the long term.
- **Why create this game?**
  The main purpose is to create an enjoyable and fun game about banks and the financial economy to popularize these topics, and at the same time, this game helps in explaining a financial crisis and possible outcomes to people. Through this game, the players can gain knowledge about the mechanisms that drive a financial crisis, and experience the (in)effectiveness of the actions each one of them can perform individually. In addition, by recording the players' actions in the game, researchers can gain a deeper understanding on how humans react to certain situations, and use it to further improve and calibrate their models.
- **Where does the game take place?**
  The game takes place in a virtual world with households, firms, and banks. The world simulates the normal business operation of free-market countries, and as such it mimics Europe. The 'normal business operation' manifests in stock-, and commodity markets, and in direct interactions between firms, and banks.
- **What is different?**
  This game promotes a new agent-based model of the economy, which combines a macro and a financial agent-based model. Earlier games of this type are based on traditional differential-equation models which, by nature, limit the possible outcomes, because they prescribe a limited behavior of the world in the equations. The agent-based model underlying this game allows for a richer behavior.

Appendix 2: Background Information On Designing Computer Games

In this section we discuss some general notions related to the game developed within the CRISIS project. The discussed points are independent aspects of the game, but they all relate to how the game is set up, and what the players should experience during the game.

9.1 Player Styles

Regarding the attitude of the players, we can differentiate two different styles: the *casual player* and the *hardcore player*. These styles differ mainly in how often and how long the players play the game. Assuming one or the other kind of player, however, has consequences on how the game is perceived by the players, and even on how the game is designed and set up.

9.1.1 Casual Player

"Casual gamer" is a loosely defined term used to describe a type of video game player whose time or interest in playing games is limited compared with a hardcore gamer[1]. Casual gamers can conceivably consist of any people who show more than a passing interest in video games, therefore it is difficult to categorize them as a group. For this reason, games which attempt to appeal to the casual player tend to strive for simple rules and ease of game play, the goal being to present a pick-up-and-play experience that people from almost any age group or skill level could enjoy.

Most casual games have similar basic features:

- Extremely simple gameplay, like a puzzle game that can be played entirely using a one-button mouse or cell phone keypad.
- Allowing gameplay in short bursts, during work breaks or, in the case of portable and cell phone games, on public transportation
- The ability to quickly reach a final stage, or continuous play with no need to save the game

9.1.2 Hardcore Player

Hardcore gamers prefer to take significant time and practice on games, and tend to play more involved games that require larger amounts of time to complete or master[2]. Competition is a defining characteristic of hardcore gamers, who often compete in organized tournaments, leagues, or ranked play integrated into the game proper. Hardcore gamers get involved with the game they play more deeply than casual gamers. They spend time to learn the game, to discover each option, and often play the game repeatedly even after achieving the main goal in the game.

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1 http://en.wikipedia.org/wiki/Casual_game

2 http://en.wikipedia.org/wiki/Gamer#Hardcore_gamer

In contrast to casual games as discussed earlier, hardcore games have the following characteristics:

- Require a significant amount of time (1-2-3 hours) to play a game, and take the full attention of the players while in game.
- It is typically difficult for the players to achieve their goals, and they can save and continue the game to allow for a rest.

Accordingly, the major difference between the casual and the hard-core play styles is that while the casual player seeks a quick pick-up-and-play experience, the hard core gamer invests time in the game, learns to master it, and enjoys playing it for a long time. The consequence is that casual games have to offer an easy game play with intuitive controls, and complicated problems that assume a deeper knowledge of the game will only be overcome by hard-core gamers.

9.2 Time Keeping

Strategy games might be classified based on several different aspects, but one of the most common is time keeping. On the one hand, there are turn-based games where the tactical players take turns and there is no advance in the game until a given point (e.g., periodically, or until all of the players moved, or in sequential gameplay, until the active player finishes his turn and passes). In this approach, there might be no consequence of the player choices until the “end of the turn” reached, and allows full control over game flow. On the other hand, there are real-time games, which allow completely simultaneous actions by the gamers.

9.2.1 Turn-Based Game

Turn-based games are a common platform for different browser-based games. Their advantage is that they might be more attractive for casual players who do not want to spend all their time on playing the game (either because they do not have the motivation or the time for it). In real-time games, such casual players are clearly handicapped, as they cannot spend an equal amount of time in the game as their opponents. They are in a disadvantageous position that might, for instance, result in frustration in game conflicts with other players.

A few examples:

- Civilization
- Colonization
- Master of Orion
- Panzer General series
- Battalion: Nemesis (Web + Multi)

9.2.2 Real-Time Game

Because of their generally faster-paced nature (and in some cases a smaller learning curve), real-time strategy games have surpassed the popularity of turn-based strategy computer games. There are three main criticisms voiced against real-time strategy games. One of them is that they tend to devolve into "click-fests", in which the player who is faster with the mouse generally wins, because he/she can act at a faster rate. Another common criticism is that real-

time gameplay often degenerates into "rushes" where the players try to gain an initial advantage in resources, and produce large amounts of relatively powerful but still quite cheap units, and thereby overwhelm the opponents. The third criticism of the RTS genre is the importance of skill over strategy in real-time strategy games. The manual dexterity and ability to multitask and divide one's attention is often considered the most important aspect to succeeding at the RTS genre.

The common retort to such criticisms is that success in real-time games involves not just fast clicking but also the ability to make sound decisions under time pressure, and that trying to gain advantage early in the game is an application of a successful strategy, and it is a realistic representation of what happens in real life.

Some very successful representatives of the genre:

- Warcraft
- Starcraft
- Dune 2
- Command&Conquer

Relating the turn-based vs. real-time debate to the play styles discussed in the previous section, we believe that a real-time game setting prefers the hard-core gamers. Since acting quickly provides an advantage in such a game, it is essential that the player masters the game, and once the decision is made, he/she can perform the corresponding action quickly. Along a similar line of thought, the turn-based setting fits casual players more than a real-time setting, as it allows them to study the situation, and carefully select their next move.

9.3 Motivation

Perhaps the most difficult task is to catch the players and maintain their attention. Hard-core players will invest time to learn the game, but they will keep playing it only if it offers a challenging game-play, and exciting and varying experiences. Casual players will pick up the game and keep playing it if it is simple to play, and it provides, although maybe only on the long run, the feeling of achievement to the players. In the following, we describe some options of motivating the players to keep playing the game.

9.3.1 Social Bonding

If players are given the chance to communicate, compete and cooperate, they build social bonds over time and learn to work in a team. This may become a great influencing factor for players, since people like to spend more time with their friends. Some mechanisms that may help us to reach such bonding, for example, high-score tables, in-game chatting options and online forums, are discussed in the following sections.

9.3.1.1 High-score Tables

A high-score table is a simple scoring system, where the players can compare themselves to the top players easily. We can use different parameters (profit, leverage, maximum exposure,

etc.) to create a ranking among the players. More diversified the lists are, the more different ways the players could compare their effectiveness and gain motivation.

High-score tables emphasize the competition among the players by ordering them according to different measures. In the next two sections, we describe features that prolong the cooperation among the players rather than competition.

9.3.1.2 Chat

An instant messenger integrated in the game provides a perfect communication channel for players. In a real-time game, when players are connected to the same game at the same time, an instant messenger provides the ability for the players to discuss the situation and to reach a collaborative decision. In the CRISIS Game, where players are bankers, the players can, for example, discuss the state of the economy before engaging in loaning activity, or they can make direct deals for trading assets. Public channels are also excellent opportunities for new acquaintances to be created when a larger player base is on-line.

An integrated instant messenger connects players who are on-line at the same time in the same game. In the next section, we describe another tool that facilitates cooperation among the players without the requirement for them to play the game at the same time.

9.3.1.3 Forum

Compared to the in-game chat, the forum is a more leisurely off-game communication channel between the players. On the forum, players can freely discuss about the game sessions and strategies, describe their experiences and organize tournaments. A forum has a great bonding power, and it has the further advantage that it can be an official communication channel between the game operators and the players.

The high-score tables, the in-game chat, and the off-game forum are the most important tools a game developer can employ in order to generate a social bonding between the players and the game, and among the players through the game. These tools satisfy both the competitive and the cooperative emotions triggered by the game. In the next section, we discuss another important emotion, pride, that has to be triggered and fulfilled by the game.

9.3.2 Pride

Pride is one of the most basic emotions that motivate players in a game. Players can be proud of winning a game, or achieving a high rank on the high-score table, or simply by solving an in-game situation in an elegant new way. In the following sections we describe how we can boost players' pride by providing challenging objectives, by allowing them to develop and use various strategies, and by allowing them to reach extra achievements in a game.

9.3.2.1 Objectives

One of the simplest methods for raising players' pride is to provide multiple objectives in a game. Besides the main goal of a game (e.g., surviving the crisis), we can set up different

objectives players can reach during the game. Some examples are the objectives “Keep your leverage below X%”, or “Earn a 10 Million profit per year”, etc. Such extra objectives force the players to consider multiple, sometimes contradicting options, and even when they fail in one, they can still reach others.

After completing the objective, the player can get some reward. The reward can be a higher score on the high-score table, or it can be some sort of points (e.g., experience points) that can be used in following games to achieve more objectives.

Providing multiple objectives in a game also allows the players to develop various strategies to play. This in itself is another motivator that can boost a player's pride.

9.3.2.2 Various Strategies

The existence of multiple viable strategies makes the gameplay more interesting and varied. This is true even if there is only a single objective in the game, but games with multiple objectives provide more options for alternative strategies. Some people love experimenting and developing new techniques. In the CRISIS Game, these players would search for alternative solutions to financial problems occurring in the game, and thereby provide interesting new insights about the underlying problems simulated in the game. Supporting this activity is one of our main goals in creating the CRISIS Game.

In addition to being able to reach multiple objectives and to develop alternative strategies, defining different achievements in the game is a third way of intensifying the players' feeling of pride.

9.3.2.3 Achievements

In addition to the main goal of the game and the multiple objectives, we can define a number of achievements that can be accomplished independently of the objectives. These achievements are unrelated to the main goal, and making them does not ensure a higher ranking for the player, but they offer different *badges* to the players. Typical achievements are search missions, when a player has to find another player with a certain characteristic. The reward for such an achievement would be some sort of *private investigator badge*.

Multiple objectives, various strategies, and achievements influence the players pride while playing the game. A similarly strong motivator is when players find a special meaning or value in playing the game. In the next sections, we discuss such motivators.

9.3.3 Provide Meaning & Value

When a game has a special purpose, it changes how players think, feel and behave about or in the game. If players think that there is something to play for, they become more engaged. This can be achieved by simply offering a prize or by offering the feeling that the players are part of some important activity. In the next sections, we describe these options.

9.3.3.1 Prize

If we grant different useful rewards (in-game or real life), then repetitive, boring tasks get more sense. In-game reward could be, for example, experience points, that you can spend on things what gives you some advantage in follow up games. An example for a real-life reward could be a challenge session where the top scored player receives some prize. In any case, if the player joins a game with a specific purpose, it greatly influences his/her decisions in the game.

In addition to the utilitarian approach, players can be engaged by the feeling of being part of something important. This is described in the next section.

9.3.3.2 "You are part of something great!"

Being part of something great, e.g. charity, or scientific research in our case, could potentially draw many people's attention. People like to help good causes, but there are limits to what they are willing to do for them. Also, the actions and reactions of people in the game can be different in the case when they play for a prize and when they play for the cause. Additionally, if we communicate that the games are closely monitored and the data will be the basis of a scientific publication, they may act differently. Therefore, this motivator should be handled with care.

Besides social bonding, pride, and the meaning of the game, there is a last motivator: fun. In the last section, we discuss the fun-factor.

9.3.4 Easy Fun

Easy fun is typically sought by casual players, who play just for fun. They don't want to complete objectives or be the best. They would simply like to enjoy the game. Their main motivator is curiosity. When we explore the simulated world then, similarly to reading a novel, we want to know what the end will be like. Unfortunately, the genre of the game is not too easy, so this kind of fun will not be supported very well. A possible way to support this is to create simple and fun missions, in which players have simplified controls with most of the decisions automated. In such missions, the role of the players would be to control and tune the automated decisions instead of making the decisions themselves.

9.4 Summary

In this section we reviewed some of the key questions in designing computer games. We discussed the different types of audiences, the casual and the hard-core player, and different time-keeping methods, like the turn-based and real-time games. We concluded that real-time games favor hard-core players, because they get more involved in the game which provides an advantage in real-time strategy games. Similarly, we thought that the turn-based operation mode fits casual players more, as they can more freely choose the amount of time they spend in the game.

In the rest of the section, we discussed various motivators that can be used to keep the players attention on the game. We listed a few tools that influence social bonding, a few features of games that can boost the players' pride, and some ways to provide a special meaning or value

for playing the game. In the end, we discussed how easy fun can be provided to players that only have a light experience in economics.