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Modelling and simulation of parallel monetary systems for countries without their own currency

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Summary

Greece is one of the countries still struggling after the financial crisis in 2008. With a debt burden of almost the double the gross domestic product, they are in a situation where repaying the debt can seem nearly impossible without extreme measures. This thesis will examine Trond Andresen's idea from 2010, to implement a parallel currency issued out by the Greek government, alongside the Euro. First, a generic model will be made describing a land in crisis, then this model will be simulated with values that correspond to the economic situation in Greece in the time frame 2008-2015. The results shows that under the assumptions made for this model, this new currency, if it gets into circulation, will slowly induce growth to the gross domestic product, which will enable Greece to repay their debt and stabilize their economy. This may be a viable solution to the economic situation in Greece, if the EU allows it.

Preface

This master thesis contains an examination on whether implementing a new, parallel, government controlled currency may be a viable solution to their growing debt burden. It was written in my final semester at Engineering Cybernetics at NTNU. The project was given to me by Trond Andresen, who has had the idea of a parallel currency since 2010, but needed someone to model and simulate it.

My background is in cybernetics, and therefore, incorporating the correct economic underlying principles have been the biggest challenges during this process. I am satisfied with the model I arrived at in the end, keeping it as simple as possible, but also with reasonable and realistic assumptions.

I would like to thank my supervisor, Trond Andresen, for many valuable discussions and talks that guided me to this final result. I would also like to thank Fredrik Bysting and Tuva Bongard Munkeby, who both carefully read through this thesis and gave me a handfull of pointers and tips. Lastly, I would like to thank my girlfriend, Trine Elise Gjermstad, who has been a moral support in good and bad weather, and always assured me that I would make it when I thought otherwise.

I hope this thesis is as enjoyable to read as it was for me to write.

Håkon Teigen Lund

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Abbreviations

GDP = Gross Domestic Product
IBD = Investor's Business Daily
TIPP = TechnoMetrica Market Intelligence

Chapter 1

Introduction

In 2008, the financial crisis hit the world, and it hit the world hard. One of the nations still struggling to recover, is Greece. The debt burden is still rising [1], and the gross domestic product (GDP) is still sinking [2]. The country has been given debt cuts [3] in order to help them stabilize their own economy and perhaps escape the reinforcing loop of increasing debt, but it has not had any remarkable results. As per now, there is still talk about more debt cuts [4], but looking at the previous results, there might need to be applied other solutions if these debt cuts are actually going to have more than a dampening effect.

In 2010, Trond Andresen proposed a suggestion to help Greece, by implementing a parallel currency besides the Euro. The reader is advised to read the articles [5] - [11] that explains this idea thoroughly. A quick summary of this suggestion is that Greece introduces a new parallel and electronic currency which is to be issued out by the government in the form of welfare or other governmental payments. In return, the government will allow a portion of the taxes to be payed in this new currency. This new currency is fiat money [12], and has thus a base in Modern Monetary Theory. [13]

The plan is that this imposed value by the government will lead to this new currency being used to pay for other goods and services, not just taxes. This new currency will have a perceived value which is lower than the existing currency, and therefore, people will try to get as much as they can from it - before paying taxes. Because of the need imposed by the economic crisis, private firms will in the end have to accept at least a portion of it.

The advantages of this new currency, is that it might stimulate productivity even though the economy is falling. With this new currency in circulation the employment rate will hopefully increase, which will again raise the GDP of the country, and maybe rebuild some trust in the government. Since this is more or less a local currency, which can not be used abroad, a hope is also that it stimulates the exports more than the imports, which again can lead to an ability to repay debt. The currency is also electronic, which means that tax evasion and corruption is going to be so insignificant that it may be ignored.

There will also be obstacles. Take for instance a car dealer, importing cars and selling them. This importer needs to have an income which is largely based on the existing currency, since this new currency can not be used in the countries he's importing cars from. However, this car dealer will probably still have workers working for him. He can pay their wages in partly existing and new currency, and therefore also sell his car for both the new and existing currency inside of Greece.

The task of this thesis is to model and simulate a social system in crisis, which implements this new parallel currency, mainly by the use methods from [14], [15] and [16]. Lastly, there will be a discussion and analysis of the results from the simulation, if this is a viable solution to the economic crisis in Greece.

Problem outline

With the problem briefly described in the introduction, this thesis will model and simulate a system, or a nation, in a debt crisis, without it's own currency. Then, a new, parallel currency is to be introduced to the system, which will be issued out by the government and to the households. This new currency will have a value which will enable citizens to pay a portion of their taxes with it. The effect of introducing this currency will be based on the assumptions made below.

Throughout this chapter, assumptions will be made in order to simplify the proposed model as much as possible, without losing functionality. However, too much simplification might cause a loss in the readability of the system. Therefore, this chapter will aim to describe the system thoroughly in order for the reader to get an overview, and then make the assumptions to simplify the model for an easier understanding of the functionality and the results presented later in this thesis.

2.1 Overview of the system

The system takes basis in a monetary system which consists of three separate economic units: The private households, the government, and the firms. Money flows between these stocks as shown in the stock-flow diagram in figure 2.1. This is a simple description of a closed economy, with no banks or stock markets. However, this model does lack variables to make the flow of money dynamic, which will be added.

The *willingness to spend* (money velocity) and the *total amount of money in stock* is driven by a factor called *optimism*, which is then driven by the societies trust in government, and personal financial outlook. In other words, this optimism is assumed to drive the entire nations economy, and will be used as a symbol on how well the nation is doing. The optimism will also have upper and lower boundaries.

This is the basis for the system in question. Since optimism is bound from above and

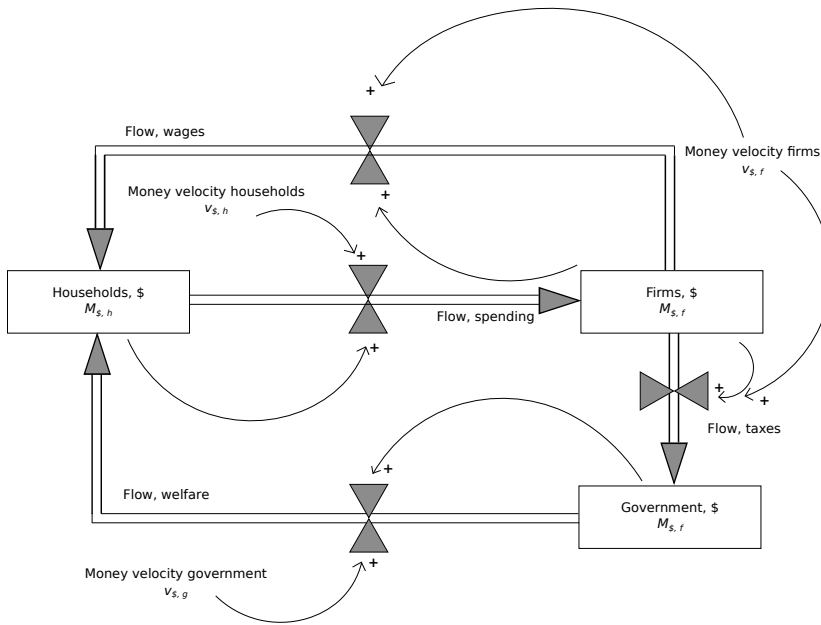


Figure 2.1: Stock flow model for the closed economic system.

below, the money flow will stabilize quickly. However, this is a country in economic crisis, therefore the exogenous ¹ factor *Distrust in government* will be added, which is caused by the debt burden in the society. Debt burden will *not* be brought in as an endogenous ² variable to the system, which will be given a reason for more thoroughly below.

2.2 Calculation of GDP

The calculation of GDP is done by summarizing the total spending the country does [17]. This is spending from the consumers, the government, investments from firms and the government, and the net exports. In the model, this would yield several separate flows from the three economic units within the monetary system. In order to keep the amount of flows low, the assumption is made that this entire spending, the entire GDP, will be calculated from the flow out of the households.

This is already incorporated in figure 2.1. Another assumption which is done is then also that all taxes are paid by the firms. Neither of these assumptions will have any impact on the final calculated GDP, but it's important to keep in mind that the outflow from the households is also the spending and investment from the government and the firms. This

¹Exogenous: introduced from or produced outside the organism or system; specifically: not synthesized within the organism or system.

²Endogenous: proceeding from within; derived internally.

also means that the welfare and wages inflow into the households will in fact be all money assigned to pay for investments and spending from the respective economic units.

2.3 The currencies

The monetary system will consist of two currencies. The already existing one, which the nation does not control, and the new currency introduced by the government. These two currencies will be denoted as dollar (\$) and alpha (@), respectively.

2.3.1 The existing currency, the dollar (\$)

The dollar will be the already existing currency, and also the *currency of highest value*. Even though this thesis is about Greece, the proposed model will be generic for any country in crisis. Therefore, dollar will be used as the main currency throughout this thesis.

The value of the dollar is assumed to stay constant, and this is the currency that will always have the highest perceived value by the public. However, the flow of this currency will be greatly influenced by the optimism. To simplify, it will only affect the flow from the households. This because the flow from the households is what will be considered the GDP, and consists of not just the spending from the households, but the entire spending of the nation.

However, more assumptions need to be made in order to make this simplification valid, without losing functionality. The optimism might affect the spending from the private households directly, but the lack of spending by the private households will not necessarily result in a lack of spending by the government and the firms instantly. They will probably have reserves to keep the investments and spending running. After a while, these reserves might decrease, and cutbacks will be made, which will then affect the investments and spending. Therefore, because of the way this model will be built, there will be a time lag from the optimism and to its effect on the GDP.

2.3.2 The new currency, the alpha (@)

The alpha will be the new currency, introduced by the government. Whereas before, they got 100% dollars in welfare and other payments by the government, they will at the time the new currency is introduced, get 75% dollars and 33% alphas. The only value this currency will have from the start, is that the government allows the tax payers to pay 25% of their taxes with it. Even though it will have no trust in the public from the beginning, the exchange rate is assumed to never go below a half of the dollar. This because of the implied value on it. Note that there will also be issued out a bit more of the alpha than the amount of dollars it's replacing. This to give the receivers a larger share to spend, to get it into circulation.

To simplify the model, stock markets will also be left out, thus implying that the new currency can only be used within the nation. This also implying that the alpha can never reach the same value as the dollar, since the dollar has a bigger market. However, this also

means that the a larger flow of alpha will correspond to a larger domestic productivity, thus assuming that this satisfies a growth in exports.

This currency is also assumed to be an electronic currency. Note that this is to be introduced in a land in crisis, with possibly a higher rate in corruption and tax evasion because of it's lack of trust in the government. Corruption and tax evasion can be quite hard to model because they are so hard to predict, but since electronic money is highly traceable and hard to duplicate or destroy, this is neglected from the model.

The flow of the alpha will be influenced by the optimism. However, it's assumed that whenever someone gets this new currency in hand, they will try to spend it. The question is whether or not it will be accepted by the receiver. This, in the beginning, will happen independently of each other, and therefore there will *not* be a time lag from optimism and into the GDP. However, this optimism will merely be used as an indicator of the probability that a person will accept the alpha.

The initiation and flow of alpha will also be affected by the *need to sell* in a country. This is assumed to be prominent, since this is a model of a land in economic crisis. This will in fact be assumed to be the reason for the entire initiation of the use of alpha.

It is assumed that after the first years of spending the alpha, if it gets into circulation, the model for the flow will gradually become more similar to the model for the flow of dollars. However, implementing this will be quite complex, and will not yield any new interesting data. The importance lies in the transient phase of this new currency, not necessarily the stabilization phase.

2.4 The goal

The goal with this new currency is to bring the nation out of crisis, which is when they make more money than their yearly payments on their loans. The timing of this can be hard to calculate, because of the difficulty of calculating the net exports and debt cuts. This will be described more thoroughly below.

2.4.1 Import and export

In order to know how much money the country "earns" per year, the export rate and import rate needs to be known in order to calculate the revenue or loss. If the import rate is higher than the export rate, then the nations stock of dollars will decrease.

However, finding the export and import rate can be quite difficult. There is not necessarily any correlation between the employment level and export rate, nor is there any significant correlation between import rate and GDP. Therefore, one can not include the variables import and export when building the model, and it is therefore needed to make other assumptions in order to know if the export rate is higher than the import rate.

2.4.2 The national debt

In order to reach the goal, there should also be a way to tell that the national debt is decreasing. Even with import and export calculated in the model, this could be almost impossible, seeing that they will also get debt cuts. This can be hard to predict, so therefore one can only assume that *if* the nation manages to get a healthy import/export rate, debt cuts will be given so that they can actually pay their debt. These debt cuts is assumed to be made, because the loaners accept the fact that the nation is in crisis - and a smaller portion of the money paid back is surely better than nothing.

Another factor, is that some of the loans are probably from investors residing in the given country. When introducing the new currency, one can also assume that debt cuts will be given in the form that they can be payed back in alpha instead of dollars, to some extent. This will also be a hard factor to model, and thus it will be left out.

2.4.3 The use of alpha

Now, as stated above, the alpha can only be used for domestic trades - thus it stimulates national production. Looking at the new equation for the GDP, it will now look like

$$Y_{sum} = C_{\$} + I_{\$} + G_{\$} + NX_{\$} + C_{\alpha} + I_{\alpha} + G_{\alpha} + NX_{\alpha}$$

where NX_{α} will always be positive. This does imply that a more widespread and larger use of alpha *can* lead to higher rates of exports, at the very least gives the country the prerequisites it needs to increase their net exports. A country in crisis is assumed to would want to end their crisis, and thus are assumed to capitalize on the opportunities they get to increase their net exports.

Therefore, if the alpha is being used, and the GDP of dollars increases, the country is assumed to be heading back from it's crisis. By that, the exports are assumed to rise, and the country's stock of dollars will increase, and there will be made deals to cut the debt down to a healthy level.

2.5 Tools

This thesis will model this economic system into a series of differential equations, which will then be transcribed into block diagram form, and simulated in *Matlab* [18] and *Simulink* [19]. Throughout the text there will also be used *Causal Diagrams* and *Stock Flow Diagrams* [14]. These diagrams are not precise as they cannot be translated into a mathematical equation, but they are very convenient in order to get an overview of the system.

Theory

This section will contain theory and methods used throughout this thesis in order to derive the proposed macroeconomic model and its behaviour. It will be a mix of control theory, economics, and control theory in economics.

3.1 First order material delay [14]

Consider a material in transit, M , observed from a control volume with an inflow F_i and outflow F_o . The derivative of the material in transit can thus be written as

$$\dot{M} = F_i - F_o. \quad (3.1)$$

Assuming the material is perfectly mixed, so the order of the material doesn't matter, the outflow from a first order material delay can be written as

$$F_o = \frac{M}{T} \quad (3.2)$$

where T is the *time lag*. The pulse response of the system (3.1-3.2) can be seen in figure 3.1. Keep in mind that this response can also be used to describe *information delay* as well.

3.2 Block diagram representation of money circulation [15]

An economic system is considered to consist of several economic units (houses, firms, banks, etc.). This unit might be compared to a vessel, or some container with some substance in it which is perfectly mixed, so the order doesn't matter. This substance is, in this case, money M . This unit both receives money and spends money in the form of *flows*,

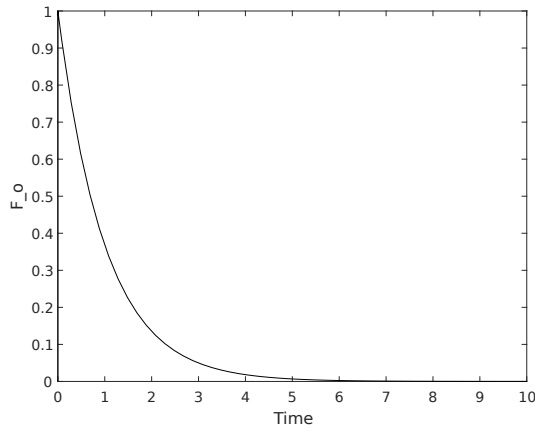


Figure 3.1: Pulse response of a first order material delay.

which will be considered the inflow F_i and outflow F_o . The flows in relation to the stock of money, can be written as the equation

$$F_i - F_o = \dot{M}. \quad (3.3)$$

This outflow is decided by the size of the volume M , but also by the money velocity, v . This v is used to represent in what fractional speed the money in stock is being spent, and has the denomination $[1/t]$. For instance, in optimistic times the v will be high, whereas in bad times it will be low. This yields the equation

$$F_o = Mv \quad (3.4)$$

This is in fact similar to a first order material delay from section 3.1 with $v = \frac{1}{T}$. Therefore, in block diagram form, the economic units will be presented as blocks of first order material delays, whereas one's inflow is another's outflow. A simple example with the economic units *households* and *firms* can be seen in figure 3.2.

3.3 Okun's law [20]

Okun's law is an empirically observed law that can be stated as:

For every 1% decrease in a country's employment rate, the country's GDP will be approximately 2% lower than its potential GDP.

However, later observations have concluded that the loss in potential GDP may vary from country to country, but the relation is still there. Thus, in this thesis, a more general version will be used, described by the equation

$$\frac{Y_p - Y}{Y_p} = c(u - \bar{u}) \quad (3.5)$$

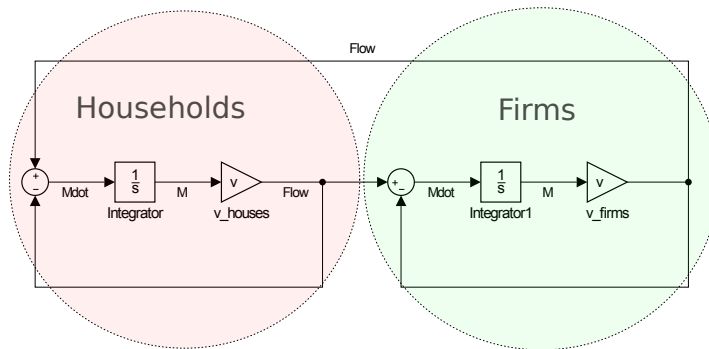


Figure 3.2: Simple example of a economic system with two economic units: Households and firms.

where Y is actual output, Y_p is potential GDP, u is the actual unemployment rate, \bar{u} is the natural unemployment rate, and c is the factor relating changes in unemployment and output.

3.4 Gresham's law [21]

Gresham's law is based on the observation that *bad money drives out good*. In other words, this is an observation that states that if there are two different currencies or values circulating in an economy, people will always try to spend their currency which has the lowest perceived value first. This is an important observation, because it states that when issued a new currency, people will always try to spend the new currency before they spend the existing currency. Therefore it will always be an incentive to get it in circulation, which is what the problem outline in chapter 2 has based the use of alpha on.

3.5 The Bass Diffusion model [14]

The Bass Diffusion model describes the adoption of new ideas and products, which is based on a model describing the infection process of an epidemic. The adoption of the new ideas and products often have S-shaped growth patterns, much like epidemics. The difference is, where you have infection by contact in epidemics, you have "infection" (or adoption) by word of mouth instead.

Consider two stocks - the potential adopters, and the adopters. As the adopters increase, the effect of word of mouth increases, and there will be an exponential growth - until the potential adopters are the same level as the adopters. After that point, the adopters will be a larger stock than the potential, and even though the word of mouth effect will increase, there will be less probability of being in contact with a potential adopter. Therefore, after that point, the growth will decay, exponentially. This S-shaped growth can be seen in figure 3.3.

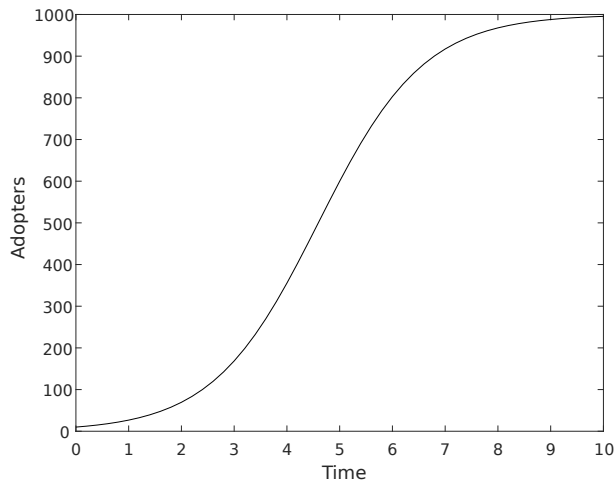


Figure 3.3: S-shaped growth.

What has been described here, is in fact the logistic model, the predecessor of the bass diffusion model. The issue with this model, is that it has an equilibrium at 0. Thus, when there are no initial adopters, there will be no growth. The difference between this model and the bass diffusion model, is that the bass diffusion model also incorporates *adoption from advertising*. This does make it possible to have a growth in adopters even when there are no initial adopters. The stock flow diagram of this model can be seen in figure 3.4.

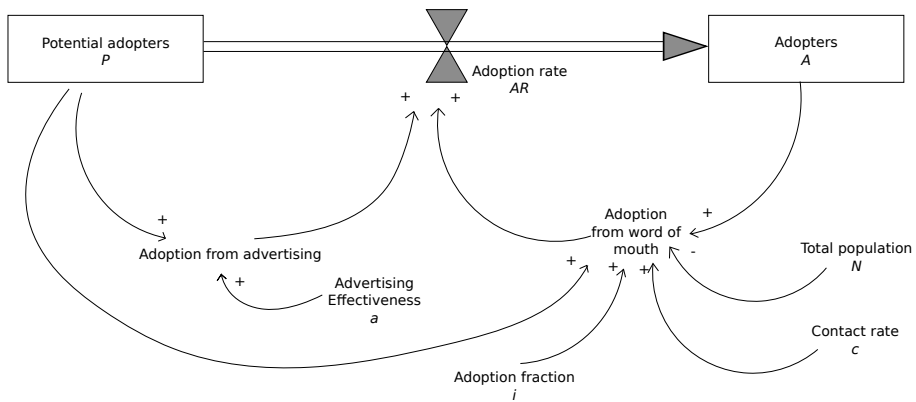


Figure 3.4: The bass diffusion model.

The differential equations for the variables in the Bass Diffusion Model are as follows:

$$\begin{aligned}\frac{dA}{dt} &= AR \\ \frac{dP}{dt} &= -AR \\ AR &= A \cdot P \cdot \frac{ci}{N}\end{aligned}\tag{3.6}$$

3.6 Product dominance [14]

Consider a market with two new, competing and incompatible products. For instance, the battle between the Blu-ray and HD DVD, where the utility of the products depends on the size of the installed base of the products. The larger amount of people who own a Blu-ray player, the more movies and series will be made for Blu-ray, again resulting in a larger amount of people buying a Blu-ray player and not an HD DVD player. This entire process can be seen in figure 3.5.

As seen in the figure, there are two reinforcing loops, the *network effects*. Both of these two are bound by their respective market saturation. This model is basically just two similar and parallel processes, but because of these mentioned loops, one of the products will always end up taking control of the entire market, while the other will fade away. When simulating with random noise seeds, the winner will vary from simulation to simulation.

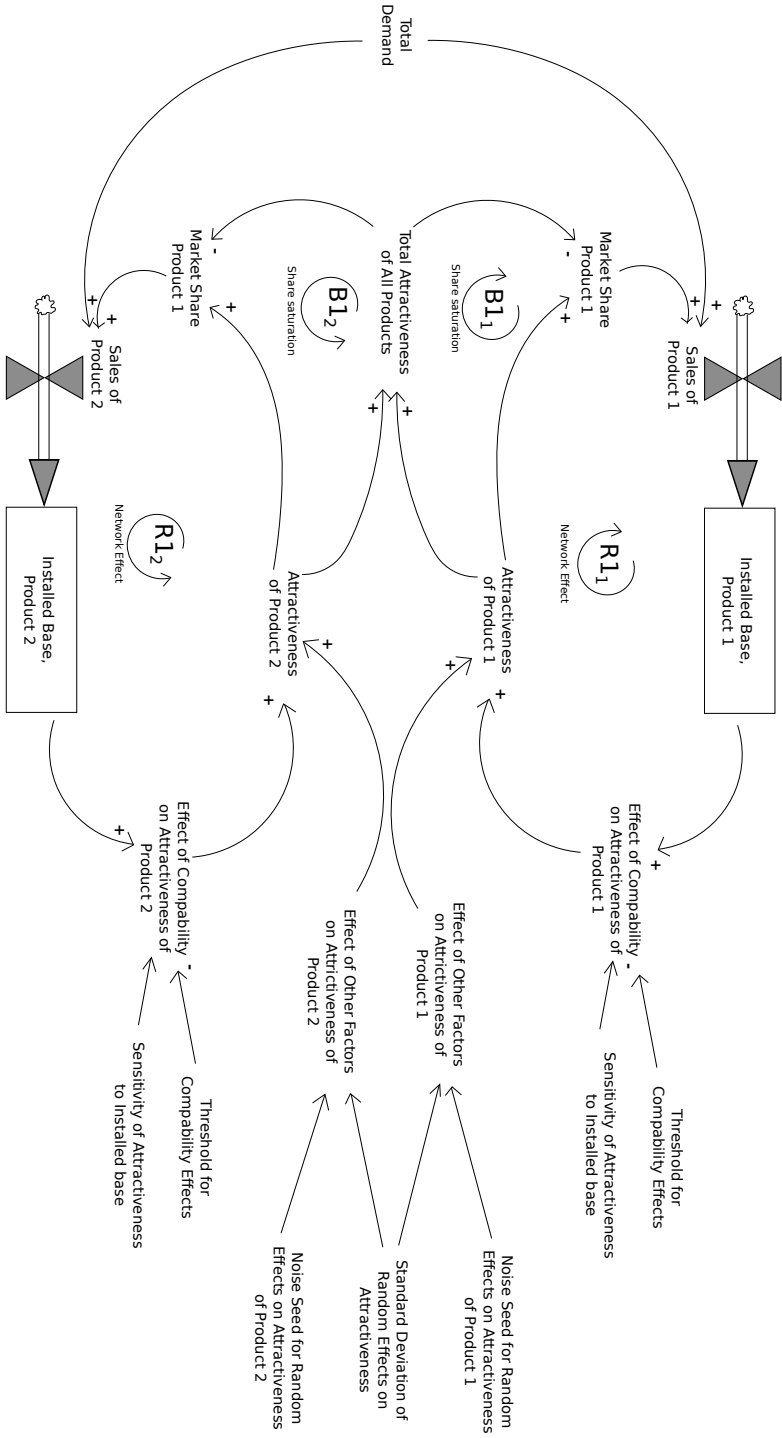


Figure 3.5: Stock flow model of product dominance.

Chapter 4

Modelling

This section will focus on making a model of the system described in chapter 2, using the theory described in chapter 3. The model will consist of three main subsystems:

1. The flow of dollars (\$)
2. Optimism
3. The flow of alphas (@)

First off, the system will be modelled with only the subsystem containing the flow of dollars. This to get a base for the model.

Then, the optimism block will be introduced, which will reflect the nations trust in the governments economic policies, and the private persons trust in their own economic situation. This will be pushed off equilibrium by a massive decrease in trust in government, driven by the sudden increase in debt burden. This will affect the previous stable flow of dollars to become a decreasing flow.

Last, the flow of alphas will be implemented into the model, parallel to the flow of dollars, with a connection to the optimism, in an attempt to drive the flow of dollars and optimism up.

4.1 The flow of dollars (\$)

The system is separated into three economic units:

1. The private households
2. The firms
3. The government

For simplicity, debt will only be considered as an exogenous variable, to be introduced to the optimism later on in this thesis. The flow of money will be described as a series of first order material delays, as explained why in section 3.2. The households spends their money on products and services from firms, the firms pay their taxes to the government and wages to the households, while the government pay their welfare and other wages to the private households. ¹

This entire system can be seen in figure 4.1, and also described by the stock-flow model in figure 2.1 for an easier understanding.

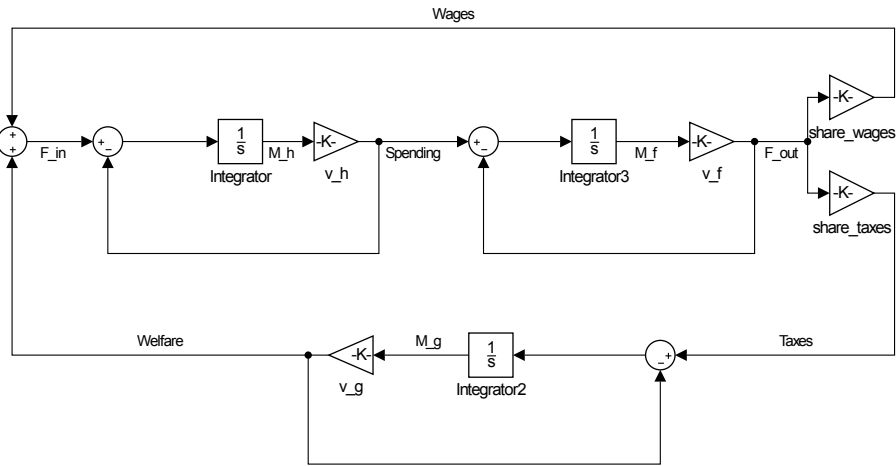


Figure 4.1: Simple money flow model.

With test values as the initial values of the integrators, it's seen that the flows will naturally decrease or increase, depending on how far they are from equilibrium, before they stabilize at some value. This is as expected, and can be seen in the plots in figure 4.2.

4.2 Optimism

The model is, per now, based on the assumption that the flow of dollars is constant, and does not increase nor decrease after reaching it's equilibrium. However, this is not how the economy works. Therefore, the variable *optimism*, O , is introduced, to describe the economic optimism of a nation. This is a dimensionless number ranging from 0 to 1, where 0 is full pessimism and 1 is full optimism.

Investor's Business Daily and TechnoMetrica Market Intelligence (IBD/TIPP) performs a monthly survey in USA, which calculates the country's economic optimism based on three questions: [22]

¹For simplicity, the firms pay all the taxes and the private households receive the entire flow from the government. This does not change the dynamics of the system.

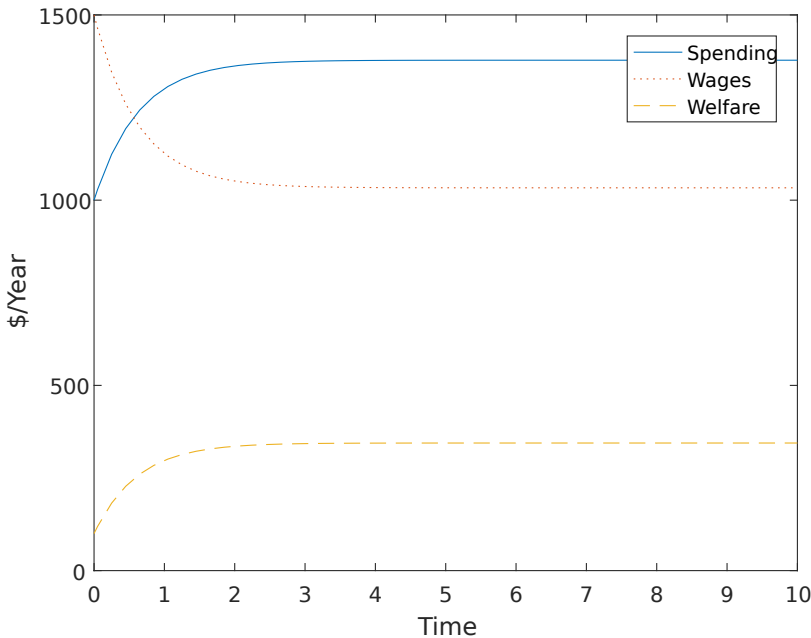


Figure 4.2: The plots of the simple money flow model.

1. In the next 6 months, do you think that economic conditions in the country will be better, worse, or about the same as compared to now?
2. In the next 6 months, do you think that your personal financial situation will be better, worse, or about the same as compared to now?
3. How satisfied are you with the current federal economic policies meant to keep the economy going in the right direction: Very satisfied, somewhat satisfied, not very satisfied or not at all satisfied?

These three questions base themselves around a trust in the government, and the personal outlook from the citizens on their economic situation. Therefore, the optimism is split into two sub variables O_{pf} and O_{tg} , describing the personal financial situation, and the trust in government, respectively. Equal weight on these two variables yield

$$O = \frac{1}{2} \left(O_{pf} + O_{tg} \right), \quad (4.1)$$

4.2.1 Personal financial situation

A reasonable approach would be to say that the personal financial situation is reflected by the nations GDP, and the unemployment rate. However, by Okun's law from section 3.3, there is a linear relation between the GDP and the unemployment rate. Therefore, O_{pf} is

simplified to only be affected by the GDP. Based on Okun's law, O_{pf} is then set to the nations GDP divided by it's potential GDP:

$$O_{pf} = \frac{Y_{\$}}{Y_{\$,p}} \tag{4.2}$$

4.2.2 Trust in government

The variable describing the trust in the government will be denoted as Tr_{govt} . For now, this will only be affected by the increase in debt burden. As mentioned earlier, this is considered to be exogenous, since any control of the debt burden should be affected by the exports and imports of a country. As also mentioned, this could be hard to predict from the data available. Thus, a source that goes from 1 to 0 in a small time span is introduced.

An easy solution to this could be to just use a ramp function, with a steep slope. However, this might not be as descriptive. Instead, the *bass diffusion model* from section 3.5, is considered. This, with variables that suit the decrease in trust, can be seen in figure 4.3.

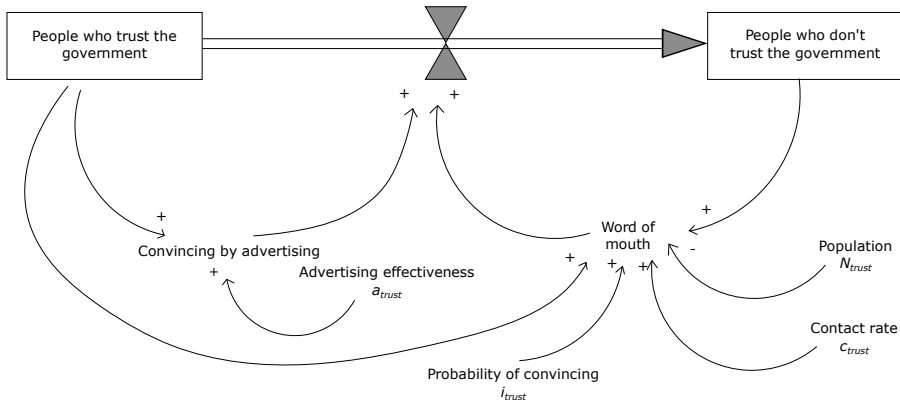


Figure 4.3: Stock-flow diagram of the trust fall.

Here, the i_{trust} is the *the probability of being convinced to distrust*. The variable c_{trust} is the contact rate, N_{trust} is the total population, and a_{trust} is the *advertising effectiveness*, which initiates the whole process. This could for instance be negative media coverage.

The stocks P_{trust} and A_{trust} , are the people who trust the government, and those who don't trust the government, respectively. Later on, the values will be adjusted to fit the

country in question, but for now, some generic and realistic values are used, namely

$$\begin{aligned}
 i_{trust} &= 1 \\
 c_{trust} &= 3 \\
 N_{trust} &= 1000 \\
 a_{trust} &= 0.1
 \end{aligned}
 \tag{4.3}$$

which yields a behaviour for A_{trust} seen in figure 4.4.

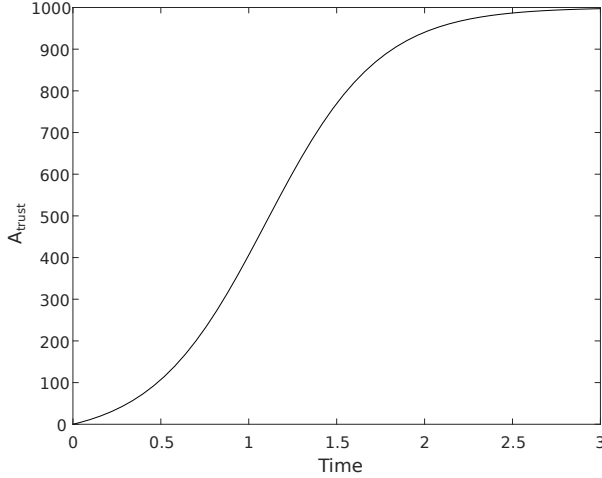


Figure 4.4: Behaviour of the trust-fall.

Note that the N_{trust} is quite small, this is in order to minimize computation time. The size is not that important since the *normalized value*, $\frac{A_{trust}}{N_{trust}}$, is the value needed for further use. The block diagram can be seen in appendix B, figure B.10.

However, letting the trust go all down to 0 makes the model crash, which is not the wanted behaviour. Therefore, a boundary is implemented, so that the trust never can go below some bound, $b_{trust,l}$. The trust-fall decreases the trust down to $b_{trust,l}$ instead, which yields

$$Tr_{gout} = 1 - (1 - b_{trust,l}) \cdot \left(\frac{A_{trust}}{N_{trust}} \right)
 \tag{4.4}$$

4.2.3 Inserting the optimism into the main model

Recall from chapter 2 that the optimism will only affect one economic unit, which will be the money flow from only the private households. Since the optimism does not affect the money flow directly, the variable *effect of optimism*, O_{effect} is defined, which is the direct effect applied to the money flow. Thus, when the effect of optimism is at its highest, then the flow of dollars should also be at its highest, given its stock of dollars. If $v_{h,\$}$ is the highest money velocity possible, which will be set at $1 [1/t]$ throughout this thesis², then

$$Y_{h,\$} = M_{h,\$} \cdot v_{h,\$} \cdot O_{effect} \quad (4.5)$$

A simple description on how the the economy affects the optimism and vice versa, can be seen in the causal diagram in figure 4.5

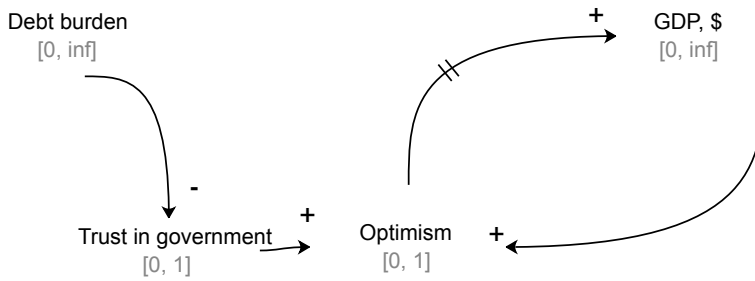


Figure 4.5: Causal diagram on how optimism and trust affects the economy.

As mentioned in section 2.3.1, there is a time lag before the optimism has an effect on the GDP. Therefore, a first order information delay from section 3.1 is introduced, with the time lag T_O from O to O_{effect} . This is set, for now, to $T_O = 1[1/t]$. With the optimism block inserted into the model, the figures 4.6 and 4.7 shows the behaviour of GDP and optimism, respectively.

This decreases the optimism in a similar curve as Tr_{govt} , while the GDP slowly lags behind, which is the expected behaviour.

²This to reduce the number of degrees of freedom in the model, since the purpose is only to inspect the flow of money, not M or v separately.

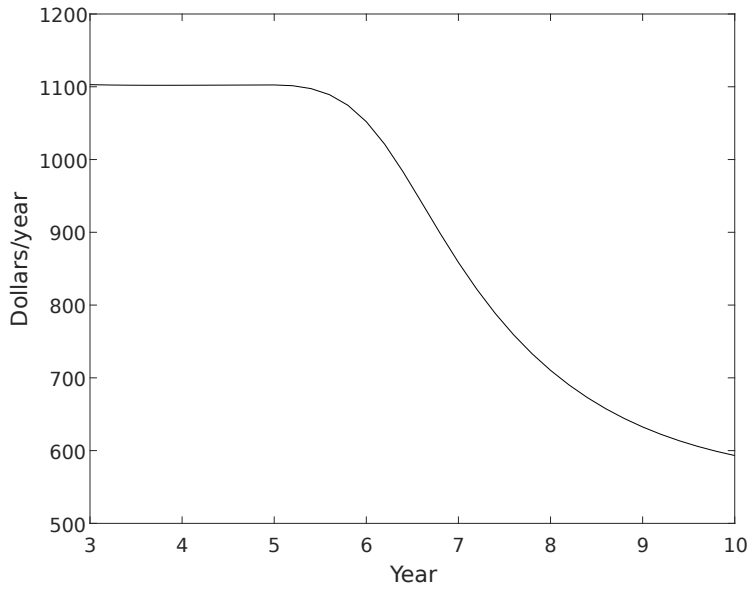


Figure 4.6: The GDP's reaction to the trust-fall.

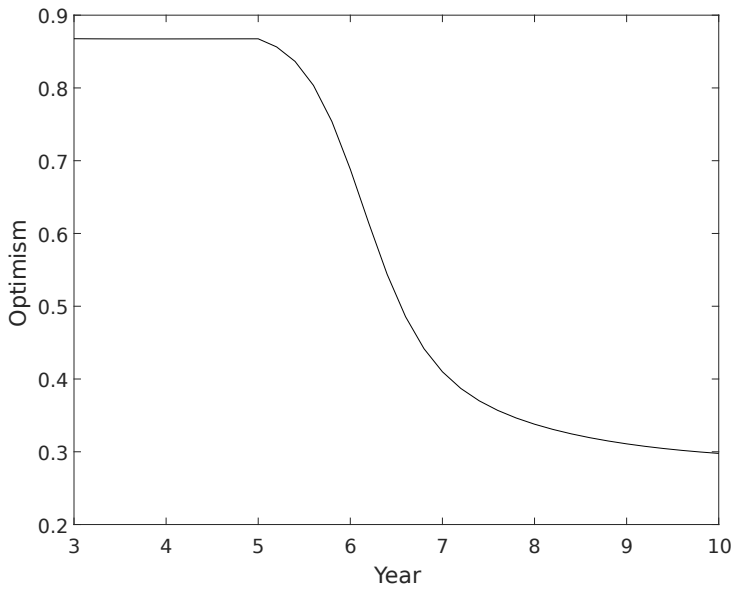


Figure 4.7: Optimism before injecting the new currency.

4.3 The flow of alphas (@)

As with the flow of dollars, the system is split into three economic units - the government, the firms, and the private households. It's assumed that both the firms and the government will spend their money the same way as they spend their dollar. The government are the ones to initiate the entire process, while the firms will gladly give out alpha in their wages instead of dollars - since this is perceived as a smaller value.

However, the private households will have some problem with spending this new currency. The stores will not necessarily accept it at first, but, because of the need, eventually one store will accept it. And when one store accepts it, they can get the advantage over the other stores that they accept this new currency - which forces the other private firms to accept it. The more it gets used, the more people will *start* using it. This can be compared to an epidemic, and is therefore modelled as the bass diffusion model from section 3.5.

4.3.1 The effect of optimism and need

Now, this entire "infection"-process will be heavily influenced by optimism. The more optimistic and trustworthy people are to this new currency, the higher probability that they will start using it. Therefore, the optimism is used for the variable i , the probability of infection.

Optimism is not the only factor the infection-process is dependent on. The variable need, n , is also a factor. This is the variable that reflects the need to sell, or need to make money. In a land in crisis, there will always be a need to sell, even though the deal is sub par. A portion of dollars will always be better than no dollars, so therefore, the variable n is a in the bass diffusion model, the "advertising effect". This altered bass-diffusion model can be seen in figure 4.8.

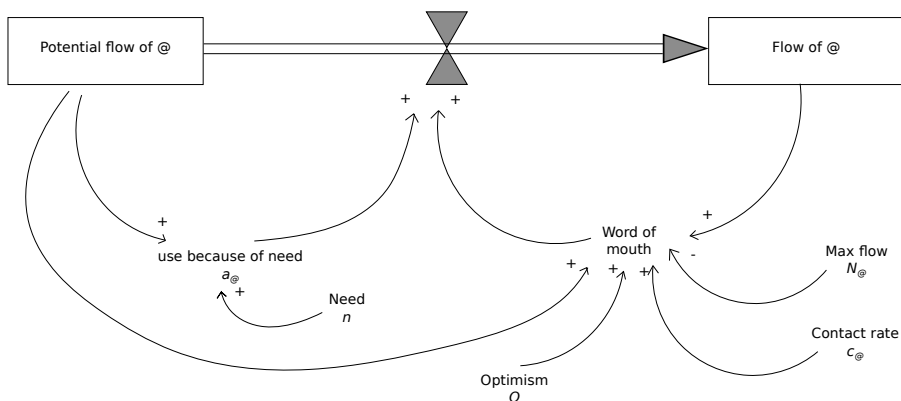


Figure 4.8: Stock-flow diagram of the introduction of alpha to the economy.

Need is chosen to be defined as the complement of optimism, thus

$$n = 1 - O. \quad (4.6)$$

So, in the beginning, need will be high, but it will decrease as the optimism increases.

4.3.2 The effect on optimism

The use of alpha also has an effect on the optimism. Since this currency is issued out by the government, it will be used as a new measure for the part of optimisms which reflects the trust in the government. The same technique as with the dollar will be applied, which is to compare its GDP³ to the *potential GDP*. However, this trust is more based on for instance media coverage, or other forms of information after analysis, and therefore an information delay from the GDP of alpha and into the optimism is added.

Now, this is enough to test out the flow of alphas, but before doing that, the exchange rate needs to be calculated in order see how much this value will have an impact on the total GDP and wealth.

4.3.3 The exchange rate

The exchange rate is assumed to be dependent of the optimism. Since optimism is some number describing trust and outlook for the future, it seems like a decent approach. However, as mentioned in section 2.3.2, the exchange rate cannot be infinitely small. Therefore, the smallest value of the alpha is assumed to be a half of the dollar, and thus calculating the exchange rate as:

$$xr = (1 - b_{xr,l}) \cdot O + b_{xr,l} [$/@] \quad (4.7)$$

where the bound $b_{xr,l} = \frac{1}{2} [$/@]$. Now, this exchange rate will yield the same value as the dollar when the optimism is 1, and a half of the dollar when the optimism is 0. With all these new variables, a simple description of this model can be seen in figure 4.9.

4.3.4 Running the model with test variables

Running this model with some test variables, and constant need and optimism, at $n = 1$, $O = 1$, yields the following plots for all the flows of alpha, as seen in figure 4.10.

Looking at this, one can see that the GDP⁴ does get a peak before it in fact decays, whereas the wages and taxes slowly rise. This is partly because the optimism and need is chosen to be high, which is actually contradicting to the proposed definition of the two variables. Even though it's unreachable, it does pose an extreme of a situation, which does force an assumption to be emphasized: This is that the firms in the "firms" section are completely separated from the government, that is, none of the firms are owned by the government in any way.

³The GDP calculated in dollars, not nominal.

⁴Note that the GDP shown here is nominal.

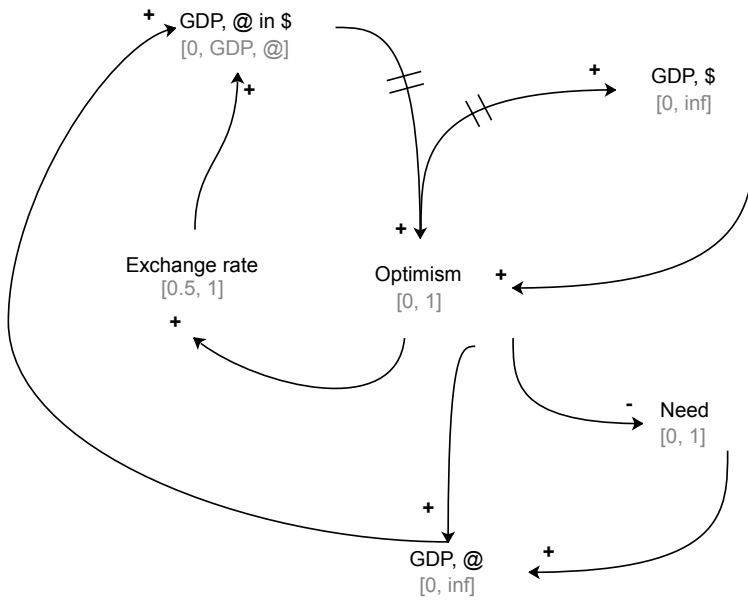


Figure 4.9: Causal diagram of the economy after the trust-fall, and when alpha has been introduced.

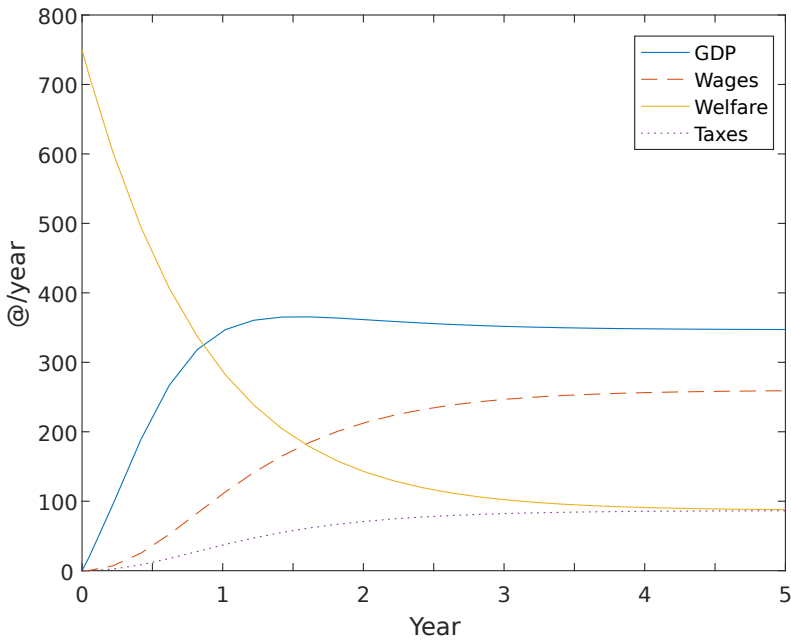


Figure 4.10: Flows of alpha with constant optimism and need.

Now, this means that there are in fact some firms in the government section of the system, and therefore some might say that this is wrong: all firms, with connection to the government or not, should be portrayed in the firms section of the system, and should then let some firms also have an initial value of alphas from the beginning. However, this makes the model more complicated, but still has no impact on the dynamics of the GDP. Since the GDP is what is important here, this would be an unnecessary complication to the model, and thus it is ignored.

However; what really happens here is that the money velocity of the household unit rises above the money velocity of the government. This could in fact be compensated by the government by "making more alpha's". Now, this function could be implemented into the system, but the changes would not be significant. The function is also chosen to be ignored in order to avoid accusations to the system that extreme inflation could be a big issue.

4.3.5 Inserting into the main model

Inserting the flow of the alpha into the main model, and running this again with the same test variables as before, yields a new flow of alpha as seen in figure 4.11

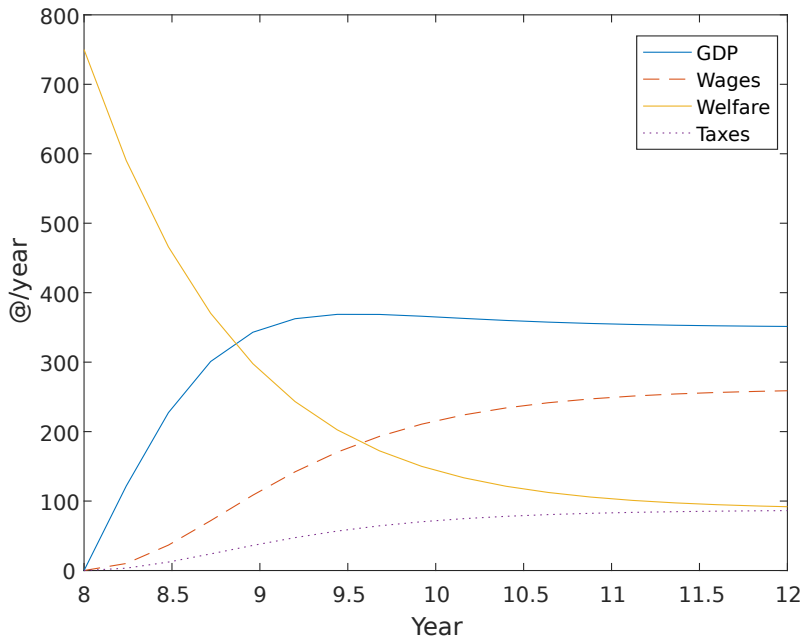


Figure 4.11: Flows of alpha with dynamic optimism and need.

The GDP still gets the peak as in the previous section, but now it takes more time to reach the point where everyone is using the alpha. However, as will be seen later on in this thesis when simulating, is this peak will *not* occur in the GDP of alpha calculated as dollars, and there are in fact other ways to explain what's happening when the optimism and need is dynamic. But, for now, this does indeed look reasonable considering the assumptions, and the model is ready to do simulations. The entire model in block diagram form can be seen in appendix B.

Chapter 5

Simulation

In order to get more insight on the effect of the alpha, simulations will be done by running the model with initial values that correspond to real data from a country in debt crisis. Greece is chosen as the country to simulate. Greece has a national debt of about 183% [1] of the GDP, and the number is still rising. Looking at the export [23] and import [24] rate, Greece has historically had an import rate larger than the export rate. Their unemployment rate is (Oct 2016) 23% [25], many times larger than the natural unemployment rate. Greece is therefore a perfect candidate for this simulation.

First off, there will be simulations in order to set all the initial values such that the GDP corresponds to the historical data in the given time frame. Then, simulations will be done *with* the alpha, in order to see the effect it has on the countries economy. Last, disturbances will be implemented and variables will be adjusted in order to check the margin of errors.

5.1 Setting the initial values

In order to find the initial values, it's necessary to decide where to start the simulation. Looking at the GDP of Greece, a good time to start is to start in year 2008, when the financial crisis struck. The available data stops at year 2015, and therefore, and the time frame is chosen to be 2008-2015.

5.1.1 Initial optimism value

Before finding the initial optimism value, the potential GDP of Greece needs to be calculated. To do this, Okun's law from section 3.3 is applied with the GDP and unemployment data from the years 2008 and 2009 (figures A.1 and A.2). The natural unemployment is chosen to be 5%, and the potential GDP is found to be 391 billion USD/year, which yields

an initial value for the optimism,

$$O_{init} = \frac{1}{2} \left(\frac{354.5}{391.0} \right) + \frac{1}{2}$$

$$O_{init} = 0.95$$

5.1.2 Values for the flow of dollars

Now, the next task is to find the initial values of the dollar-stocks in the private households, firms and government, that stabilizes around 354 billion USD/year in GDP. For simplicity, all money flows are divided by 1 billion, which thus yields numbers in hundreds.

The initial values can be written as a product of the stabilizing GDP and some weight. By using trial and error, the weight is found to be 1.024, which yields the following initial values:

$$M_{h,\$,init} = w_{init} \cdot 354[\$]$$

$$M_{f,\$,init} = w_{init} \cdot 354[\$]$$

$$M_{g,\$,init} = \frac{w_{init}}{4} \cdot 354[\$]$$

Adding these initial values together will yield what will be referred to as the *total stock of dollars*.

5.1.3 Values for the trust-fall and time lag from optimism

There is also a need to find more suitable values for our trust-fall and time lag from optimism to GDP in dollars. When this was modelled in section 4.2.2, the trust-fall reached it's stabilizing value after about three years, which is a bit too slow. A more aggressive function is wanted. Therefore, the advertising effect is changed to $a_p = 3$ instead. This will force the trust-fall to decrease to it's wanted value after about one year, which is more descriptive to the financial crisis.

The trust-fall should also have a larger effect on the optimism. In order to do that, the bound is set to $b_{trust,l} = 0.05$. Note this also means that the alpha will have a larger effect on the optimism as well.

With these values, the GDP of Greece decreases too fast, and therefore the value of the time lag from optimism to GDP should be adjusted. This is set to $T_O = 2.7[t]$. This yields the following plots for the optimism, distrust and GDP as seen in figures 5.1 and 5.2.

As seen here, the distrust will drag the optimism down to a pessimistic level (below 0.5) the first year, and this leads to the GDP slowly decaying, which again effects the optimism to decay even more. This is the dangerous reinforcing loop that is the heart of the crisis, which can be hard to escape without any new or external measures.

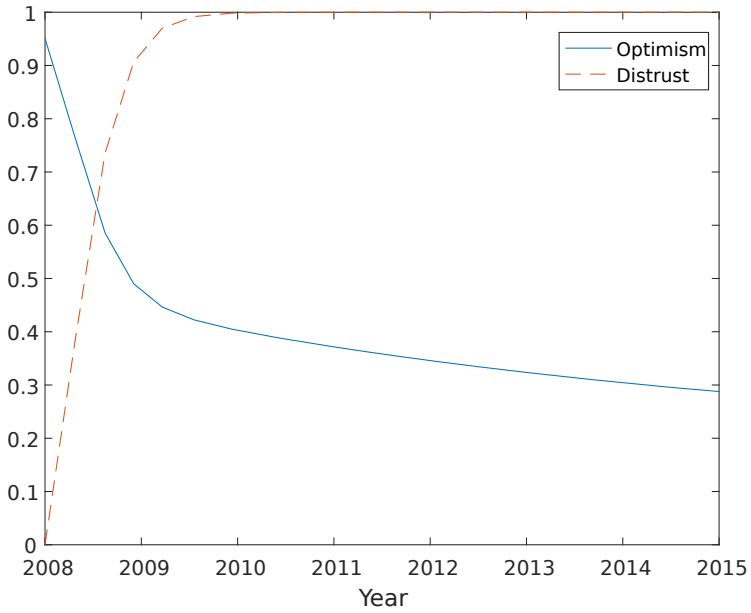


Figure 5.1: The optimism and distrust before alpha is introduced.

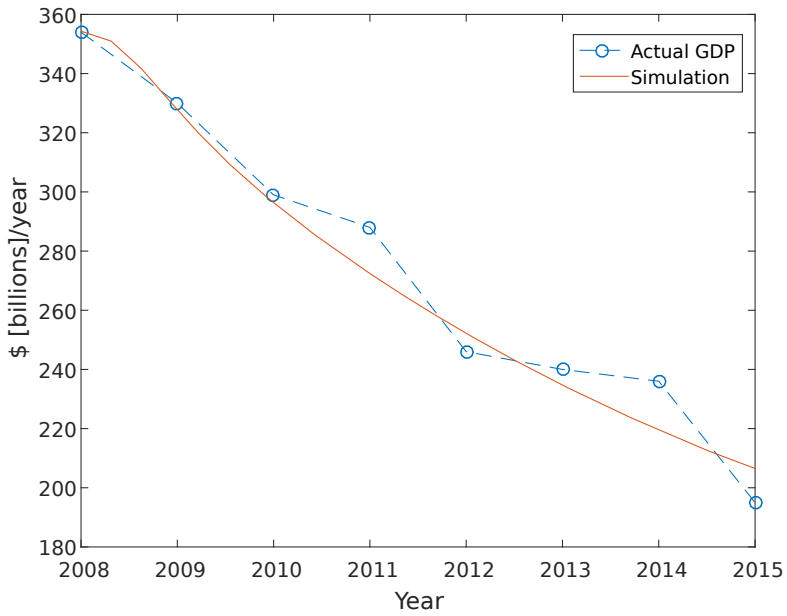


Figure 5.2: The GDP of Greece before alpha is introduced.

5.1.4 Initial values for the alpha

The initial values of the flow of alpha is not that important - only that it's not introduced to much or too little of it. To be consistent with the problem outline, a third of the total amount of dollars in stock is issued out. All the alpha starts in the government, and thus the initial value is the entire stock.

Now, to find the potential GDP of the alpha, the entire stock of dollars is compared to it's potential GDP, and this fraction is used to find the potential GDP of alpha. Now, everything is in order to do the first simulation. The matlab code containing the initial values can be seen in appendix C.

5.2 Simulation 1: Standard simulation

First off is the standard simulation. The alpha is introduced at year 2011, and the impact it has on the GDP can be seen in figure 5.3. As seen here, the GDP contribution from alpha will grow fast the first two years, before it keeps growing - slowly - in the next two. The GDP from dollar will lag behind, and rise slowly and evenly the years after 2012.

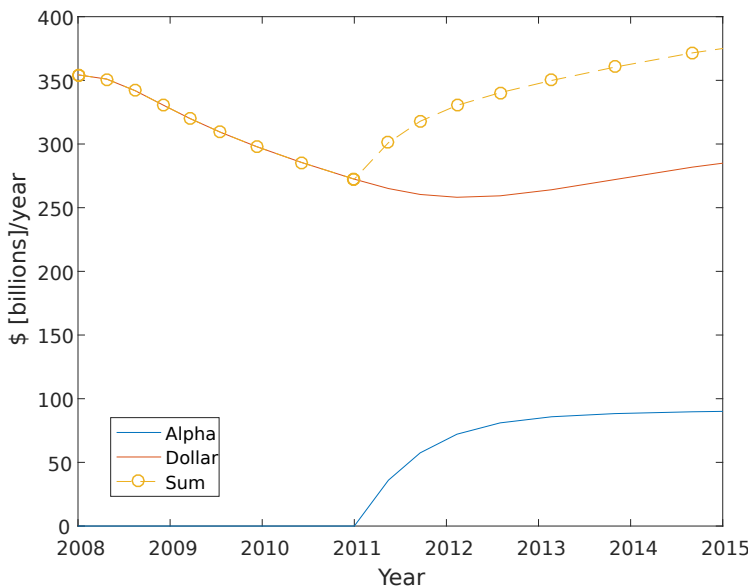


Figure 5.3: GDP contributions of alpha and dollar, first simulation.

The optimism gets a plot as in figure 5.4. The first three years are no different from before introducing the alpha, but when the alpha is introduced, the optimism will slowly rise again, and ends up at about 0.7 in year 2015.

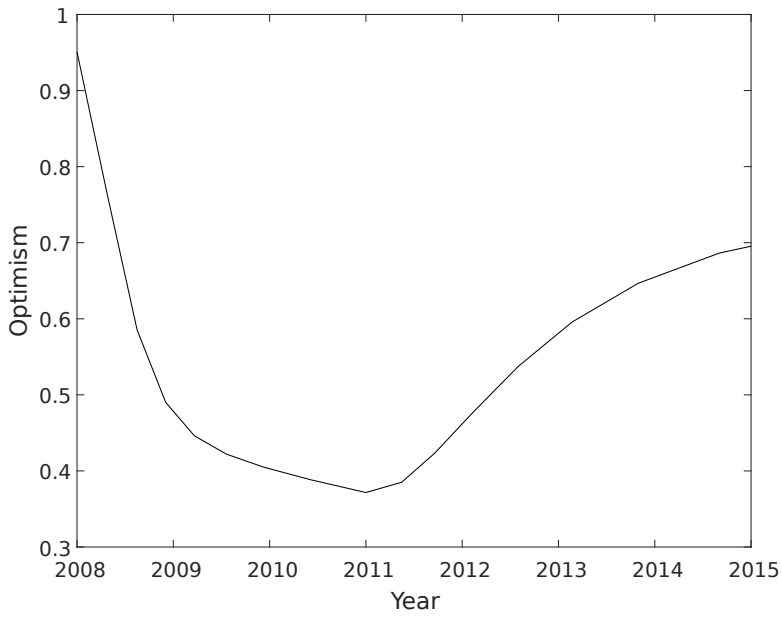


Figure 5.4: Optimism, first simulation.

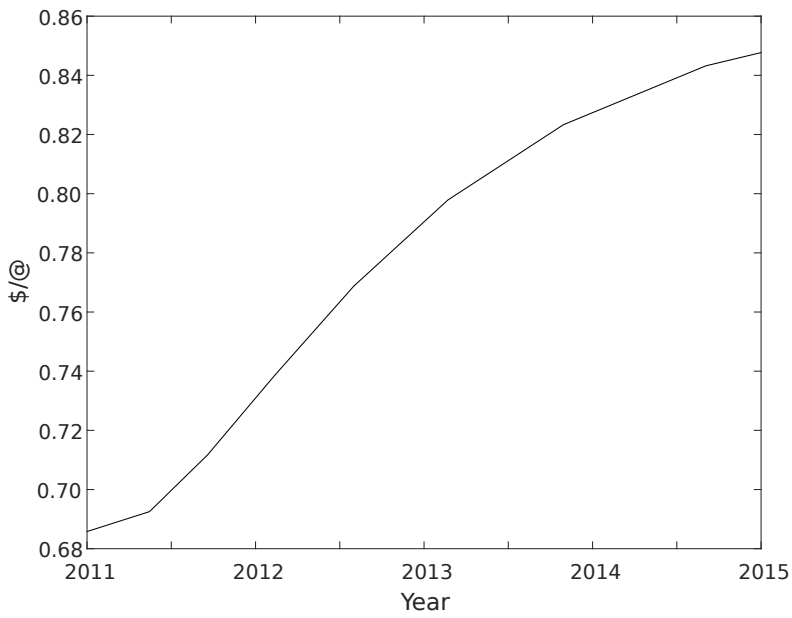


Figure 5.5: Exchange rate for the alpha, first simulation.

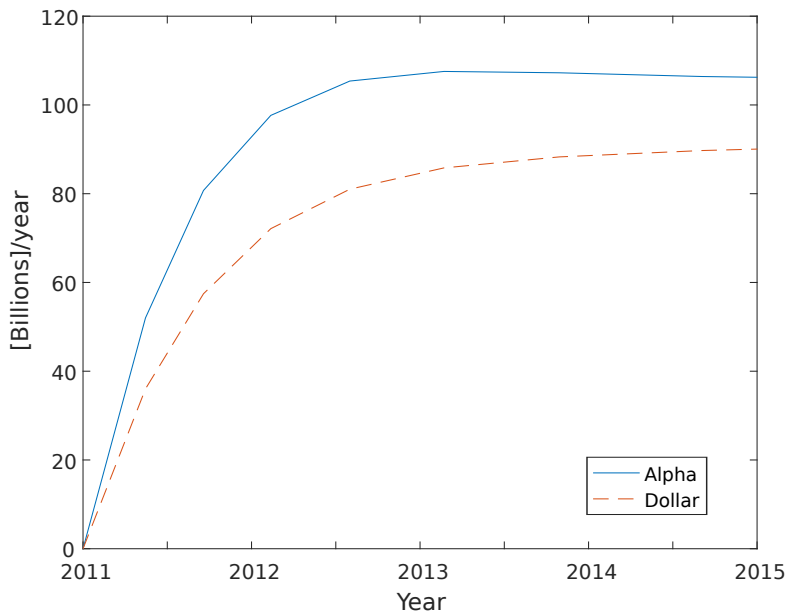


Figure 5.6: The GDP of alpha calculated in dollars and nominally, first simulation.

Looking at the exchange rate and the plots for the circulation of alpha in both @ and \$ (figures 5.5 and 5.6), the exchange rate is rising along with the GDP of alpha in dollars. However, the nominal GDP of alpha reaches a peak and then slowly decays a bit, as seen in the modelling chapter.

5.3 Simulation 2: With correction for government welfare of dollars

Looking at the previous simulation, some might argue that we should incorporate an extra decrease on the dollar flow from the government when the alpha is introduced. This being because when the alpha is introduced, the government will pay out *less* dollars than usually. Therefore, in order to reach this, a decreasing ramp is implemented into the model, which will decay when alpha is introduced. This will be the new money velocity for the welfare in dollars. First off, this is only reduced to $0.75 [1/t]$.¹

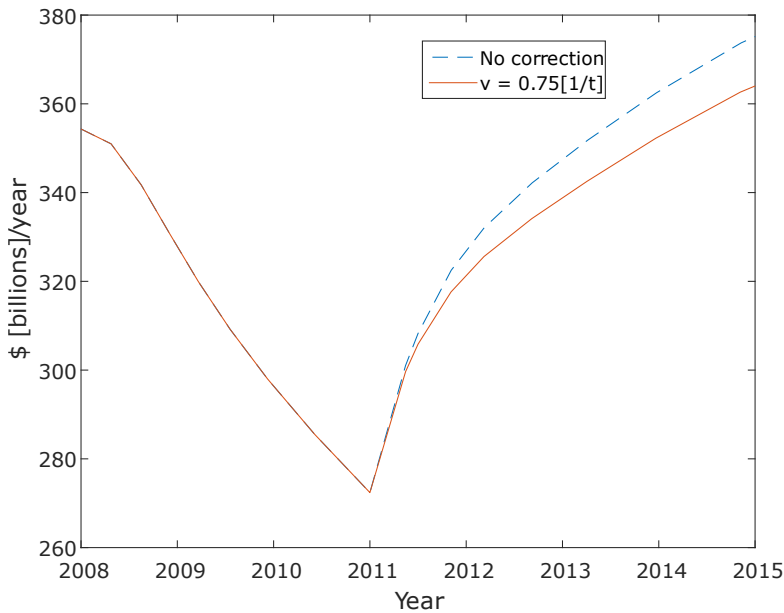


Figure 5.7: The GDP with and without corrected government welfare.

The figure 5.7 shows the resulting GDP. As seen here, this makes almost no impact on the previous results. However, it does pose an interesting question, which is how much can the money velocity from the government be decreased before it makes impact? A simulation is run with a few values for $v_{g,\$}$, to find the resulting GDP for the dollar. The time axis is also expanded to 2020, to more easily spot the trends.

¹The default money velocity was 1.

The result is seen in figure 5.8. As seen here, one can in fact decrease the money velocity quite much before the GDP of dollars gets a negative growth. At $v_{g,\$} = 0.25[1/t]$, the growth is negative, and this will yield in a sinking optimism and sum of GDP. This can be seen in figure 5.9 for the sum of GDP.

The decrease in the optimism is a bit harder to see, but looking only at the years 2016-2020, it starts sinking in the year 2018. This can be seen in figure 5.10.

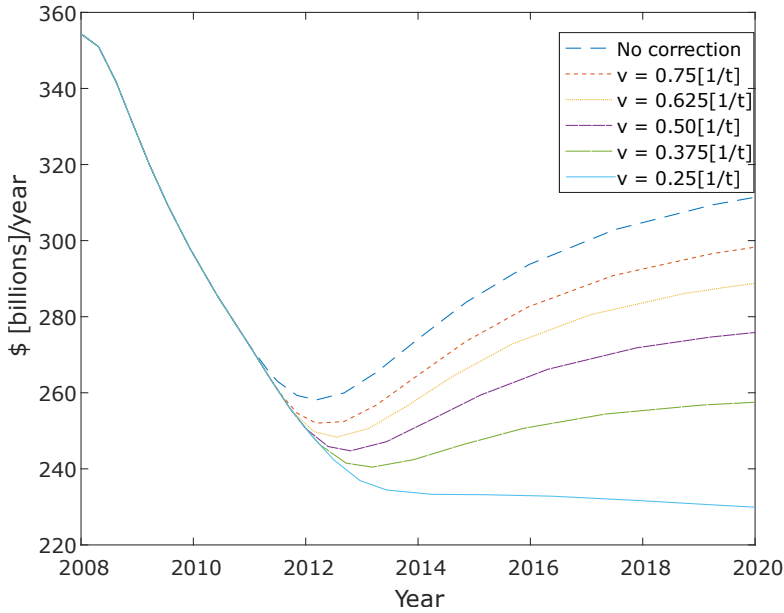


Figure 5.8: The GDP from dollar flow with different government money velocity.

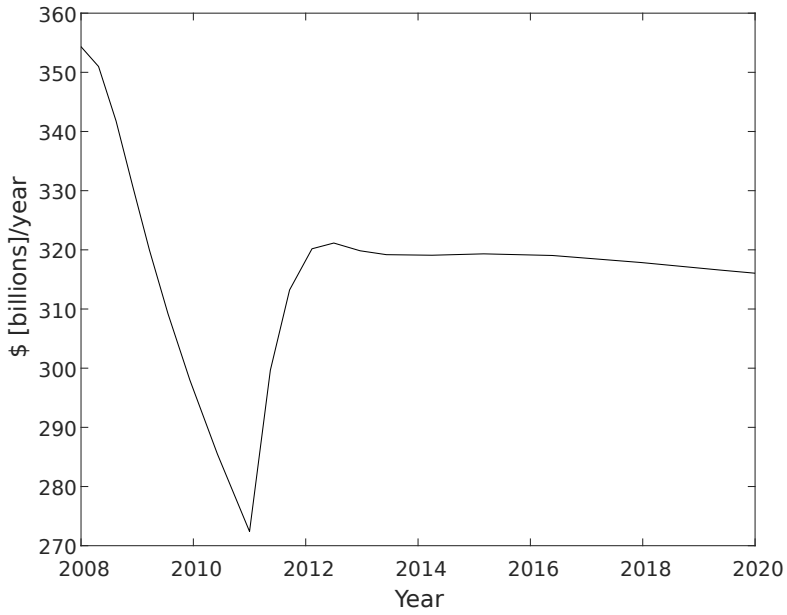


Figure 5.9: Sum of GDP with $v = 0.25$ [1/t].

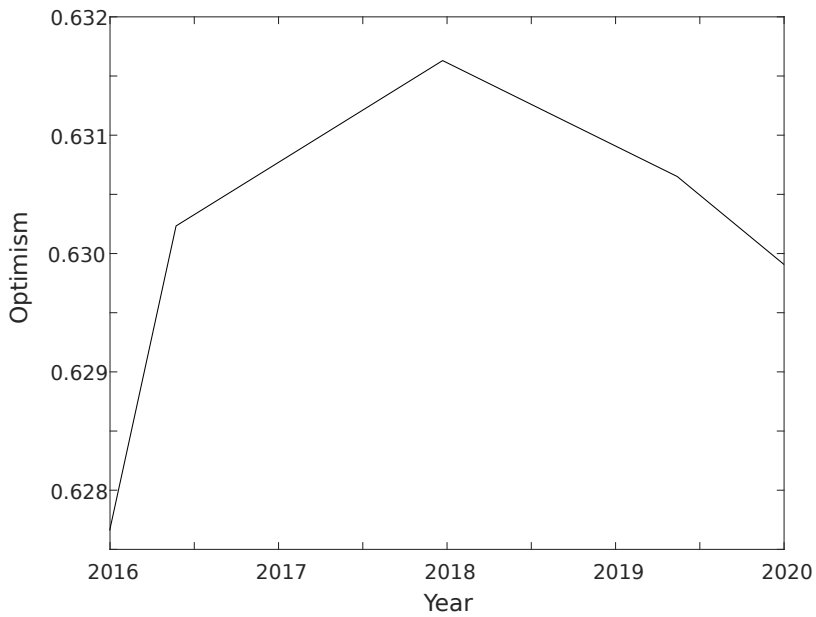


Figure 5.10: Optimism with $v = 0.25$ [1/t].

5.4 Simulation 3: With constant and values for need

Another factor that can be necessary to investigate more, is the impact *need* has on the simulations. Need has been dynamic by being inflicted by optimism, but some might say that the need is an exogenous variable, or that need should stay constant throughout the process - since this is merely an investigation of a rebuild phase from a crisis, not necessarily everything that happens *after* the country is out of the crisis.

Therefore, a simulation with different constant values for need is run, compared to the dynamic need that has been used in the previous simulations. These simulations are also expanded to year 2020, to more easily spot the trends. The figures 5.11-5.13 shows the results. As seen, the need needs to be quite low in order to stop the growth of optimism and GDP. Only the simulation with $n = 0.1$ has negative growth. $n = 0.2$ yields a stable GDP, while everything above yields growth.

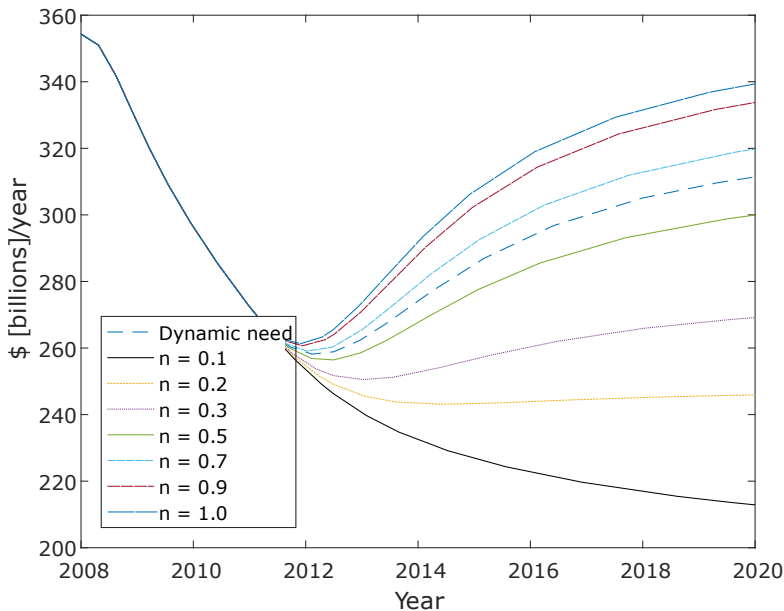


Figure 5.11: GDP of dollar with different values for need.

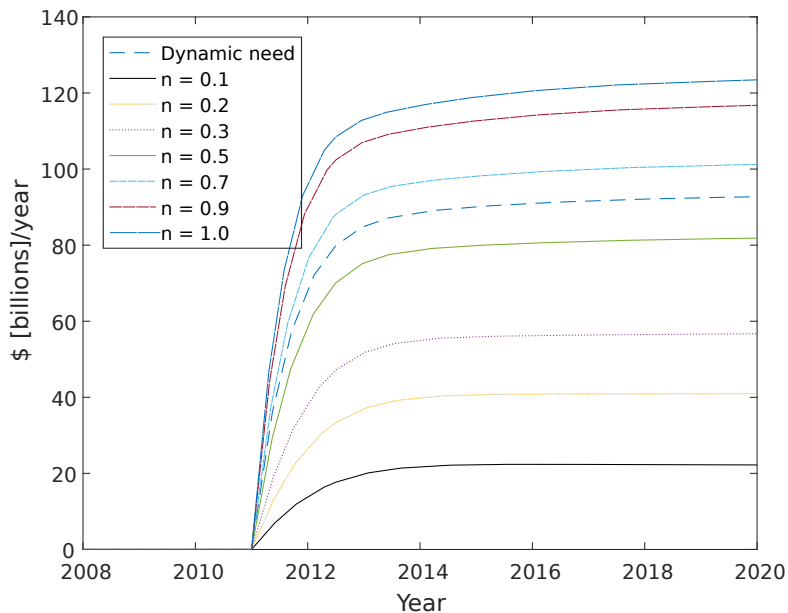


Figure 5.12: GDP of alpha with different values for need.

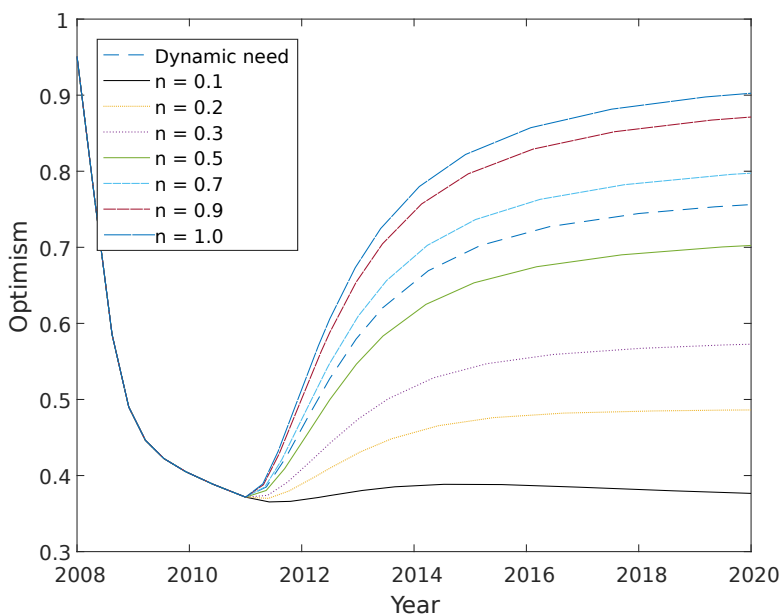


Figure 5.13: Optimism with different values for need.

5.5 Simulation 4: Different lower bounds for the exchange rate

To get more insight, a simulation the system with different lower bounds on the exchange rate is run. It has been set it to 0.5 [$\$/\text{@}$] previously, but some might argue that it's a bit high. Again, the time axis is expanded to 2020 to more easily spot the trends. The results of the different lower bounds can be seen in figure 5.14.

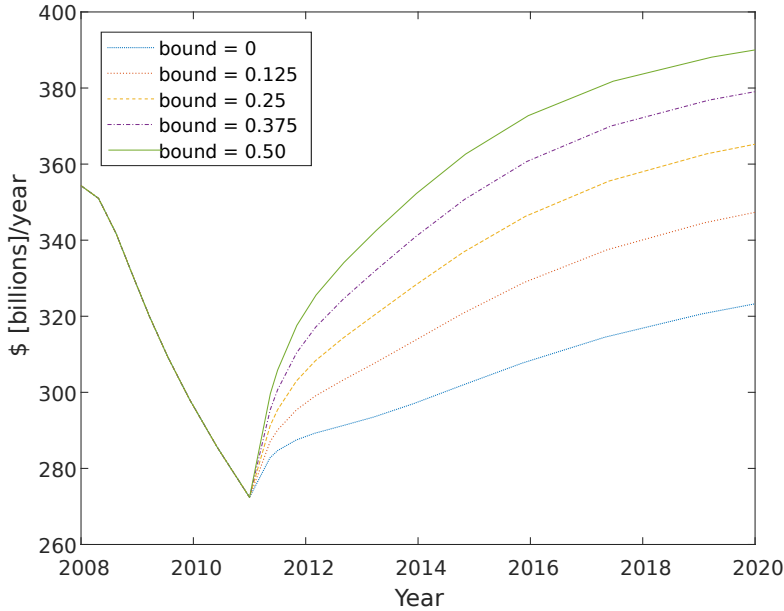


Figure 5.14: GDP sum with different bounds on the exchange rate.

This will only yield a dampening effect on the growth. Not even a non-existing bound will yield negative growth.

5.6 Simulation 5: With constant effect from optimism to use of alpha

Last, the effect the optimism has on the use of alpha will be checked. Thus, instead of using the dynamic optimism as previous, this simulation will simulate for different constant values, compared to the dynamic optimism. Again, the time horizon is expanded to 2020 to more easily spot the trends. The results can be seen in figure 5.15.

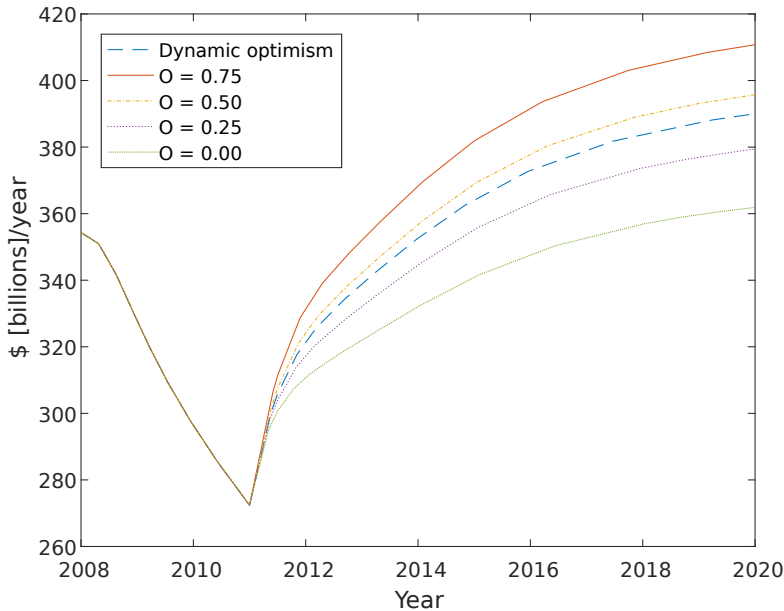


Figure 5.15: GDP sum with constant optimism effect on the use of alpha.

Much like the exchange rate, this only has a dampening effect. Even with an optimism effect of 0 throughout the process, the alpha will still get spent, because of the need.

Chapter 6

Discussion and analysis

This section will look at the results from chapter 5, and try to interpret the different plots from their respective simulations. What is the impact of introducing the new currency, alpha, and under which circumstances does it succeed?

6.1 Analysis of simulation 1

6.1.1 The GDP contributions

The GDP contributions, as seen in figure 5.3, rises nearly immediately after the alpha has been introduced in year 2011. This is because the increased use in alpha is higher than the decrease in use of dollars. Since the use of alpha has an impact on the optimism, the use of dollars will also increase, eventually. However, because of the time lag from optimism to the spending of dollars, it will not happen before after 2012. This is a reasonable result, and shows the importance of both bringing the time lag from the optimism to the dollar, and also bringing the time lag from the spending of alpha to the optimism.

Since the opportunity for the government to issue out more alphas than they start with is not included, the GDP of alpha will rise not so rapidly after the first two years. The growth of the contribution of alpha can be split into two parts - First, the growth caused by all the alpha's to get into circulation. This will be the rapid growth in the first two years. Second, the exchange rate increasing. This will contribute to the more slow growth the next years. This can be seen more easily in figures 5.5 and 5.6, which are the figures for the exchange rate and the GDP of alpha, respectively.

In chapter 4, the peak in the nominal GDP of alpha was explained by the money velocity of the households going higher than what the government was able to provide. However, with the dynamic optimism and need, this peak can also be explained by stabilization of value. *Nearly* everyone uses this new currency at that point, and the exchange rate is just rising. This will also result in less use of the new currency, since it's worth more. This can

be an explanation to the peak in nominal GDP in alpha.

6.1.2 The optimism

Since the GDP grows both in alpha and dollars after 2011, one should assume that the optimism should grow as well, and this is indeed the case. Figure 5.4 shows that it gets a stable growth, and ends up at about 0.70 in 2015.

This might seem low, but it has an explanation. The model is quite strict in how it treats the use of alpha as a indicator of trust in the government. The potential GDP is calculated in the same ratio as with the dollars, but it's compared to the GDP of alpha in dollars, not the nominal GDP. Therefore, because of the exchange rate, the GDP of alpha in dollars will be much lower than it's potential GDP, and therefore the impact will not be so radical.

Also, as mentioned in chapter 2, the model for the flow of alphas should gradually transform into a more similar model like the model for the flow of alphas, with the optimism having a greater impact on the money velocity or stock of alphas. This might also yield a more significant increase in the optimism in the long run, but, this is as explained, left out.

One could argue with a growth like this, the optimism should be higher. But, in order to show if this new parallel currency could work or not, it's better to be more strict than loose in that sense, to show that the currency is robust even under tough circumstances.

6.1.3 Impact on the imports and exports

So what can be told about the impact on the imports and exports from this simulation? Well, even though it's hard to find good correlations between increased productivity and increased export rate, what can be told, is that an increase in the use of alpha does *not* mean an increase in imports. This because of the assumptions that alpha can only be used inside the country, and therefore it would be impossible to use it to import anything.

Also, it's not a irrational thought that the increase of domestic productivity should at least lead to increased flow of exports. Looking at the figure for the GDP contributions, figure 5.3, it's seen that the contributions from the alpha is higher than the contributions from the dollar. This should at least stimulate the opportunity for the exports to be higher than the imports, which again should contribute to the Greece's ability to repay their debt, as mentioned in chapter 2.

6.2 Analysis of simulation 2

In this simulation, it's tried out what will happen when the flow of dollars decrease as the alpha is being issued out. This will happen in the case of issuing out the alpha, which will also somewhat increase the value of the new currency. The idea, as has been mentioned, is that the government goes from issuing out 100% dollars to 75% dollars and 33% alphas. Therefore, in order to test out this effect, the simulation decreased the velocity of the

dollars to $0.75 [1/t]$ from $1.0 [1/t]$. This will not necessarily mean that the the *flow* from the government decreases 25%, but in order to achieve this specific ratio by calculation, one might have to divide by zero at some point, which is something that should be avoided.

Therefore, the figure 5.8 shows the results of money velocities that yields flows *below* 75%. All the way down to a money velocity of $v = 0.375[1/t]$, this will only have a *dampening* effect on the growth. Thus, the flow of dollars from the government sector can go below 75% without having an impact on the actual end game.

However, the flow can not be too small. When $v = 0.25[1/t]$, a breaking point is reached where the optimism is still decreasing. What this shows is that, with the amount of alpha being issued, and the way that the model is built, one can not completely disregard the dollars from our system. This is not too strange since:

1. The amount of alpha being issued out is only 33% of the total amount of dollars in the system, thus one would need the exchange rate to go higher than the dollar for this to work, which this model does not allow.
2. The optimism is reliant on the spending of dollars. Even though the alpha is being spent and incorporated in society, the optimism will never go above 0.5, since a half of the optimism is the fraction from GDP of dollars to it's potential GDP. One would need to change the entire optimism block in order to achieve success here, and rather use the sum of GDP as a comparison.

What the results does tell, is that this model is quite robust, unless your goal is to cut out dollars entirely. There is a big enough margin of error when it comes to the flow of dollars to tell that this will not be a problem to the end result.

6.3 Analysis of simulation 3-5

This section analyzes the final three simulations. The reason these are grouped together, is because they can all be seen as some exogenous disturbances, trying to inflict the usage of the new currency. EU might not be to pleased with Greece introducing a parallel currency, in the fear that they might stop using the euro [26].

The way these negative disturbances are interpreted, are as if they're constantly oppressing the effects trying to drive the usage of alpha up. In the three simulations, from 3-5, there has been disturbances to the start up phase, the exchange rate, and the effect optimism has on the usage of the currency, respectively. Now, looking at the last two simulations, it's seen that with reasonable negative disturbances, this only has a dampening effect, thus not changing the final result, necessarily.

However, when tampering too much with the need, which is the initial advertising effect, usage of the alpha will be non-existent, and the crisis will not be averted. This is perhaps the biggest danger when issuing a new currency like this - not being able to get

it into circulation in the beginning. There is indeed a high probability that there will be forces trying to stop this new currency to hinder it getting into circulation. Therefore, this will be investigated even further in the next section.

6.4 Investigation of the initiation of the new currency

Now, as mentioned in the previous section, the perhaps most vulnerable period when introducing the new currency, is the start-up phase. When there is a large push/pull between the forces wanting this to fail and the government, the bass diffusion model might not be the right model when it comes to explaining what's happening. That's because, even though it fails when the battle between need and negative media coverage goes below a certain level, the dynamics of alpha in circulation will still be as previously seen, only in a much smaller and unnoticeable scale.

A better way to describe this battle, would be to use the product dominance as described in section 3.6. Imagine this market being Greece, and the two incompatible products competing being the alpha, and *not alpha*. The demand is the inflow of alpha, whereas the installed base is either the alpha in use, or the alpha which is not in use. In figure 3.5, it's seen that the outcome of the battle between the two products is decided by the random noise seeds. These are instead set to be *need* and *negative media coverage*. Therefore, the strongest of these two will decide the outcome of the battle.

As seen in this model, instead of just a small amount of alpha being put to use with a low need, there's the situation where it's all or nothing. Either everything comes into circulation, or the entire currency will just die. When the alpha comes into circulation, the results would be what we have been getting previously. If the alpha does *not* come into circulation, nothing will happen, and the crisis will continue.

The issue with viewing the start up phase as a battle for product dominance, is that it's impossible to predict the negative media coverage, and the battle between that and need will merely be a guess. However, what can be done, is discuss different types of solutions or assessments to increase the need.

A solution to this could be, instead of saying that a portion of the taxes *can* be payed in alpha, the government can say that a portion of the taxes can be payed in alpha, but a smaller portion *must* be payed in alpha. Another solution could also be to expand the payment in alpha to all government services from the start, saying that a smaller portion *must* be payed in alpha, here as well.

The downside of this is for instance the exporters, who will have a harder time getting a hold of this new currency, since they will mostly receive an international currency for their trades, and have no instances where they will receive alpha's naturally. Another downside is that the more rules you impose in this new currency, the more negative media coverage it will get, and the negative media coverage might be more than the increase of need.

Another solution could be to lower the sum of negative media coverage by trying to get support in this new currency that the nation trusts. To try to ensure some trust before introducing the new currency. How this should be done in Greece is however beyond the scope of this thesis.

Chapter 7

Conclusion

With the results, it's seen that the GDP and optimism will rise, which will again, by Okun's law, have an impact on the unemployment rate. These are the tools to get the nation out of their pessimism, and increase productivity. By the increased use of alpha over the use of dollar, the country will have everything laid out for them to increase their exports above their imports, which will get Greece out of their economic crisis.

However, the increase of GDP is not that big, and because of the high debts and interest rates, they would probably need a portion of the debt to be cut. This is not so unlikely seeing that getting repaid a bit is better than not being repaid at all. Debt cuts are also on the agenda [4], and seeing this currency succeed would hopefully make other debtors more cooperative.

The model that has been built with the assumptions made, is very robust. Even with a very pessimistic view of the outcome, there needs to be some heavy and improbable disturbances in order for the alpha to flop. With high margins on the exchange rate, optimism, and decrease in the spending of dollars, one could say that even if the applied numbers and bounds aren't exactly correct, it will not have a big impact on the outcome in the end.

The Achilles heel of the model is the start up phase, and the whether or not the need will triumph over the negative media coverage. This is of course hard to predict, and some solutions to what can be done have been mentioned, even though they have their negative aspects as well. Therefore, one is advised to have a solid plan on how to handle this crucial part if introducing this new currency. What to be done preemptively, and what to be done if the currency fails.

The last bit to think about, is what is there to lose and what is there to gain by introducing this new currency? From the perspective of the results presented in this thesis, there is only something to gain, seeing that introducing this new currency will never make the GDP or unemployment sink more rapidly than it already does. However, there might

be other repercussions, for instance a lack of trust by the debtors, a lack of trust in the government, or even punishments for trying to introduce a parallel currency, if it fails. But, it will surely fail if no one tries, and it sure does have the fundamentals for success if introduced properly.

Bibliography

- [1] Eurostat (n. d.). Debt, Greece. [Online]. Available: http://ec.europa.eu/eurostat/en/web/products-datasets/-/GOV_10DD_EDPT1. Accessed May 24, 2017.
- [2] The World Bank (n. d.). GDP, Greece. [Online]. Available: <http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=GR>. Accessed May 24, 2017.
- [3] The Guardian. (2012, Nov. 27). EU and IMF agree tentative deal to cut Greek debt. [Online]. Available: <https://www.theguardian.com/business/2012/nov/27/eu-imf-greek-debt>.
- [4] Daily News. (2017, May 22). Greece falls short in efforts to secure deal with creditors. [Online]. Available: <http://www.nydailynews.com/newswires/news/business/greece-falls-short-efforts-secure-deal-creditors-article-1.3185403>
- [5] Trond Andresen, "A parallel emergency currency via the mobile phone network", BVMW, Berlin, Dec. 2012.
- [6] Trond Andresen, "Paying with a type of government bond as a supplement in a dollarized country", unpublished.
- [7] Trond Andresen, Robert W. Parenteu, "A program proposal for creating a complementary currency in Greece", *real-world eco. rev.* issue 71, pp. 2-10
- [8] Trond Andresen, "The Central Bank with an expanded role in a purely electronic monetary system", *real-world eco. rev.* issue 68, pp. 66-73
- [9] Trond Andresen, "Improved macroeconomic control with electronic money and modern monetary theory", *real-world eco. rev.* issue 63, pp. 134-141
- [10] Trond Andresen, "What if the Greeks, Portuguese, Irish, Baltics, Spaniards, and Italians did this: high-tech parallel monetary systems for the underdogs?" *real-world eco. rev.* issue 59, pp. 105-112.

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- [11] Trond Andresen, "Ten advantages and two possibilities with a parallel electronic currency", unpublished.
- [12] N. Gregory Mankiw, "The kinds of money," in *Brief principles of macroeconomics*, 7th ed, Stamford, 2014., pp 220.
- [13] ric Tymoigne and L. Randall Wray, "Modern Money Theory 101: A Reply to Critics", Levy Economics Institute of Bard College, New York, NY, 2013.
- [14] John D. Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, Boston: Irwin McGraw-Hill, 2000.
- [15] Trond Andresen, "A block diagram approach to macroeconomic dynamics, and why IS/LM is fatally flawed",
- [16] Trond Andresen, "The Macroeconomy as a Network of Money-Flow Transfer Functions", NTNU, Dept. of Eng. Cyb., Trondheim, January 27, 1999.
- [17] Investopedia. (n. d.). Gross Domestic Product - GDP. [Online]. Available: <http://www.investopedia.com/terms/g/gdp.asp>. Accessed June 03, 2017.
- [18] Math, Graphics and programming, MATLAB, (1 Apple Hill Drive, Natick, MA, USA, 2014).
- [19] Modelling software in MATLAB, Simulink, (1 Apple Hill Drive, Natick, MA, USA, 2014).
- [20] Investopedia. (2017, May 12). Okun's Law: Economic Growth And Unemployment. [Online]. Available: <http://www.investopedia.com/articles/economics/12/okuns-law.asp>
- [21] Encyclopdia Britannica (n. d.). Gresham's law. [Online]. Available: <https://www.britannica.com/topic/Greshams-law>. Accessed May 21, 2017.
- [22] Tipp. (2010, Jan. 05). Methodology. [Online]. Available: <http://www.tipponline.com/tipp-indexes/methodology>
- [23] The World Bank (n. d.). Exports of goods and services (% of GDP). [Online]. Available: <http://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=GR>. Accessed June 1, 2017.
- [24] The World Bank (n. d.). Imports of goods and services (% of GDP). [Online]. Available: <http://data.worldbank.org/indicator/NE.IMP.GNFS.ZS?locations=GR>. Accessed June 1, 2017.
- [25] The World Bank (n. d.). Unemployment rate, Greece. [Online]. Available: <http://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?locations=GR>. Accessed May 24, 2017.
- [26] Reuters. (2017, May 23). After Brexit, EU plans 'offer you cannot refuse' to expand euro zone: Moscovici. [Online]. Available: <https://www.reuters.com/article/us-eurozone-future-euro-idUSKBN18J207>
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Appendix

A Real data plots

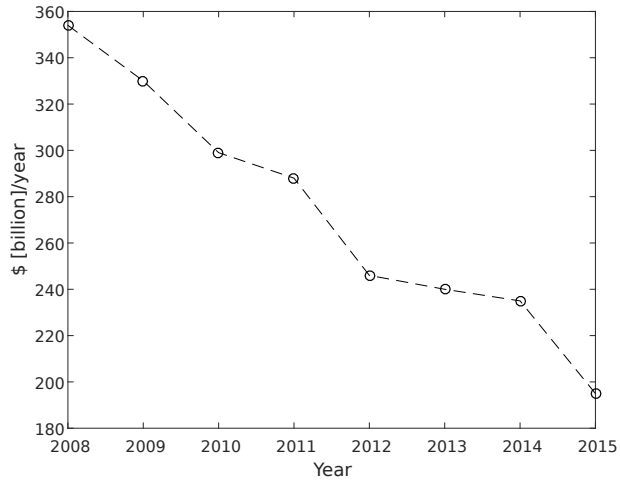


Figure A.1: GDP of Greece, 2008-2015 [2].

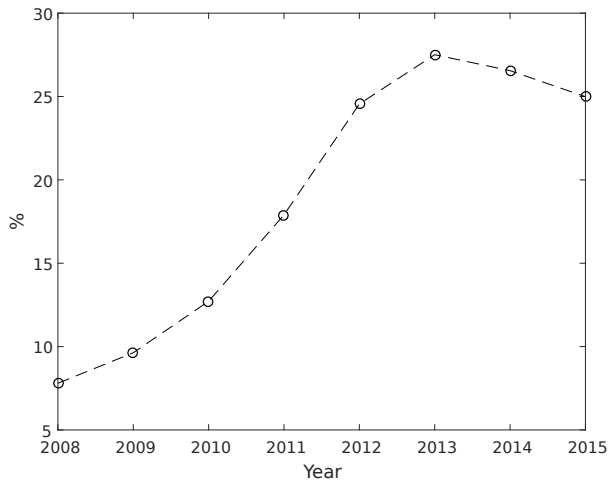


Figure A.2: Mean unemployment of Greece, 2008-2015 [25].

B Simulink model

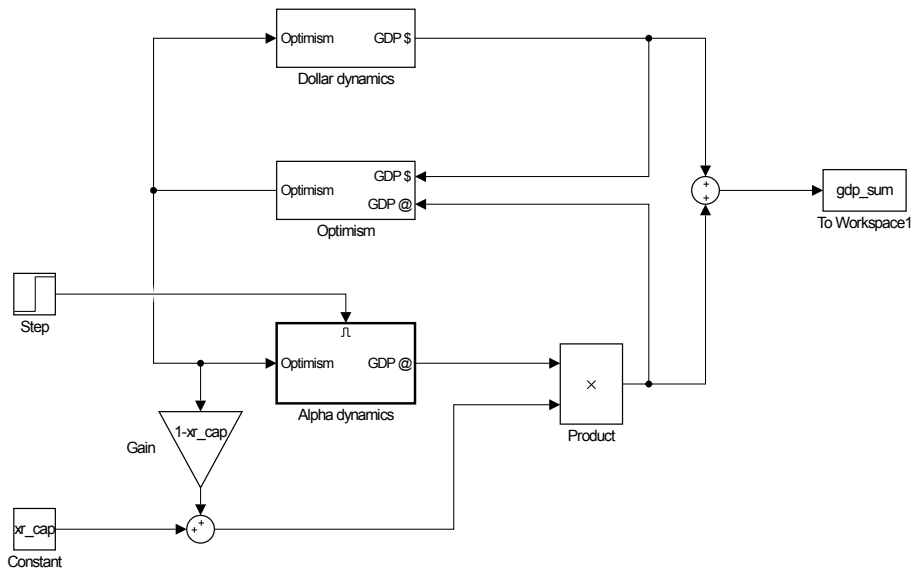


Figure B.3: Model overview

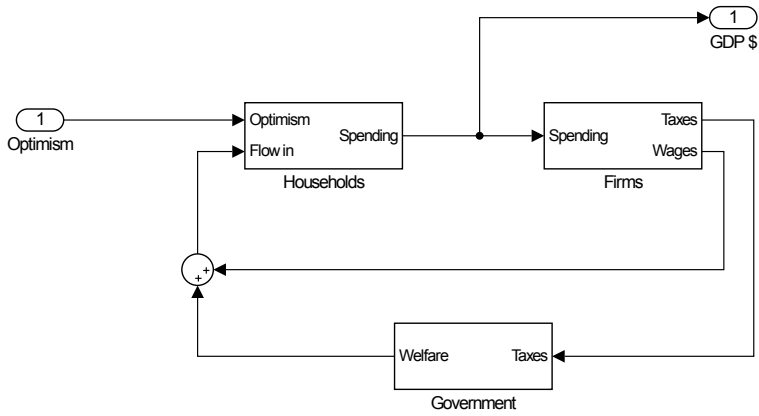


Figure B.4: Model overview/Dollar dynamics

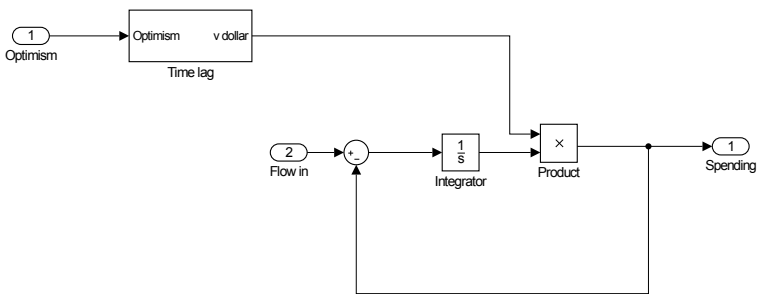


Figure B.5: Model overview/Dollar dynamics/Households

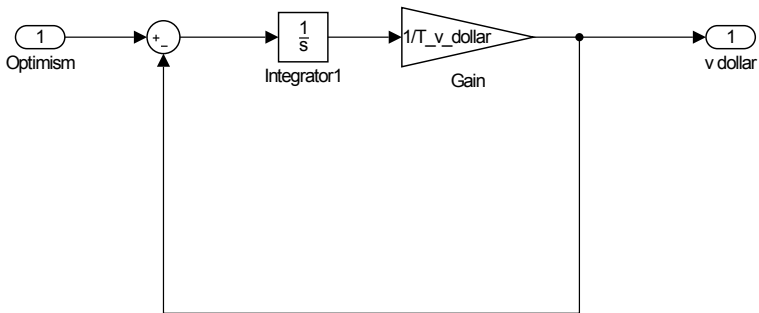


Figure B.6: Model overview/Dollar dynamics/Households/Time lag

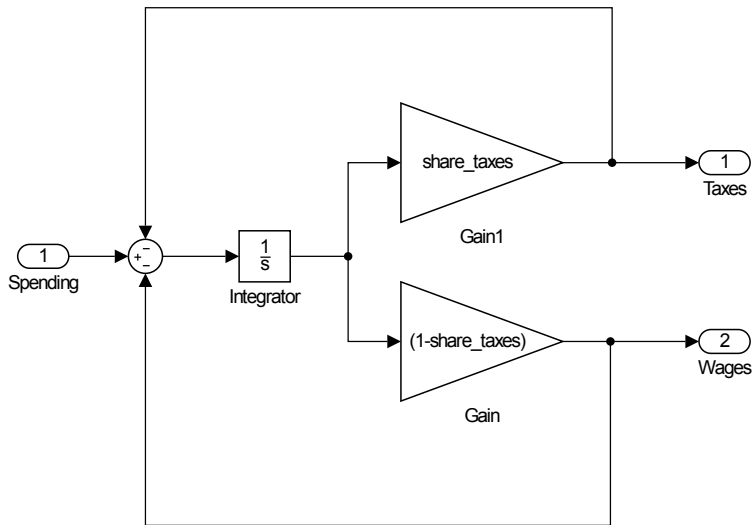


Figure B.7: Model overview/Dollar dynamics/Firms

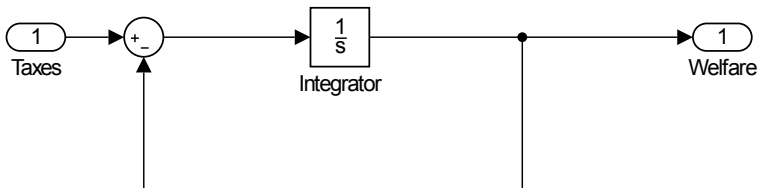


Figure B.8: Model overview/Dollar dynamics/Government

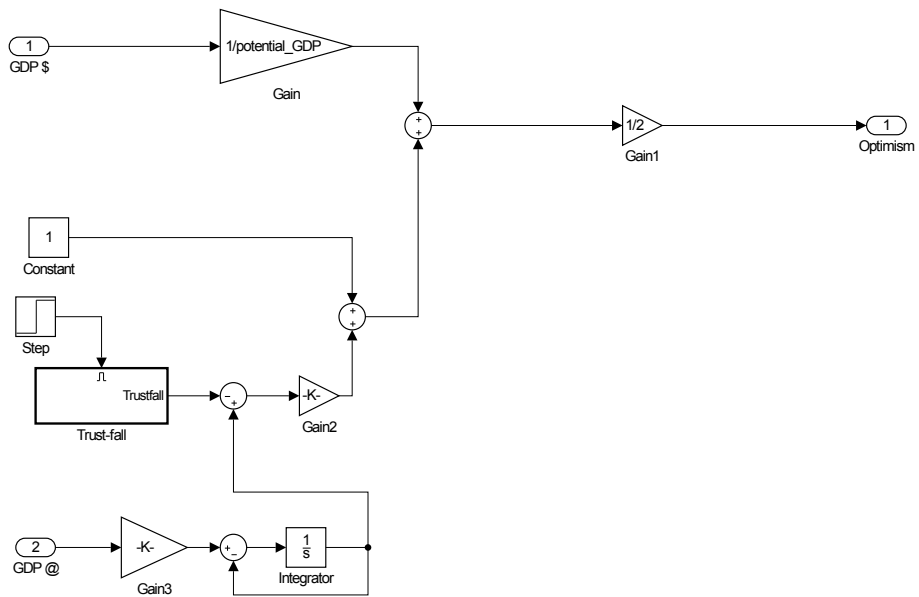


Figure B.9: Model overview/Optimism

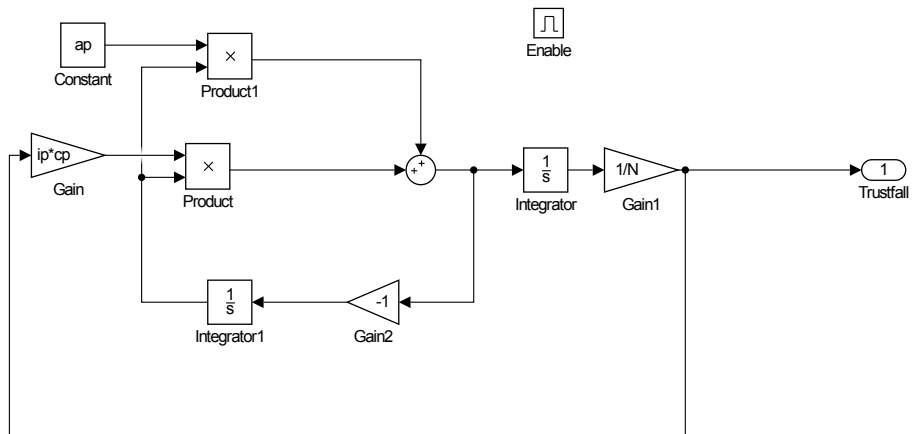


Figure B.10: Model overview/Optimism/Trust-fall

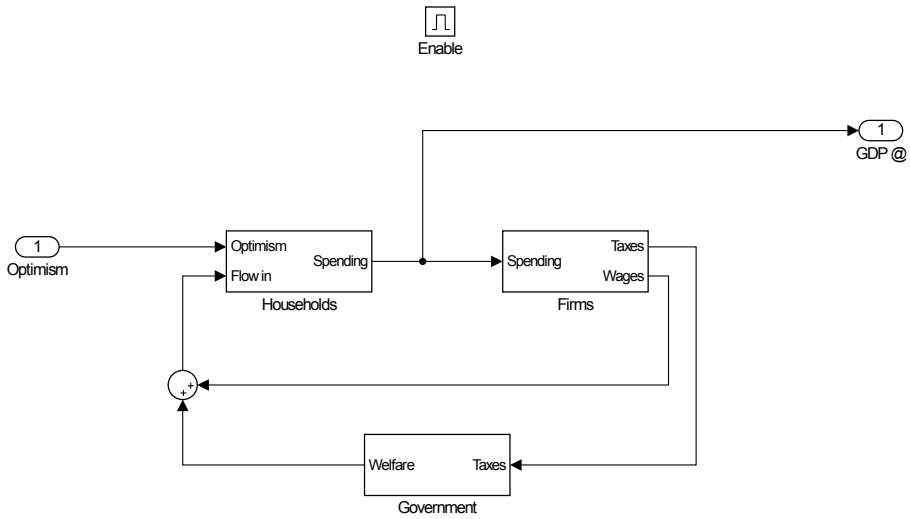


Figure B.11: Model overview/Alpha dynamics

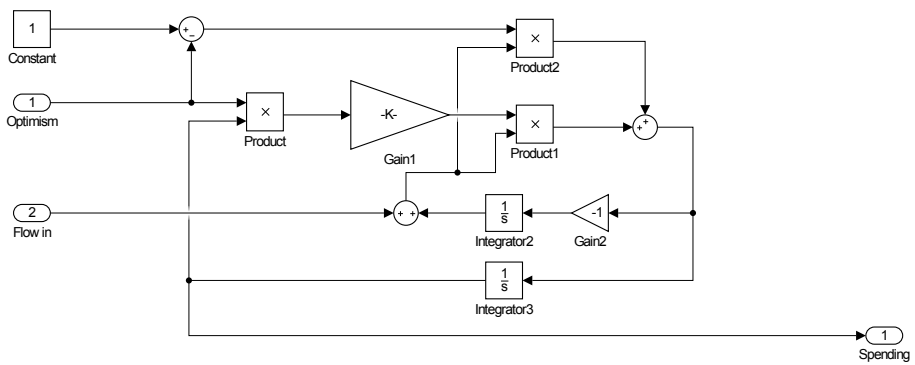


Figure B.12: Model overview/Alpha dynamics/Households

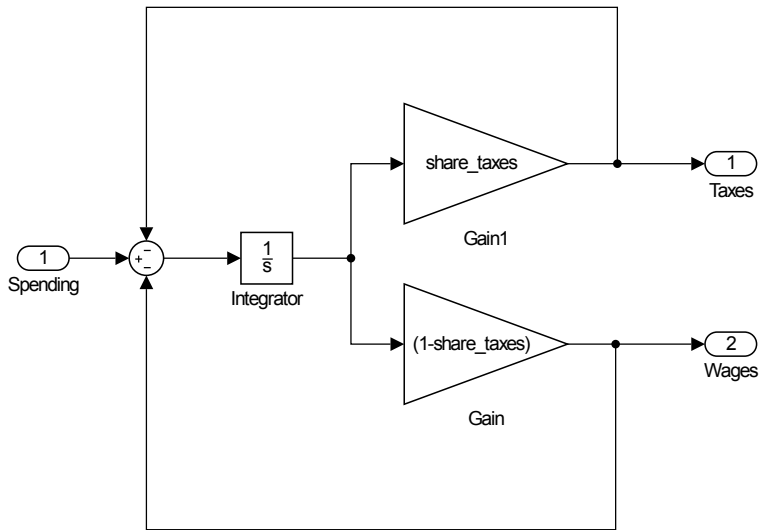


Figure B.13: Model overview/Alpha dynamics/Firms

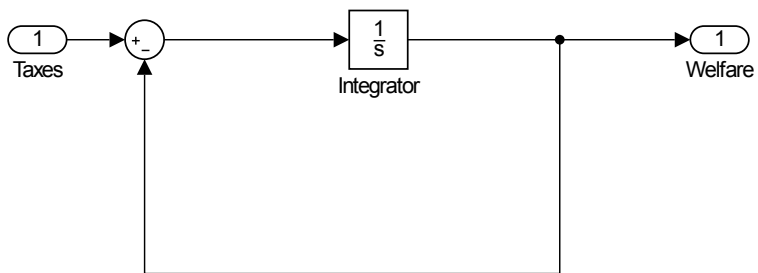


Figure B.14: Model overview/Alpha dynamics/Government

C Matlab code

```
share_taxes = 1/4;

init_GDP = 354;
potential_GDP = 393;
w_gdp = 1.024;

house_int_init_dollar = init_GDP * w_gdp;
firms_int_init_dollar = init_GDP * w_gdp;
govt_int_dollar_init = init_GDP/4 * w_gdp;
stock_dollars = house_int_init_dollar + firms_int_init_dollar +
                govt_int_dollar_init;

govt_int_alpha_init = (stock_dollars)/3;
potential_GDP_alpha = potential_GDP/stock_dollars *
                    govt_int_alpha_init;

ip = 1;
cp = 3;
ap = 1;
N = 1000;

c_alpha = 2;
N_alpha = govt_int_alpha_init;

T_v_dollar = 2.7;
T_trust_govt = 1;
need_init = 1;

crisis_time = 2008;
alpha_time = 2011;

xr_cap = 0.5;
```