Income from Speculative Financial Transactions will always Lead to Macro-Economic Instability

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***Abstract*— Starting with a macro-economic model based upon the NAIRU (the nonaccelerating inflation rate of unemployment), we show that, in a world with no (speculative) financial transactions, the macro-economy shows a stable equilibrium state. Including income from (speculative) financial transactions will lead to instability if the amount is sufficiently large. Considering the present amount of financial transactions, stability is impossible. Therefore, further financial crashes are not only likely but inevitable.**

***Keywords*—** *system dynamics; instability; speculative financial transactions; conserved value; chaos.*

1. Introduction

Economic models are in some sense the experiments of economists. Real experiments, such as in physics, are impossible in economics, so scrutinizing the economy is either done through executing fiscal policy or by "playing" with economic models. While access to the first method is limited to very few people (and may be immoral), the second method is the way of choice for most economists in science. Needless to say, there are very many different economic models. It is virtually impossible to address even a small part of them.

Our focus is *not* to add yet another new macro-economic model to the long list already existing. The main focus in many economic models is on finding the equilibrium state when some parameter is changed. One may, for instance, want to know by how much inflation would rise if the central bank lowered the interest rate by a certain percentage. Furthermore, one might like to know within what time span this new equilibrium would be reached. These are important questions and answering them is essential for fiscal policy makers.

Besides creating and solving an economic model, one should always prove its stability. What happens when all input parameters (e.g., tax rates) stay the same and the model is put off equilibrium for a short period of time? Will it come back to equilibrium (stability) or shift to a new state (instability). In a stable economic system, conducting fiscal policy makes sense. If an economic system is unstable, however, fiscal policy will never steer toward a proper equilibrium. In some sense capitalism should be declared a failure. Since real economic systems are extremely complex, instability will lead to chaotic fluctuations (in a mathematical sense, cf., e.g., Schuster (1984)). Neither predictions nor governance are possible then.

Surprisingly little can be found about stability analysis in economic systems. If done, the focus is typically on a very particular model, and the goal is to prove or forecast a particular scenario like a financial crisis. Chiarella (2012) examined the "financial meltdown" in that vein in 2008. Our focus is slightly different, though. We want to give a more general answer.

To see the point, we have to take a step back. An economy is nothing other than an arrangement of individual human beings and companies. Trying to forecast a particular person's income for the next year or a company's cash flow is surprisingly simple, and the forecasts are highly accurate , see, e.g., SAP, a manufacturer of ERP systems, in Appel (2011). To predict its cash flow is quite simple. It can be represented as a slightly rising line over many years with hardly any fluctuations. Its stock price should be proportional to its (future) cash flow. Surprisingly, it fluctuates by ± 20 % within months as a typical result. As explained recently by Appel (2011, 2012), this is due to the often ignored difference between price and value. Unfortunately, a rising stock price may create real cash and therefore value to be invested in the *Realwirtschaft*. Based on the work of

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Grabinski (2004, 2007), Appel (2011, 2012) defined the term *conserved value* in contrast to *non-conserved value*. Both values can be measured in monetary units, and they may be physically existent. However, conserved value can only change if something else changes accordingly. This is like the conserved quantity energy in physics; it is highly predictable. In contrast, there is such a thing as the "value" of a stock. It is not conserved, and may change without notice at any time. A non-conserved quantity is by no means suitable to describe a system. If the system is sufficiently complex, there will be chaotic fluctuations which are not predictable.

Within this concept, the momentum effect could be explained (Appel (2012)). Furthermore, one can show that a Tobin tax would always be positive and could even be introduced nationally (Dziergwa (2013)). As far as stability is concerned, one can also show that dealing in financial products is in most cases identical to gambling, Klinkova (2013). Dziergwa (2015) applied the concept of conserved value to a new accounting principle: Conserved value based accounting principles (CVBAP). Our goal is to apply it to the macro-economic world.

The conjecture that something has gone wrong in economic modeling is not far-fetched. Consider, for instance, a situation where a central bank raises or lowers the interest rate by half a percentage point. Reactions won't be long in coming. With lower interest, for example, borrowing is cheaper, and investment should increase, eventually leading to higher GDP. The reasoning behind this seems almost trivial. The magnitude of its impact, however, is surprising: Lowering interest rates by half a percentage point will have a measurable effect. It will not affect the investment decisions of (real-world) companies, though. Typically one may demand a gross return on investment of around 20 %, with an assumed capital borrowing rate of, perhaps, 7 %. Not a single decision would be changed if the borrowing rate were 6 % or 8 %. (The latter of the authors of this paper has advised many companies on investment decisions in the past. As a rule, an interest rate varying by ± 1 percentage point wouldn't even lead to the calculation being redone) There must be another reason for this effect, and the only candidate is trade in financial products. There, non-conserved value is created by (regularly) borrowing money, investing it in the stock market, and paying it back after rapidly selling the stocks (or derivatives). Depending very strongly on the interest rate, such deals can be profitable or unprofitable (in the short run). Hence the turnover and, with it, the profits (and losses) on the stock market depend heavily on interest rates.

Therefore, a suitable economic model should distinguish between investments from the *Realwirtschaft* (in general savings from work) and the proceeds from financial transactions being invested. It is hard to imagine that the former will lead to instability. Based on the work of Klinkova (2013), it is almost likely that the latter may imply instability.

Ryshenko (2012) had a conjecture that instability may occur in his own models, such as Ryshenko (1999, 2001, 2002). That is the starting point of this work.

In chapter 2, we will construct a model. It has to be a model that is very general and assumed to be valid in *all* cases. On the other hand, it is not necessary for this model to lead to accurate economic forecasts. In other words, it should be a model that will be accepted by (almost) everybody. Arguably, there are two things agreed upon within the otherwise much divided economic community: *comparative advantage* and *NAIRU* (short for "non-accelerating inflation rate of unemployment").

A famous supporter and architect of the NAIRU concept is Tobin (1980). NAIRU isn't actually an economic model in its pure form. It links the change in inflation to the rate of unemployment, so one gets two variables and one equation, which makes it insoluble from a mathematical point of view. Therefore, in chapter 2, we will create two independent (non-linear) differential equations based upon NAIRU. There, we will strictly stick to investments from the *Realwirtschaft* into the *Realwirtschaft* and will avoid income from (speculative) financial transactions. Our model is very general and therefore always valid. (Please note that it is not very suitable for making economic forecasts, as it contains (unknown) constants. But this is of no consequence for our purpose here.) The equations are soluble or at least integrable even in their non-linear version. Their solutions are *always* stable.

In chapter 3, we will introduce "speculation" to our model, allowing investment from (speculative) financial transactions. In other words, we will allow non-conserved value to be transferred into the *Realwirtschaft*. As a result, the differential equations become more coupled. A rigorous stability analysis shows that the solutions are unstable as soon as the percentage of investment from speculations increases too much. Assuming realistic values for the constants, the solution will always be unstable and this, in turn, results in the sorry fact that (over a longer period of time) financial crises are inevitable. Setting the "correct" interest rates can at best soften the effect or prolong the period of time between two crises. In order to avoid a future financial crisis, income from financial transactions should be sufficiently low. A Tobin tax would be a good way of accomplishing this (Dziergwa (2013)), but, most likely, it would not suffice. New accounting principles such as the ones suggested by Dziergwa (2015) and additional tax legislation are the only possible way to achieve this, but a discussion of this is essentially left to further research, as stated in chapter 5.

In chapter 4, we will discuss our model critically. As a result, we will see that, despite all possible shortcomings, our postulate that speculation always lead to instability will remain valid. In chapter 3, we will show that financial crises are (almost) inevitable. Describing the dynamics of a financial crisis itself is impossible not only within our model but within *all* models based upon differential equations.

In Appendix A, we will derive our models from a very general mathematical point of view. This will prove that they are correct in the lowest non-trivial order. While it is impossible to tell whether this lowest order is sufficiently accurate to describe real economic dynamics, it has *no* influence on the stability analysis. In other words, our results about instability due to speculation hold true even for the most general model.

In Appendix B, we will comment on the connection between our model and neo-classical and Keynesian approaches.

2. The Extended NAIRU Model

NAIRU is arguably the most fundamental approach in macro-economics. It states that there is a certain equilibrium rate n of unemployment u(t) so that inflation I(t) stays constant (in equilibrium). If unemployment u(t) > n, inflation will decrease. This is logical because many unemployed people are typically willing to work for less money, which will result in a deflation in labor costs. While labor is cheap, employers tend to hire, which brings down unemployment until equilibrium has been reached.

A similar mechanism works for too low unemployment u(t) < n. Workers are scarce, so labor costs will rise, resulting in an inflation in labor costs. Because of the inflation, more money is needed to build such things as factories, for example, which will lead to less jobs being created and, therefore, to an increase in unemployment until eventually u(t) = n is reached. Please note that we do not add effects such as the ones of minimum wages or job security, as we want to have the "pure" model and prove its stability or instability. Doing the same in a more advanced model would always lead to the question whether the original model or the add-ons produced the stability or instability.

Classic textbooks will normally give a formula such as this

$$\partial_t I(t) = -a \cdot (u(t) - n) \qquad (1)$$

Here, the derivative with respect to time t is proportional to the negative deviation of unemployment u(t) from equilibrium unemployment n. The constant "a" must be positive (a > 0), else the argumentation above would not hold. Eq. (1) contains two variables (I(t) and u(t)). Therefore, a second differential equation is necessary to solve it. The employment rate 1 – u is proportional to the number of jobs and therefore to the capital c(t) invested in jobs:

$$1 - u(t) = b \cdot c(t) \qquad (2a)$$

The constant "b" is obviously positive because the capital c(t) is positive, and the unemployment rate u(t) ≤ 1 (u(t) = 1 means nobody is employed. Eq. (2a) implies

$$\partial_t u(t) = -b \cdot \partial_t c(t) \qquad (2b)$$

In order to find capital c(t) to be invested in jobs, said capital must be created first. In our case, people have to work for it and save or invest what they do not consume. ("The creation" of money through financial transactions will be addressed in the next chapter.) This means the change in capital is proportional to the employment rate 1-u (the number of people who are working) and the incentive they get for saving, the interest rate z. Of course, interest alone is no incentive; only the difference between interest and inflation can be an incentive. This leads to

$$\partial_t c(t) = \frac{\kappa}{b \cdot a} \cdot \left(z - I(t)\right) \cdot \left(1 - u(t)\right) \qquad (2c)$$

The proportional constant κ/(b a) has been chosen in this way to keep the final result simpler. Of course, this proportional constant must be positive and so is κ. Eliminating ċ(t) from Eq. (2c) by using Eq. (2b) yields

$$\partial_t u(t) = \frac{\kappa}{a} \cdot (I(t) - z) \cdot \big(1 - u(t)\big) \qquad (2)$$

Eqs. (1,2) are a set of coupled ordinary first order non-linear differential equations which can be solved. The interest z from Eq. (2) and normal rate of unemployment n from Eq. (1) are the equilibrium rates of I(t) and u(t), respectively. Please note that the interest rate z is generally not equal to the interest rate set by a central bank. However it is a monotonous function of it. (For a more general approach, please see Appendix A.) The interest rate z is a rate which makes people save money. A number of psychological factors may be involved in that. The same is true for the strength of the investment (or divestment) κ. With the following substitution

$$I(t) = z + \varepsilon(t) \quad and \quad u(t) = n + \eta(t) \qquad (3)$$

Eqs. (1,2) become

$$\partial_t \varepsilon(t) = -a \cdot \eta(t) \qquad (4)$$

$$\partial_t \eta(t) = \frac{\kappa}{a} \cdot \varepsilon(t) \cdot \big(1 - n - \eta(t)\big) \qquad (5)$$

Eqs. (4,5) are differential equations for inflation ε(t) (= deviation from equilibrium inflation) and unemployment η(t) (= deviation from equilibrium unemployment). They yield no more information than Eqs. (1,2), but they are more convenient for our purpose. Of course, Eqs. (4,5) are easily transformed into two decoupled second order differential equations:

$$\ddot{\varepsilon} = -\kappa \cdot \varepsilon \cdot \left(1 - n + \frac{1}{a} \cdot \dot{\varepsilon}\right) \qquad (6)$$

$$\ddot{\eta} = -\kappa \cdot \eta \cdot (1 - n + \eta) - \frac{\dot{\eta}}{1 - n - \eta} \qquad (7)$$

Just by taking the linear parts of Eqs. (6,7), it is easy to see that they display a harmonic oscillator with a frequency of

$$\sqrt{\kappa \cdot (1 - n)}$$

Even in their non-linear version Eqs. (6,7) can be integrated. Their solutions are almost identical to their linear versions. Only for extremely high inflation (say, 70 %) will the sinusoidal variation of inflation turn into a saw-tooth like shape with a lower frequency. Unemployment hardly changes due to the non-linear terms. The details of this will be published elsewhere. As has been stated several times already, we are not focusing on solving an economic model; we want to prove or disprove its stability. This is done by linearizing Eqs. (4,5) to

$$\partial_t \begin{pmatrix} \varepsilon(t) \\ \eta(t) \end{pmatrix} = \begin{pmatrix} 0 & -a \\ \frac{\kappa}{a} \cdot (1 - n) & 0 \end{pmatrix} \begin{pmatrix} \varepsilon(t) \\ \eta(t) \end{pmatrix} \qquad (8)$$

The eigenvalues λ_i of the matrix of Eq. (8) are

$$\lambda_{1,2} = \pm\sqrt{-\kappa \cdot (1 - n)} \qquad (9)$$

With both λ_i being purely imaginary, we have an undamped harmonic oscillation, just as stated above. Just for the sake of completeness, we will also give the corresponding eigenvectors:

$$\vec{e}_{1,2} = \frac{1}{\sqrt{1 - \frac{a^2}{\kappa \cdot (1 - n)}}} \begin{pmatrix} \frac{\mp a}{\sqrt{-\kappa \cdot (1 - n)}} \\ 1 \end{pmatrix}$$

This gives the formal solution of Eq. (8), which can also be obtained by using a linear combination of sin and cos functions as an ansatz:

$$\varepsilon(t) = A \cdot \sin(t \cdot \lambda) + B \cdot \cos(t \cdot \lambda) \qquad (10)$$

$$\eta(t) = B \frac{\lambda}{a} \cdot \sin(t \cdot \lambda) - A \frac{\lambda}{a} \cdot \cos(t \cdot \lambda) \qquad (11)$$

where $\lambda = |\lambda_1| = |\lambda_2|$ from Eq. (9) and A and B are arbitrary constants determined by the initial

conditions. Fig shows a typical plot of the Eqs. (10,11). The parameter κ essentially determines the period, here chosen so that the "economic cycle" is seven years. Of course, any other length would also be possible. The parameter "a" (defined in Eq. (1)) determines the shift between inflation and unemployment. It also determines the strength of the non-linearity, cf. Eq. (6). As stated, it does not matter here.

The solution does not show any instability. Please note that the solution might never look as smooth as shown in Fig. This has essentially to do with the fact that κ is influenced by the willingness to save, which may change. The same is true for the perceived interest z (cf. Eq. (2c)). And, of course, the interest rate set by the central bank may change too.

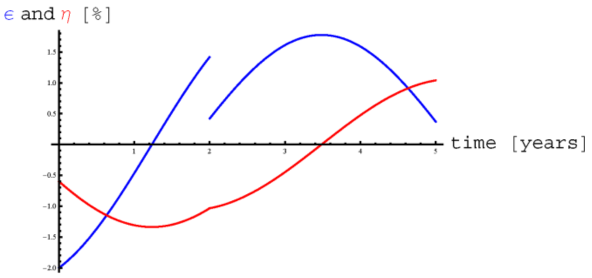

Figure 1: Plot of off-equilibrium inflation ε and unemployment η n = 5 %, κ ≈ 0.85/year^2 and a =1.5/year with one percentage raise in interest after two years

Please note that the interest rate z does not appear in the general solution of Eqs. (10,11). This is surprising at first glance only. As long as the difference between inflation and interest rate remains constant, nothing will change. But, of course, changing the interest rate within a certain system will change its behavior. In order to see how it works, take a look at Fig. After two years, inflation has grown by over three percentage points, which is why the central bank might raise the interest rate by one percentage point, and this has the same effect on z. As can be seen in Eq. (2), $\dot{u}(t)$ will decrease immediately. Such sudden

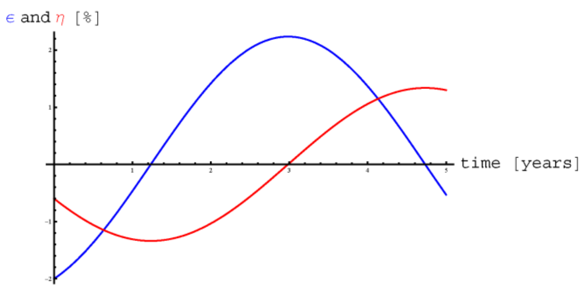

Figure 2: Plot of off-equilibrium inflation ε and unemployment η n= 5 %, κ ≈ 0.85/year^2 and a =1.5/year

change will certainly have a big effect on the non-linear terms. A detailed discussion will be published elsewhere. Here, we will stick to the linear equations. Of course, these will not give the correct result in close proximity of t = 2 years, but otherwise the result should be fine. It is displayed in Figure 1. After the rise in interest, inflation and unemployment are growing less rapidly, but, as stated earlier, in this chapter, we assume a world without speculation, which is unrealistic anyway. The next chapter will eliminate this shortcoming.

3. The NAIRU Model with speculation

Besides "creating" money through an increase in conserved value, the financial industry also provides money by changing it into non-conserved value, Appel (2011, 2012) and Dziergwa (2015). This process is commonly referred to as *speculation*. This does not change Eqs. (2a, 2b), but it will change the mechanism of how capital is created. Therefore, Eq. (2c) will get an extension:

$$\partial_t c(t) = \frac{\kappa}{b \cdot a} \cdot \left(z - I(t)\right) \cdot \left(1 - u(t)\right) + \frac{\boldsymbol{\kappa_S}}{\boldsymbol{b \cdot a}} \cdot \left(\boldsymbol{I(t) - z_S}\right) \qquad (2c_S)$$

If inflation I(t) is sufficiently high compared to an effective interest z_S , the amount of capital created through speculative financial transactions will grow. Please note that the effective interest rate z_S will typically change with the interest rate set by the central bank without being identical to it. For a more formal consideration, please see Appendix A. The constant κ_S is assumed to be positive. However, the *willingness* to invest in stocks and especially in the more advanced financial products, such as derivatives and the like, can change quite suddenly. As shown by Appel (2011) and Dziergwa (2013), no capital is created in the long run. Mathematically speaking, we have

$$\int_{-\infty}^{+\infty} dt\, \frac{\kappa_S}{b \cdot a} \cdot \left(I(t) - z_S\right) = 0 \qquad (11)$$

Typically, κ_S will be positive for a long time. For very short periods of time, it will turn into a large negative number, though. Any such period of time is commonly referred to as a financial crisis. Changing Eq. (2c) into Eq. ($2c_S$) leads to an extended Eq. (2):

$$\partial_t u(t) = \frac{\kappa}{a} \cdot \left(I(t) - z\right) \cdot \left(1 - u(t)\right) - \frac{\kappa_S}{a} \cdot \left(I(t) - z_S\right) \qquad (2_S)$$

Eqs. ($1,2_S$) are the new set of differential equations to be solved, and the procedure is identical to the one in the previous chapter. Note that a discussion of the non-linear terms can be found elsewhere. Here, we will stick to the linear version around the equilibrium. The ansatz like Eq. (3) transforms into

$$I(t) = \bar{z} + \varepsilon(t) \quad and \quad u(t) = n + \eta(t) \qquad (12)$$

Because of the new couplings in Eqs. ($1,2_S$), the equilibrium inflation $\bar{z}$ is some combination of z and z_S:

$$\bar{z} = \frac{\kappa\,(1-n)}{\kappa\,(1-n) - \kappa_S} \cdot z + \frac{\kappa_S}{\kappa_S - \kappa\,(1-n)} \cdot z_S \qquad (13)$$

Besides the slightly more complicated form of the equilibrium inflation, it can be positive or negative:

$$\boldsymbol{case\ 1}\text{:}\quad \kappa_S > \kappa\,(1-n) \ \ and \ \ z_S < z \cdot \frac{\kappa\,(1-n)}{\kappa_S}$$

$$\Rightarrow \ \ \bar{z} < 0$$

$$\boldsymbol{case\ 2}\text{:}\quad \kappa_S < \kappa\,(1-n) \ \ and \ \ z_S > z \cdot \frac{\kappa\,(1-n)}{\kappa_S}$$

$$\Rightarrow \ \ \bar{z} < 0$$

$$\boldsymbol{case\ 3}\text{:}\qquad else \qquad \bar{z} > 0$$

Case 1 holds for a sufficiently large amount of speculation. Unfortunately, this is quite likely because proceeds from speculative financial transactions are much higher than the ones from the Realwirtschaft, see, e.g., Dziergwa (2013). Case 2 also leads to a negative equilibrium, but this may not occur very often in reality. It is only case 3 that leads to a positive equilibrium value. In summary, a sufficiently high level of speculation implies a negative equilibrium inflation, which is, of course, never attainable. This does not come as a surprise. "Profits" from speculative financial transactions are nothing other than inflation (within a certain area), cf. Dziergwa (2013). This is identical to "printing money" in order to invest in jobs, and will always lead to too high inflation.

But the problem of no equilibrium inflation is a minor one compared to the problem of instability. To see the point, one has to derive an equation analogous to Eq. (8) from Eqs ($1,2_S$). A straightforward calculation yields

$$\begin{pmatrix} \dot{\varepsilon}(t) \\ \dot{\eta}(t) \end{pmatrix} = \begin{pmatrix} 0 & -a \\ \frac{\kappa}{a}\,(1-n) - \frac{\kappa_S}{a} & \frac{\kappa}{a}\,\Delta z \end{pmatrix} \begin{pmatrix} \varepsilon(t) \\ \eta(t) \end{pmatrix} \qquad (14)$$

with

$$\Delta z \equiv \bar{z} - z = \frac{\kappa_S}{\kappa_S - \kappa\,(1-n)} \cdot (z_S - z) \qquad (15)$$

The matrix in Eq. (14) has the eigenvalues

$$\lambda_{1,2} = \frac{\kappa\,\Delta z}{2\,a} \pm \sqrt{\kappa_S - \kappa\,(1-n) + \left(\frac{\kappa\,\Delta z}{2\,a}\right)^2} \qquad (16)$$

Depending on κ_S , one can distinguish between five cases:

$$\boldsymbol{case\ 1}\text{:}\quad \kappa_S > \kappa\,(1-n) \quad \Rightarrow \quad \boldsymbol{\lambda_1} > 0$$
$$and \quad \lambda_2 > 0 \ \ if \ \ \Delta z > 0$$

$$\boldsymbol{case\ 2}\text{:}\quad \kappa\,(1-n) \geq \kappa_S > \kappa\,(1-n) - \left(\frac{\kappa\,\Delta z}{2\,a}\right)^2$$
$$and \ \ z_S < z \ \ implies\ at\ least \quad \boldsymbol{\lambda_1} > 0$$

$$\boldsymbol{case\ 3}\text{:}\quad \kappa\,(1-n) \geq \kappa_S > \kappa\,(1-n) - \left(\frac{\kappa\,\Delta z}{2\,a}\right)^2$$
$$and \ \ z_S > z \ \ implies \quad \boldsymbol{\lambda_{1,2}} < 0$$

$$\boldsymbol{case\ 4}\text{:}\quad \kappa_S < \kappa\,(1-n) - \left(\frac{\kappa\,\Delta z}{2\,a}\right)^2$$
$$and \ \ z_S < z \ \ implies \quad \boldsymbol{Re}\{\boldsymbol{\lambda_1}\} > 0$$

$$\boldsymbol{case\ 5}\text{:}\quad \kappa_S < \kappa\,(1-n) - \left(\frac{\kappa\,\Delta z}{2\,a}\right)^2$$
$$and \ \ z_S > z \ \ implies \quad \boldsymbol{Re}\{\boldsymbol{\lambda_{1,2}}\} < 0$$

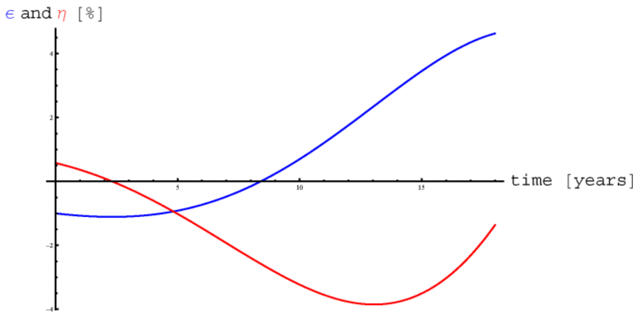

Figure 2: Plot of off-equilibrium inflation ε and unemployment η n = 5 %, κ ≈ 0.85/year^2, a =1.5/year, z = 2 %, z_S = 0.3 %, and κ_S = 0.9 κ

Please note that the inequalities above are implicit because Δz is a function of κ_S, cf. Eq. (15), and that it is not straightforward to make them explicit. Because it is impossible to stick to one eigenvector in real-life situations, instability will occur in the above cases 1, 2, and 4. Stability, on the other hand, will only occur in the above cases 3 or 5. In other words, a sufficiently large amount of speculation will always imply instability. This is the major result of this publication.

In order to make the result more transparent, we also give the explicit results of Eq. (14):

$$\varepsilon(t) = A \cdot e^{\lambda_1 \cdot t} + B \cdot e^{\lambda_2 \cdot t} \qquad (17)$$

$$\eta(t) = -\frac{\lambda_1}{a} A \cdot e^{\lambda_1 \cdot t} - \frac{\lambda_2}{a} B \cdot e^{\lambda_2 \cdot t} \qquad (18)$$

A and B are arbitrary real constants. Of course, only the real parts of Eqs. (17,18) are solutions in the real world. It is now possible to discuss the five cases above in detail, which can be found elsewhere. To illustrate the general line of our argument, we will stick to case 4 here. Cases 1 and 2 are trivially instable. Case 3 is an untypical stable solution, and case 5 is stable because it is the limit toward no speculation. As a typical result, case 4 gives a plot such as in Figure 3. We stayed close to the values of

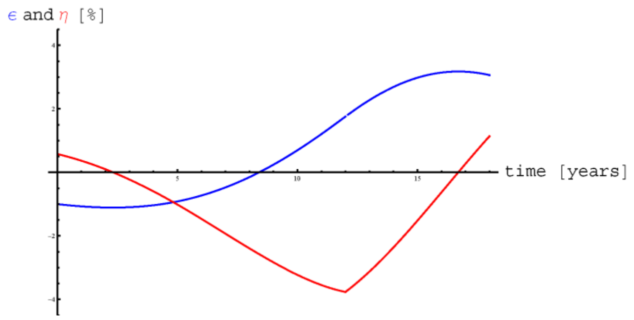

Figure 3: Plot of off-equilibrium inflation ε and unemployment η
$n = 5$ %, $\kappa \approx 0.85/\text{year}^2$, $a = 1.5/\text{year}$, $z = 2$ %, $z_S = 0.3$ %, and $\kappa_S = 0.9\ \kappa$; $z = 2.1$ % and $z_S = 0.5$ % after twelve years

Fig and included some small amount of speculation.

Both inflation and unemployment show an oscillation with an increasing amplitude. The length of the business has roughly tripled compared to Fig. But this is not very important here because it is not our goal to insert the economic data of any one particular real country.

After twelve years, Figure 3 shows a rise in inflation of about 4 percentage points. Maybe the central bank will decide to raise interest rates, which would typically have a big effect on z_S and a smaller one on z. (This is because the financial world reacts strongly to changes in interest, while the Realwirtschaft is usually left fairly unimpressed, as already stated in the introduction.)

As one can see in Figure 4, an increase in interest slows down inflation but will also raise unemployment (in this case, from a very low base). Please note that the non-linear terms will also have a big effect on the curves of Figure 4 at $t \approx 12$ years, but the general line of argumentation will stay the same. Within our model (speculation included), non-linear terms may have an effect for reasons discussed in Appendix A. Although these may or may not have an effect on areas of stability or instability, the general line of argumentation should not change.

4. Critical evaluation

In the previous chapter, we have shown that speculative financial transaction will, in almost all cases, lead to non-stable solutions in the dynamics of unemployment and inflation. Most of the other economic variables show some more or less close relationship to unemployment and inflation so that their stability is affected in the same way. And it is the important quantity GDP, in particular, that is strongly tied to unemployment (and inflation).

Although our model is very general and contains the perhaps most basic economic variables, unemployment and inflation, these variables are not without flaws. In contradiction to some of the basic textbooks, one has to say that inflation is defined precisely yet hard to measure accurately. The opposite is true for unemployment: It is generally ill-defined but very easy to measure within its particular definition.

Inflation occurs when the same product or service will cost more at a later point in time than they do now. No one, of course, can take account of *all* products and services. Therefore, a basket of goods is defined as representative, which results in the emergence of at least two separate inflation rates: "consumer price inflation" and "industrial price inflation." As a matter of fact, there should be different baskets depending on the specific industry or the individual's style of living. (This is the same problem as with the definition of purchasing power parity) With it, inflation becomes an almost arbitrary quantity. Furthermore, any basket is normally dominated by energy and housing. Speculation or a bursting bubble can cause a huge inflation spike or our current problem of deflation. Hence the strangely low inflation or outright deflation in Japan has most likely to do with the bursting property bubble of the 1990s, cf. The Economist (2015), and is no counterexample to the theory of inflation and demography.

It is also hard to decide what is meant by the terms "same product or service." Consider a laptop, for example. If we take the word *same* at face value, we have a huge deflation where laptops are concerned. If we however assume that "the same product" only ever means the premium laptop model, then inflation is highly overstated.

Unemployment has an exact definition, which differs from country to country, and it is impossible to give the one most reasonable definition. Of course, one could take all non-working people in a country and divide this figure by the total population. But what does non-working mean? How many hours a week does a person need to work to be considered working? Furthermore, dual education, for instance, counts as work, while a university student is considered non-working. And when a rich single parent hires a nanny, a job is created and unemployment decreases. If, however, he or she marries the nanny, the job is destroyed and unemployment rises. Similar arguments apply to the elderly, the disabled, or people wealthy enough to stay at home.

These remarks on inflation and unemployment apply to *all* economic models. Therefore, it is almost impossible to decide whether an economic model reflecting, say, 90 % of reality is better than a model that shows 80 % accuracy.

In addition, there is another problem with almost all economic models (and with the ones in management science). Its formulation goes back to Grabinski (2004): Any economic outcome is the sum of all actions of all participating human beings. Humans have free will, which means that, strictly speaking, even equations for NAIRU such as Eq. (1) are *always* wrong, and can only be understood as a statistical result. In order to use statistics, one has to consider many actions, without a single one of them being dominant. This, by the way, does not have its origin in man's free will. A gas consists of a large number of molecules (with no free will whatsoever). A macroscopic description by differential equations is only possible if one considers time scales which are long compared to the time of the individual interactions between the molecules. The same is true for the length scale.

At first glance, this does not seem to be an important limitation. There are, however, particular situations in physics where the internal length scales become very long. This is, for instance, the case when water freezes into ice or ice melts into water. At this very point, none of the differential equations that otherwise describe the behavior of water or ice perfectly at almost all other temperatures can be used.

For some strange reason, physicists sometimes speak of the "catastrophe theory" when, for instance, describing the phase transition of water to ice. Similar things may occur in economic models. Consider Eq. (11) of our model, for example. Typically, it implies a leap from $\kappa_S > 0$ to $\kappa_S < 0$ at a certain point in time (e.g., because suddenly almost everybody is selling his or her stocks). From a purely mathematical point of view, one can solve the model as long as non-linear terms are taken into account. This would be a waste of time and effort, though. Here, we have individual actions triggering an avalanche, which makes *any* statistical approach, the prerequisite for using differential equations, impossible. This means we are faced with the sorry fact that none of the models based upon differential equations and the like is useful for describing the dynamics of a financial crisis. In a typical financial crisis, *any* economic model will leave the range of validity.

It is hard to imagine that a proper description, such as "catastrophe theory" in physics, will ever be found in order to simulate the dynamics of a financial crisis although (unlike in physics) the word *catastrophe* theory seems very appropriate here.

5. Conclusions and next steps

We have shown that speculation will (almost) always lead to non-stability. Furthermore, the equilibrium rate of inflation can be negative due to speculative financial transactions. Therefore, central banks and financial policy makers can at best mitigate the severity of financial crises. The only way out would be to make speculative financial transactions become extinct, with one way being to prohibit them altogether. But this approach would be hard to manage (What exactly is meant by "speculative financial transaction"?). Furthermore, prohibiting them would not fit into our liberal world. Another way would be to implement a proper tax policy.

There are two ways of achieving this that appear to be easy and very effective: one would be the introduction of a Tobin tax, as suggested by Dziergwa (2013). The effect on *reasonable* financial transactions would be minimal because they occur less frequently than speculative financial transactions by a factor of one thousand or even one million. The other possible measure would be to tax derivatives differently. As stated by Klinkova (2013), their market is much more instable than the "ordinary" stock market, and the potential crashes there are much more severe. Supporters of derivatives claim that they are a reasonable way of providing insurance against such risks as fluctuating oil prices. But if it is an insurance, it should be treated as such. For one, it is not allowed, for instance, to insure your neighbor's house against fire (i.e., to receive money in case it burns down without having suffered a financial loss). Again, it may be difficult to judge whether a person or company is really exposed to damage due to changing oil prices or whether that is just speculation. However, when there is a real risk, people are willing to pay some sort of tax on this insurance. To see how it works in reality, consider insurance in Germany, for example: An insurance tax of 19 % is imposed on the premium you pay. And unlike the value added tax, it is not refundable. Individuals and companies experience substantial losses in case their house or factory burns down. Therefore, almost all homeowners and companies in Germany have fire insurance, and the 19 % insurance tax does not seem to hurt anybody. So why not introduce a similar tax on "oil price insurance?"

The next steps in our area of research will be to:

1. Scrutinize the present model, and especially the five cases in chapter 3, in more detail. .
2. Take non-linear terms into account. This should prove that our general line of argumentation is not affected by non-linearities. Furthermore, effects of changes in interest can be displayed more realistically. There may be a chance to find interesting effects, such as mathematical chaos.
3. Check other models (unrelated to this one) for instability.

6. Appendix A

Eqs. (2c,2c$_S$) give the relation between change in capital and interest. Although our argumentation should be very plausible, one could not say that other terms are forbidden or of less importance. Because Eq. (2c$_S$) is a generalization of Eq. (2c), it will do to stick to the first one.

A change in capital c(t) may come from the Realwirtschaft. In that case, it must be proportional to the employment rate 1 – u(t). It may also come from speculative financial transactions. Both parts will also depend on the effective interest rate. Hence the most general formulation of Eq. (2c$_S$) will take the following form:

$$\partial_t c(t) = f\big(i - I(t)\big) \cdot \big(1 - u(t)\big) + g\big(i - I(t)\big) \quad (19)$$

Here, "i" is the interest set by the central bank; f and g are *arbitrary* functions. It is hard to imagine having a more general approach. As long as f and g are analytical functions, they have a Taylor expansion. (If they were non-analytic, there would always be arbitrarily accurate approximations to them which would be analytic) The Taylor expansions of f and g are as follows:

$$f(i - I) = a_0 + a_1 \cdot (i - I) + O((i - I)^2) \quad (20)$$

$$g(i - I) = b_0 + b_1 \cdot (i - I) + O((i - I)^2) \quad (21)$$

Of course, the a_n and b_n are easily given by

$$a_n = \frac{1}{n!}\frac{\partial^n f(x)}{\partial x^n}\bigg|_{x=0}, \; b_n = \frac{1}{n!}\frac{\partial^n g(x)}{\partial x^n}\bigg|_{x=0}$$

Making the following substitutions in Eq. (20,21)

$$a_0 \equiv \frac{\kappa}{b \cdot a} \cdot (z - i) \quad and \quad a_1 \equiv \frac{\kappa}{b \cdot a}$$

$$b_0 \equiv \frac{\kappa_S}{b \cdot a} \cdot (i - z_S) \quad and \quad b_1 \equiv -\frac{\kappa_S}{b \cdot a}$$

and inserting them into Eq. (19) will transform Eq. (19) into Eq. (2c$_S$) if higher order terms are neglected. So we have a proof that Eq. (2c$_S$) is correct in the lowest order.

It is an interesting question whether this lowest order expansion makes sense. If z and z_S were the equilibrium values of the inflation I(t), it would be absolutely correct within our stability analysis. However, the $\bar{z}$ from Eq. (13) is the true equilibrium value of I(t). Linearization and stability analysis is, of course, still possible. However, the values of κ and κ_S will change with the deviation of z and z_S from the central bank interest rate i. This might change the regimes of stability.

7. Appendix B

Our models are constructed from a very general approach, especially when considering Appendix A. Quite often macro-economic models are classified into two categories: the neo- classical (or neo-liberal) models on the one hand and the Keynesian approach on the other. We did deliberately not follow this classification. To have two *schools* and not to know which one of them is the correct one resembles a religious approach to macro-economics. Our model should be scientific rather than creedal.

Nevertheless, some readers might ask whether our model is Keynesian or neo-classical. In short, it is both (or maybe neither). To see the point, consider Eq. ($2c_S$) again:

$$\partial_t c(t) = \frac{\kappa}{b \cdot a} \cdot \big(z - I(t)\big) \cdot \big(1 - u(t)\big) + \frac{\kappa_S}{b \cdot a} \cdot \big(I(t) - z_S\big) \qquad (2c_S)$$

The first part (with κ) connects labor and its proceeds with change in capital. The main point is that one has to work and save in order to invest in the economy. This is the typical neo-classical approach. The Keynesian critique of it would be that, if everybody (or at least a lot of people) saves money (instead of spending it), employment will shrink and the economy will enter a downward spiral. As Keynes put it, the otherwise reasonable micro-economic approach is not valid in the macro-economic world. (We will comment on this "conundrum" further below)

The second part of Eq. ($2c_S$) (with κ_S) implies an increase in capital (for the creation of jobs) as long as borrowing money is sufficiently cheap. It does not question the origin of said money. This is exactly the kind of financial stimulus Keynes would have suggested. So our model encounters both worlds, the neo-classical and the Keynesian one. Again, this confirms that this is the most general of models. Sadly, although the Keynesian stimulus may create jobs, it will never lead to stability.

Now we will come back to the "conundrum" mentioned above. If micro-economic mechanisms were not valid in the macro-economic world, *all* macro-economic models would be invalid. This is because integrating (solving) differential equations is nothing but the summing up of particular (micro-economic) happenings.

To solve this puzzle, consider a heavily indebted country, for example. All economists will agree that this country obviously consumed more than it earned by working, whereas people in countries abroad earned more than they consumed, or else they couldn't have lent any money to this country. The neo-classical remedy would be to save money. In other words, the indebted country ought to consume less and work more in order to repay its debts. The Keynesian critique would be that, if the people in the indebted country consume less, fewer goods will be needed. And producing fewer goods will imply less work and, thus, fewer jobs. However, this outcome is not the only possible one: The people in the indebted country could still produce more goods and consume less. Using the excess, they could repay their debt. In the real world, Keynesians, in particular, might argue that the goods these people produce might not be greatly sought after in foreign countries. This might even be the reason why their country got into debt in the first place. But generally, this is not true; people do not like or dislike certain products. What they do like or dislike is the product-to-price-ratio. In other words, you can flood the world market with almost any product as long as it is sufficiently cheap. So the neo-classical answer to an indebted people would be as follows: Work more, without receiving more pay. Consume only part of these products. Because of their low production costs, the rest of these goods can be exported. And since you consume less, you will be able to repay your debts.

This means that fiscal policy should only soften the hardship the indebted people most likely experience. One way of achieving this would be to encourage investments, either to produce new products or to improve the efficiency in producing the old ones. But even if the invested money is borrowed, that does not mean that debt isn't sometimes a good way of helping countries to get out of it. It is a common misunderstanding to assume that borrowing money in order to invest it means getting into debt. This is only the case if one only considers cash flow. However, as any accountant knows, one has to consider both sides of the balance sheet. Sadly, countries do not do so in their "accounting." So, if there is a reason why one cannot add up all the micro-economic entries to describe the macro- economy, it lies in the cameralistics of governmental accounting. It may not be easy to include assets and liabilities in governmental accounting, but ignoring them and drawing the wrong conclusions is just plain stupid. As shown by Agarwala (2012), even a rough estimate can lead to completely new and interesting results.

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