2014-2015 – Licence 3 – Macro

Lecture 7 : Hyperinflation

Franck Portier
franck.portier@TSE-fr.eu

Toulouse School of Economics

Version 1.1
01/12/2014
Changes from version 1.0 are in red

Disclaimer

These are the slides I am using in class. They are not self-contained, do not always constitute original material and do contain some "cut and paste" pieces from various sources that I am not always explicitly referring to (not on purpose but because it takes time). Therefore, they are not intended to be used outside of the course nor to be distributed. Thank you for signaling me typos or mistakes at franck.portier@TSE-fr.eu.

0. Introduction

- A lot of fascinating questions related with money :
  - × Why does money have a value ?
  - × What are the functions of money ?
  - × Why does monetary policy matter ?
  - × What is then optimal supply of money ?
- We will not address those questions but another fascinating one : the disapperance of money during hyper-inflation episodes :
  - × We will fist look at long run facts connecting money and inflation,
  - × Then look at two historical episodes : Germany in the 1920's and Zimbabwe in the late 2000's.
  - × Finally, we'll study a model that likes inflation with money creation and expectations, the Cagan's model.

0. Introduction

Plan of the Lecture

1. Long Run Facts
2. Hyperinflation in the Weimar Republic
3. Hyperinflation in Zimbabwe 2008-2009
4. Modeling hyperinflation and the role of expectations
5. Summary
6. References

1. Long Run Facts

George McCandless and Warren Weber, "Some Monetary Facts", Minneapolis Fed QR, 1995

- 110 countries over 30 years
- Compute the long-run geometric average rate of growth for :
  - × the standard measure of production : gross domestic product adjusted for inflation (real GDP) ;
  - × a standard measure of the general price level : consumer prices ;
  - × three commonly used definitions of money (M0, M1, and M2)
- They also look at 2 more homogenous sub samples : 21 OECD countries and 14 Latin American countries.
- They obtain three main results.

1. Long Run Facts

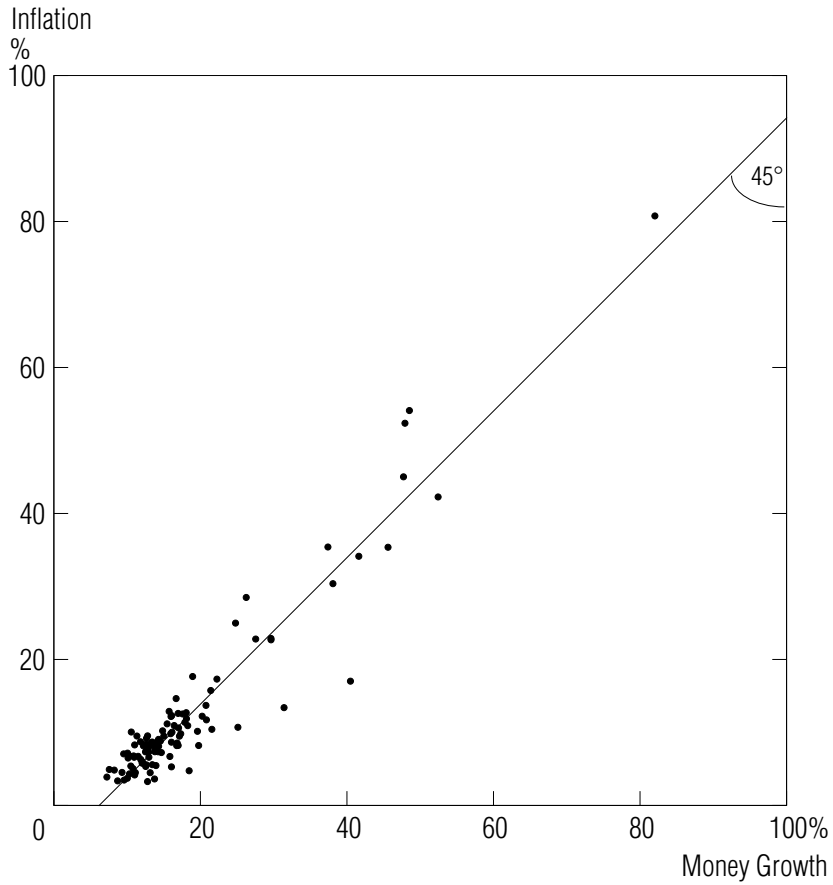
Result 1

Money Growth and Inflation : *In the long run, there is a high (almost unity) correlation between the rate of growth of the money supply and the rate of inflation. This holds across three definitions of money and across the full sample of countries and two subsamples.*

1. Long Run Facts

Result 1

FIGURE 1: Money Growth and Inflation : A High, Positive Correlation



Average Annual Rates of Growth in M2 and in Consumer Prices During 1960-90 in 110 Countries

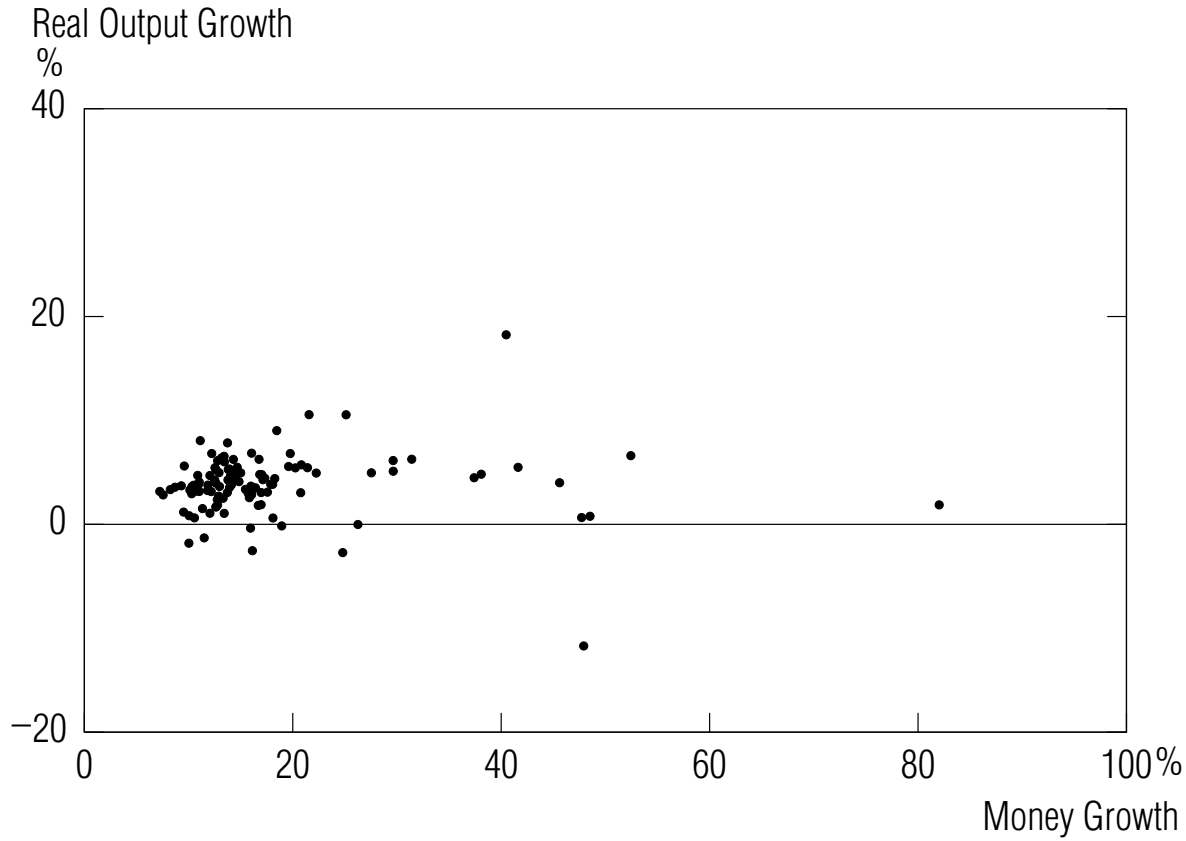
Result 2

Money Growth and Real Output Growth : *In the long run, there is no correlation between the growth rates of money and real output. This holds across all definitions of money, but not for a subsample of OECD countries, where the correlation seems to be positive.*

1. Long Run Facts

Result 2

FIGURE 2: Money and Real Output Growth : No Correlation in the Full Sample ...

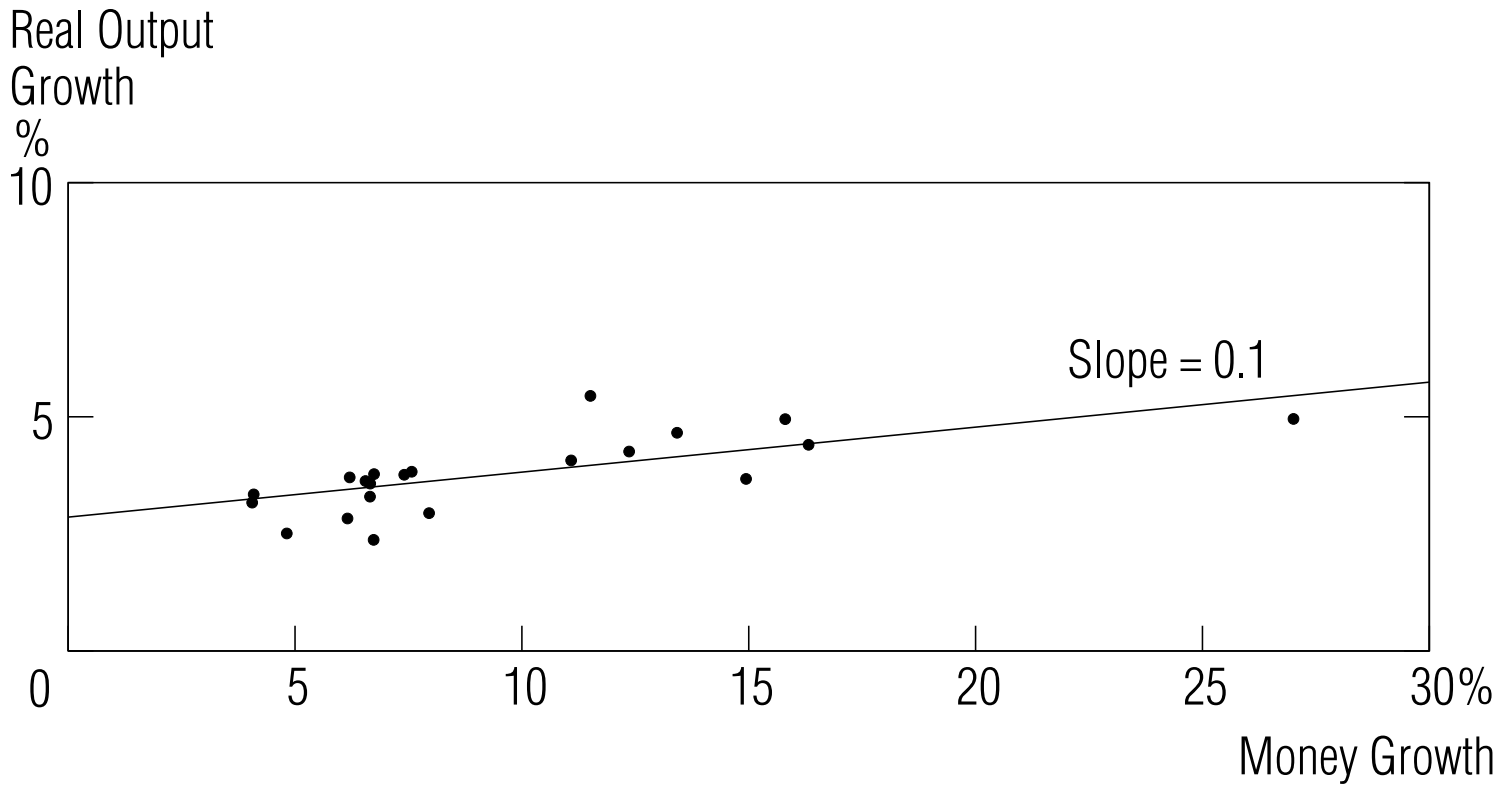


Average Annual Rates of Growth in M2 and in Nominal Gross Domestic Product, Deflated by Consumer Prices During 1960-90 in 110 Countries

1. Long Run Facts

Result 2

FIGURE 3: ... But a Positive Correlation in the OECD Subsample



Average Annual Rates of Growth in M0 and in Nominal Gross Domestic Product, Deflated by Consumer Prices During 1960-90 in 21 Countries

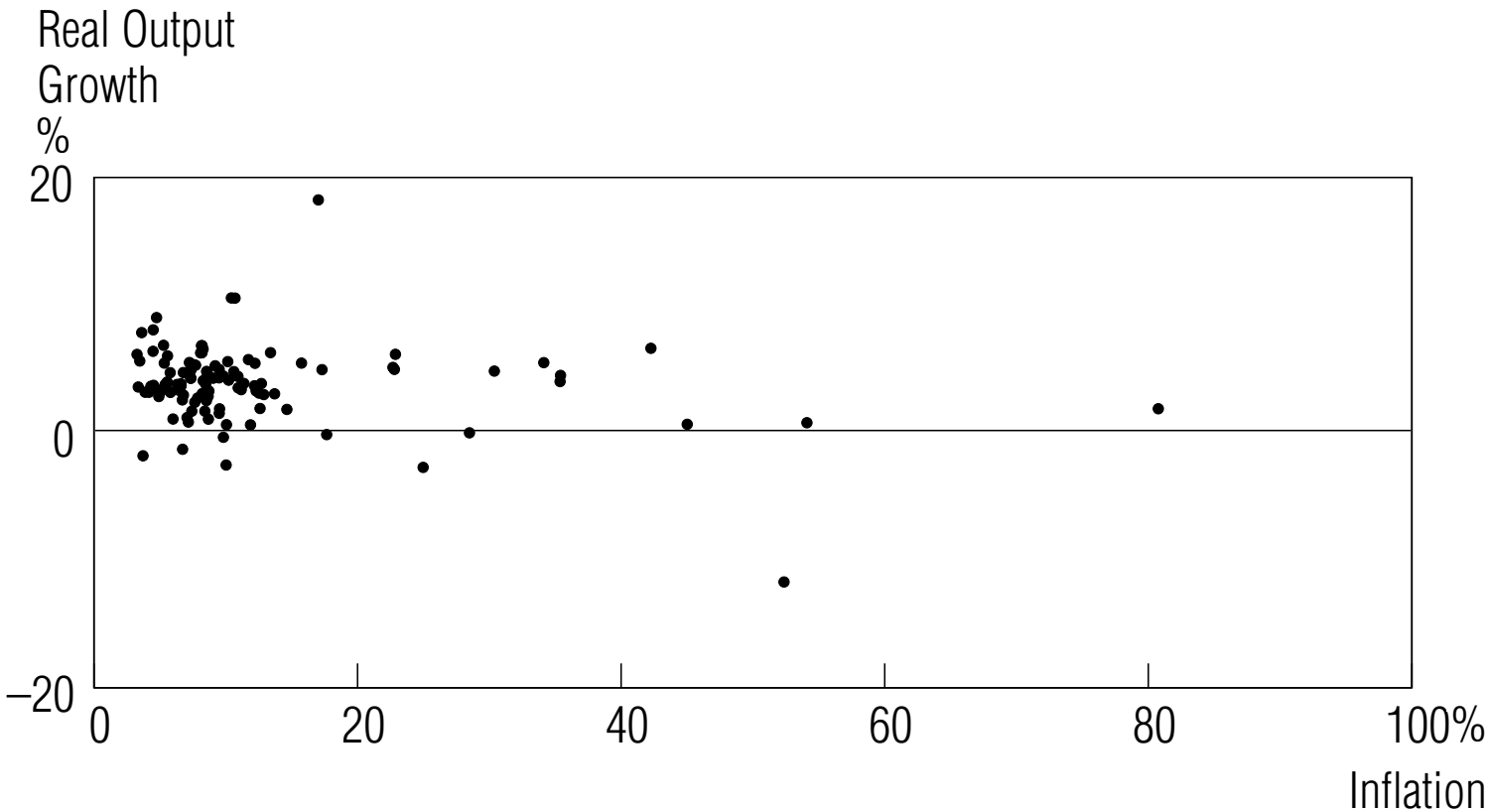
Result 3

Inflation and Real Output Growth : *In the long run, there is no correlation between inflation and real output growth. This finding holds across the full sample and both subsamples.*

1. Long Run Facts

Result 3

FIGURE 4: Inflation and Real Output Growth : No Correlation



Average Annual Rates of Growth in Consumer Prices and in Nominal Gross Domestic Product, Deflated by Consumer Prices During 1960-90 in 110 Countries

1. Long Run Facts

How to make sense of those results

- Let us state the following equation

$$Mv = PY$$

aka (also known as) the *equation of exchange* (*quantitative theory of money* if one assumes some direction of causality)

- When log-differentiated, this equation gives

$$\underbrace{\frac{\dot{M}}{M}}_{\text{Money growth}} + \underbrace{\frac{\dot{v}}{v}}_{\text{velocity growth}} = \underbrace{\frac{\dot{P}}{P}}_{\text{Inflation}} + \underbrace{\frac{\dot{Y}}{Y}}_{\text{Real output growth}}$$

- The above results tells us that, *in the long run*, $\frac{\dot{Y}}{Y}$ is essentially disconnected from $\frac{\dot{M}}{M}$ and $\frac{\dot{P}}{P}$, and that $\frac{\dot{P}}{P}$ moves essentially one to one with $\frac{\dot{M}}{M}$.

1. Long Run Facts

Jean Bodin (1530-1596)

- Professor of Law in Toulouse in the 1560s.
- 1568 : "*Réponse de J. Bodin aux paradoxes de M. de Malestroit*"
- One of the first analysis of *inflation*
- Since 1550, increase in the money supply in Western Europe
- Main cause : silver arriving via Spain from the South American mine of Potosi,
- Jean Bodin is making that link between the rise in prices and the influx of precious metals

Figure 5: Jean Bodin



LA RESPONSE DE MAI-
STRE IEAN BODIN ADVOCAT EN
LA COVR, AV PARADOXE DE MONSIEVR
de Maleſtroit, touchant l'encheriſſement de tou-
tes choſes, & le moyen d'y remedier.

DEVANT que paſſer outre,
ie mettray brieuement les
raiſons de monſieur de
Maleſtroit. On ne peult,
dit il, ſe plaindre, que vne
choſe ſoit maintenãt plus

1. Long Run Facts

Hyperinflation

- This long run relation between money creation and inflation also exists in the short run
- It is interesting to look at paroxysmal episode where such a link is exacerbated : hyperinflations
- Some famous episodes :
  - Argentina, May 1989-Mar. 1990
  - Austria, Oct. 1921- Sep. 1922
  - Bosnia and Herzegovina, Apr. 1992- Jun. 1993
  - France, May 1795- Nov. 1796
  - Hungary, Mar. 1923- Feb. 1924
  - Ukraine, Jan. 1992- Nov. 1994
- Let us study two other famous episodes : Weimar Republic of Germany in the 1920's and Zimbabwe in 2008-2009.

2. Hyperinflation in the Weimar Republic

Reparations

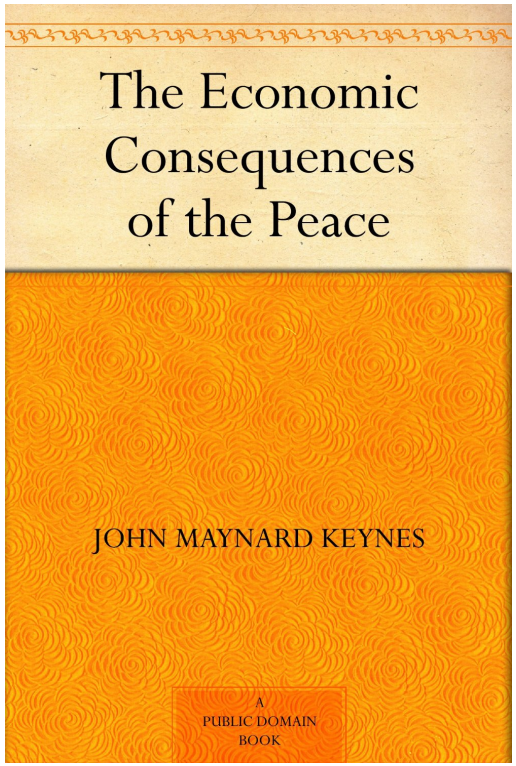
- After WWI, following the Versailles treaty, Germany had to pay large *reparations* (132 billions gold marks) (20 will be eventually paid from 1920 to 1931)
- When the war broke out, Germany suspended the convertibility of its currency into gold
- Instead of financing part of the war with income tax (as France), the war was funded by borrowing.
- War reparations were required to be repaid in foreign currency and not in *Papiermark*.
- Germany decided the mass printing of bank notes to buy foreign currency which was in turn used to pay reparations.
- This greatly exacerbated the inflation rates of the paper mark

2. Long Run Results

Keynes' view on reparations (1919)

- Keynes was the principal representative of the British Treasury at the Paris Peace Conference,
- He resigned from the Treasury in June 1919 in protest at the scale of the reparations demands,
- He protested publicly in *"The Economic Consequences of the Peace"* (1919).
- In his view, so high reparations
  - × would traumatise innocent German people,
  - × damage the nation's ability to pay
  - × limit her ability to buy exports from other countries - thus hurting not just Germany's own economy but that of the wider world.

Figure 6: Keynes [1919]



2. Hyperinflation in the Weimar Republic

Occupation

- January 1923 : French and Belgian troops occupied the Ruhr.
- The goal was to ensure that the reparations were paid in goods, such as coal from the Ruhr and other industrial zones of Germany.
- Workers in the Ruhr went on a general strike,
- German government printed more money in order to continue paying them for “passively resisting”.
- Overall, the excess of Papiermark printing caused hyperinflation.

2. Hyperinflation in the Weimar Republic

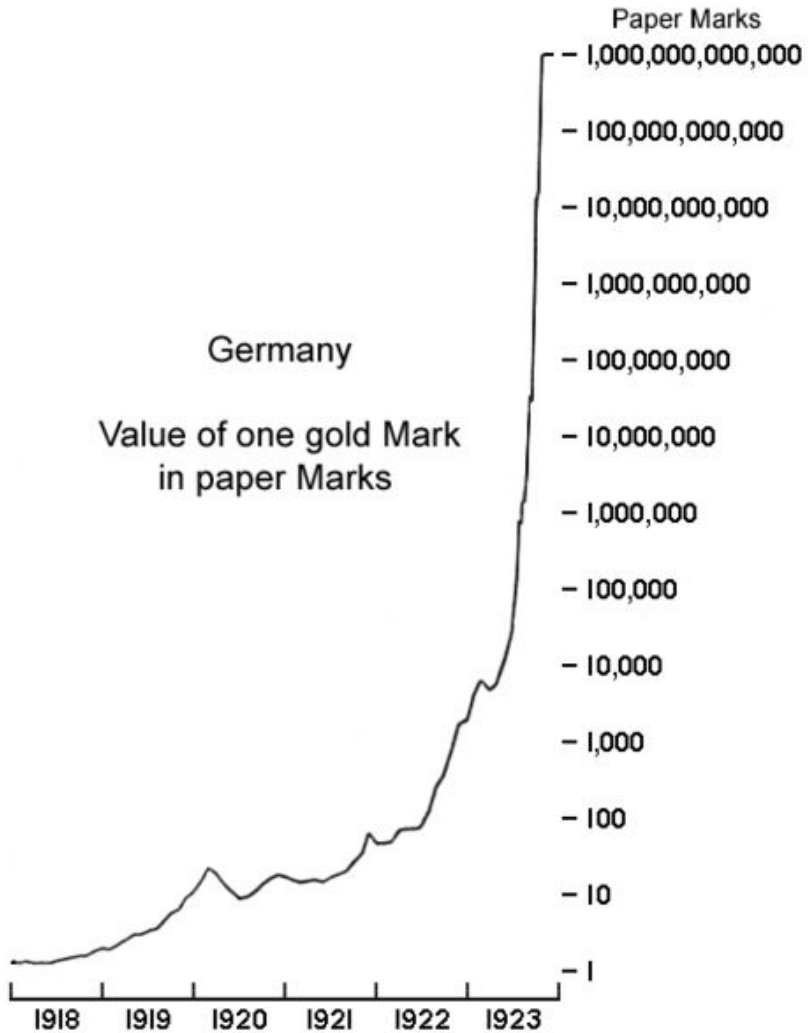
Some data

- First half of 1922, the Mark was about 320 Marks per Dollar.
- By December 1922, it felt to 800 Marks per Dollar
- The cost-of-living index was 41 in June 1922 and 685 in December.
- By November 1923, the American dollar was worth 4,210,500,000,000 German marks.

2. Hyperinflation in the Weimar Republic

Some data (2)

FIGURE 7: The Value of one gold Mark in Papiermark



2. Hyperinflation in the Weimar Republic

Pictures

FIGURE 8: A 50 billions note



2. Hyperinflation in the Weimar Republic

Pictures

FIGURE 9: Kids



2. Hyperinflation in the Weimar Republic

Pictures

FIGURE 10: A wheelbarrow of Marks



2. Hyperinflation in the Weimar Republic

The end of hyperinflation

- 15 November 1923 : the Reichsbank stopped monetizing government debt and issuing new money.
- At the same time, it was decided to make one trillion Papermark (1,000,000,000,000) equal to one Rentenmark.
- On 20 November 1923, Havenstein (Reichsbank governor) died suddenly of a heart attack.
- He was replaced by Hjalmar Schacht (Doctor Schacht) that stabilized the Papermark against the US dollar : 4.2 trillion Papermark = one US Dollar.
- As one trillion Papermark = one Rentenmark, the exchange rate was 4.2 Rentenmark for one US dollar.
- This was exactly the exchange rate that had prevailed between the Reichsmark and the US dollar before World War I.
- "Miracle of the Rentenmark" : inflation was stopped

3. Hyperinflation in Zimbabwe 2008-2009

Context

- 18 April 1980 : the Republic of Zimbabwe was born from the former British colony of Southern Rhodesia.
- 1991-1996, the government of president Robert Mugabe followed an Economic Structural Adjustment Programme , designed by the IMF and the World Bank
- 2000 : confiscation of land from the rich whites to the black poor : production collapsed.
- 2002 : repeated violations of human rights : economic sanctions from the USA and the EU.
- The Mugabe government financed war in the Democratic Republic of Congo and government spending by money creation.
- *Olivera-Tanzi effect* : high inflation $\rightsquigarrow$ decline in the volume of tax collection $\rightsquigarrow$ money creation to finance the public expenditures.

3. Hyperinflation in Zimbabwe 2008-2009

Data

TABLE 1: Annual inflation, Zimbabwe 1980-2003 (Wikipedia "Hyperinflation in Zimbabwe")

Date	Rate	Date	Rate	Date	Rate	Date	Rate
1980	7%	1986	15%	1992	40%	1998	48%
1981	14%	1987	10%	1993	20%	1999	56.9%
1982	15%	1988	7.3%	1994	25%	2000	55.22%
1983	19%	1989	14%	1995	28%	2001	112.1%
1984	10%	1990	17%	1996	16%	2002	198.93%
1985	10%	1991	48%	1997	20%	2003	598.75%

3. Hyperinflation in Zimbabwe 2008-2009

Data

TABLE 2: Annual inflation, Zimbabwe 2005-2008 (Wikipedia "Hyperinflation in Zimbabwe")

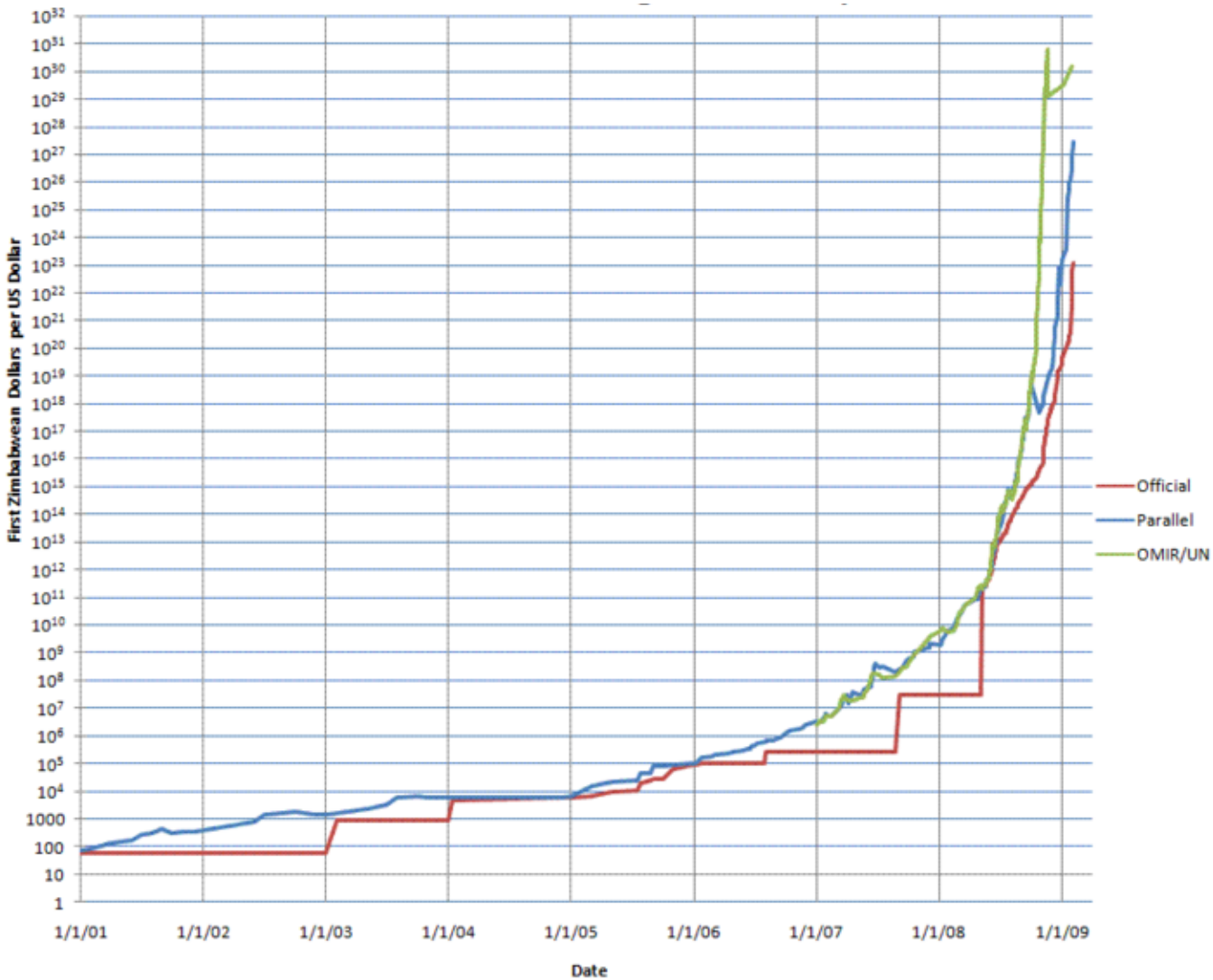
Date	Rate
2004	132.75%
2005	585.84%
2006	1,281.11%
2007	66,212.3%
2008 Jul.	231,150,888.87%
2008 Aug.	471,000,000,000%
2008 Sep.	3,840,000,000,000,000,000%
2008 Mid-Nov.	89,700,000,000,000,000,000,000%

- Zimbabwe's peak month of inflation is estimated at 6.5 sextillion (10^{51}) percent in mid-November 2008

3. Hyperinflation in Zimbabwe 2008-2009

Pictures

FIGURE 11: The ZWD/USD exchange rate (Wikipedia "Hyperinflation in Zimbabwe")



3. Hyperinflation in Zimbabwe 2008-2009

Pictures

FIGURE 12: A one hundred trillion note



3. Hyperinflation in Zimbabwe 2008-2009

The end of the hyperinflation episode

- January 2009 : No more retrictions to use only Zimbabwean dollars.
- Citizens were allowed to use the US dollar, the euro, and the South African rand (*"dollarization"*)
- "Dollarization" helped bringing back inflation to 5% a year

4. Modeling hyperinflation and the role of expectations

Lessons from the case studies

- Hyperinflation happens in situation of political instability
- Hyperinflation is always related with fiscal deficits that are financed by money creation (that are *monetized*)
- Economic agents run away from money because they expect prices to increase even further, and therefore reduce the real value of money balances.
- Phillip Cagan proposed in 1956 a model that can account for those hyperinflation episodes

4. Modeling hyperinflation and the role of expectations

Cagan's model assumptions

- Two equations (variables are in logs except interest rates) :
  - × individuals' demand for money
  - × evolution of inflation expectations over time
- Money demand :

$$m_t + v_t = p_t + c_t$$

and

$$v_t(i_t) = \alpha i_t$$

with $\alpha > 0$

- The velocity of money is increasing in the nominal interest rate i.
- Since bonds and money are both safe assets (in nominal terms), the opportunity cost of holding money is the nominal interest foregone.
- Therefore, if the nominal interest rate increases, money should turn over more quickly (velocity should rise) as individuals substitute away from money towards bonds.

4. Modeling hyperinflation and the role of expectations

Cagan's model assumptions (2)

- Fisher equation :

$$i_t = r_t + \pi_t^e$$

  where $\pi_t^e = p_{t+1}^e - p_t$ is expected inflation and r is the real interest rate.
- We can then write

$$m_t - p_t = c_t - \alpha r_t - \alpha \pi_t^e$$

- Cagan studied episodes where prices changes a lot but real variables little.
- Simplification : $c_t = c$ and $r_t = r$.
- Let us normalize $c = r = 0$ (this simply allow to drop the constant terms – it would not change anything to make a different normalization)
- The money demand function is therefore

$$m_t - p_t = -\alpha \pi_t^e \tag{1}$$

4. Modeling hyperinflation and the role of expectations

Expectations π_t^e

- Assume that agents form adaptive expectations.
- Expected inflation is a weighted average of current inflation $p_t - p_{t-1}$ and past expectations of inflation :

$$\pi_t^e = \lambda \pi_{t-1}^e + (1 - \lambda)(p_t - p_{t-1}) \tag{2}$$

with $0 < \lambda < 1$.

  - × If λ is close to one, then individuals expectations are slow to update, they place a lot of weight on past expectations and little weight on current expectations.
  - × If λ is close to zero, individuals place a lot of weight on current experience.

- *Solving the model* means finding the value of the endogenous variable p_t as a function of parameters, the exogenous money supply m_t and of past values of m and p.
- The solution will depend on the way expectations are formed (here the parameter λ)
- This is a very important feature of socio-economic models : current outcomes depend on what agents expect for tomorrow.

4. Modeling hyperinflation and the role of expectations

Solving the model (2)

- We use a "guess and verify" approach :
  - × Suppose a solution for prices of the form

$$p_t = \beta_1 p_{t-1} + \beta_2 m_t + \beta_3 m_{t-1}$$

    for some unknown coefficients β_1, β_2 and β_3 that we need to find.
  - × Fin those coefficients such that the solution satisfies (1) and (2).
- Rewrite (1) as

$$\pi_t^e = -\frac{1}{\alpha}(m_t - p_t)$$

- This equation taken in $t-1$ gives

$$\pi_{t-1}^e = -\frac{1}{\alpha}(m_{t-1} - p_{t-1})$$

Solving the model (3)

- Now plug those expressions of π_t^e and π_{t-1}^e in (2) :

$$-\frac{1}{\alpha}(m_t - p_t) = -\frac{\lambda}{\alpha}(m_{t-1} - p_{t-1}) + (1-\lambda)(p_t - p_{t-1})$$

- Simplify

$$m_t - p_t = \lambda(m_{t-1} - p_{t-1}) - \alpha(1-\lambda)(p_t - p_{t-1})$$

- which gives

$$p_t = \frac{\lambda - \alpha(1-\lambda)}{1-\alpha(1-\lambda)} p_{t-1} + \frac{1}{1-\alpha(1-\lambda)} m_t - \frac{\lambda}{1-\alpha(1-\lambda)} m_{t-1}$$

Solving the model (4)

- Now we can compare this solution with the guess we have made :

$$\begin{array}{rcccccccc} p_t & = & \beta_1 & p_{t-1} & + & \beta_2 & m_t & + & \beta_3 & m_{t-1} \\ p_t & = & \frac{\lambda-\alpha(1-\lambda)}{1-\alpha(1-\lambda)} & p_{t-1} & + & \frac{1}{1-\alpha(1-\lambda)} & m_t & + & -\frac{\lambda}{1-\alpha(1-\lambda)} & m_{t-1} \end{array}$$

- so that

$$\begin{cases} \beta_1 & = & \frac{\lambda-\alpha(1-\lambda)}{1-\alpha(1-\lambda)} \\ \beta_2 & = & \frac{1}{1-\alpha(1-\lambda)} \\ \beta_3 & = & -\frac{\lambda}{1-\alpha(1-\lambda)} \end{cases}$$

4. Modeling hyperinflation and the role of expectations

Interpreting the solution

$$p_t = \frac{\lambda - \alpha(1-\lambda)}{1-\alpha(1-\lambda)} p_{t-1} + \frac{1}{1-\alpha(1-\lambda)} m_t - \frac{\lambda}{1-\alpha(1-\lambda)} m_{t-1}$$

- If $-1 < \frac{\lambda-\alpha(1-\lambda)}{1-\alpha(1-\lambda)} < 1$, then the inflation dynamics of the system is dynamically stable.
- If the government stabilizes the money supply process m_t, then the price dynamics will stabilize too.
- In this case, once a government gets control of the money supply process, inflation will eventually come under control too.

Interpreting the solution (2)

$$p_t = \frac{\lambda - \alpha(1-\lambda)}{1-\alpha(1-\lambda)} p_{t-1} + \frac{1}{1-\alpha(1-\lambda)} m_t - \frac{\lambda}{1-\alpha(1-\lambda)} m_{t-1}$$

- If $\frac{\lambda-\alpha(1-\lambda)}{1-\alpha(1-\lambda)} > 1$, then even a stable monetary process may lead to hyperinflations driven purely by "momentum"
- Individuals extrapolating future inflation from past inflation behavior will create hyperinflation, even if the money supply is controlled.

4. Modeling hyperinflation and the role of expectations

Cagan estimation

- Cagan estimated the coefficients βs for monthly data on European hyperinflations in the 1920s and 1940s

Table 3: Cagan's data

Country	Period	Average infl. rate (% per month)	Real balances (minimum/initial)
Austria	Oct 1921–Aug 1922	47.1	.35
Germany	Aug 1922–Nov 1923	322	.030
Greece	Nov 1943–Nov 1944	365	.007
Hungary	March 1923–Feb 1924	46.0	.39
Hungary	Aug 1945–June 1946	19800	.0003
Poland	Jan 1923–Jan 1924	81.1	.34
Russia	Dec 1921–Jan 1924	57.0	.27

Table 4: Cagan's estimates (1)

Episode	α	λ	R^2
Austria	8.55	.95	.978
Germany	5.46	.80	.984
Greece	4.09	.85	.960
Hungary	8.7	.90	.857
Hungary	3.63	.85	.996
Poland	2.3	.7	.945
Russia	3.06	.65	.942

Table 5: Cagan's estimates (2)

Episode	$\lambda - \alpha(1-\lambda)$	$1 - \alpha(1-\lambda)$	$\frac{\lambda-\alpha(1-\lambda)}{1-\alpha(1-\lambda)}$
Austria	.516	.556	.928
Germany	-.292	-.092	**3.17**
Greece	.236	.386	.611
Hungary	.03	.13	.23
Hungary	.305	.455	.67
Poland	.01	.31	.032
Russia	-.421	-.07	**5.92**

4. Modeling hyperinflation and the role of expectations

Cagan estimation

- In most episodes inflation dynamics were driven purely by fundamentals ($|\beta_1| < 1$) and not by momentum effects.
- In the case of Germany (1922-1923) and Russia (1921-1924), $\beta_1 > 1$
- This indicates that in these episodes inflation had a significant momentum component too.

4. Modeling hyperinflation and the role of expectations

Lessons from the model

- One of the important messages that economists take away from CAGAN's paper is the need
  - × for fiscal discipline and/or an independent central bank, to prevent monetized deficits that can allow a hyperinflation to get started
  - × the need for individuals' inflation expectations to be "anchored" – and thereby relatively unlikely to lead to a momentum-driven inflation break-out.
- Part of the trick to anchor inflation expectations is for government policy to be credibly seen as inflation fighters.

5. Summary

- There is a long run one to one relationship between inflation and money creation,while not much of a long run relationship between economic growth and inflation or money creation,
- The Weimar Republic or the Zimbabwe episodes show that hyperinflation episodes are associated with monetization of fiscal deficits and political instability,
- This episodes are ended with fiscal discipline and expectations anchoring.
- The Cagan's model shows how expectations matter for hyperinflation episodes.

6. References

- George McCandless and Warren Weber, "*Some Monetary Facts*", Minneapolis Fed QR, 1995
- Phillip Cagan, "*The Monetary Dynamics of Hyperinflation*". In Miton Friedman (ed.). Studies in the Quantity Theory of Money. Chicago : University of Chicago Press.