Macroeconomics and Complex System Analysis

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Introduction

More is different certainly applies in social/ economic contexts. Understood qualitatively since origin: division of labor.

Economic activity: maze of countless interactions, in different settings, between agents with cognitive abilities comparable to researcher, doing analogous info processing.

Self- organization («invisible hand»), but also potential for economy- wide coordination failures: macroeconomic disturbances.

Introduction

Macro analysis *must* schematize representations drastically. Understandable coexistence of different approaches; models with variable ranges of potential validity.

Still, substantial open questions on how to deal in practical terms with system´s intricacies, in terms of individual behaviors and patterns of interacions. Particularly relevant for study of large-scale macro shocks like big recessions, debt crises, high inflations.

Introduction

 Standard macro: based on notion of general equilibrium (conditioned by «frictions»), with presumption of optimizing agents and rational expectations (typically viewed as correspondence between perceived and actual distributions).

 Much work done using general framework, theoretical and applied.

Introduction

Substantial shortcomings, concerning relevance and also logic.

◦ Optimization requires adapting setup to technique. Also: who optimizes (agent, analyst with late-vintage model)?

◦ RatEx, problematic as analytical construct. Ambiguous notion, inconsistencies in usual implementation

◦ Problems in representing large-scale disturbances

• However: development of widespread alternatives (including, particularly, agent-based models) still limited. In part, sociology of profession, but also sundry open questions.

Introduction

Plan of talk:

◦ Use elementary framework to illustrate centrality of issues of coordination and info processing in macro settings.

◦ Show some evidence of analytically relevant features of big macroeconomic fluctuations/disturbances: changing trends, frustrated expectations, buildups and sudden transitions.

◦ Present simple- minded example of representation of learning/imitation effects in macro context and point out limitations.

◦ Discuss potential of complex- system modeling in macro, and some issues looking ahead.

◦

A Simple Illustration:
Two Polar Models

Two models on a similar question: macroeconomic effects of changes in propensity to save (abstain from consuming, demand assets)/invest(demand current resources to produce future output); «thrift and enterprise».

Elementary prototypes of large bodies of literature, substantially different answers

A Simple Illustration: Two Polar Models
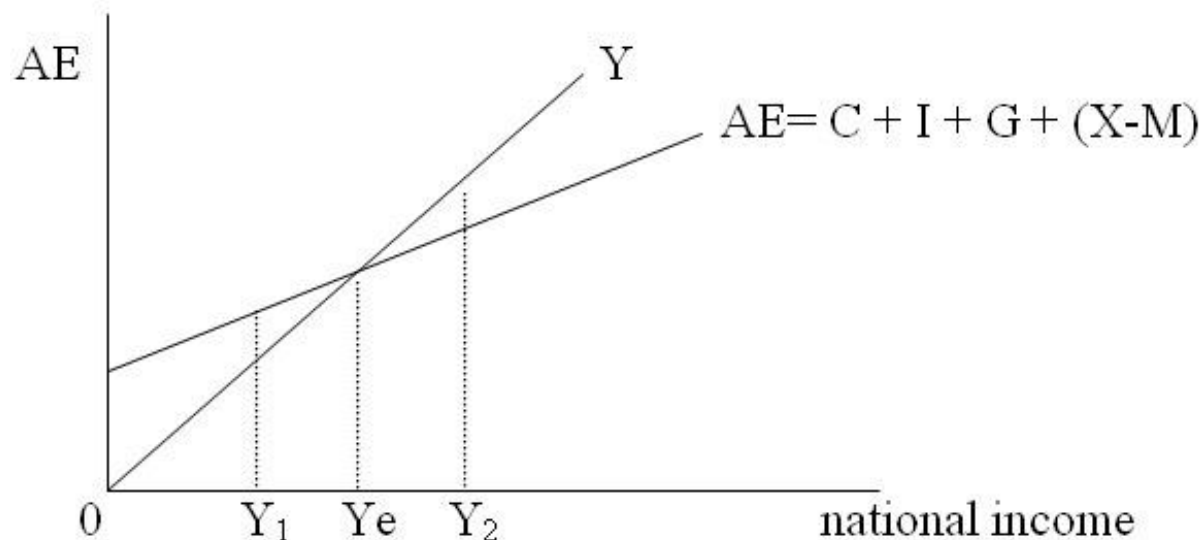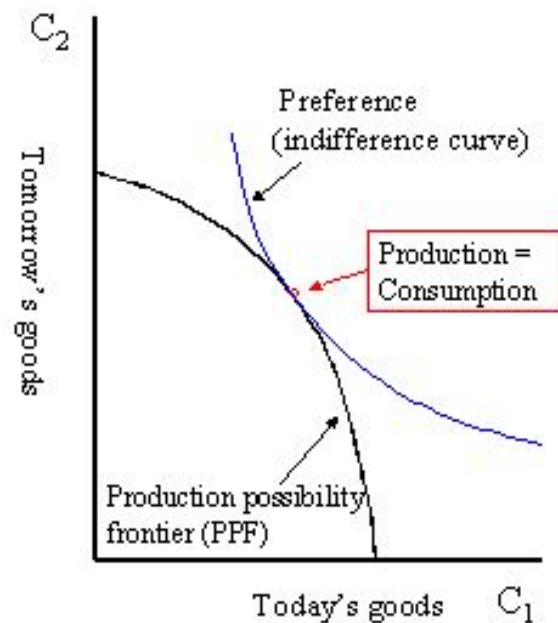
A Simple Illustration: Two Polar Models

M1:

◦ As if economy= single individual +nature

◦ Increase in desired savings automatically implies decision to invest (taking into account «technological» decreasing returns to *I*)

◦ Output remains at resource-constrained level; utilization of production varies; future consumption vs present consumption; matter of allocation according to preferences, production possibilities («deep parameters»)

A Simple Illustration:
Two Polar Models

M2:

◦ Households and Firms (S, I «not decided by same people»)

◦ Savings detract from consumption, output demand- determined, investment exogenous (in the limit, no interest rate effect)

◦ Paradox of thrift: higher propensity to save self- defeating, only causes fall in output. Formally, if attribute to model full range of validity (no capacity constraints), unlimited potential level of output in case savings («antisocial refusal to consume») go to zero

A Simple Illustration: Two Polar Models

Logic of M1: savings implies demand for future consumption, and supply of credit to fund additional investment.

Transformation of S into I relies on: i) communication of future demand for goods; ii) increased availability of resources to invest through financial markets.

A Simple Illustration: Two Polar Models

M2: coordination does not occur at all: investment plans unaffected by predisposition to save: no signal of future demand, no effect through credit.

Mechanisms taken for granted by M1 never operate.

A Simple Illustration: Two Polar Models

M1:

$$\hat{c} = \frac{r(k) - \boldsymbol{\rho}}{\sigma}, \quad \hat{y} = \frac{\boldsymbol{s}}{k}$$

Growth positively related to propensity to save, «patience» (thrift).

M2:

$$y = \frac{\bar{\iota} + g}{\boldsymbol{s}}$$

Output decreasing with propensity to save («paradox of thrift»)

A Simple Illustration:
Two Polar Models

Coordination (of intertemporal decisions): plausible generally in the limit of small, primitive closed community.

Macroeconomic question: large economy, high degree of division of labor.

A Simple Illustration:
Two Polar Models

Potentially different behaviors:

- ◦ Savings in growing economy, channeled toward investment credit, perceptions of solvency; solid anticipations on economic activity, discernible patterns in composition of demand; or
- ◦ Savings motivated by fear; distrust of prospective debtors.

- • Outcome dependent on state of expectations, generation and transmission of information in system with multitudes of agents, goods.

A Simple Illustration:
Two Polar Models

Will actual outcome lean towards M1 or M2 scenario?
Have to weigh:

◦ Immediate signal of lower consumption demand.

◦ Higher demand for assets (which?), potential increase of supply of loanable funds; response of financial operators/intermediaries.

◦ Predisposition to borrow/invest by firms (or, perhaps, willingness of other households to consume on credit). Demand expectations, projects «waiting to be financed»

A Simple Illustration:
Two Polar Models

Natural environments for complex systems analysis, ABMs, to help specify conditions, parameterize alternative patterns of performance.

But: questions about appropriate representation: expectational schemes, decision rules, information generation and diffusion, configuration of trades.

Instances of Large Macro Fluctuations

Features: changes in trends, mistaken forecasts, buildups and sudden transitions

Spain
(Log GDP and Recursive HP)
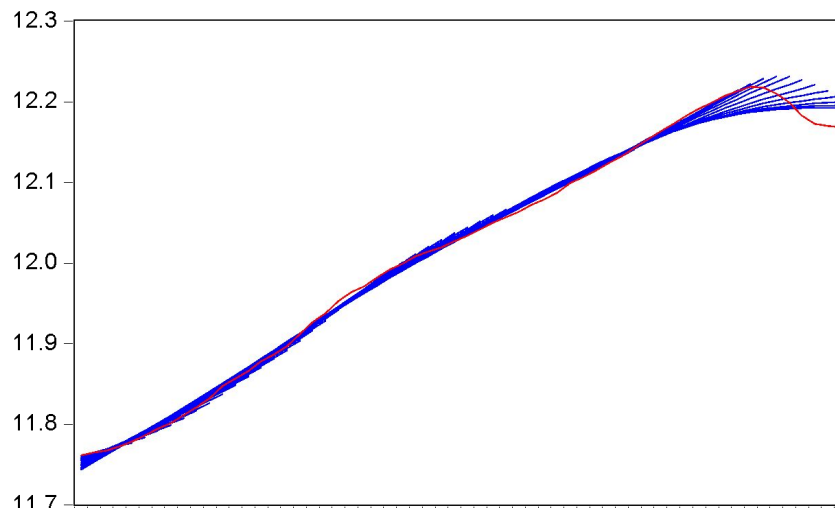
Greece
(Log GDP and Recursive HP)
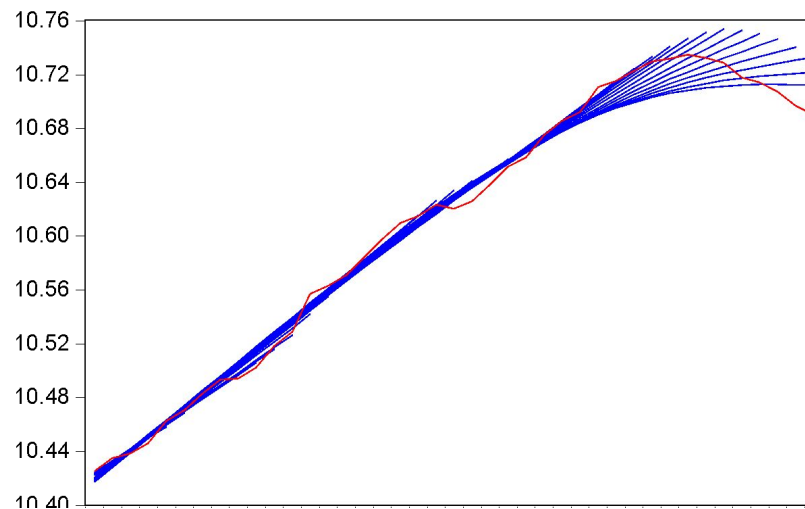
Ireland
(Log GDP and Recursive HP)
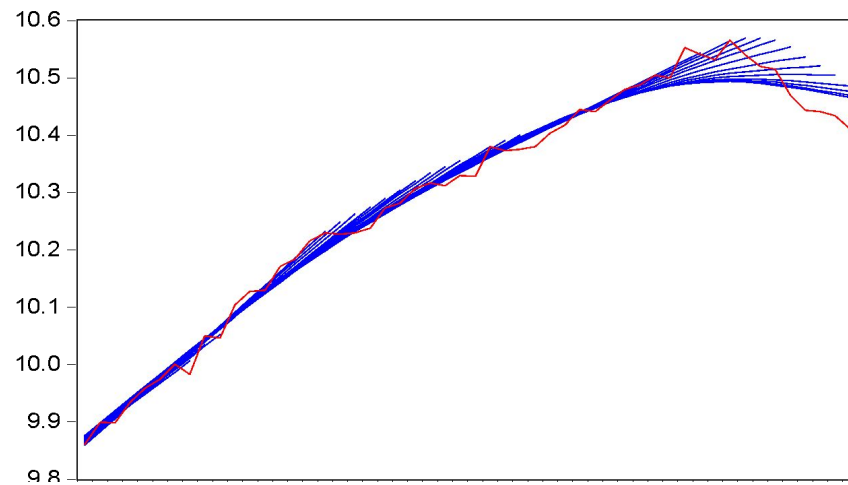
Portugal
(Log GDP and Recursive HP)
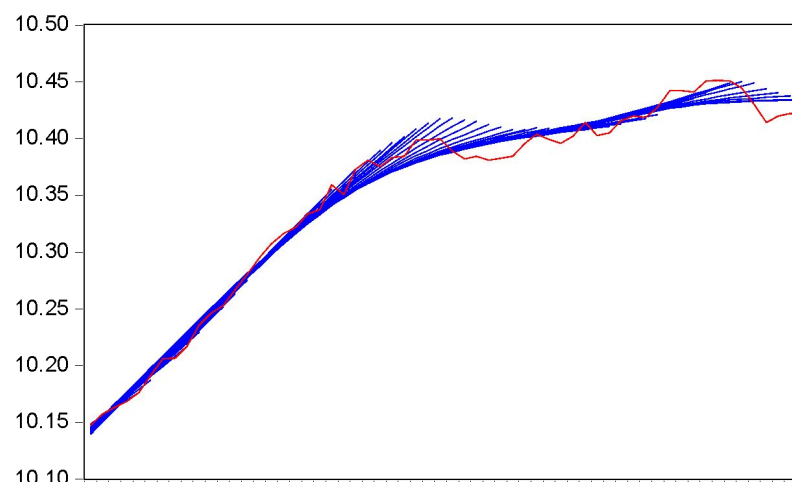
Big Recessions: Recoveries

Examples of countries that **returned** to trend:
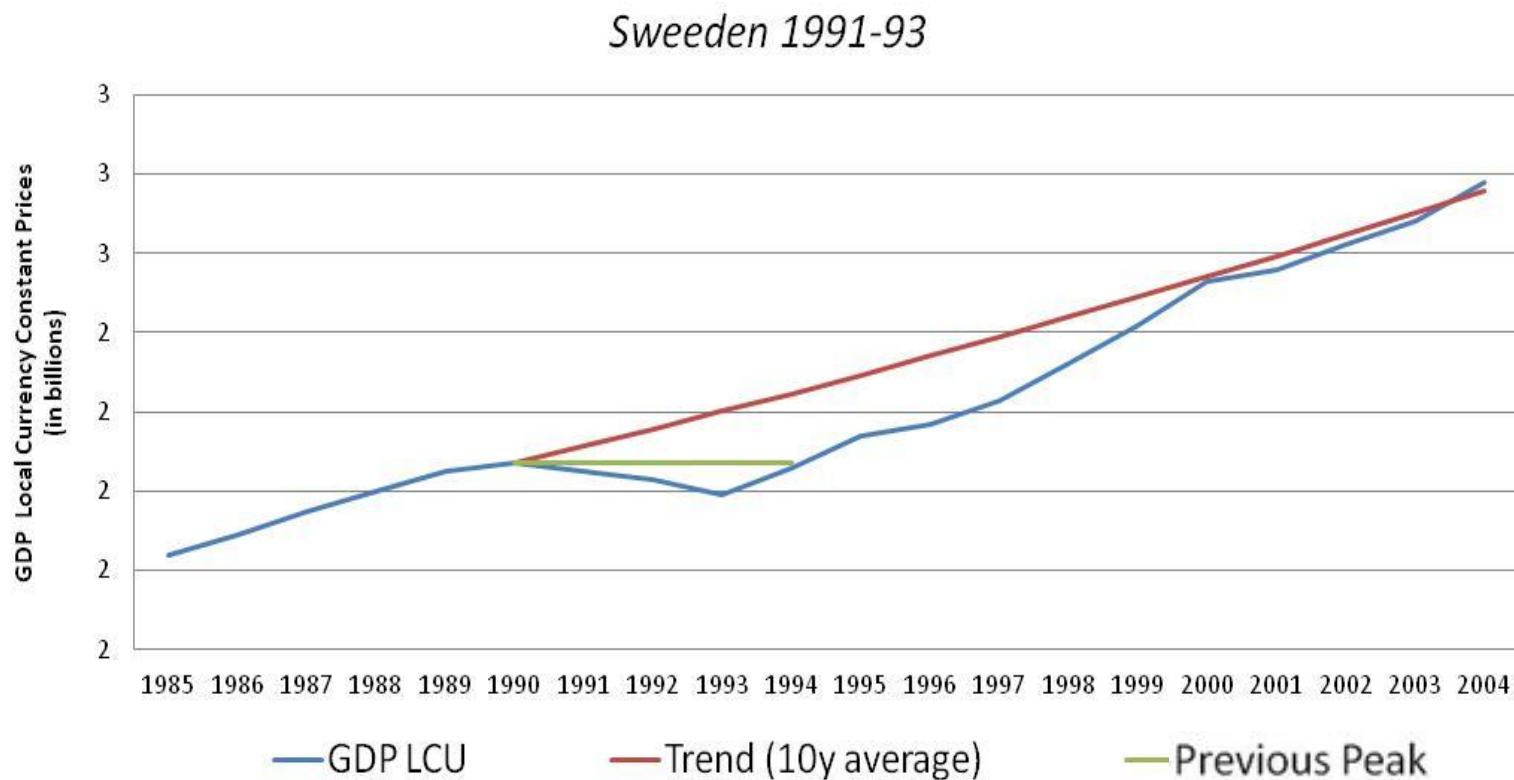
Sweeden 1991-93

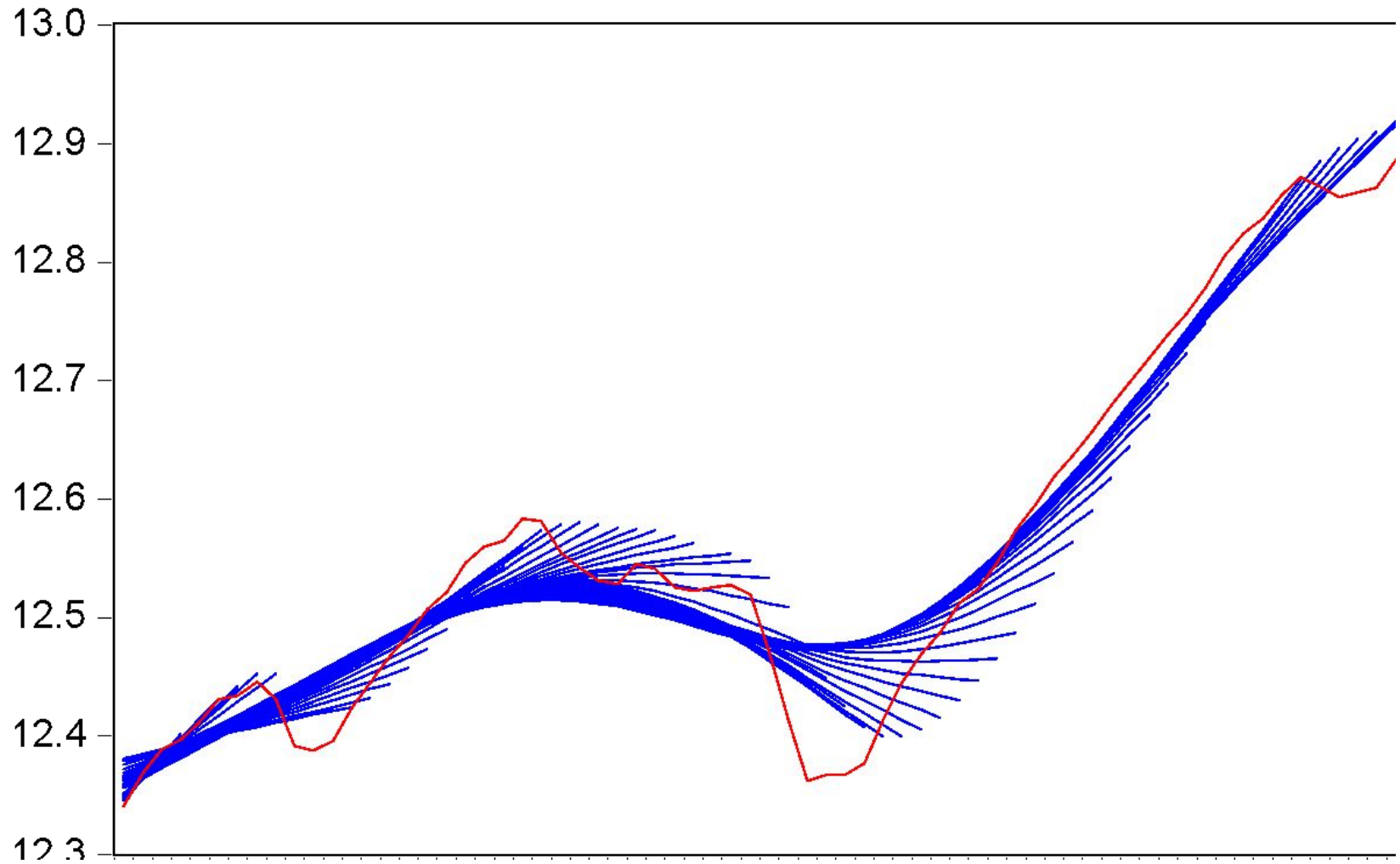# Big Recessions: Recoveries

Examples of countries that **did not return** to trend:

Finland 1991-93

Big Recessions: Recoveries

Examples of countries that **did not return** to trend:

Thailand 1997-98
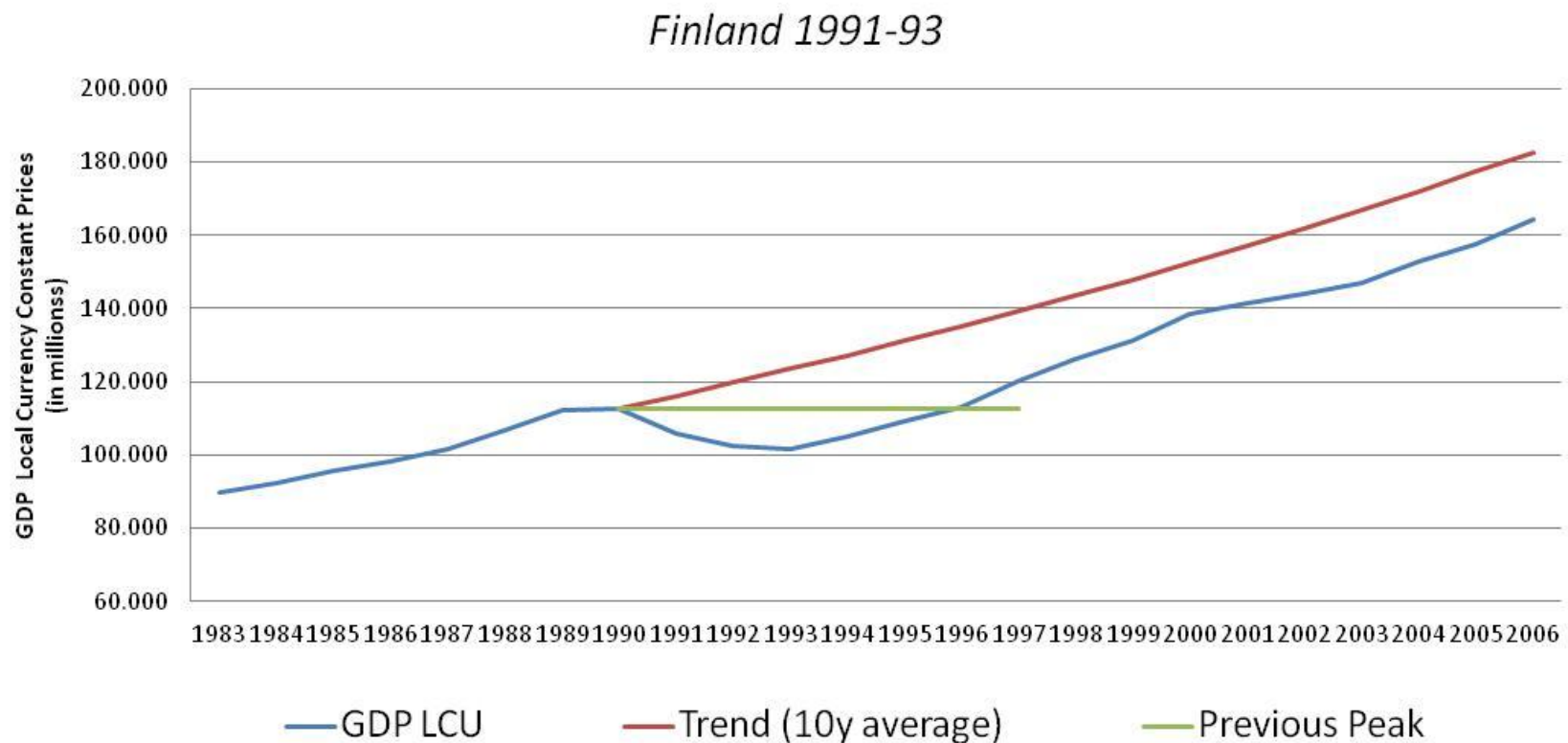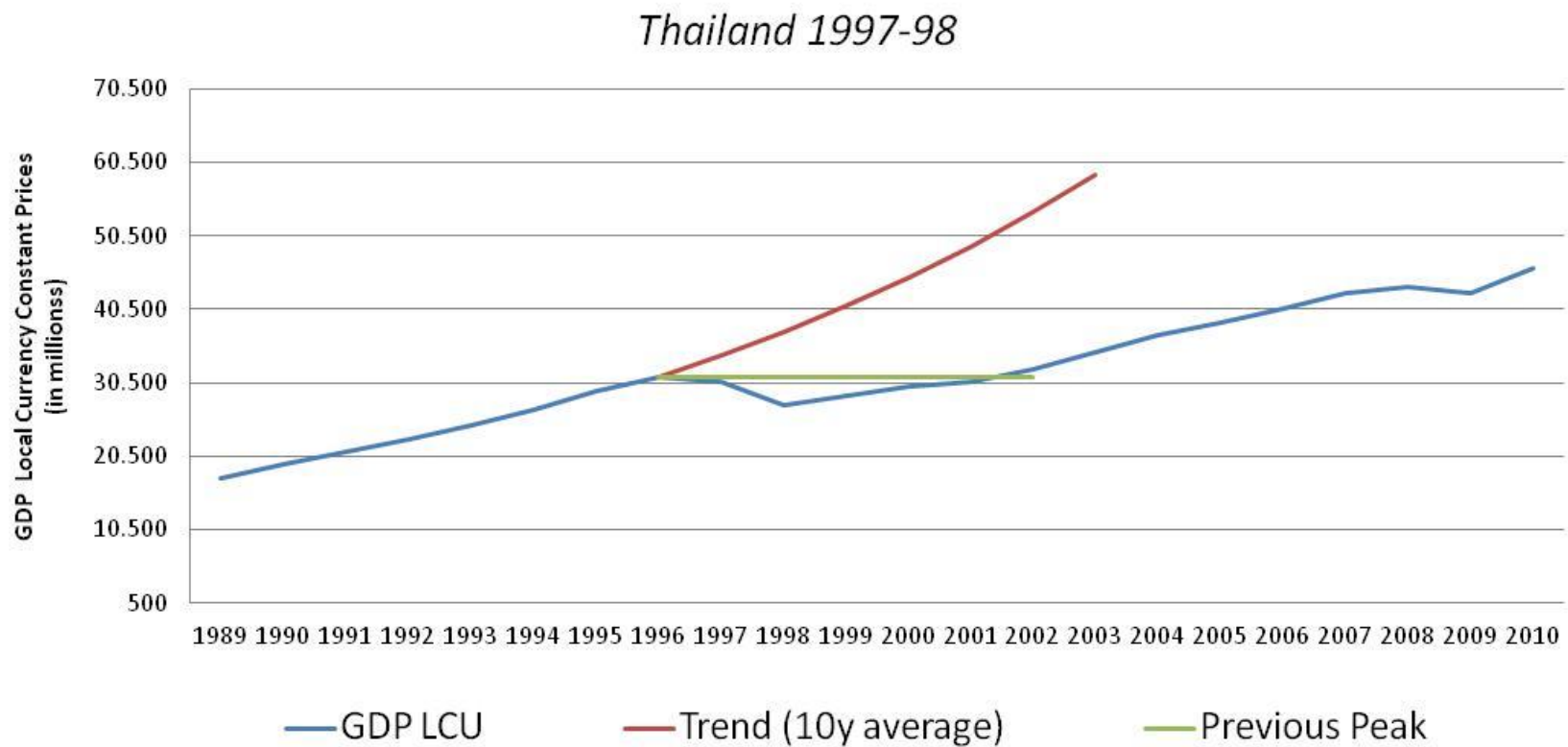
Greece: Actual GDP and IMF´s WEO Forecasts
Index: 2001 = 100
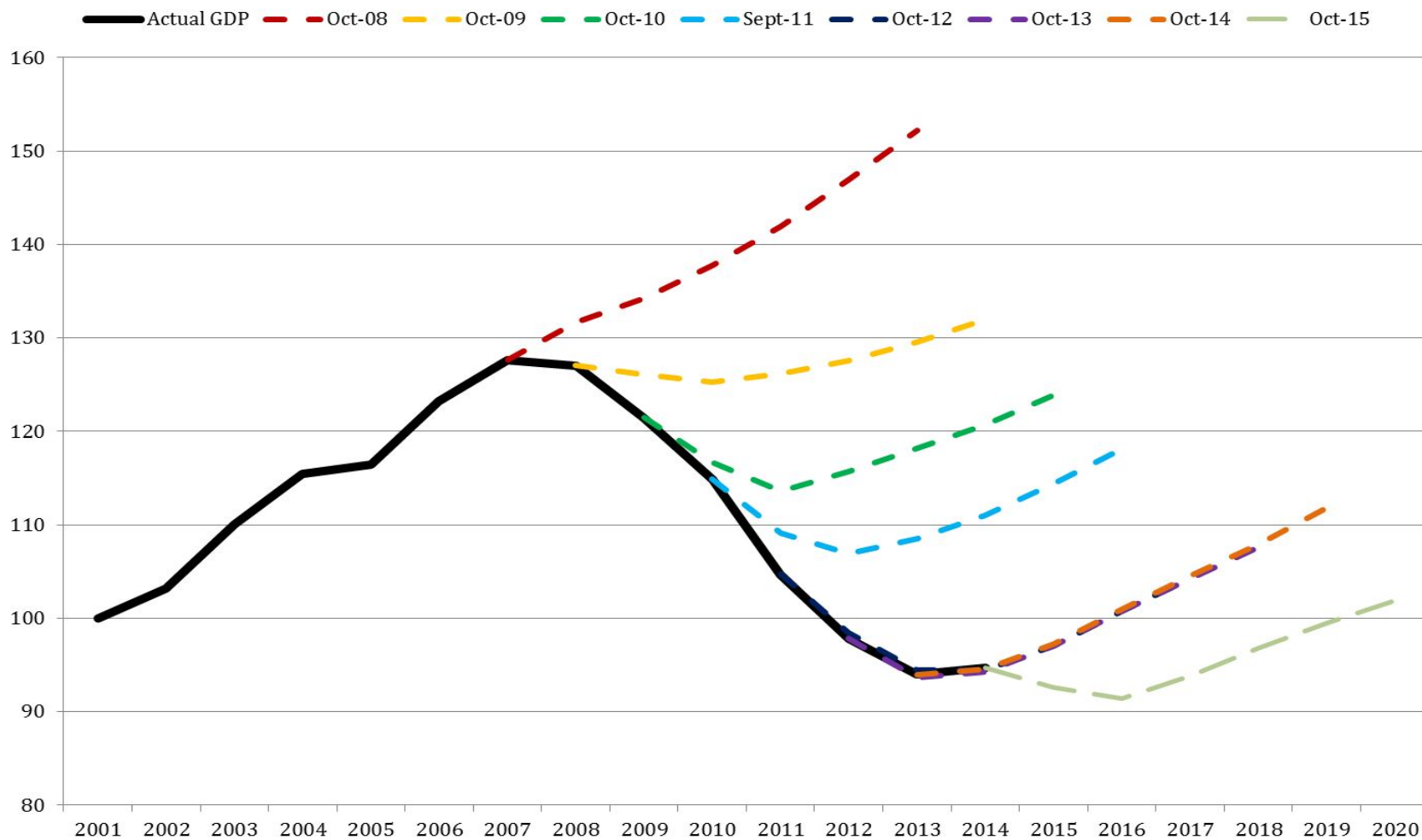
Argentina
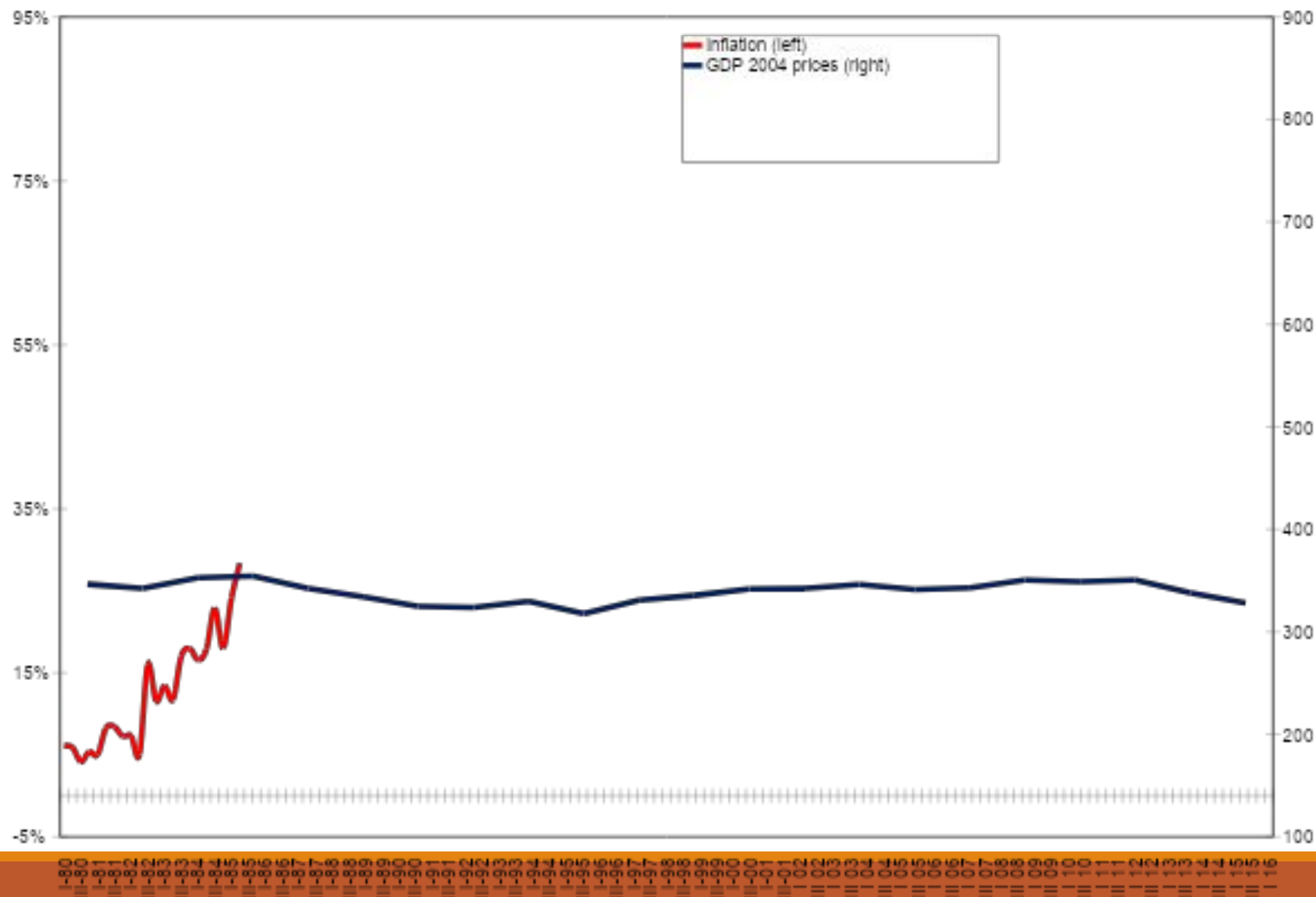## (Log GDP and Recursive HP)

Big oscillations, sudden transitions
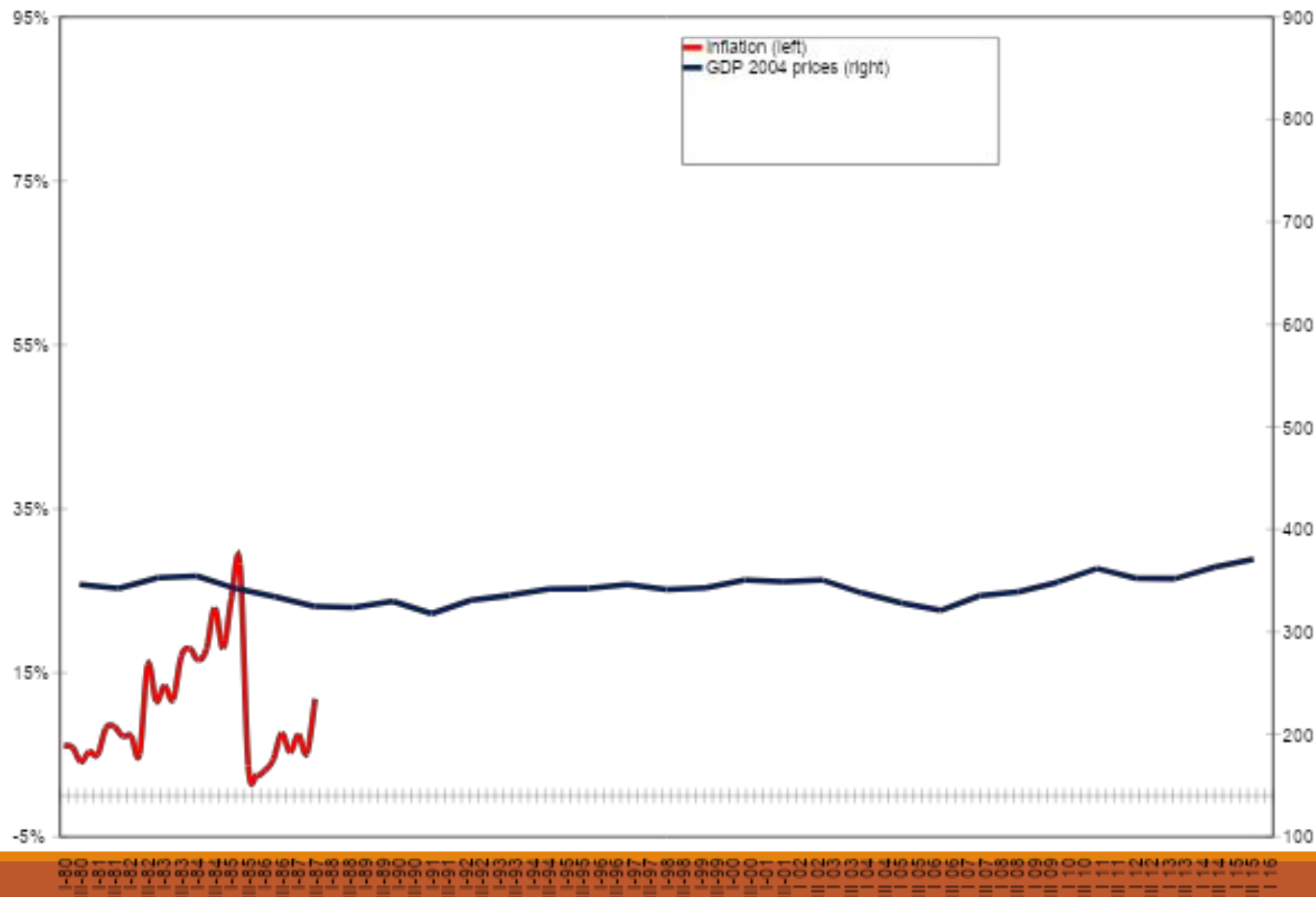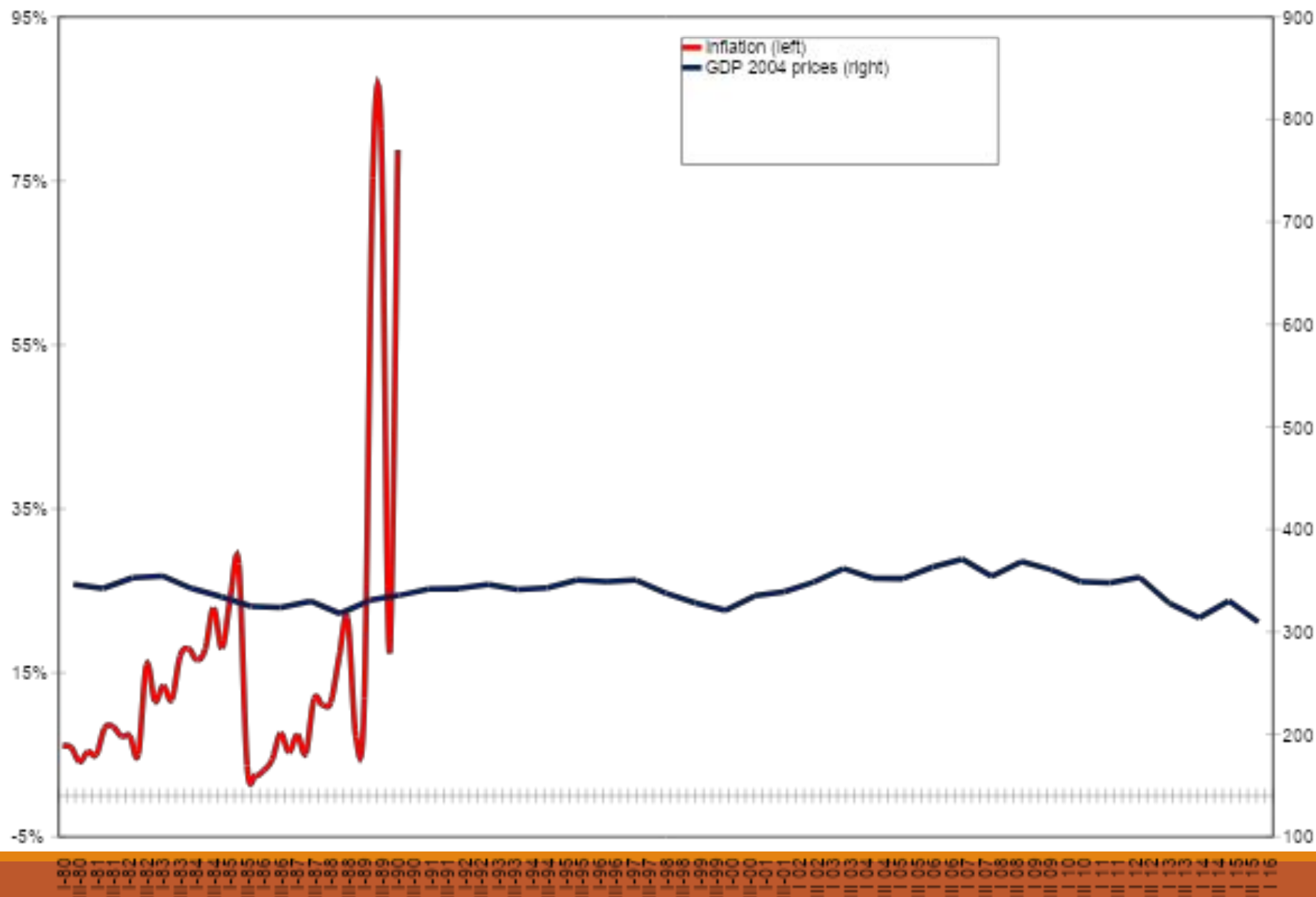
GDP at constant prices and CPI inflation rates

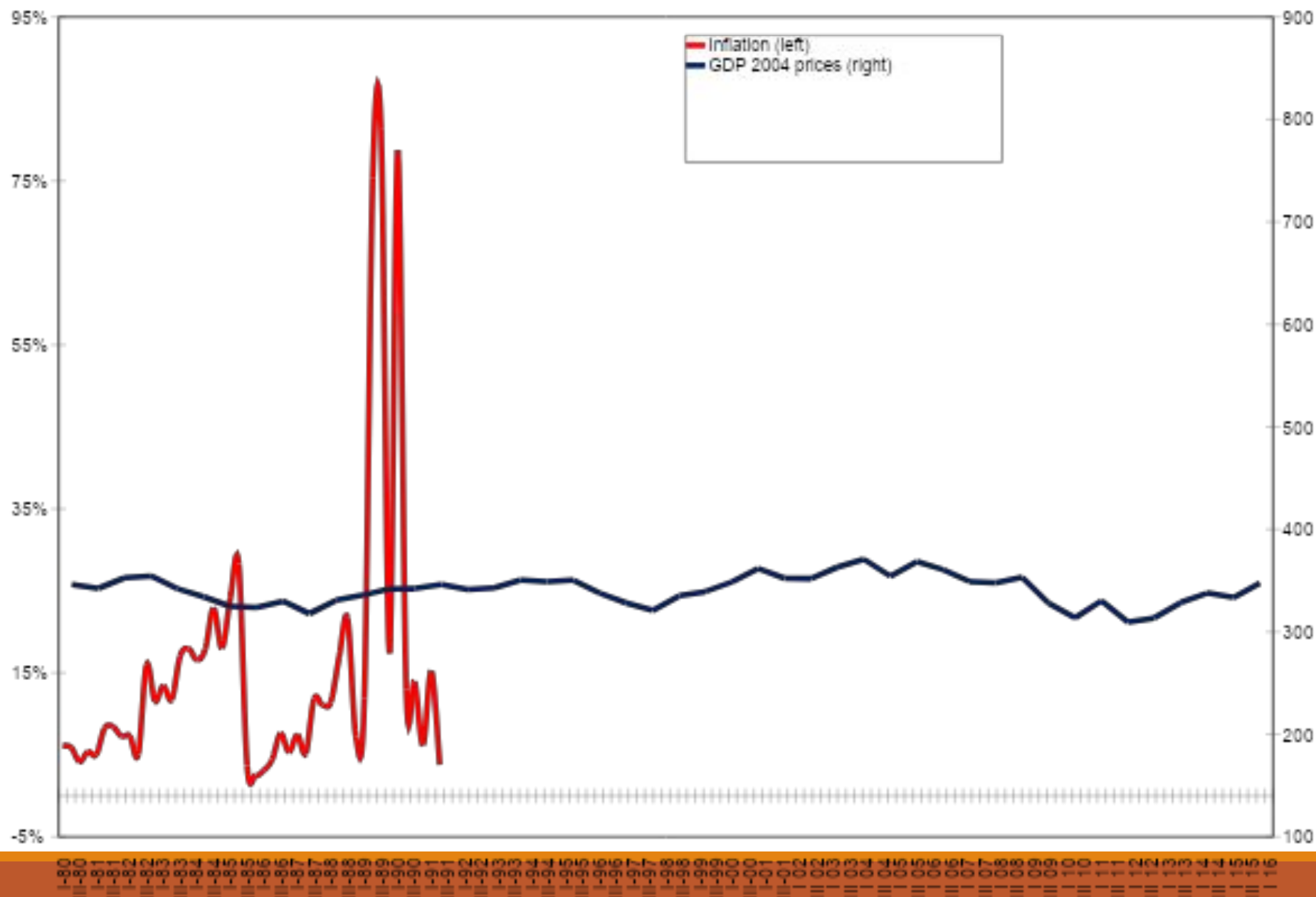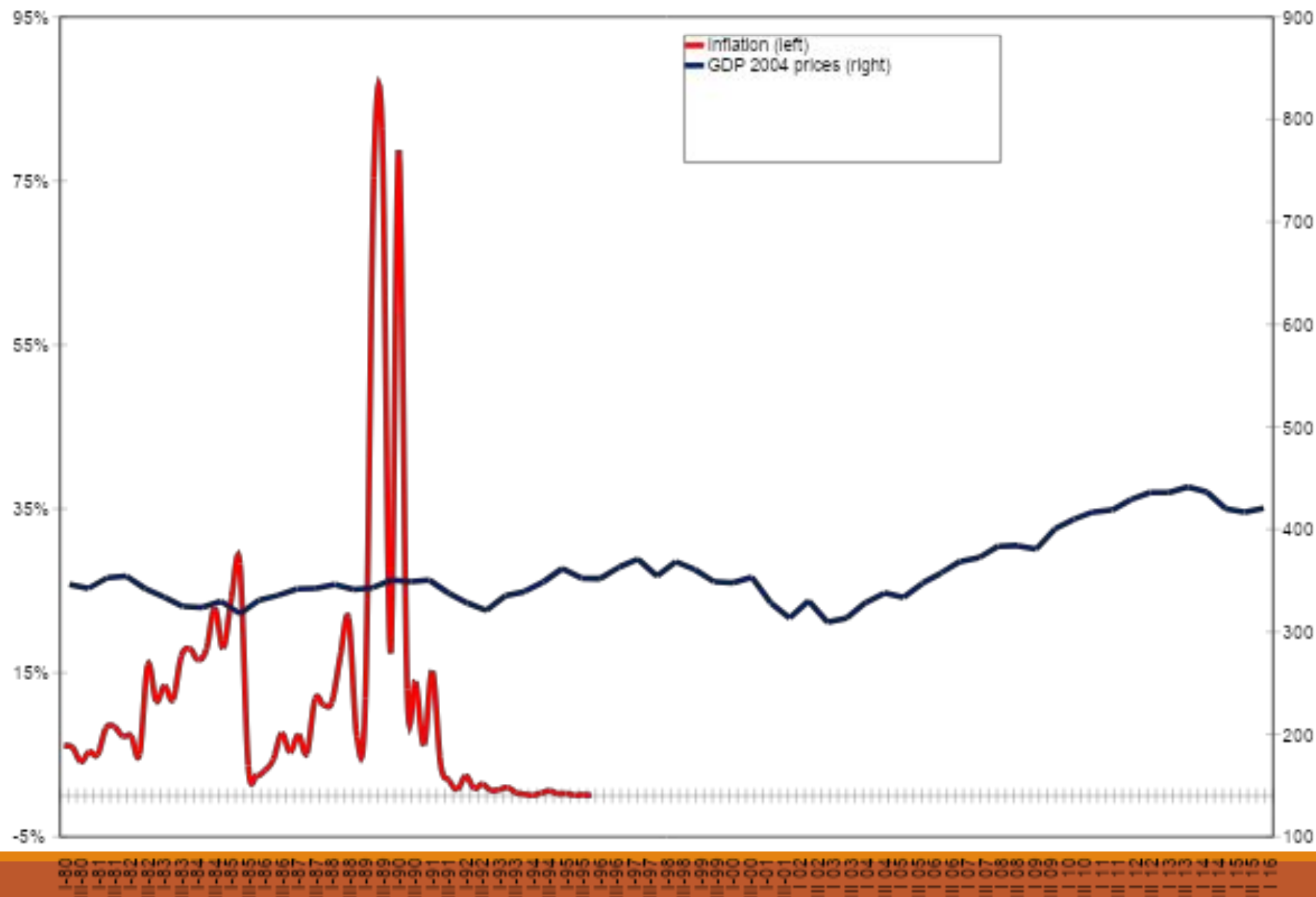# GDP at constant prices and CPI inflation rates

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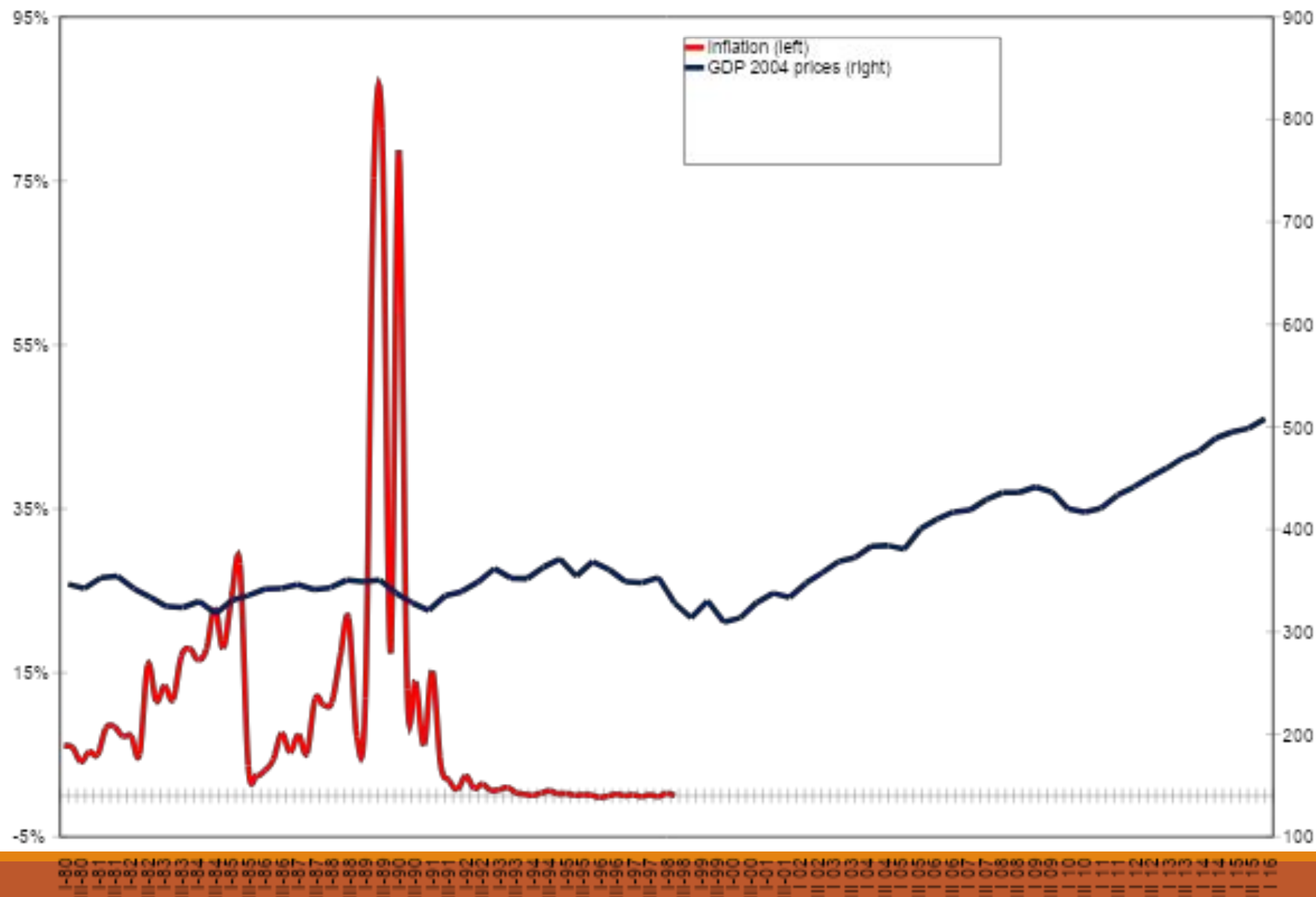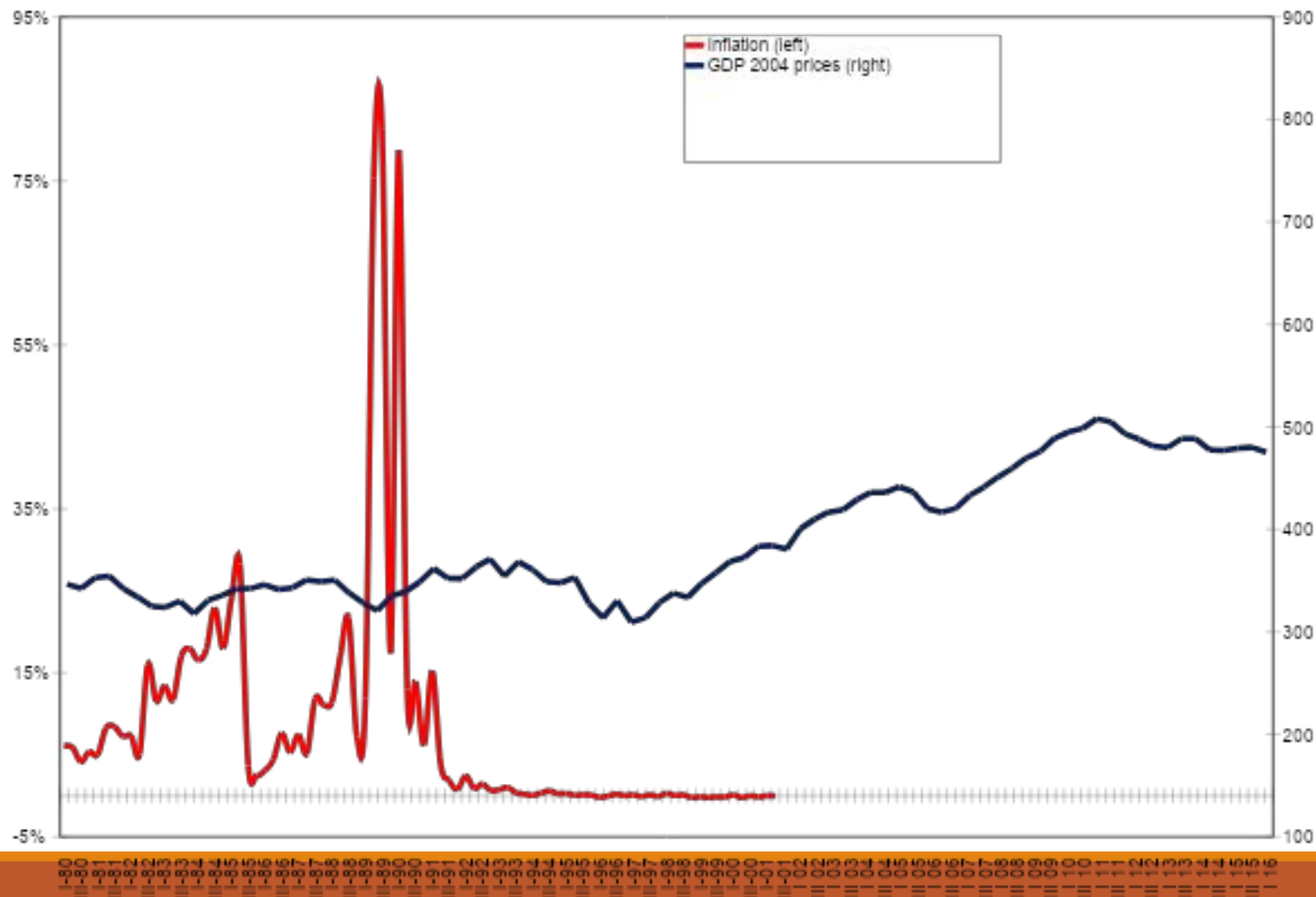
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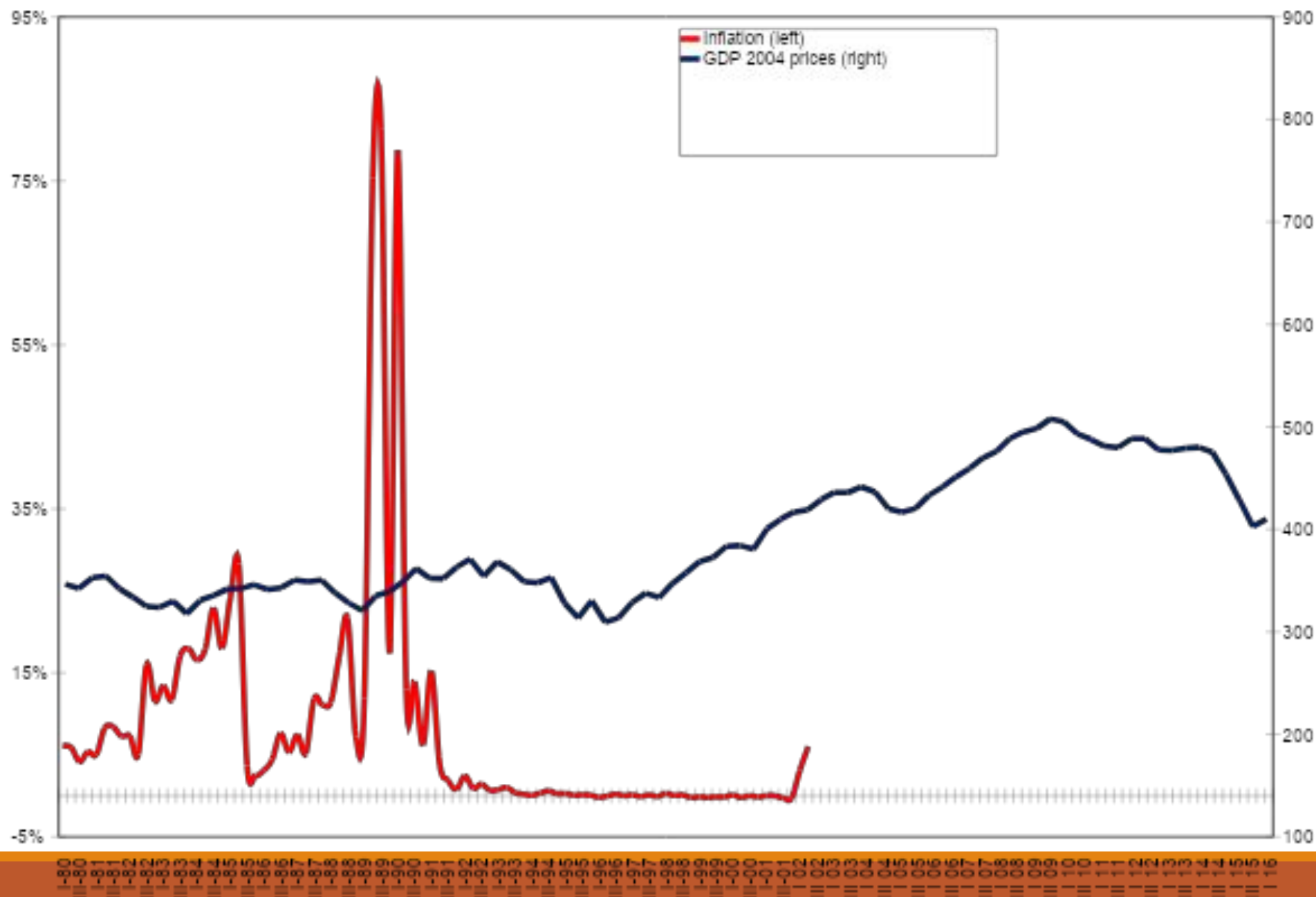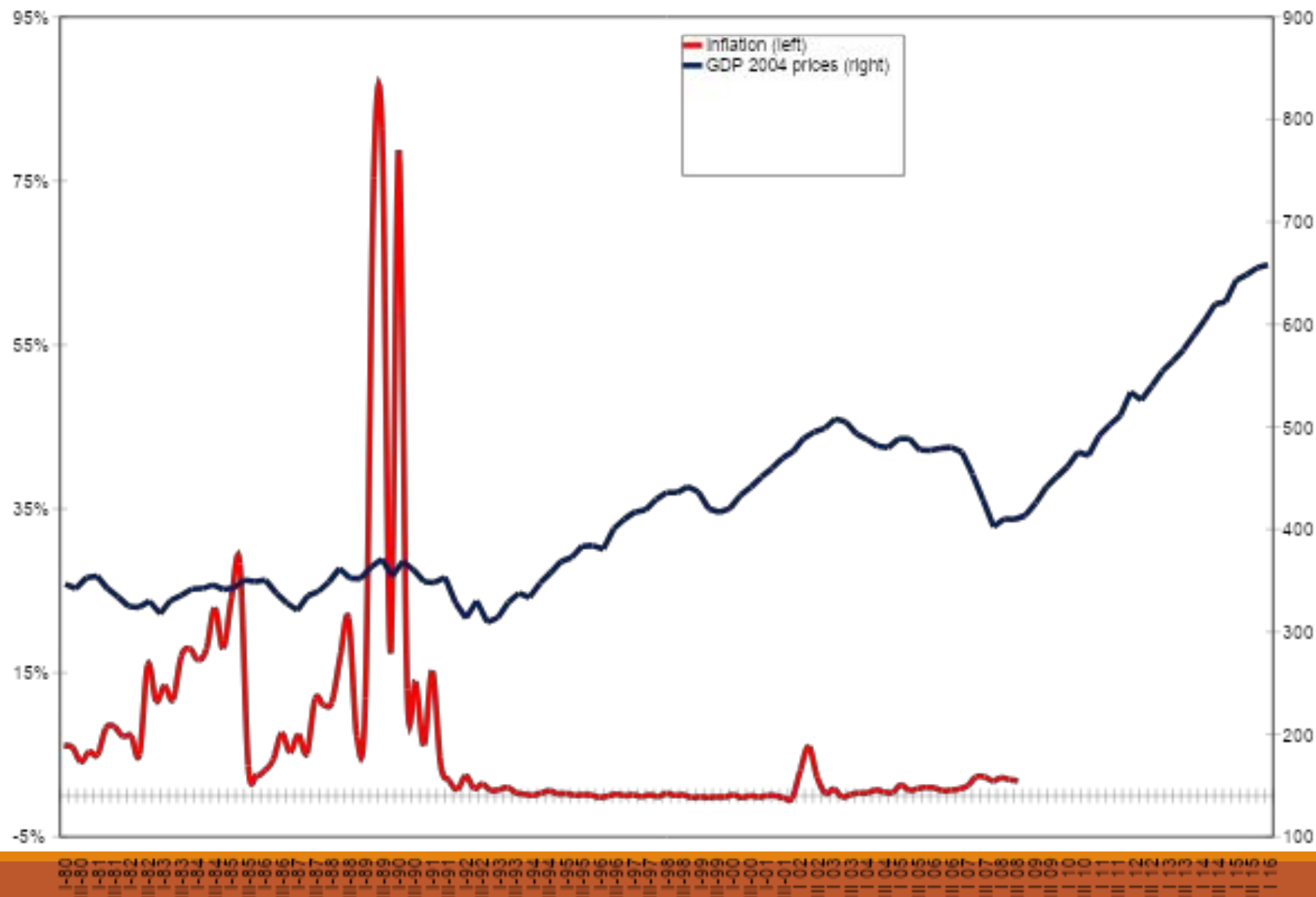# GDP at constant prices and CPI inflation rates

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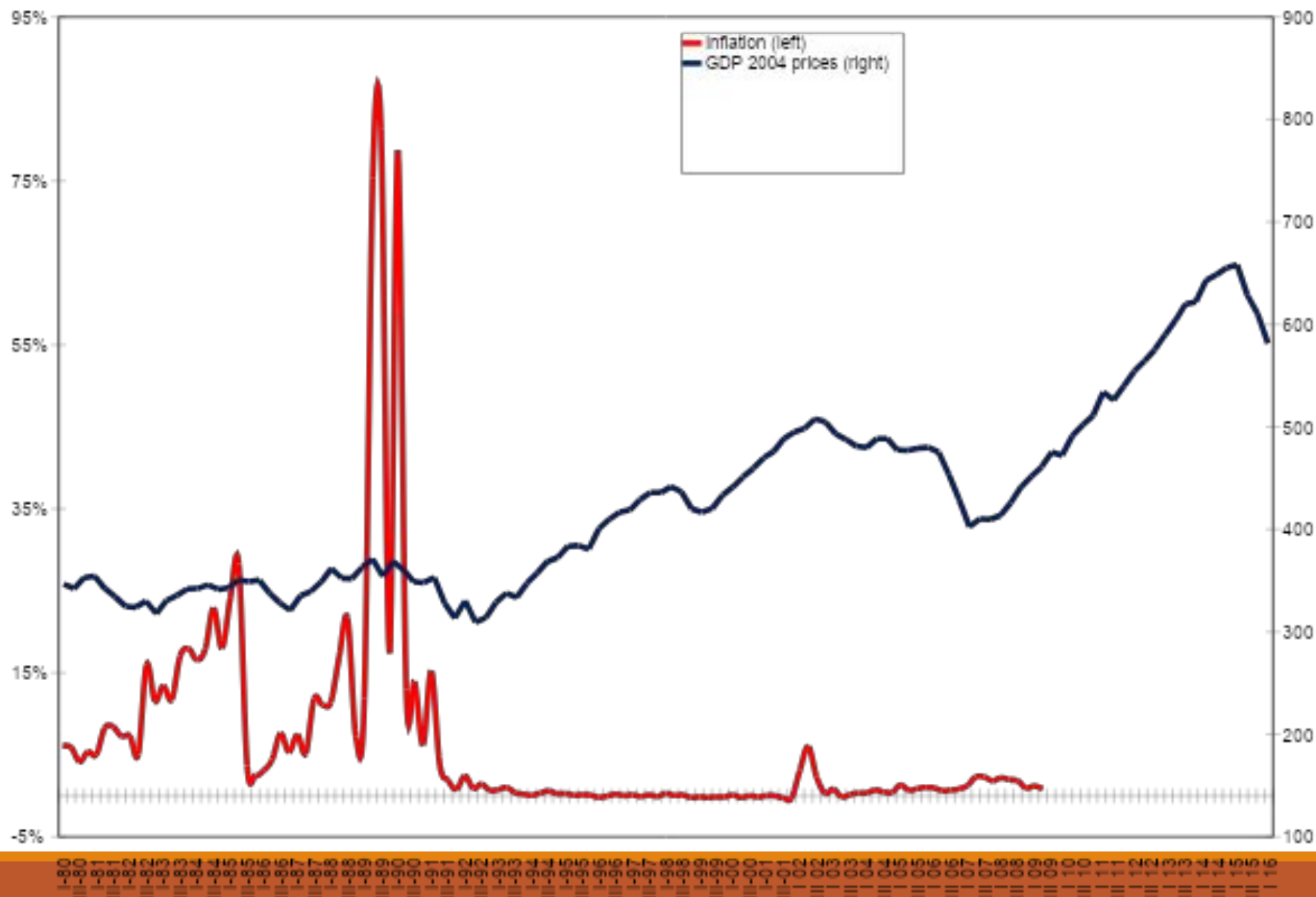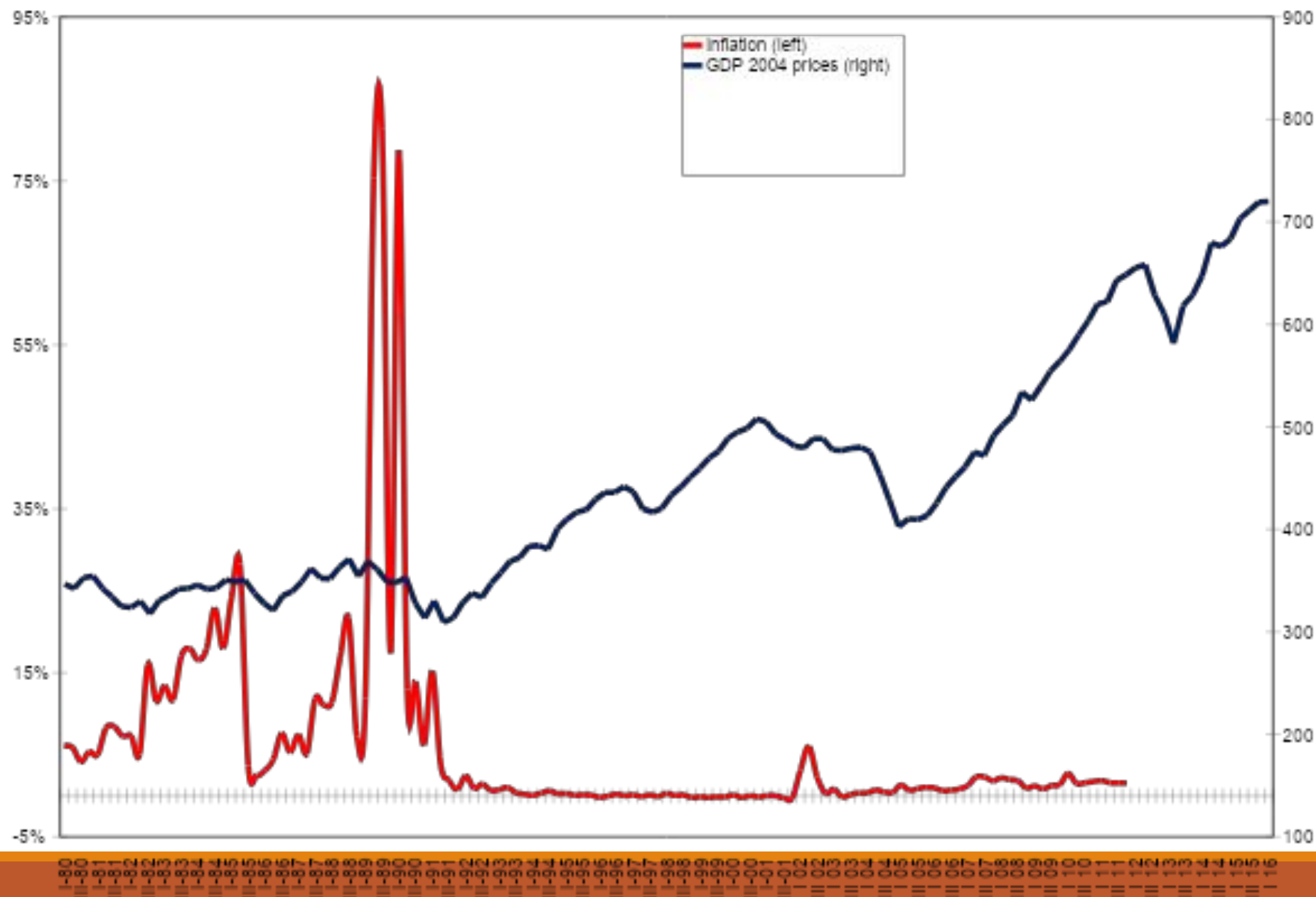# GDP at constant prices and CPI inflation rates

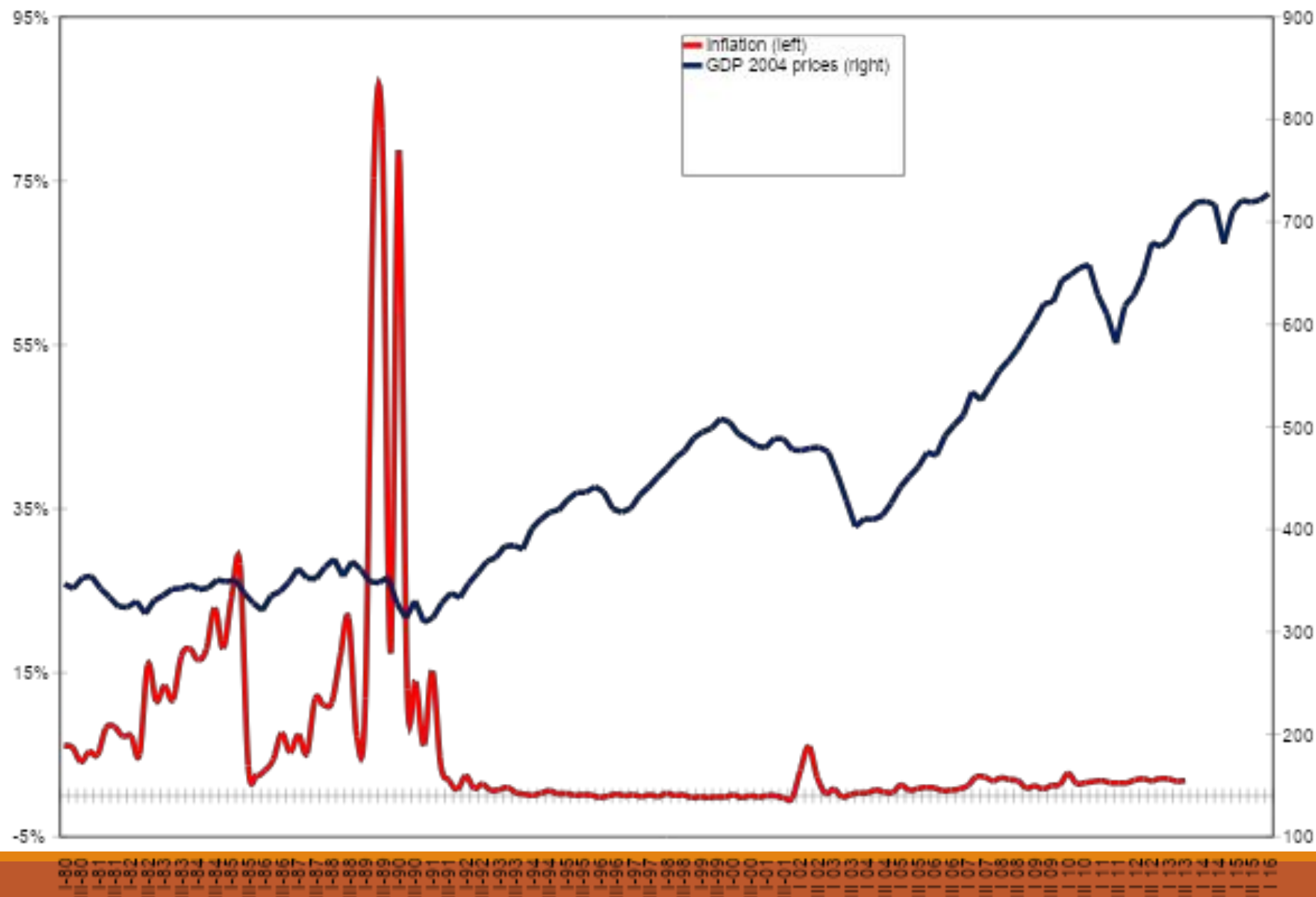# GDP at constant prices and CPI inflation rates

GDP at constant prices and CPI inflation rates

GDP at constant prices and CPI inflation rates

Learning and imitation: schematic setups and macro counterparts

Argentina: bank deposits during 1995 financial crisis:
actual, and simulated with BAM- type model
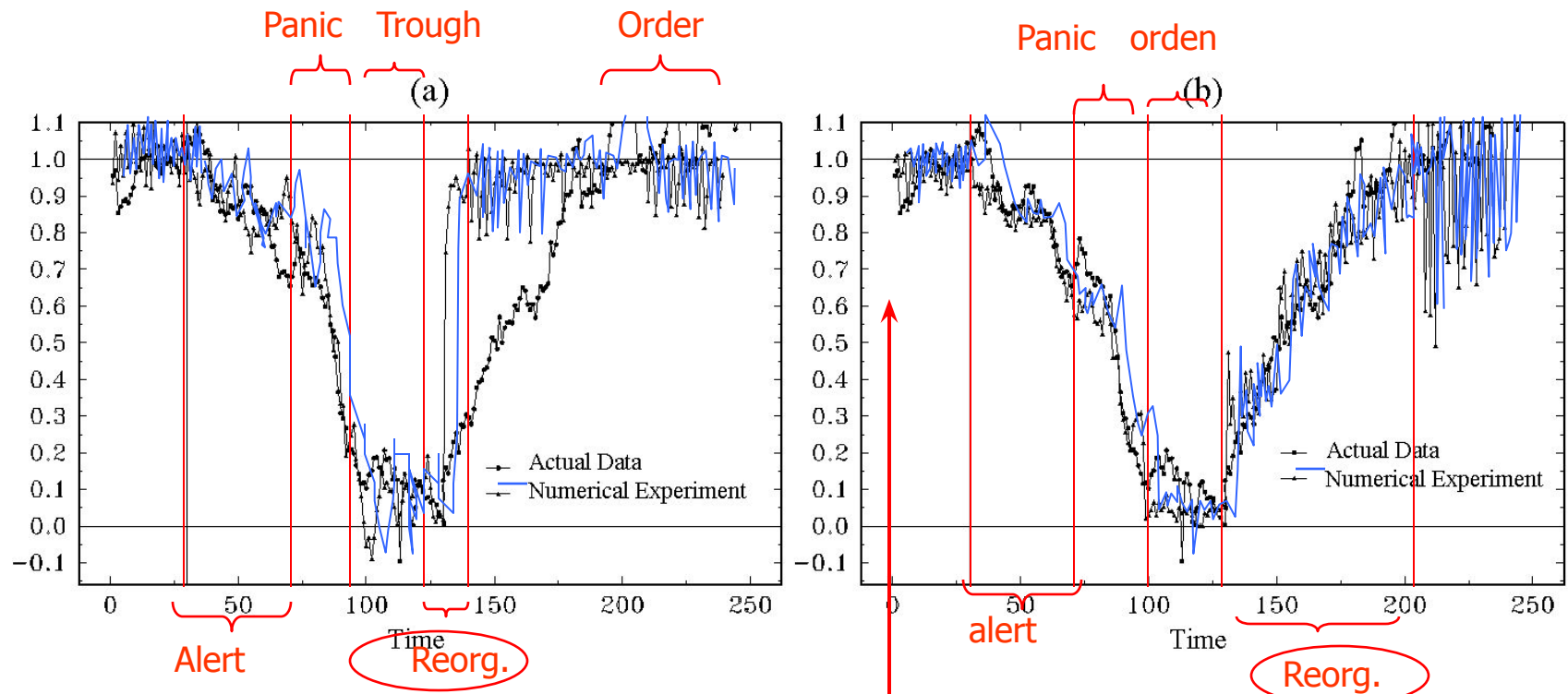
Agents without «caution» in recovery

Agents with «caution» in recovery

Learning and imitation: schematic setups and macro counterparts

Both «fundamental» news and propagation/ contagion.

In any case, simple-minded, basically metaphoric representation.

Looking ahead

Development of complex- system analyis,
reasonable line of progress for macroeconomics

Meanwhile

…

Various open questions

Looking ahead

Range of problems on which ABMs concentrate, or claim special relevance?

◦ Specific matters (e.g. effects of topology of input-output trades, interbank debts, on propagation of shocks).

◦ General purpose modeling for broad questions (e.g. likelihood of large recessions in economies for different sets of parameters)

AMB macro models centered on identifying distributions, stylized dynamics: how much emergent properties, how much potentially reduced to aggregate dynamic specification directly from behavioral assumptions?

How much structure in models?

Cf. Fagiolo and Roventini (2016): KISS («keep it simple, stupid»), vs. KIDS («keep it descriptive, ditto»).
Note: strategies for empirical validation under discussion.

Looking ahead

Modeling behavioral rules:

◦ In general, actual decision problems of agents unstructured, very hard to formulate as readily solvable optimizations (eg. pricing of multi- product firm, sequential purchases of consumer with periodic receipts).

◦ Use of relatively simple heuristics makes sense ("bounded rationality" redundant expression). But large space of potential specifications/parameters.

◦ How to choose? Sensitivity analysis when large number of alternatives? Also note: "n-th equation issue" due to budget constraints.

Looking ahead

Modeling behavioral rules (cont.):

◦ Artificial agents: how smart? Representation of beliefs? Note: in crises, "behavioral" effects but, particularly, disappointed rationalizations. Analysis of crises calls for study of procedures/implicit models used in forming expectations.

◦ Complementarity with experiments: How to systematize?

Looking ahead

If movement to large models based on typification of observed behaviors (cf. Geanakoplos et al., 2012 on real estate markets):

ABMs, cottage industry or Big Business?

Conclusions

ABMs

«provide only way in which we can explore the self- regulatory capabilities …and adaptive dynamics of actual economies»

(Leijonhufvud, 2006)

Conclusions

Active field with interesting contributions. To name a few:

◦ **Kirman and Vriend** (2000), analysis of actual (fish) market

◦ **Clower and Howitt** (2000), emergence of monetary exchange, market- making intermediaries

◦ **Deissenberg, Van Der Hoog and Dawid** (2008), large ABM for European economy

◦ **Wright** (2009), macro model with zero- intelligence agents

◦ **Battiston, Delli Gatti, Gallegati, Greenwald and Stiglitz** (2009), credit networks and bankruptcy cascades

◦ **Haldane and May** (2011), credit risks in banking ecosystems

◦ **Gaffard and Napoletano**, eds. (2012), policy analysis with ABMs

◦ **Dosi, Fagiolo, Napoletano, Roventini and Treibich** (2014), macro policy analysis in ABM

◦ **Klimek, Poledna, Farmer and Thurner** (2015), crisis resolution policies

◦ **Sinitskaya and Tesfatsion (**2015): ABM with different decision criteria

In any case: much work to do…

Thank you!