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How Moderate was the Great Moderation and how Destabilizing is Secular Stagnation?*

Fiscal and monetary policy implications based on evidence from US macro data

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Summary

This paper aims to challenge the mainstream view that the path towards full employment, optimal and sustained growth is necessarily a stable and steady balanced growth path. Mainstream explanations of the great moderation and explanations about the secular stagnation hypothesis are grounded on a historical analysis of aggregate data of growth rates and output gaps. They often serve to justify fiscal and monetary policies that aim at reducing output fluctuations, targeting low inflation rates and achieving stable sustained growth. Such policy recommendations assume that sustained growth is a balanced equilibrium path, so that countercyclical measures are considered desirable. To put this theory to the test, this paper seeks to study the dynamics of market clearing and its stability. Instead of looking at aggregate data of growth rates and output gaps, data of private sector value added and of personal consumption are studied using nonlinear methods to estimate fluctuation phases. Unlike standard explanations, results show evidence of market instability during the great moderation. For the period of secular stagnation results indicate that markets are cleared and stable. Contrary to mainstream literature on policy recommendations, such findings imply that sustained growth is associated with unstable and volatile markets and that during stagnation, markets clear and their dynamics are stable. If so, countercyclical measures might not be desirable. Mainstream monetary and fiscal policy recommendations may require fundamental revisions.

Key words: Great Moderation, Secular Stagnation, Market Economy, Nonlinear Dynamics, Stability Analysis.

JEL classification: C22 – E52 – E63 – O47

1. Introduction

In mainstream macroeconomics, fiscal and monetary policy ought to be prompted by countercyclical measures to dampen the amplitude of fluctuations while maintaining price stability (Summers, 2014; Taylor, 2013). Accordingly policy recommendations during the 1980s and 1990s were grounded on 'historical

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analysis emphasizing that we were in a great moderation'. In a Keynote address at the National Association for Business Economics Policy conference in February 2014, Summers (2014) challenged the view that GDP growth fluctuations are cyclical in the first place. So that the downward trend in output 'is likely to be related to a decline in the equilibrium or natural real rate of interest'. The difficulty is in 'the inability of monetary policy to accomplish much more when interest rates have already reached their lower bound' (ibid). Accordingly fiscal and monetary policy should be focused on avoiding secular stagnation instead of being concerned with minor adjustments to stabilize the economy about a given trend.

This paper aims to challenge the mainstream view by the idea that the path towards full employment, optimal or sustained growth is not necessarily stable. If so, countercyclical measures in fiscal and monetary policy may not be desirable at all. Unlike standard analysis of GDP aggregate data, evidence is sought in data representing the market economy. Two fundamental questions are proposed in what follows: Do markets clear? Are markets stable?

To search for answers, the present paper offers an analysis of US data of private sector Business Value Added and of Personal Consumption Expenditures, which are considered proxies for excess demand variables. To answer the questions, market clearing is then studied using nonlinear and stability analysis. Time series are then examined respectively for each one of the time periods under consideration.

This paper is organized as follows. Section 2 starts with a bird's eye overview of explanations about periods of great moderation and secular stagnation. Section 3 presents the logic of the tools employed to analyze data and to study market stability. The discussion narrows the problem to trend extraction and instantaneous phase estimation prior to stability analysis. Trend and phase estimation are studied in the first part of section 4. Stability analysis is discussed in the second part. Section 5 concludes the paper with an overview of the findings. It ends with a discussion of the findings and draws some monetary and fiscal policy implications and conclusions.

2. A bird's eye overview of the great moderation and of the secular stagnation explanations

The great moderation and the secular stagnation hypotheses are grounded on empirical analysis of growth rates and output gap time series. The explanations in the literature on the great moderation, inflation targeting, and on secular stagnation, aim at proposing effective policy instruments to promote sustained growth and maintain low inflation. While the inflation targeting view advocates for disclosed policy rules to 'spark another great moderation' (Taylor, 2014), the secular stagnation view recommends lower real interest rates coupled with fiscal policy targeting demand driven growth. Both views are based on explanations of sustained growth in the late 1980s and 1990s (Orphanides, 2003) and from an ever rising output gap since the trough of the great recession in 2009 (Summers, 2014).

The first explanation comes from the observation that the output gap and the volatility in growth rates declined substantially during the late 1980s and all the way through the 1990s. This observation was explained as the result of a stabilizing countercyclical monetary policy adopted by the Federal Reserve at the time. A policy that Orphanides (2003) described as 'consistent with natural growth targeting variants of the Taylor rule'. During this period growth rates were stable, expansions lasted long, unemployment was low, recessions were short and recovery was fast (Taylor, 2013).

On the other hand secular stagnation is explained by an ever rising gap between potential and actual output since the trough of the great recession in early summer of 2009. According to this explanation, the economy suffers from capacity underutilization, financial instability and lackluster recovery (Summers, 2014; Gordon, 2014; Krugman, 2014; Blanchard, 2014). With monetary instruments at the lower zero bound effective policy should shift towards readjusting the growth path by reducing the real rate of interest and raising productivity though fiscal policy, and by promoting demand driven growth policies.

A problem with such explanations arises from the fact that both observations are grounded on aggregate GDP data. One pitfall of national accounting GDP statistics is that they are measured by the sum of economic performance with other institutional and fiscal policy data (Landefeld, et al., 2008). For instance suppose that the public sector was expanding for some time period at the expense of the market economy, and that growth in the public sector was faster so that GDP growth rates were sustained. In such a case, aggregate GDP data will indicate healthy economic performance while in fact markets are shrinking. In consequence aggregate GDP indicators may be misleading as they cannot prove to be a reliable tool for the assessment of fiscal and monetary policy and their impact on markets. This problem begs the question about what happened in the market economy during the times of the so called great moderation and secular stagnation.

3. Description of data samples and methods of analysis

Provided that the great moderation view seeks to explain that the US economy was stable during the period starting from late 1980s till the end of the 1990s and that on the other hand the secular stagnation hypothesis explains an increasing output gap since the great recession because of market and financial instability, the following empirical analysis aims to put these explanations to the test by studying market clearing and stability during these two time periods.

Evidence of market clearing is sought in data of US national accounts to pick proxies for excess demand variables – i.e. supply and demand variables. Given pitfalls associated with common measurement and national accounting techniques that are used for estimating GDP – such as indirect estimates, adjustments for gaps in the source data, adjustments for dependent estimates, estimation and classification difficulties in some sectors such as services for instance, and so on (Landefeld, et al., 2008) – two different estimation approaches are considered for selecting time series: the value-added and the expenditure approach.

Quarterly monetary indicators of Business Value-Added and of Personal Consumption Expenditures are chosen as proxies for excess demand variables to study overall market dynamics. This is grounded on measures of independent variables based on independent surveys following the Value-Added and the Expenditure approaches respectively. The Business Value-Added indicator measures Gross Output as the gross sales – including intermediate inputs – less change in inventories for each industry. The Consumption Expenditures indicator on the other hand measures the monetary value of household consumption of final goods and services (Ibid).

The sample is chosen from US national income and product accounts quarterly data. The time period spans from 1969 quarter one to 2016 quarter one. The choice of the sample is based on the results of Groth, et al. (2011) and of De Carvalho, et al. (2012), who used a similar methodology to estimate average instantaneous phases of business cycles. The data set may be consulted on the web page of the Bureau of Economic Analysis[1].

To study market dynamics and stability, a non-linear approach is adopted. Given the nonlinear nature of the data, markets clear whenever the ratio of the trends in Personal Consumption Expenditures and Business Value-Added equals one, and oscillation phases are synchronized (Tesfatsion, 2006, pp. 846-847). This implies that, if markets clear, the coupling ratio is equal to one and the ratio of trend is also equal to one. It follows that the problem can be narrowed to one of extracting trends and cycles (Hodrick & Prescott, 1997).

Considering the typical spectral shape of economic time series in the presence of trends (Granger, 1966), trends are extracted, oscillations are estimated and white noise tests are performed to solve the problem of 'spectral leakage'; or in other terms the problem of confusing long cycles with trends. The analysis is carried out as follows: (1) trends are extracted; (2) residual oscillations are filtered for white noise to estimate instantaneous phases; and (3) the stability of market clearing is studied.

Although some improvements can be made by means of other procedures[2] (Cogley & Nason, 1995), the widely common use of HP filter (Hodrick & Prescott, 1997) is applied to extract trends and cycles. Note that it was shown by Baxter & King (1999) that the HP method yields similar results to band-pass filters provided that time series are not stationary.

The Singular Spectrum Analysis [SSA] methodology (Broomhead & King, 1986), (Ghil, et al., 2002) is then used to smooth HP cycles by eliminating white noise, and to estimate instantaneous phases by means of a Hilbert transform (Groth, et al., 2011). Based on Takens' embedding theorem (1981, pp. 370-372) and motivated by applications of chaos theory to climatic time series and the reconstruction of the Lorenz attractor (Broomhead & King, 1986). (Ghil, et al., 2002), the SSA smoothing procedure finds more recent applications in 'predicting' financial markets (Hassani, et al., 2010) and in estimating average business cycle duration (Groth, et al., 2015), (De Carvalho, et al., 2012). For the purpose of the present paper the SSA method for smoothing HP cycles is applied strictly as an adequate procedure in order to estimate phases at each time point.

Once trends are extracted and phases are estimated, market clearing conditions may be ruled-out by plotting Lissajous curves (Strogatz, 1994, p. 295). To study the stability of market clearing three notions are taken into consideration. These notions are about bounded and asymptotic and orbital stability. They are examined respectively for each one of the time periods under consideration. Bounded dynamics may be studied by computing complex roots, stable asymptotic convergence can be ruled-out by computing Liapunov exponents and reccurent time invariant patterns may be detected by the presence of limit cycles in the phase plane. The logic and the criteria of these tests follow from the properties of exponents, complex roots, trigonometric functions and Lissajous curves.

4. Market stability during the great moderation and the great recession

4.1. Extracting trends and estimating phases

Applying the HP method (Hodrick & Prescott, 1997) and using the conventional parameter λ_{HP} = 1600 for quarterly data (Baxter & King, 1999, p. 590), yields the time series filtered for trend and oscillations components of Business

[1] Data set accessed on September 20, 2016 http://www.bea.gov//national/nipaweb/DownSS2.asp.
[2] By means of a band-pass filter for instance.

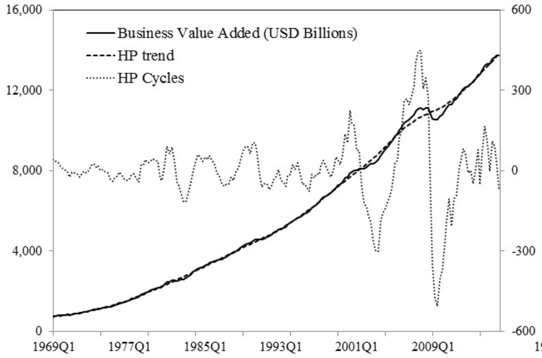

Fig.1. a - HP Filter for Business Value Added

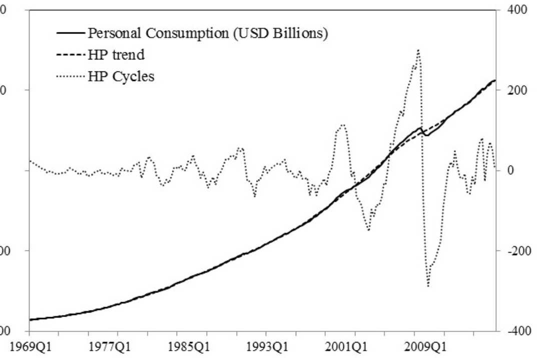

Fig.1. b - HP Filter for Personal Consumption Expenditures

Value Added and Personal Consumption Expenditures data. The results are shown respectively in figures 1.a and 1.b.

To estimate instantaneous phases, HP cycles are normalized at first hand to yield a standard deviation that is less than unity without affecting the duration of oscillations. To obtain smoothed normalized series using the SSA methodology the series are reconstructed by singular value decomposition. Normalized HP residuals are shown in figures 2.a and 2.b.

Given a time series x_t, let *l* be a delay window. By means of the method of delays, it follows from Takens embedding theorem (Takens, 1981, pp. 370-372) that it is possible to statistically reconstruct a smooth function by singular value decomposition:

$$\boldsymbol{X} = \boldsymbol{U\Sigma V^T}$$

Where $\boldsymbol{X}$ is a matrix of dimension *l x n*;

$\boldsymbol{U} = (u)_u$ and $V = (v)_{nn}$ are square matrices whose components are singular vectors *u* and *v*; $\Sigma = (\sigma)_{ln}$ is a diagonal matrix whose elements are singular values of $\boldsymbol{X}$. By definition we have $\boldsymbol{U} \triangleq \boldsymbol{XX^T}$ thus $\boldsymbol{U}$ is the covariance matrix of the components of $\boldsymbol{X}$; $\boldsymbol{X}$ is called a 'trajectory matrix' which is an embedding generated from a time series vector x_t by the method of delays over points with a delay window *l* '.

Let *m* denote a smoothing window, the statistical reconstruction of x_t is:

$$\bar{x}_t = \sum_{j=1}^{m} (\boldsymbol{\sigma}_j \boldsymbol{u}_j) \boldsymbol{v}_j{}^T$$

To obtain smooth reconstructed vectors, only sufficiently large singular values are considered for reconstruction. Accordingly a smoothing window *m = 7* is applied. The SSA windowing procedure (Ghil, et al., 2002) yields the results plotted in figures 2.a and 2.b.

In the error term the variance of the spectral density (Cooley & Tukey, 1965) is 43×10^{-7} and 46×10^{-7} respectively for the reconstruction series of Personal Consumption Expenditure and Business Value-Added cycles. Reconstruction errors are thus estimated as white noise.

Provided variable phases in time and performing a Hilbert transform defined by:

$$z_t \triangleq x_t + i\mathcal{H}_t\{x_t\}$$

Instantaneous phases of smoothed oscillations may be estimated by the angle of the Hilbert transform:

$$\theta_t = \tan^{-1} z_t$$

Having trends and phases estimated from empirical data, it is possible to proceed by studying whether markets clear and whether market clearing is stable.

4.2. Market clearing and stability analysis

Since market clearing dynamics are dependent on phase and on growth path convergence, the problem is narrowed to one of extracting trends and cycles. Having estimated

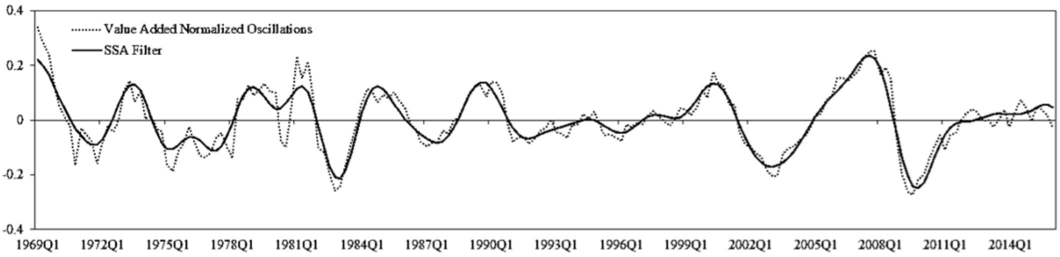

Fig. 2.a - Business Value Added oscillations SSA Filter

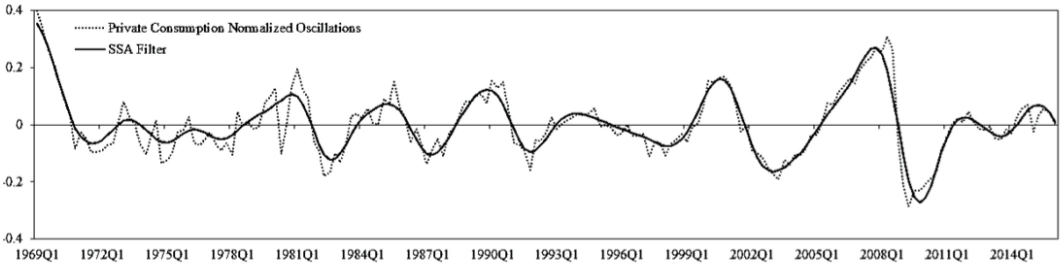

Fig. 2.b - Personal Consumption Expenditure oscillations SSA Filter

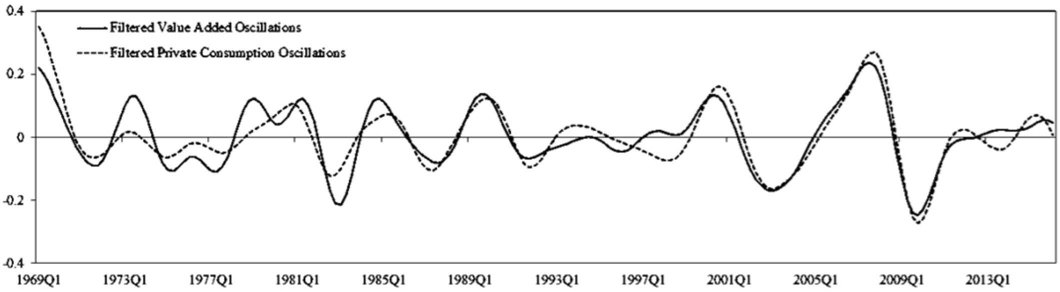

Fig. 2.c - Personal Consumption and Business Value-Added SSA reconstruction

trends and instantaneous phases, the question about stability and convergence towards market clearing is explored with three notions of stability. Analysis of such dynamics is proposed with three criteria to rule out oscillation volatility, convergence, and regular orbital recurrence. These criteria follow from bounded, asymptotic and orbital notions of stability respectively.

It follows from the properties of exponents, complex roots, trigonometric functions and Lissajous curves, that clearing conditions may be ruled-out by plotting Lissajous curves. Bounded stability is analyzed by computing complex roots, asymptotic convergence is ruled-out by computing Liapunov exponents, and evidence for periodic recurrent patterns is verified by drawing limit cycles in the phase plane.

Ruling out Market clearing

Given fluctuations around growth paths in the data, markets are cleared at some point in time if:(1) trends in Personal Consumption Expenditure and in Business Value-Added are equal, and (2) oscillations of both variables are synchronized i.e. the phase difference is equal to zero. One way of showing whether phases are coupled or synchronized, is by drawing Lissajous curves (Strogatz, 1994, p. 295). Let x and y denote respectively the horizontal and vertical axes, and let $A_S(t)$ and $A_D(t)$ be the value of the trend components of Business Value-Added and of Personal Consumption Expenditures indicators respectively at some point of time *t*; and let θ_S *(t)*; θ_D *(t)* denote instantaneous phases of oscillations around the growth path respectively denote instantaneous phases of oscillations around the growth path respectively for Value-Added and for Personal Consumption Expenditures. Value-Added and for Personal Consumption Expenditures. It follows from the properties of trigonometric functions that: replacing the values of θ_S *(t)*; θ_D *(t)*; A_S *(t)* and A_D *(t)* at each time point in the Lissajous curve parametric equation, yields the following elliptical figures only if the phase difference is zero:

$$\frac{x^2}{{A_S}^2}+\frac{y^2}{{A_D}^2}=[\sin\theta_D(t)]^2+[\cos\theta_S(t)]^2=1$$

Substituting with the results of estimated instantaneous phases obtained in section 2.1, Lissajous figures show that since 1990Q1 markets cleared during the following time intervals [1990Q2: 1991Q4], [1993Q3], [1994Q3], [1995Q1], [1996Q3], [2001Q2: 2002Q3], [2003Q3: 2006Q4] and [2007Q4: 2016Q1]. At these intervals the curve draws elliptical shape and the equilibrium conditions are met. This condition however is not met during the following intervals: [1992Q1: 1993Q2], [1993Q4: 1994Q2], [1994Q4], [1995Q2: 1996Q2], [1996Q4: 1998Q3], [1999Q2: 2001Q1], [2002Q4: 2003Q2], [2007Q1: 2007Q3].

Figure 3.a shows arbitrary shape of the Lissajous curve for the year 1998 at the peak of the dot-com bubble which implies that markets did not clear. In contrast since the great depression the elliptical shapes in figure 3.b for the year 2010 show that phases are in sync and that the conditions for market clearing are met.

Asymptotic stability

A dynamic system x_t is said to be asymptotically stable if after an extremely small and arbitrary departure from x^* the diffusion process 'leads back to the equilibrium fixed point after *t* time periods.' Asymptotic stability may be ruled out by computing Liapunov exponents. Consider at point $x_0+\delta_0$ an extremely small and arbitrary departure δ_0 from initial conditions x_0 and let δ_t denote the deviation after *t* period iterates. The Liapunov exponent being defined by the following equation:

$$|\delta_t|=|\delta_0|e^{\lambda t}$$

It follows from the properties of exponents that if after *t* iterates, *x(t)* has a negative Liapunov exponent, λ, δ_t will asymptotically converge towards zero and we may say that *x(t)* is locally and asymptotically stable. Taking logarithms and expanding by the chain rule yields the Liapunov exponent:

$$\lambda=\frac{1}{n}\sum_{t=0}^{t-1}ln|f'(x_t)|$$

Results computed for both the coupling and trend ratios are shown in figures 4.a and 4.b. Negative Liapunov exponents in figure 4.a show that trends in Personal

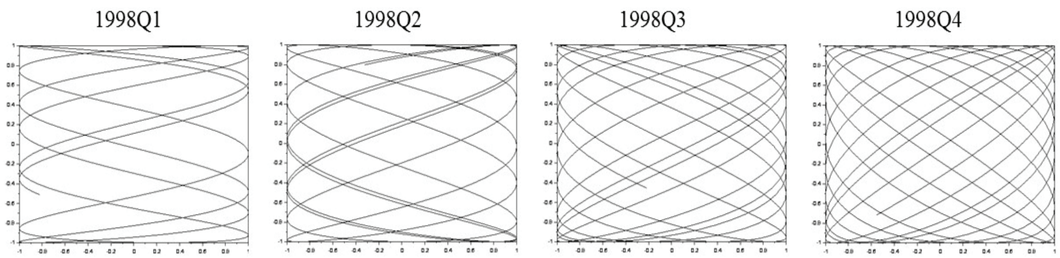

Fig.3. a - Lissajous figures for the year 1998

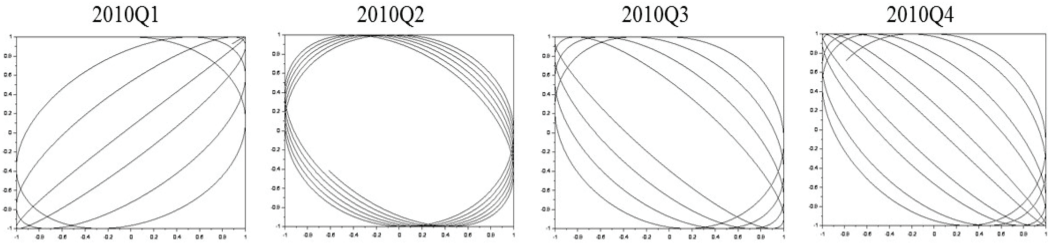

Fig.3. b - Lissajous figures for the year 2010

Consumption Expenditures and Business Value Added converge asymptotically towards market clearing. However oscillation phases do not always converge.

During the great moderation, Liapunov exponents are positive as shown in figure 4.b. On the other hand results indicate negative Liapunov exponents and therefore asymptotical convergence towards coupled dynamics.

These results indicate that contrary to the great moderation explanation, disequilibrium prevailed during the period spanning since the late 1980s till the end of the 1990s, markets were unstable and they did not clear. Moreover and also contrary to the secular stagnation

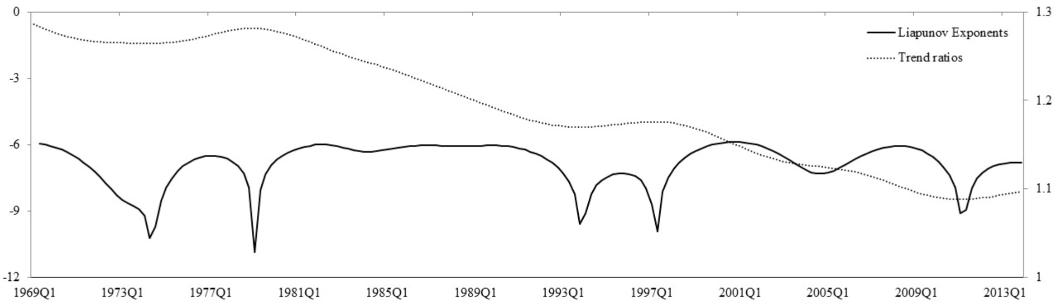

Fig.4. a - Liapunov exponents of trend ratio

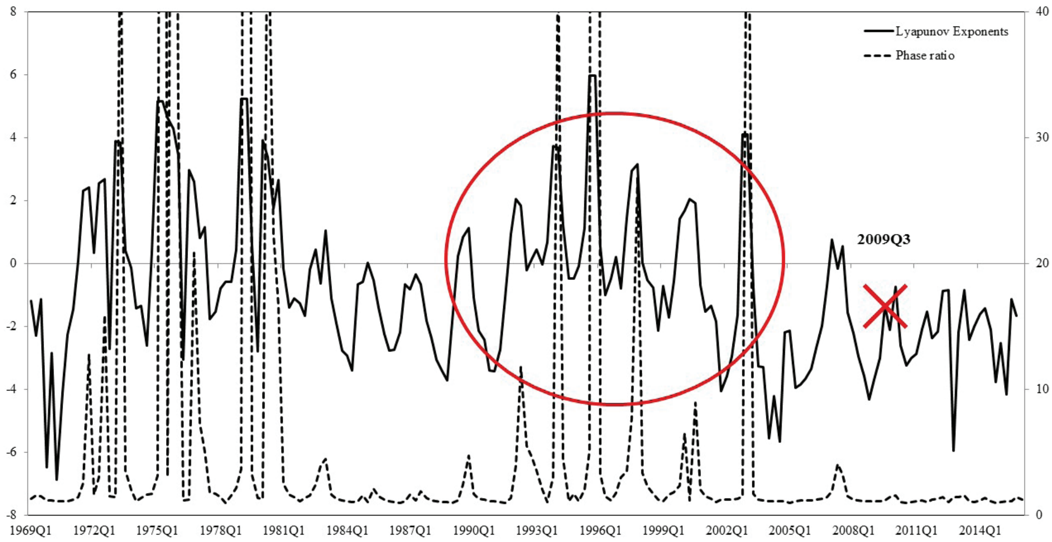

Fig.4. b - Liapunov exponents of phase coupling

hypothesis, markets cleared and have been stable since the trough of the recession in 2009.

Bounded stability

Roots are then computed to find out whether these patterns are explosive or not. A time series *x(t)* is said to be bounded and asymptotically stable if the absolute value of the complex roots u_n of *x(t)* are strictly less than unity:

$$|u_n|<1$$

Orbital stability

Even if markets don't clear oscillations can be cyclic or may reveal recurring patterns. Such recurring behavior can be detected in the phase plane. If growth paths converge and phases are locked at some coupling ratio, oscillations display periodic recurrence. The velocity of the time series orbits a fixed point drawing limit cycles in the phase plane without ever reaching a

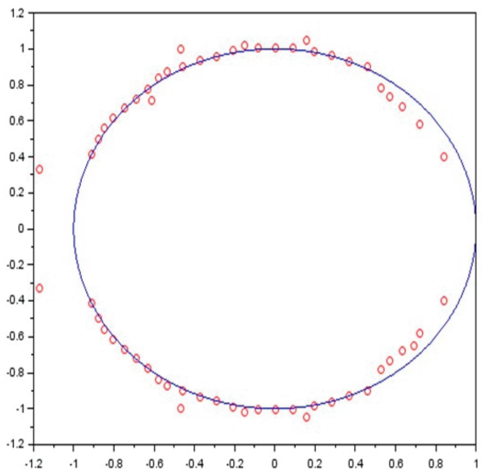

Fig.5. a - Coupling ratio roots 1985Q1-1999Q4

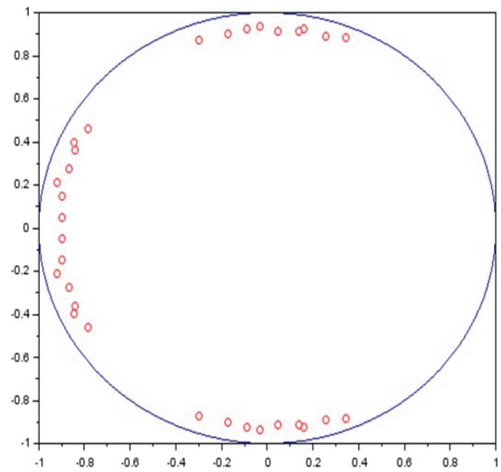

Fig.5. b - Coupling ratio roots 2008Q1-2016Q4

Conversely if $|u_n|>1$; oscillations are explosive. If $|u_n|=1$; the case yields oscillations of the same magnitude. It Follows that *x(t)* is said to be bounded if the absolute value of the complex roots of *x(t)* is less than or equal to unity. This is illustrated on the complex plane in figures 5.

Complex roots of the phase coupling ratio in figures 5.a and 5.b show that unlike the great depression, the relationship during the period of the great moderation is explosive and unstable. In the aftermath of the great depression on the other hand and since 2008Q1 the roots in absolute values are strictly less than unity which implies that the phase relationship is bounded and asymptotically stable.

state of stable cleared markets equilibrium. After removing trends, the results of the coupling ratio – noted *r* in Figure 6 – provide no evidence of limit to cycles orbiting the

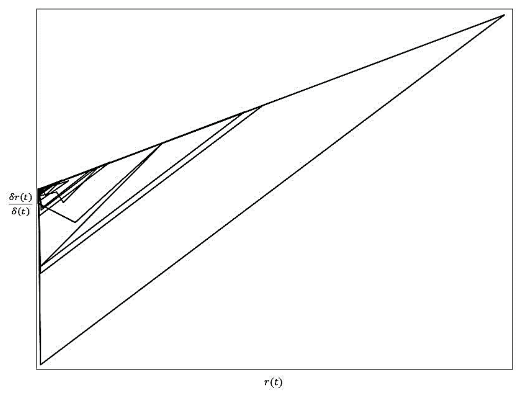

Fig. 6 - Coupling dinamics in the phase plane

fixed point as shown in the phase plane. No periodic regularity or time invariant dynamics can be detected.

5. Conclusion: Overview of the findings and few remarks on Policy implications

The present empirical study attempted to answer questions about market clearing and its stability by studying US data representing the market economy. Personal consumption and private sector business value added data were considered as proxies for excess demand variables. After narrowing the problem to trend extraction and instantaneous phase estimation, nonlinear and stability analysis yielded results that contradict prevalent views in monetary and fiscal policies, especially explanations about so called times of great moderation or of secular stagnation.

The findings show that during the great moderation markets did not clear since results don't meet the criteria tested with the Lissajous figures. Moreover these deviations from equilibrium do not converge back to a state of market clearing, which suggests that markets during the so called 'great moderation' were in fact unstable. In addition oscillations were found to be explosive during that period as shown in the analysis of complex roots. Such oscillations during the 1990s are found to be unpredictable since no limit cycle – or in other words since no recurrent or time invariant behavior – can be detected.

On the other hand, and contrary to explanations in the literature on secular stagnation, the analysis shows that markets did clear since the trough of the recession at about summer 2009. The results of plotting Lissajous figures show that market clearing conditions are satisfied during that period. Moreover the results of computing Liapunov exponents and complex roots show that a state of market clearing was stable for the same time period. Deviations from equilibrium were bounded and converged asymptotically towards market clearing. These findings show that the argument explaining secular stagnation because of market instability is somewhat debatable.

The findings also imply that sustained growth is associated with economic instability rather than moderation, and that market stability is associated with stagnating economic performance. If such relationship is true, countercyclical policies aiming at stabilizing output about a given trend may not be desirable at all. Policies as such would require fundamental revisions if not radical rethinking. On the other hand, evidence of market clearing during secular stagnation may also suggest an optimal roundabout path towards full employment. According to the turnpike theorem (Dorfman et al., 1958; McKenzie, 1963), and assuming proportionate growth, such results imply that fiscal and monetary policy may not be much effective and in some cases may lead to slower recovery and to further lags or deviations from the optimal path towards sustained growth.

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