Are turbulences of Sargent and Ljungqvist consistent with lower aggregate volatility of Stock and Watson?*

Anna Batyra†

VERY PRELIMINARY

April 2007

Abstract

Sargent and Ljungqvist (1998, 2005, 2006a, 2006b) impute the persistence of long term unemployment in Europe since 80s to the welfare state's inability to cope with more turbulent times. They claim that global economic conditions have been more turbulent in 80s and 90s, comparing to earlier decades, and construct a model based on search with a turbulence at micro level to reproduce the evolution of unemployment in laissez-faire and welfare economies. Plethora of research, among others Stock and Watson (2002, 2003, 2005), document on the other hand a fall in aggregate volatility of macro series in the US and G7 countries since 80s. We attempt to reconcile these two findings. Can the model of Sargent and Ljungqvist (1998) based on micro turbulence be consistent with macro data? We look at macro series of productivity and real wages (plus GDP and employment) for a number of countries and find a decline in aggregate volatility since 80s. We then generate macro series based on Sargent and Ljungqvist (1998) search model and establish what sort of aggregate volatility it predicts for welfare and laissez-faire economies under different degrees of turbulence, and find that it is potentially consistent with macro data.

Keywords: Search unemployment, turbulences, volatility

JEL-Code: J64, C52, E32

*Special thanks to Zvi Eckstein for supervision on this project.
†Université Catholique de Louvain; email: batyra@ires.ucl.ac.be.

1 Introduction

According to Sargent and Ljungqvist (1998, 2005, 2006a, 2006b) global economies have become more turbulent since 80s as a result of rapid technological progress, financial markets deregulation, sectoral reallocation, increased international competition and alike. The authors quote indirect empirical evidence in favour of their claim, construct a search model with turbulences applied to agents' individual human capital levels and succeed in reproducing the evolution of unemployment in laissez-faire and welfare economies. A number of researchers on the other hand, for example Stock and Watson (2002, 2003, 2005), document a fall in aggregate volatility of macro series in the US and G7 countries since 80s. In our paper, given potentially divergent trends in micro and macro variables, we show that Sargent and Ljungqvist (1998) model could potentially be consistent with macro data. That paves a new way to thinking about search frictions as giving rise to certain aggregate patterns, consistent with micro turbulence, and labour market policy as a potential driver of international differences in macro-level volatility moderation.

Sargent and Ljungvqist's (1998) is a general equilibrium search model along the lines of McCall (1970) with human capital accumulation during employment and human capital obsolescence when unemployed. The degrees of economic turbulence are defined as the amounts of skills lost when a worker is laid off. In a welfare — as opposed to a laissez-faire — economy government provides unemployment benefits determined by workers' past earnings and financed by proportional taxation on wage income. The model is capable of explaining how in a relatively tranquil time until mid 70s both the US and Europe maintained similar unemployment rates, however Europe's generous welfare states have been unable thereafter to cope with the increased turbulence in the economic environment. In the model, transient shocks applied to both economies lead to a prolonged period of long-term unemployment in a welfare state, while a laissez-faire economy recovers promptly. Persistent turbulence, on the other hand, results in a higher steady-state unemployment in a welfare economy.

The authors quote Gottschalk and Moffitt's (1994) result as indirect evidence that the economic environment has become more turbulent since 80s. Specifically, Gottschalk and Moffitt find between the periods of 1970-1978 and 1979-1987 an increase in the dispersion of both permanent and transitory components of individual earnings, which Sargent and Ljungqvist interpret as an increase in the degree of economic turbulence. They use their model to successfully replicate these data and in this way check the model's validity. Moreover, they successfully replicate the result of Jacobson, LaLonde and Sullivan (1993) of income losses experienced by long-tenured displaced workers in 80s.

Subsequent studies of Sargent and Ljungqvist (2005, 2006a, 2006b) are used to corroborate the results so far obtained. Sargent and Ljungqvist (2005) extend the former model by adding firing costs, aging and stochastic on-the-job wage changes. These allow to explain (1) the European success story of 60s, when Europe — while offering higher unemployment protection — maintained lower unemployment rates than the US, and (2) a substantial rise from 70s onwards in long-term unemployment among older workers. Sargent and Ljungqvist (2006a and 2006b), on the other hand, place the model into matching, search-island and representative family frameworks.

In turn, the phenomenon of the Great Moderation — a decline in the volatility at the aggregate level in the US and internationally — has been well documented, starting with Kim and Nelson (1999) and Blanchard and Simon (2000). Since then a lot of work has been done to uncover and explain the fall in volatility in numerous macro series for numerous countries (for survey and some analysis see Cecchetti, Flores-Lagunes and Krause 2006, Summers 2005, Trehan 2005). Most commonly advocated as lying behind the Great Moderation are monetary policy (Clarida, Gali and Gerler 2000, Castelnuovo 2006), good luck in the form of favourable shocks (Stock and Watson 2002, 2003, 2005, Gordon 2005), or structural change. The latter includes the popular hypotheses of improved inventory management influenced by advances in information technology (McConnel and Perez-Quiros 2000, Khan, McConnell and Perez-Quiros 2005), financial markets deregulation (Dynan, Elmendorf and Sichel 2005), sectoral reallocation away from volatile manufacturing (Eggers-Ioannides 2006) and opening to international competition (Barrell and Gottschalk 2004). In reality it is likely that many of the above have taken place simultaneously[1].

Can the model of Sargent and Ljungqvist (1998) based on micro turbulence be consistent with macro data? Interestingly, the structural drivers of micro level turbulence to human capital as named my Sargent and Ljungqvist (1998) are identical to those identified in literature as the drivers of declining aggregate volatility. Moreover, there is observed dichotomy between declining aggregate volatility and growing instability at the disaggregated level. For example, while the volatility of aggregate consumption and residential housing component of GDP fell, individual consumption became more unstable (Blundell and Preston 1998), which could well reflect higher dispersion of incomes *à la* Gottschalk and

[1]A lot of effort has gone into attempts to reconcile these claims. Khan and McConnell (2005) argue that new inventory control is consistent with smaller shocks hypothesis as agents make smaller mistakes and better neutralise external shocks. This is parallel to improved monetary policy where central banks create themselves smaller shocks and better react to the arriving disturbances. Hence, if structural change is not explicitly captured in a macro model, the estimation may wrongly attribute the reduction in volatility to good luck. Moreover, smaller shocks can be confused with monetary policy if not carefully modelled. Gordon (2005) finds that, controlling for supply shocks, monetary policy has not contributed to reducing volatility. In fact the volatility of output gap is in 1/3 due to favourable supply shocks (different price variables included) and in 2/3 due to favourable demand shocks (less volatile government spending due to lower military expenditures; less volatile inventories due to improvements in information technology and alike; and less volatile residential housing due to financial market reforms). Bivin (2006) shows that smaller shocks indeed account for most of stabilisation of GDP, and the components affected are predominantly inventories and residential investment. Finally, it is difficult to distinguish the effects due to monetary policy from the effects due to changes in institutional environment and financial structure (Ceccheti et al. 2006). As for the timing of volatility decline and its underlying causes, while most view the Great Moderation as a break point in 80s, which could be consistent with monetary policy change, there is also some evidence that the Great Moderation has been a trend (Blanchard and Simon 2000, or Stock and Watson 2002, 2005, for only some series and some countries), which could be consistent with more gradual structural change.

Moffitt (1994). Further, Comin and Mulani (2005, 2006) document discrepancy at firm versus aggregate level volatility in sales and productivity. Comin and Philippon (2005) set a decline in aggregate volatility against a rise in different measures of firm volatility (sales, equity returns, credit rankings, credit spreads). Comin and co-authors show through variance decomposition of their series that the fall in volatility at the aggregate is due to a fall in the correlation between sectors, and propose an endogenous growth model with RnD and General Innovation to explain jointly the diverging micro and macro trends in the time of structural change such as financial innovation.

Directly of interest to our focus on labour markets are the findings that relate firm level volatility to labour market outcomes. Comin, Groshen and Rabin (2006) show a positive relationship between firm level volatility and dispersion of wages at occupational levels. Hence there are real economic risks pertaining to firm volatility. Guvenen and Philippon (2006) conclude that firm level volatility measured across industries in COMPUSTAT is a good predictor of employment risk and wage inequality in PSID. Consequently, there is a clear link between structural change, leading to firm level volatility, and turbulent individual labour market outcomes that could be modeled as an idiosyncratic shock at micro level as in Sargent and Ljungqvist (1998).

Our aim is to uncover implications for the labour market volatility at the aggregate (productivity, real wages, GDP, employment) arising from frictions and adjustment costs inherent in a search model, and labour market policy, when micro turbulence increases. Dichotomy in the volatility and correlation of hours and employment at plant and aggregate levels can already to some extent be explained by accounting for employment adjustment costs. Work on adjustment costs on the demand side (Cooper, Haltiwanger and Willis 2004) shows that non-convexities of costs are crucial, but not sufficient, to explaining plant level moments consistent with aggregate observations. A broader treatment of frictions is desirable and search frictions on the supply side are a good candidate. McCall's (1970) search model as applied by Sargent and Ljungqvist (1998) is the simplest model of one-sided search.

In this study, we first look at macro series of real wages and productivity, and real GDP and employment, for a number of countries, to show a decline in aggregate volatility in the series of interest since 80s. We then generate macro series based on Sargent and Ljungqvist (1998) model and establish what sort of aggregate volatility it predicts for welfare and laissez-faire economies under different degrees of turbulence, and whether it is consistent with macro data. Finally, we look at the mechanisms behind the results.

2 Aggregate volatility in the data

2.1 Stock and Watson (2002, 2003, 2005) — too long but for info for now...

Stock and Watson's is probably the most comprehensive in literature documentation of volatility moderation. Stock and Watson (2002, 2003, 2005) analyse the volatility of aggregate variables for the period 1960-2000. First they use a large number of time series for the US only. Subsequently, they study the real GDP per capita for the US, UK, Canada, France, Germany, Italy and Japan. Their aim is to provide a concise summary of empirical facts pertaining to the moderation of volatility and to search for possible explanations of the phenomenon.

Stock and Watson (2002) use 1959-2001 NIPA decomposition of real GDP and a number of series such as employment, money, credit, industrial production and alike from DRI-McGraw Hill Basic database in quarterly data, seasonally adjusted when available. Sample means and standard deviations are reported by decades, the latter relative to the full sample standard deviations. Plotted are the raw estimates of volatility in the form of absolute deviations from the mean. Smooth instantaneous time-varying standard deviations are estimated with non-Gaussian smoother, based on AR(4) with time-varying parameters and stochastic volatility. Historical volatility description points out to lower aggregate volatility in 80s and significantly lower aggregate volatility in 90s. Stock and Watson (2002) uncover the source of the moderation to be predominantly a break (and not a trend) in the variance (rather than the mean) of AR process around 1983 for the US. They also find that the break results from a change in impulse, rather than propagation. Finally they estimate that 20-30% of the improvement is due to better policy, 20-30% is due to favourable productivity and commodity price shocks and 40-60% is due to other good-luck factors.

Stock and Watson (2005) look at the quarterly real GDP per capita of G7 countries for 1960-2002 and find a moderation in aggregate volatility. Moreover, they show that business cycles have not become more synchronised although trade flows have increased, financial markets developed and economies have become more integrated. They attribute the reduction in volatility largely to the reduction in the magnitude of common international shocks. Similarly to the previous study, sample means and standard deviations are reported by decades. Smoothed instantaneous standard deviations are calculated using non-Gaussian smoother for two alternatives: detrended quarterly GDP growth and band-pass filtered GDP growth. The excercise shows a fall in volatility in all countries, although the pattern of change is not identical: volatility reduction is less marked in France, it is gradual in Germany, starts in the UK in 70s and resurfaces in Japan in 90s. Regarding the source and dating of the moderation, in five countries the tests of constant conditional mean are rejected (except the US and Germany) and most commonly the mean breaks in mid 70s. In six countries the tests of constant conditional variance are rejected (except Japan) and most commonly the variance breaks around 1980. Tests for the moderation in conditional variance being a trend or a break, and their timing, show mixed patterns[2].

For the G7, Stock and Watson (2003) estimate four macro models (Rudebusch-Svensson, Stock-Watson SVAR, Smets-Wouters US, Smets-Wouters EU) and conclude that monetary policy is responsible for only a small fraction of volatility reduction. Most of moderation at business cycle frequencies seems to come from a favourable inward shift of inflation-output frontier. Is the shift permanent or transitory? Permanent shift would be expected due to structural change (innovation, deregulation), while transitory shift would rather be due to relatively quiet macroeconomic environment (quiesent macro shocks, absence of major supply disturbances). Stock and Watson (2003) conclude in favour of the latter.

2.2 Data description

To start with, we look at productivity, real wage, GDP and employment series for the US — an example of a laissez-faire economy — and three European countries: Italy, France and West Germany. Series for real wages, productivity (real GDP per worker), GDP and employment are quarterly and seasonally adjusted data.

The source of the series for wages in manufacturing and CPI for all countries (1960-2005) are Comparative Subject Tables in OECD Main Economic Indicators, hence we are able to calculate real wages for the four economies for the entire period. Real GDP series for the US, Italy, France (1960-2002) and West Germany (1960-1990) are Stock and Watson series available online. Employment data for the USA (1960-2005), Italy (1960-2005) and West Germany (1962-2004) come from Comparative Subject Tables in OECD Main Economic Indicators. Employment for France (1965-2004) is drawn from OECD Quarterly Labour Force Survey. We accordingly obtain the series of real GDP per worker for the US and Italy (1960-2002), France (1965-2002) and West Germany (1962-1990).

So constructed series are transformed into quarterly growth rates and detrended using Hodrick-Prescott filter with lambda equal 1600.

2.3 Volatility since 1960s

Figures 1-4 show detrended quarterly growth in real wages and productivity for the US, Italy, France and West Germany. Tables 1-4 report the sample means, standard deviations and standard deviations relative to full-period standard deviations for both series for the four countries by decade and by two-decade periods (60s and 70s versus 80s and 90s).

[2]In particular, of interest to us for the US and Europe: US - break (1983); UK - trend and break (1980); GE - neither trend nor break are significant in a nested model but break is significant in a separate test (1993), although significant moderation is clearly observed already from late 60s; FR - as in Germany but break is significant in 1968; IT - conditional variance breaks in 1980 but there is also a declining trend.

Apart from the US, where real wages in 80s and 90s were more volatile than in 60s, but not 70s, wage volatility has decreased with respect to any previous decade in all countries both in 80s and 90s. Moreover, 90s were always less volatile than 80s. Looking at 1960-1979 versus 1980-2005, standard deviations relative to full sample standard deviations decreased in the US, halved in Germany and more than halved in Italy and France.

The volatility of productivity growth by decade, in 60s and 70s, was higher than thereafter in all countries except West Germany where it stayed roughly leveled throughout the sample period, and we do not have data for West Germany for 90s. 90s were less volatile than 80s in the US and France. Italy had 90s more turbulent than 80s, however clearly less turbulent than 70s. Two-decade relative standard deviations halved in France and were forty percent lower in the US and Italy.

Welfare economies of Europe depict a stronger fall in volatility than our laissez-faire economy.

2.4 Still to do...Now in progress

The above are very crude and untested measures of volatility. For completeness, for all our series of interest we should test the significance of variance changes between two-decade periods as in Table 2 and 4. We will proceed with the method of Stock and Watson (2002, 2005) to estimate instantaneous time-varying standard deviations, test whether lower volatility is due to changes in conditional mean or variance, whether the changes are due to a trend or a break, and estimate the break dates.

Stock and Watson (2005) perform tests for G7 only for real GDP per capita series. We are predominantly interested in real GDP per worker and real wages. For the US only, and for the series of interest to us, Stock and Watson (2002) find that (1) real GDP exhibits a break in volatility in the second quarter of 1983; (2) civilian employment and non-agricultural employment volatility breaks in the fourth quarter of 1984; (3) the volatility of real wages in manufacturing shows a break in conditional variance in the first quarter of 1983 and a break in conditional mean already in the first quarter of 1971. Hence for the moment, statistical significance of reduced volatility is established for our series of interest only in the US....

3 Aggregate volatility in Sargent and Ljungqvist (1998) model

3.1 The model

Let us briefly recall the workings of Sargent and Ljungqvist's (1998) economy. A continuum of workers have geometrically distributed life spans, indexed on the unit interval. Every period, a worker faces a probability of dying. Births equal deaths. The unemployed search for jobs with endogenously chosen search intensity which is costly. Wage offers, drawn from a specified normal distribution, arrive each period with a probability being a function of the worker's search effort in the previous period. If the worker accepts the wage offer, he is paid that particular wage for the duration of the match. He can be laid off with an exogenous probability.

There is a finite number of skill levels. An unemployed worker of given skill faces an exogenous probability that, when he enters into the next period, his skill will depreciated by one level. Otherwise, his skill will remained the same. Similarly, an employed worker faces an exogenous probability that in the next period, if he is not laid off, his skill will increase by one level. In the period following a lay-off, skill loss probability depends on the degree of economic turbulence. Thereafter, skill transition is governed by the stochastic process as in unemployment. When there is no turbulence, a laid-off worker carries into the spell of unemployment the skill level from his last period of employment. Otherwise, skill loss is determined according to the left half of a normal distribution, with the range from the lowest skill level to to the skill right before the lay-off. Higher turbulence is associate with a higher variance of such a distribution.

After observing the skill level at the beginning of a period, a worker decides whether to accept a wage offer, chooses his search intensity or quits his job. He does so after maximising the expected value, conditional on current information, of after-tax income from employment and unemployment, net of the disutility of search. The analysis is focused on the effect of the welfare state on labour market incentives and skill accumulation.

In a welfare economy, laid-off workers receive unemployment compensation which depends on their last earnings. The benefit is withdrawn if the worker rejects an offer with earnings regarded by the government as suitable in the light of the worker's past earnings. The new-born and quitters are not entitled to benefits. Incomes both from employment and unemployment are subject to a flat income tax. Government maintains balanced budget.

The solution of the model consists of the functions giving (1) optimal search intensity and reservation wages depending on past earnings and current skill for the unemployed eligible for unemployment benefits; (2) optimal search intensity and reservation wages as a function of current skill only for the unemployed not eligible for the unemployment compensation; and (3) reservation wages depending only on current skill for the employed.

Steady state of the economy is defined by the above optimal polices, time-invariant employment and unemployment distributions, government policy parameters and total unemployment benefit payments that satisfy workers' optimality conditions and the government's budget constraint. Steady states are computed in an iterative procedure as a fixed point in the tax rate. For a fixed tax rate, optimal search intensities and reservation wages, stationary employment and unemployment distributions and total unemployment compensation are calculated. A fixed point tax rate, associated with a stationary equilibrium, is defined by a balanced government budget. For all stationary equilibria, aggregate measures such as GDP, average (real) wages and average productivity are computed.

3.2 Calibration

We follow calibration as in Sargent and Ljungqvist (1998) but redefine the model in quarters, rather than two-week periods, to compare the predicted aggregate variables to quarterly data. For that purpose, we introduce eleven, rather than twenty one, skill levels and redefine the probabilities of skill changes. We adjust the subjective discount factor and the probabilities of dying and being fired. Details forthcoming....Most importantly, as in the original paper, zero, low and high turbulence are defined by the variances of skill losses at lay off equal to 0, 0.02 and 0.04, respectively. These are the values the authors use to reproduce Gottschalk and Moffitt (1994) and Jacobson et al. (1993) results.

3.3 Steady states

To start with, we reproduce the steady state results as in Sargent and Ljungvist (1998) for a laissez-faire and welfare economies for the three degrees of economic turbulence. The details of interest to our agenda are in Table 5. In no-turbulence scenarios, both economies have very similar steady states, so the efficiency costs pertaining to the welfare state are very low when economic conditions are stable. As turbulence rises, the welfare state exhibits significantly lower employment rate. The result obtains from the discouragement effect due to generous welfare provisions when unemployed and their negative effect on search intensity and reservation wages. Moreover, higher labour taxation required to finance the growing welfare economy's needs makes work less attractive. In a laissez-faire economy, employment actually increases. As shown in the original article, due to a greater skill loss, workers fall into the category of unemployment that is characterised by low reservation wages. Finally, the profiles of average wages, productivity and GDP are very similar across the two economies. This reflects the low job finding rates of the long-term unemployed with low skill levels in a welfare state.

3.4 Data generating process

We generate aggregate data from the model for low and high turbulence periods for laissez-faire and welfare economies. For the specified parameters, the equilibrium of the model yields a stationary probability distribution over individuals characterised by a triplet of state variables - skill level h, wage w, the earnings class I to which past earnings belong, and a state variable v recording whether an individual is employed, involuntarily unemployed (and receiving benefits in a welfare economy), or voluntarily unemployed. Moreover, the equilibrium produces transition dynamics for that distribution of individuals. Specifically, the transitions follow

$$x'(h', w', I', v') = G(s_e, s_u, s_l, h, w, I, v)\, x(h, w, I, v) + b,$$

where x and x' are the distributions of individuals this and next periods, G is the transition matrix and b is the vector of births. G depends on the Markov processes that govern the transition of skills when employed, unemployed or laid off. In stationary equilibrium $\bar{G}$ is such that $x' = x$.

We simulate one hundred economies over eighty periods (twenty years: 60s-70s versus 80s-90s) for four cases — laissez-faire economy in low turbulence (LF T=0.02), laissez-faire economy in high turbulence (LF T=0.04), welfare economy in low turbulence (WE T=0.02) and welfare economy in high turbulence (WE T=0.04). Economies are initiated at the model-predicted equilibrium distributions. Government policies are kept at their equilibrium levels and any additional spending on unemployment compensations is financed by lump sum taxation. Using a random number generator, for laissez-faire and welfare economies, we generate one hundred of eighty-period sequences of shocks to individual skills for the employed and unemployed, s_e and s_u, giving us one hundred different economies for the two state types. Subsequently, using a random number generator, we produce for each laissez faire and welfare economy an eighty-period sequence of shocks to skills for the laid off in tranquil and turbulent times: $s_l^{T=0.02}$ and $s_l^{T=0.04}$. Since the model predicts individual equilibrium polices, that is search intensities and reservation wages, these are used to determine individual transition dynamics conditional on the shocks generated for each individual. Hence for the four scenarios, we obtain an eighty-period sequence for the transition matrix G which is used to calculate aggregate variables of interest in each period. Specifically:

$$U_i = \sum_i x_i,$$

$$U_v = \sum_v x_v,$$

$$U = U_i + U_v,$$

$$N = 1 - U,$$

$$GDP = \sum_e e\, x(e)\, N \qquad e = h\, w,$$

$$\bar{w} = \sum_w x(w)\, w,$$

$$p = \frac{GDP}{N}$$

are involuntary unemployment, voluntary unemployment, total unemployment and employment, GDP, average wage and productivity. GDP is expressed as the total of taxable earnings, with earnings being a product of a skill level and a wage.

3.5 Properties of artificial data

Data generated by the model is turned into quarterly growth rates and passed through an HP filter with lambda of 1600. Graphs of quarterly growth variables predicted by the model are in Figures 5-6. Volatility of average wages both for laissez-faire and welfare economies falls visibly. The result for productivity is less obvious. Table 6 contains descriptive statistics from the simulated data. Variances pooled across experiments show a decrease in volatility for average wages for both economies, a small decrease in the volatility of productivity in a laissez-faire state and a small increase in the volatility of productivity for a welfare economy. F-tests for pooled variance equality, depicted in Table 7, show that these changes are very significant with the exception of the welfare state's productivity.

Because in Bartlett tests (Table 8 (Remember that shocks are drawn from normal distribution, and in the light of descriptive statistics in Table 6, I think Bartlett does fine here...)) for the equality of variances between one hundred simulated economies in each of the four experiments (LF T=0.02, LF T=0.04, WE T=0.03, WE T=0.04) the null hypothesis is always rejected — plausible in the light of descriptive statistics for max and min variances in each experiment, and to better understand the strength of volatility change in LF as opposed to WE economies, we perform individual variance tests for significance. As can be seen from Table 9, the variance of real wages decreases significantly 29 times in the laissez-faire case and 46 times in the welfare economy. As for the productivity, the volatility decreases significantly 19 times in the laissez-faire case and broadly remains unchanged in the welfare case.

At this point it is fair to say that the model can potentially be consistent with lower aggregate volatility of real wages at the time of higher turbulence at the micro level. It also seems that the fall in volatility is stronger for the welfare economy, which is plausible since discouragement effect of the welfare state causes the agents to fall out of the working population, and moreover it is consistent with our real data for the US versus Italy, France or Germany. However, the volatility of average productivity seems rather unaffected.

To shed more light on the direction of volatility changes in the model, let us look at the properties of aggregate series for GDP and employment. These are presented in Figures 7-8. GDP and employment show a decrease in aggregate volatility when micro turbulence rises. Pooled variance tests show that the decrease in GDP and employment volatility are significant for both laissez-faire and welfare economies. Individual variance tests show that in the laissez-faire economies standard deviations of GDP falls significantly 81 out of one hundred times, while in the welfare economies a significant downward shift takes place all 100 times. Employment volatility decreases 31 times in the laissez-faire case and 58 times in the welfare states. Hence, again the welfare state is more likely to see lower aggregate volatility, this time in employment, when micro turbulence rises.

Intuitively, it is plausible with the volatility changes of GDP and employment that the volatility of productivity may remain stable in the model. There remains the question why GDP fluctuations diminish so much more in the welfare state when micro turbulence rises. Recall that GDP is the function of taxable earnings and employment. From the reproduction of Gottschalk and Moffit's (1994) results, Sargent and Ljungvist (1998) conclude that the model is consistent with the variance of individual earnings increasing in the laissez-faire economy. Then the decrease in the volatility of employment and in the fractions of population in given skill-employment category must dominate. It must then be even more so the case in the welfare state....This could be checked with the model.....(What is the change over time in the variance of individual earnings in real data in a welfare state by the way...e.g. for France....??)

4 Discussion

It is too early to decidedly judge about the model....
1. As mentioned in section 2.3, for completeness, we need tests for the significance of volatility changes for real wages, productivity, GDP and employment for all considered countries and not only US — that is currently in progress...
2. Along the lines of Gali (1999), models should not be compared to unconditional moments from the data but to the moments conditional on the shocks that are in the model....but how to isolate such micro level shocks as in Sargent and Ljungqvist? One way would be to focus only on structural/productivity shocks in SVAR.
3. Does calibration matter? To check that out.
4. Other moments from the model could be looked at, e.g. autocorrelations and cross-correlations between the variables, to assess RBC properties of the model...Especially interesting would be pairs employment-wages and employment-productivity which seem to co-move in a fashion unlike in the standard RBC..
5. Sargent and Ljungvist's (2005) extension of the model to aging and stochastic wage increases during the match could potentially yield different predictions at the aggregate, in particular a more volatile average wage.
6. Sargent and Ljungqvist's (2006a) extension in the matching framework would maybe be more conducive to the study of RBC properties...Moreover, matching framework better relates individual incentives and outcomes to aggregate conditions.... Most important, however, it would be a way of modeling the demand side explicitly...Match productivity here is worker's productivity hit by turbulence. Wages are formed in Nash bargaining. For further research.

5 Conclusion

In this study we have looked at the model of Sargent and Ljungqvist (1998) which imputes the persistence of long term unemployment in Europe since 80s to the welfare state's inability to cope with more turbulent times. The authors claim that global economic conditions have been more turbulent in 80s and 90s, and construct a model based on search with a turbulence at micro level to reproduce the evolution of unemployment in laissez-faire and welfare economies. Stock and Watson (2002, 2003, 2005), on the other hand, document a fall in aggregate volatility of macro series in the US and G7 countries since 80s. We attempt to reconcile these two findings. Can the model of Sargent and Ljungqvist (1998) based on micro turbulence be consistent with macro data? We look at macro series of productivity and real wages for a number of countries and find a decline in aggregate volatility since 80s. We then generate macro series based on Sargent and Ljungqvist (1998) model and establish what sort of aggregate volatility it predicts for welfare and laissez-faire economies under different degrees of turbulence, and whether it is consistent with macro data. Possibly so.

References

[1] Barrell, R., Gottschalk, P. (2004): "The volatility of the output gap in G7", *National Institute Economic Review*, 108, 100-107.

[2] Blanchard, O., Simon, J. (2001): "The Long and Large Decline in US Output Volatility", *BPEA* 1, 135-164.

[3] Bivin, D. (2006): "Decomposing the contribution of smaller shocks to the stabilisation of GDP", *Economic Letters*, 91, 444-449.

[4] Blundell, R., Preston, I. (1998): "Consumption Inequality and Income Uncertainty", *Quarterly Journal of Economics*, 113 (2), 603-640.

[5] Caballero, R., Engel, E. (1993): "Microeconomic Adjustement Hazards and Aggregate Dynamics", *Quarterly Journal of Eonomics*, 108, 313-58.

[6] Caballero, R., Engel, E., Haltiwanger, J. (1997): "Aggregate Employment Dynamics: Building from Microeconomic Evidence", *American Economic Review*, 87, 115-37.

[7] Castelnuovo, E. (2006): "Assessing different drivers of the great moderation", Marco Fanno WP 25.

[8] Cecchetti, S.G., Flores-Lagunes, A., Krause, S. (2006): "Assessing the sources of changes in the volatility of real growth", NBER 11946.

[9] Clarida, R., Gali, J., Gertler, M. (2000): "Monetary Policy Rules and Macroeconomic Stability", *Quarterly Journal of Economics*, 15 (1), 147-180.

[10] Comin, D., Groshen, E.L., Rabin, B. (2006): "Turbulent firms, turbulent wages?", NBER WP 12032.

[11] Comin, D., Mulani, S. (2006): "Diverging Trends in Macro and Micro volatility: Facts", *Review of Economics and Statistics*, 88 (2), 374-83.

[12] Comin, D., Mulani, S. (2005): "A Theory of Growth and Volatility at the Aggregate and Firm Level", NBER WP 11503.

[13] Comin, D., Philippon, T. (2005): "The rise in firm level volatility: causes and consequences", NBER WP 11388.

[14] Cooper, R., Haltiwanger, J. (1993): "On the aggregate implications of machine replacement: theory and evidence", *American Economic Review*, 83, 360-82.

[15] Cooper, R., Haltiwanger, J., Power, L. (1999): "Machine Replcement and the Business Cycle: Lumps and Bumps", *American Economic Review*, 89, 921-946.

[16] Cooper, R., Haltiwanger, J.C., Willis, J. (2004): "Dynamics of Labor Demand: Evidence from Plant-level Observations and Aggregate Implications", NBER WP 10297.

[17] Eggers, A., Ioannides, Y.M. (2006): "The role of output composition in the stabilisation of US output growth", *Journal of Macroeconomics*, 28, 585-595.

[18] Dynan, K.E., Elmendorf, D.W., Sichel, D.E. (2005): "Can financial innovation help explain the reduced volatility", FRB Washington WP 54.

[19] Gordon, R. (2005): "What caused the decline in US BC volatility?", CEPR WP 5413.

[20] Gali, J. (1999): "Technology, Employment and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?", *American Economic Review*, 89 (1), 249-271

[21] Gottschalk, P., Moffitt, R. (1994): "The Growth of Earnings Inequality in the US Labour Market", *Brooking Papers on Economic Activity*, 2, 217-54.

[22] Guvenen, F., Philippon, T. (2006): "Firm volatility and wage inequality", mimeo.

[23] Jacobson, L.S., LaLonde, R.J., Sullivan, D.G. (1993): "Earnings Losses of Displaced Workers", *American Economic Review*, 83, 685-709.

[24] Khan, J.,McConnell M.M., Perez-Quiros, G. (2002): "On the causes of the increased stability", *FRB New York Economic Policy Review*, 8 (1), 183-202.

[25] Khan, J., McConnell, M.M. (2005): "The decline in US output volatility: what luck got to do with it?", FRB New York, mimeo.

[26] Kim, C.J., Nelson, C.R. (1999): "Has the US Economy Become More Stable? A Bayesian Approach Based on a Markov-Switching Models of the Business Cycle", *Review of Economics and Statistics*, 81 (4), 608-616.

[27] McCall, J. (1970): "Economics of Information and Job Search", QJE 84 (1), 113-126.

[28] McConnell, M., Perez-Quiros, G. (2000): "Output Fluctuations in the United States: What Has Changed Since Early 1980s?", *American Economic Review*, 90 (5), 1464-76.

[29] Rios-Rull, J.V. (1995): "Models with Heterogeneous Agents", in Frontiers of Business Cycles Research, ed. by Tom Cooley, Princeton University Press, Princeton.

[30] Rios-Rull, J.V. (1999): "Computation of Equilibria in Heterogenous Agent Models", in Computational Methods for the Study of Dynamic Economies: An Introduction, ed. by Ramón Marimón and Andrew Scott, Oxford University Press.

[31] Sargent T., Ljungqvist, L. (1998): "The European Unemployment Dilemma", *Journal of Political Economy*, 106 (3), 514-550.

[32] Sargent T., Ljungqvist, L. (2005): "The European Unemployment Experience: Obsolescence, Uncertainty and Heterogeneity", mimeo.

[33] Sargent T., Ljungqvist, L. (2006a): "Understanding European Unemployment with Matching and Search-Island Models", mimeo.

[34] Sargent T., Ljungqvist, L. (2006b): "Understanding European Unemployment with a Representative Family Model", mimeo.

[35] Snedecor, G.W., Cochran, W.G. (1967): "Statistical Methods", Sixth Edition, Iowa State University Press.

[36] Stock, J.H., Watson, M.W. (2002): "Has the Business Cycles Changed and Why?", NBER WP 9127; *NBER Macroeconomics Annual* (2002), 159-218.

[37] Stock, J.H., Watson, M.W. (2003): "Has the Business Cycles Changed? Evidence and Explanations" in *Monetary Policy and Uncertainty: Adopting to Changing Economy*, FRB of Kansas City, 9-56.

[38] Stock, J.H., Watson, M.W. (2003): "Understanding Changes in International Business Cycle Dynamics", NBER WP 9859; *Journal of European Economic Association* (2005), 3 (5), 968-1006.

[39] Summers, P.M. (2005): "What caused the great moderation? Corss-country evidence", *FRB Kansas City Economic Review*, 3, 5-31.

[40] Trehan, B. (2005): "Why has output become less volatile?", *FRB San Francisco Economic Letter*, 1-3.

A Appendix

A.1 Data

Figure 1: Detrended quarterly real wage growth

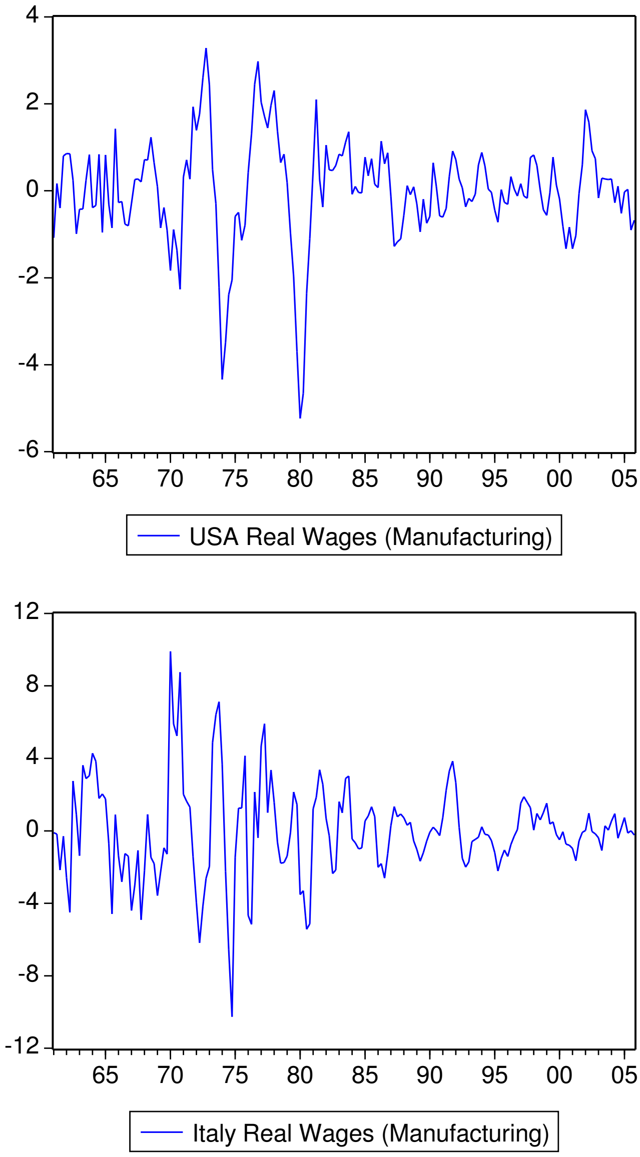
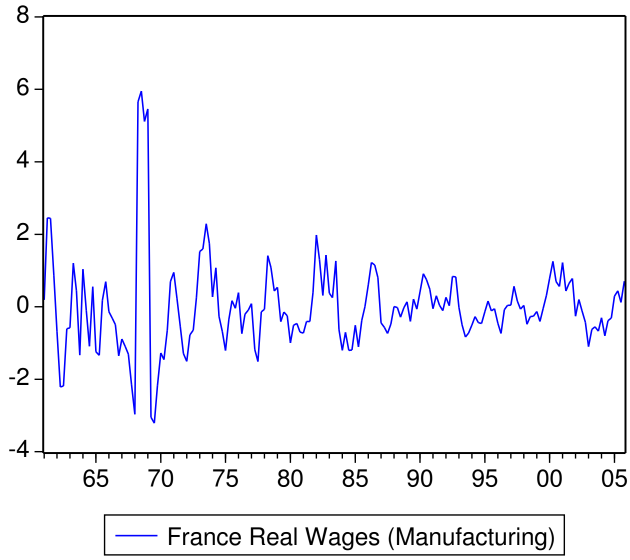


Figure 2: Detrended quarterly real wage growth ctd.



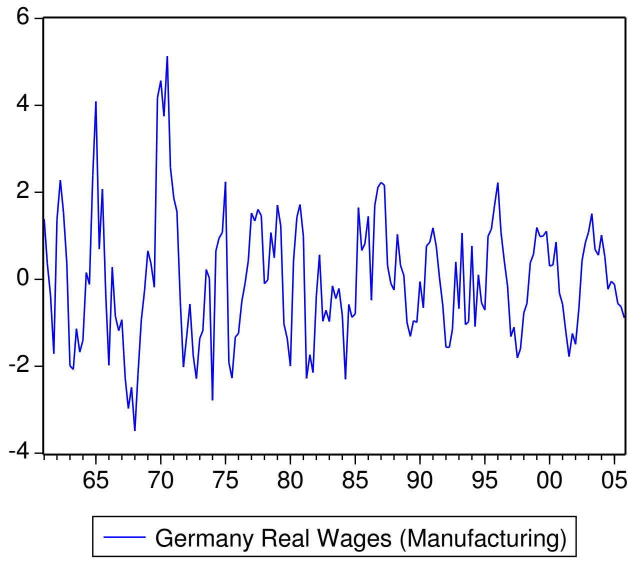
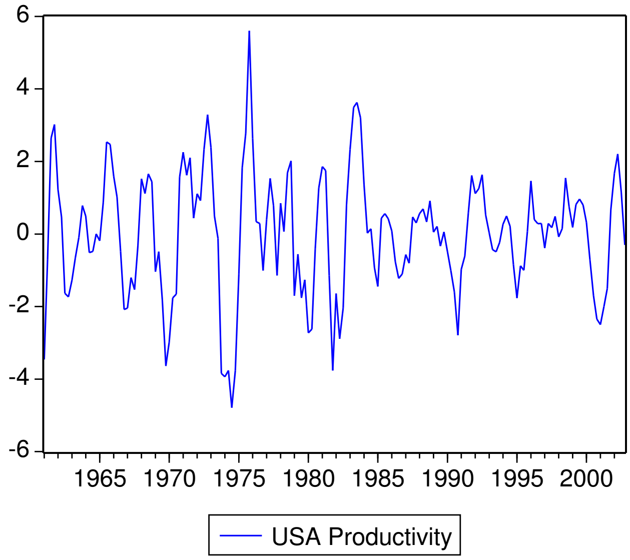


Figure 3: Detrended quarterly productivity growth



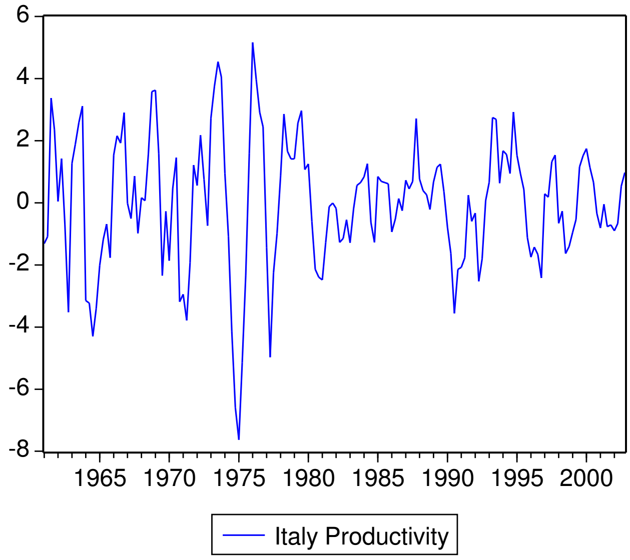
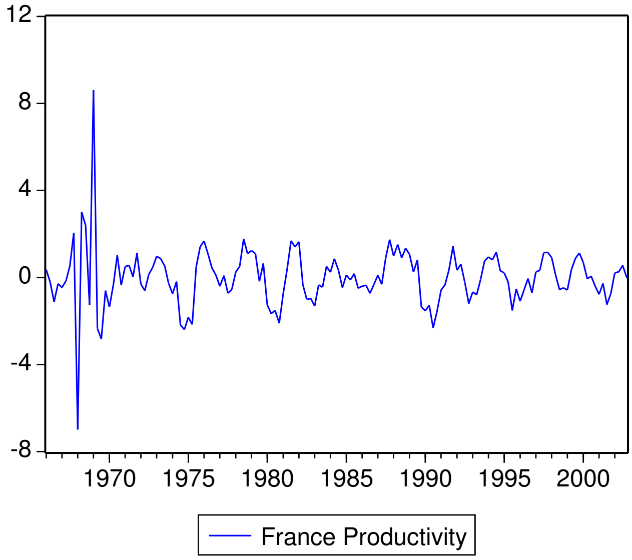


Figure 4: Detrended quarterly productivity growth ctd.



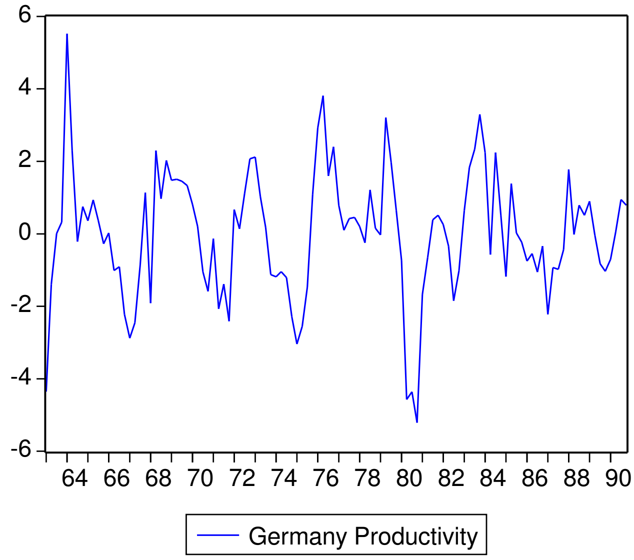


Figure 5: Average wages for LF and WE

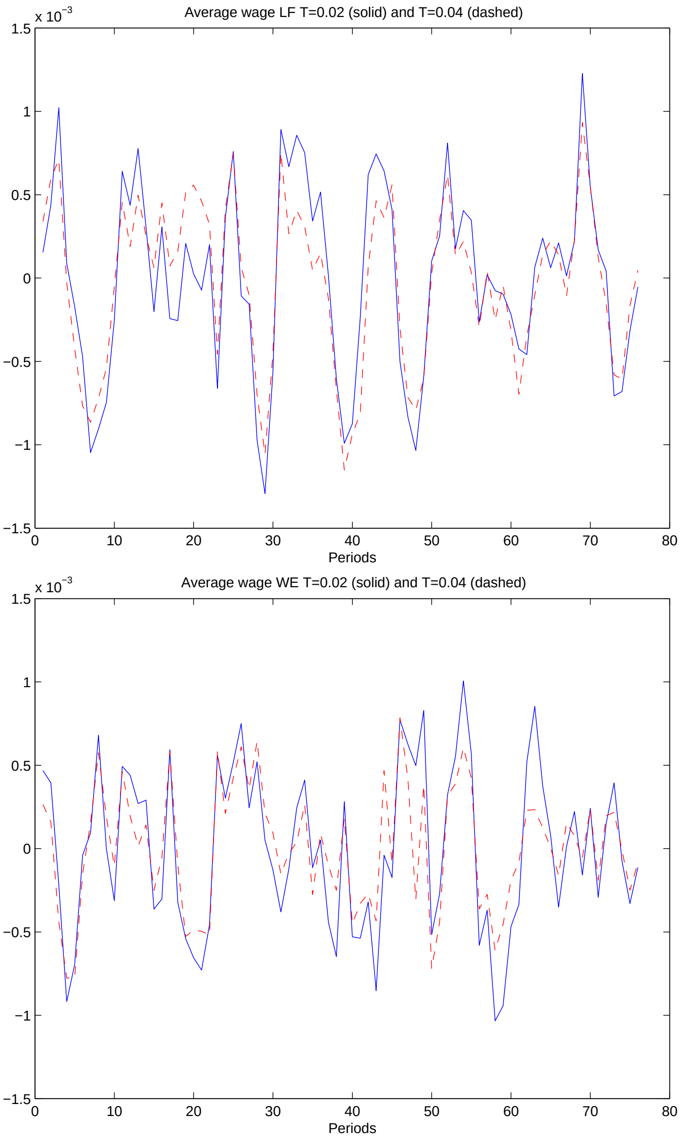


Figure 6: Productivity for LF and WE

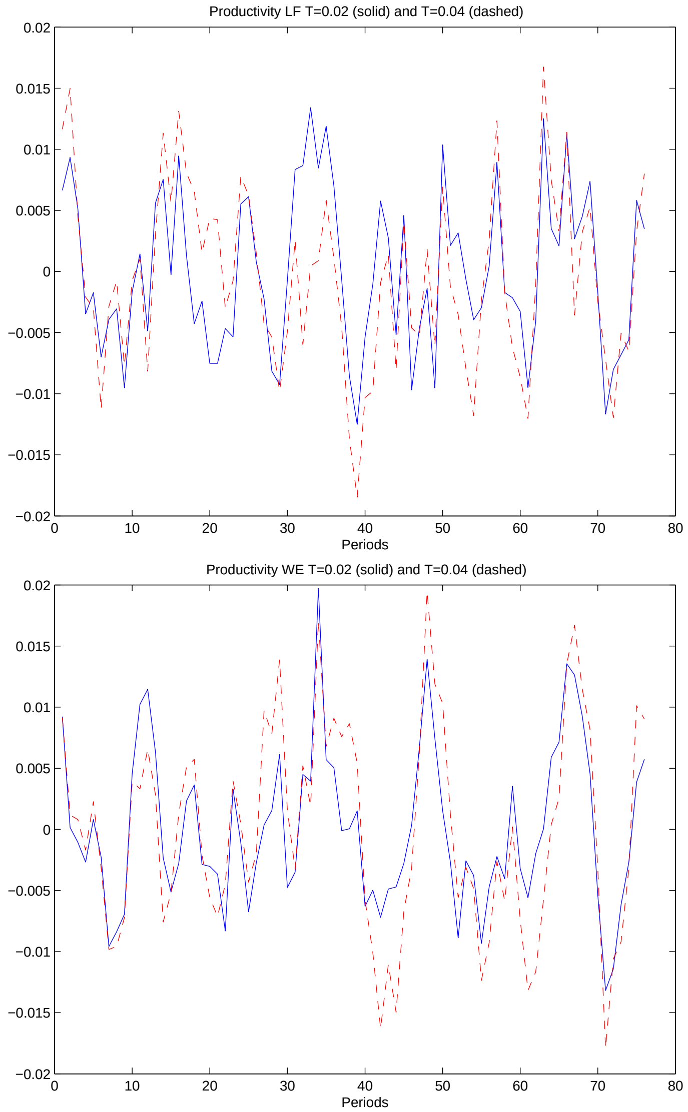


Figure 7: GDP for LF and WE

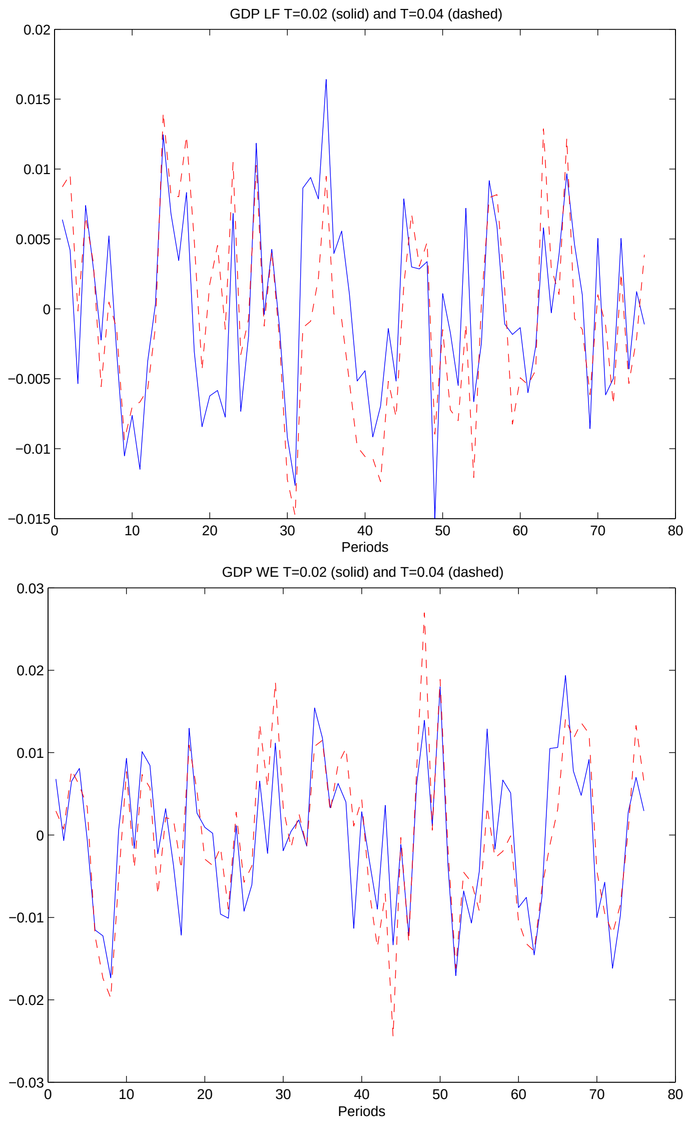


Figure 8: Employment for LF and WE

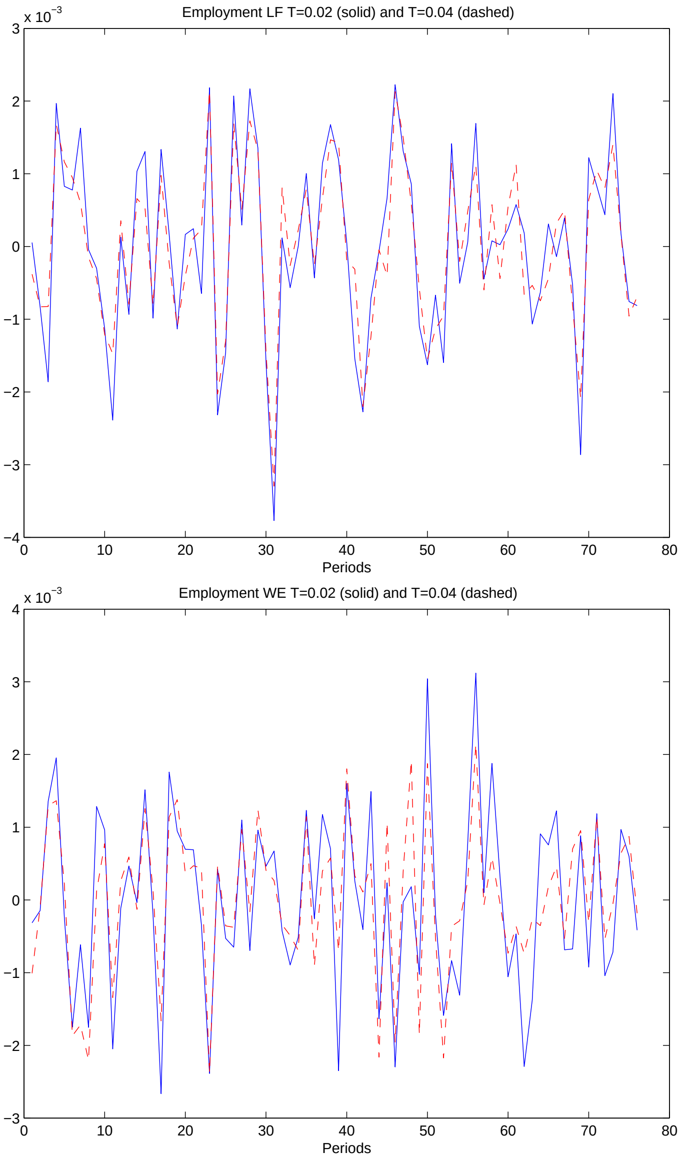


Table 1: Real wages by decade: means, standard deviations and standard deviations relative to full-period standard deviations

	Mean				
	1960-2005	**1960-1969**	**1970-1979**	**1980-1989**	**1990-2005**
US	0.355	1.623	0.798	-0.818	0.098
IT	2.602	3.878	6.905	1.047	0.167
FR	2.406	4.147	4.384	0.809	1.189
GE	2.460	5.192	3.596	1.375	0.890

	S.D.				
	1960-2005	**1960-1969**	**1970-1979**	**1980-1989**	**1990-2005**
US	1.628	0.729	2.144	1.599	0.909
IT	3.865	2.716	4.713	1.993	1.378
FR	2.200	2.608	1.502	0.939	0.831
GE	2.605	2.445	2.555	1.908	1.152

	Relative S.D.				
	1960-2005	**1960-1969**	**1970-1979**	**1980-1989**	**1990-2005**
US	1	0.448	1.317	0.982	0.558
IT	1	0.703	1.219	0.516	0.356
FR	1	1.185	0.683	0.427	0.378
GE	1	0.939	0.981	0.733	0.442

Table 2: Real wages by two decades: means, standard deviations and standard deviations relative to full-period standard deviations

	Mean		
	1960-2005	**1960-1979**	**1980-2005**
US	0.355	1.189	-0.254
IT	2.602	5.471	0.506
FR	2.406	4.272	1.043
GE	2.460	4.352	1.077

	S.D.		
	1960-2005	**1960-1979**	**1980-2005**
US	1.628	1.676	1.294
IT	3.865	4.160	1.688
FR	2.200	2.088	0.889
GE	2.605	2.613	1.499

	Relative S.D.		
	1960-2005	**1960-1979**	**1980-2005**
US	1	1.029	0.795
IT	1	1.076	0.437
FR	1	0.949	0.404
GE	1	1.003	0.575

Table 3: Productivity by decade: means, standard deviations and standard deviations relative to full-period standard deviations

	Mean				
	1960-2002	**1960-1969**	**1970-1979**	**1980-1989**	**1990-2002**
US	1.563	2.687	0.836	1.256	1.580
IT	2.912	6.041	3.254	1.951	1.222
	1965-2002	**1965-1969**			
FR	1.287	3.375	2.214	1.615	0.533
	1962-2002	**1962-1969**		**1980-1990**	
GE	2.758	4.435	3.210	1.281	

	S.D.				
	1960-2002	**1960-1969**	**1970-1979**	**1980-1989**	**1990-2002**
US	1.973	2.061	2.373	1.834	1.256
IT	2.872	2.379	3.184	1.217	1.897
	1965-2002	**1965-1969**			
FR	1.675	3.2670	1.135	1.023	0.846
	1962-2002	**1962-1969**		**1980-1990**	
GE	2.241	2.002	1.582	1.980	

	Relative S.D.				
	1960-2002	**1960-1969**	**1970-1979**	**1980-1989**	**1990-2002**
US	1	1.044	1.203	0.929	0.636
IT	1	0.828	1.109	0.424	0.661
	1965-2002	**1965-1969**			
FR	1	1.952	0.677	0.610	0.505
	1962-2002	**1962-1969**		**1980-1990**	
GE	1	0.893	0.706	0.884	

Table 4: Productivity by two decades: means, standard deviations and standard deviations relative to full-period standard deviations

	Mean		
	1960-2002	**1960-1979**	**1980-2002**
US	1.563	1.713	1.439
IT	2.912	4.574	1.539
	1965-2002	**1965-1979**	
FR	1.287	2.546	1.004
	1962-2002	**1962-1979**	**1980-1990**
GE	2.758	3.714	1.281

	S.D.		
	1960-2002	**1960-1979**	**1980-2002**
US	1.973	2.403	1.534
IT	2.872	3.143	1.668
	1965-2002	**1965-1979**	
FR	1.675	2.027	1.068
	1962-2002	**1962-1979**	**1980-1990**
GE	2.241	1.855	1.980

	Relative S.D.		
	1960-2002	**1960-1979**	**1980-2002**
US	1	1.218	0.777
IT	1	1.094	0.581
	1965-2002	**1965-1979**	
FR	1	1.210	0.637
	1962-2002	**1962-1979**	**1980-1990**
GE	1	0.828	0.884

Table 5: Model steady states

Economy	**LF**	**LF**	**LF**	**WE**	**WE**	**WE**
Turbulence	0	0.02	0.04	0	0.02	0.04
Tax rate	0	0	0	0.0407	0.0462	0.102
Average wages	3.0738	3.0596	3.0589	3.0748	3.0799	3.0919
Productivity	5.746	5.3696	5.1659	5.7468	5.3831	5.1885
GDP	5.3369	4.9994	4.8102	5.3367	4.9848	4.5139
Employment	0.9288	0.9311	0.9311	0.9286	0.926	0.8699

Table 6: Descriptive

	Economy	LF	LF	WE	WE
	Turbulence	**0.02**	**0.04**	**0.02**	**0.04**
	Pooled standard deviations				
Real wage		0.1869	0.1686	0.1528	0.1324
Productivity		1.7184	1.6652	1.6175	1.6324
GDP		1.6765	1.3163	1.5815	0.4499
Employment		1.4056	1.2465	0.1528	0.1305
	Reported as in RBC Mean and s.e. of moment				
Real wage		0.1854	0.1671	0.1517	0.1314
		(0.024)	(0.0229)	(0.0187)	(0.0161)
Productivity		1.7101	1.6486	1.6095	1.6132
		(0.1688)	(0.2353)	(0.1622)	(0.2504)
GDP		1.6677	1.3098	1.5723	0.4400
		(0.172)	(0.1316)	(0.1716)	(0.0946)
Employment		1.3968	1.2387	0.1517	0.1294
		(0.1577)	(0.1399)	(0.0187)	(0.0169)
	Individual standard deviations				
Real wage	**no. sd(T=0.02)>sd(T=0.04)**	**86**		**89**	
	max	0.2473	0.2278	0.2092	0.1743
	min	0.1338	0.1135	0.1078	0.0930
	median	0.1826	0.1666	0.1521	0.1306
Productivity	**no. sd(T=0.02)>sd(T=0.04)**	**63**		**47**	
	max	2.0558	2.2645	2.0063	2.3551
	min	1.3182	1.2056	1.1380	1.1211
	median	1.7169	1.6364	1.5994	1.5953
GDP	**no. sd(T=0.02)>sd(T=0.04)**	**98**		**100**	
	max	2.0280	1.6001	1.9902	0.8440
	min	1.2008	0.9931	1.1073	0.3401
	median	1.6683	1.2862	1.5622	0.4131
Employment	**no. sd(T=0.02)>sd(T=0.04)**	**96**		**91**	
	max	1.8450	1.5922	0.2092	0.1785
	min	0.9458	0.9158	0.1078	0.0818
	median	1.1398	1.2196	0.1521	0.1281

Table 7: Pooled

	Economy	LF	WE
	Pooled variance F test df1=df2=7500		
Real wage	**F**	1.229	1.3317
	p	0	0
		sd(T=0.02)>sd(T=0.04)***	sd(T=0.02)>sd(T=0.04)***
Productivity	**F**	1.0649	0.9819
	p	0.0032	0.7854
		sd(T=0.02)>sd(T=0.04)***	sd(T=0.02)=sd(T=0.04)
GDP	**F**	1.622	12.3568
	p	0	0
		sd(T=0.02)>sd(T=0.04)***	sd(T=0.02)>sd(T=0.04)***
Employment	**F**	1.2715	1.3715
	p	0	0
		sd(T=0.02)>sd(T=0.04)***	sd(T=0.02)>sd(T=0.04)***

Ho: sd(T=0.02)=sd(T=0.04)
Ha:
1/sd(T=0.02)=/=sd(T=0.04) (two-tail test: not reject Ho if p>=alpha/2 and 1-p>=alpha/2)
2/sd(T=0.02)<sd(T=0.04) (lower-tail test: not reject Ho if 1-p>=alpha)
3/sd(T=0.02)>sd(T=0.04) (upper-tail test: not reject Ho if p>=alpha)

***(1%)
**(5%)
*(10%)

Table 8: Bartlett

	Economy	LF	LF	WE	WE
	Turbulence	**0.02**	**0.04**	**0.02**	**0.04**
	Bartlett test df=99				
Real wage	**Chi2**	200.5473	280.2825	200.5473	221.9773
	p	0	0	0	0
		not equal***	not equal***	not equal***	not equal***
Productivity	**Chi2**	145.6642	298.3191	151.5483	349.1743
	p	0.0016	0	0.0005	0
		not equal***	not equal***	not equal***	not equal***
GDP	**Chi2**	142.8157	213.7051	142.8157	213.7051
	p	0.0026	0	0.0026	0
		not equal***	not equal***	not equal***	not equal***
Employment	**Chi2**	189.7104	189.2085	226.2259	253.5659
	p	0	0	0	0
		not equal***	not equal***	not equal***	not equal***

Ho: sd(1)=...=sd(100)
Ha: not equal for at least one pair
χ^2 test: not reject Ho if p>=alpha

***(1%)
**(5%)
*(10%)

Table 9: Individual

			LF	WE
	Inidvidual F tests df1=df2=99			
Real wage		alpha=0.1*	0	2
	sd(T=0.02)<sd(T=0.04)	alpha=0.05**	0	0
		alpha=0.01***	0	0
	sd(T=0.02)=sd(T=0.04)		**71**	**52**
		alpha=0.1*	**10**	**14**
	sd(T=0.02)>sd(T=0.04)	alpha=0.05**	**12**	**16**
		alpha=0.01***	**7**	**16**
Productivity		alpha=0.1*	4	**8**
	sd(T=0.02)<sd(T=0.04)	alpha=0.05**	3	**4**
		alpha=0.01***	1	**0**
	sd(T=0.02)=sd(T=0.04)		**73**	**74**
		alpha=0.1*	**8**	**7**
	sd(T=0.02)>sd(T=0.04)	alpha=0.05**	**5**	**5**
		alpha=0.01***	**6**	**2**
GDP		alpha=0.1*	1	0
	sd(T=0.02)<sd(T=0.04)	alpha=0.05**	0	0
		alpha=0.01***	0	0
	sd(T=0.02)=sd(T=0.04)		**18**	**0**
		alpha=0.1*	**14**	**0**
	sd(T=0.02)>sd(T=0.04)	alpha=0.05**	**31**	**0**
		alpha=0.01***	**36**	**100**
Employment		alpha=0.1*	0	1
	sd(T=0.02)<sd(T=0.04)	alpha=0.05**	0	0
		alpha=0.01***	0	0
	sd(T=0.02)=sd(T=0.04)		**69**	**41**
		alpha=0.1*	**19**	**21**
	sd(T=0.02)>sd(T=0.04)	alpha=0.05**	**10**	**18**
		alpha=0.01***	**2**	**19**

Ho: sd(T=0.02)=sd(T=0.04)
Ha:
1/sd(T=0.02)=/=sd(T=0.04) (two-tail test: not reject Ho if p>=alpha/2 and 1-p>=alpha/2)
2/sd(T=0.02)<sd(T=0.04) (lower-tail test: not reject Ho if 1-p>=alpha)
3/sd(T=0.02)>sd(T=0.04) (upper-tail test: not reject Ho if p>=alpha)

***(1%)
**(5%)
*(10%)