High-growth Recoveries, Inventories and the Great Moderation*

Máximo Camacho
Universidad de Murcia

Gabriel Pérez Quirós
Banco de España and CEPR

Hugo Rodríguez Mendizábal
Instituto de Análisis Económico (CSIC) and Barcelona GSE

Abstract

We present evidence about the disappearance of the high-growth recoveries from recessions with intense job creation typically observed until the eighties. This result matches the belief that recessions now have an L-shape as opposed to the old-time recessions that always had a V-shape. We also show how this change in business cycle dynamics can explain part of the Great Moderation. We postulate that these two phenomena may be due to changes in inventory management brought about by improvements in information and communications technologies.

Keywords: Business cycle features, Great Moderation, High-growth recovery.

JEL Classification: E32, F02, C22.

*Camacho acknowledges financial support from MICINN (ECO2010-19830). Rodríguez Mendizábal thanks the support of the Barcelona GSE research network and of the Generalitat de Catalunya, as well as the financial support of the MICINN (ECO2009-07958). All remaining errors are our responsibility. We thank two anonymous referees. We also thank one anonymous referee of the Working Paper series and seminar participants at the Bank of Spain for comments and suggestions. The views in this paper are those of the authors and do not represent the views of the Bank of Spain or the Eurosystem. Corresponding author: Gabriel Pérez Quirós (gabriel.perez@bde.es).

1 Introduction

There is a traditional debate in economics on how recessions finish, i.e., whether they are "V-shaped" or "L-shaped". The former type of recession refers to the case in which the economy springs back rapidly from its slump, whereas the latter refers to the case in which the economy faces a period of flat or at best slowly improving performance. Facing either V-shaped or L-shaped recessions has both economic and econometric implications. The economic implications of facing each of these types of recoveries are evident. V-shaped recessions are viewed as evidence in favour of Friedman's plucking model (see Friedman, 1993), in which output cannot exceed a ceiling level but is occasionally plucked downward by recessions which have only temporary effects. On the contrary, recessions which are followed by flat recoveries (L-shaped) are viewed as having permanent effects on the level of production.

The econometric implications of facing these two alternative recoveries have to do with the traditional discussion regarding whether US output exhibits either a deterministic or a stochastic trend. On the one hand, Kim and Nelson (1999b) document that US recessions were usually followed by periods of very high growth which have been called the "third phases of business cycles". Having rebounds after recessions which spring the economy back to pre-recession levels can be viewed as the economic interpretation of the papers that find evidence that GDP is trend stationary and that the effects of recessions are mainly transitory. In this context, Cheung and Chinn (1999) conclude that, with a long span of data, one can obtain evidence of trend stationarity. On the other hand, if one cannot observe the rapid recoveries in output, the negative effects of recessions can be viewed as more permanent. Supporting this view, Campbell and Mankiw (1987) show that there is a considerable permanent effect of a surprise change in output.

In this paper we show that, after the eighties, business cycle recoveries have turned out to be L-shaped, so the periods following recessions are now characterized not by high growth but by lower growth than in the course of the expansion. The change in this business cycle feature roughly coincides with the jobless recoveries from the recessions since the nineties, as documented by Groshen and Potter (2003). To provide a view of the form of US recoveries, Figure 1 shows the growth rates of GDP together with the recessions as documented by the NBER. In the graph, we can observe the decline in the relevance of the high-growth recovery phase of the cycle in the last three recessions. While the end of the seven recessions prior to the mid-eighties were characterized by above-average growth rates, the recessions after that date were followed by quarterly growth rates below the average. According to our discussion above, an important consequence of the disappearance of this high-growth recovery phase is that recessions now have the potential to have long run effects on the economy.[1]

The sluggish pace of recovery in output during the recoveries since the nineties contributes to the sluggishness of job creation observed after the latest recessions. In these recoveries, Groshen and Potter (2003) find more evidence of permanent job losses than of temporary layoffs and reallocation of jobs from one industry to another. Schreft, Singh and Hodgson (2005) show that one common feature of the recent jobless recoveries was the greater use of just-in-time employment practices, the employment of temporary and part-time workers and the use of over time to achieve a more flexible workforce.

Noticeably, the loss of the high-growth recovery phase of business cycles and the evidence of jobless recoveries roughly coincide with the period of the Great Moderation previously documented by McConnell and Perez Quiros (2000) and Kim and Nelson (1999a), which has been dated in the first quarter of 1984. In this paper we present evidence to show that these two features of US business cycle dynamics may be related. According to our measures, part of the high volatility of output growth before 1984 can be explained by the existence of the high-growth recovery phase. By means of a counterfactual exercise, we show that when this phase is removed from business cycle dynamics, the statistical evidence for a structural change in the volatility of output decreases dramatically.

[1] Sichel (1994) and Kim and Murray (2002) documented the inexistence of the third phase after the 1991 recession.

In addition, we postulate that both the volatility reduction and the loss of the high-growth recovery phase can in part share the same economic sources, which are related to changing business practices. Kahn, McConnell and Perez Quiros (2002) analyze the role of inventory management as the source of reduction in output growth volatility. In addition, Davis and Kahn (2008) and Kahn (2008) directly relate the Great Moderation to changes in the role played by inventory accumulation from avoiding stockouts (see Kahn, 1997) to smoothing production. But this change in inventory management could also explain the loss of the high-growth recoveries since the eighties. According to these authors, firms maintained inventories to avoid stockouts until the eighties. In periods of low demand, inventories are low because the probability of stockout is low. As the economy exits the recessionary period, firms increase production not only to satisfy growing demand but also to replenish inventories above the level they had during the recession which would lead to recoveries with rapid growth. Using this view, Sichel (1994) stated that the high-growth recovery phase of business cycles until the eighties could be linked to inventory accumulation. However, the rapid improvements in information technology in the eighties have led firms to rationalize the use of inventories, which are now used to smooth production. In periods of low demand, firms maintain their production levels and accumulate inventories to respond to future periods of high demand. As the economy exits the recessionary periods, increasing demand would be serviced out of inventories, which explains why rapid-growth recoveries from the recent recessions have not been observed since this change in inventory management came into place.

Although we do not analyze in the paper the marginal effect of the different sources of the Great Moderation put forward in the literature, we consider that the evidence shown in McConnell and Perez Quiros (1998), Kahn, McConnell and Perez Quiros (2002), Davis and Kahn (2008) and Kahn (2008) is enough to seriously consider the hypothesis of better inventory management as a potential explanation of the reduction in volatility.[2] Instead, this paper goes further on the implications of

[2] Herrera and Pesavento (2005) found evidence against the inventories hypothesis. However, Davis and Kahn (2008) stated that their results were potentially misleading since they used disaggregated data.

this hypothesis by putting together the effect of changes in inventory management not only on the reduction in volatility but also on the loss of the high-growth phases of business cycles and, therefore, on the evidence that recoveries are now L-shaped and with sluggish job creation.

In this sense, linking the reduction in volatility observed after 1984 with the changes in the pattern of the recoveries provides some fresh insights with which to examine other theories about the causes of the Great Moderation. Basically, these other theories fall under three groups. The first group associates the Great Moderation with "good luck", understood as a reduction in the size of shocks hitting the US economy since the mid-eighties. This is the conclusion, among others, of Ahmed, Levin and Wilson (2004). A second group of papers contends that the Great Moderation is merely a consequence of "better economic policies". For example, Clarida, Galí and Gertler (2000) argue that it is the more aggressive response of the Federal Reserve to inflation that lies behind economic stability. Finally, a third group incorporates better financial intermediation as in Dynan, Elmendorf, and Sichel (2006). None of these theories have predictions about how the alleged cause of the Great Moderation changes the shape of the recovery. According to Clark (2009), these theories are also difficult to reconcile with the fact that, in spite of the severity of the 2008-2009 recession, the Great Moderation is not over.

The rest of the paper is organized as follows. Section 2 provides support for the disappearance of the high growth recovery with data on GDP. Section 3 presents a counterfactual exercise to gauge the importance of the high recovery phase in explaining the volatility of GDP growth. Section 4 relates these two phenomena to inventory management and Section 5 concludes.

2 Recoveries and the business cycle

This section includes evidence about the disappearance of the third (or high-growth) phase of the cycle after the mid eighties. We first present some descriptive statistics that summarize this evidence and then produce a more rigorous treatment of the data.

2.1 Descriptive statistics

Figure 1, which plots the growth rate of GDP for the period 1953.1 to 2010.2, shows the systematic high-growth periods exhibited immediately after most of the recessions. To carefully examine the existence of the high-growth recovery phase, Figure 2 presents the average growth rates of GDP in recessions (represented by the column labelled "rec" in the figure) together with the average growth rates in expansions (represented by the horizontal line). It also shows the average growth rates for different quarters in the expansions. Thus, the column labelled "1-2" measures the average growth rate of GDP during the first two quarters of all the expansions in the sample; the column labelled "3-4" measures the average growth rate of GDP during the third and fourth quarters of all the expansions, and so on. The figure shows that during the first two quarters after a recession the growth rate of GDP is much larger than the average growth rate within expansions. In particular, during the first two quarters of an expansion the economy grows on average at 1.43 percent as compared with the overall expansionary growth rate of 1.01 percent. Once the expansion gets on its way, the average growth rates basically coincide with the average of that phase of the cycle.

Figure 3 illustrates the disappearance of the high-growth period that followed the end of a typical pre-1990 recession. The figure presents the average growth rate of the first two quarters after each of the recessions documented by the NBER minus the average growth rates in expansions. For reference, the dates of the corresponding recession appear on the label of each column. As it is evident in the figure, right after every recession until the eighties the US economy grew at a growth rate which was above the average growth rate of expansions. This phenomenon of high-growth recoveries does not appear in the expansions that followed the recession of the 90s and the first two recessions of the 21st century. In the first two quarters of those expansions the economy grew around 0.5, 0.3 and 0.2 percentage points below the average growth rate of the expansions in the sample.

Figure 4 presents an equivalent graph as Figure 3 but for recessions. It shows the average growth rate of GDP for the first two quarters of each recession minus the average growth rate of all recessionary quarters in the sample. Unlike Figure 3, we cannot detect any discernible pattern in this series. This evidence points to the conclusion that the mid 80s have brought a change on the way the economy recovers from recessions and not on the way the economy exits the expansions.

We can provide more evidence on the disappearance of the third phase by looking at the evolution of certain business cycle features within the sample considered. Following Harding and Pagan (2002) we assume business cycles to be a recurrent sequence of recessions and expansions identified by peaks and troughs. In Figure 5, a *peak* (point P) represents the top of economic activity and indicates the end of an expansion. A *trough* (point T) corresponds to the bottom of economic activity and characterizes the end of a recession. With this figure in mind, the *duration* of an expansion is measured as the number of quarters between a trough and the following peak. Furthermore, the *amplitude* of an expansion measures how deep it is and is computed as the vertical distance between points T and P.[3] Additionally, another feature of the cycle is the *excess* defined as the difference between the actual accumulated gain in GDP during the expansion and the accumulated gain that would have occurred if the expansion had been linear. This feature is represented by the grey areas in Figure 5 and approximates the steepness of the expansion. When the excess is positive, as it happens on the left panel of Figure 5, the expansion is convex with a steep beginning and a flat end. This is the case in the presence of a high-growth recovery phase of the cycle. On the contrary, with a negative excess the expansion is smooth at the beginning and becomes sharper at the end. This case is represented on the right panel of Figure 5.

According to the previous definitions, Table 1 presents the estimates of US business cycle characteristics for the sample considered using as peaks and troughs the dates determined by the NBER dating committee. The first line includes these statistics for the whole sample between 1953.1 and 2010.2. On average, the duration of expansions is about 20 quarters while the duration

[3] The definitions of the corresponding statistics for recessions are equivalent to the ones for expansions. However because of the evidence presented in Figures 3 and 4, we concentrate only on expansions.

of recessions is below 4 quarters. Expansions mean a gain of about 21 percent with respect the value of GDP in the initial trough while recessions represent a loss of less than 2 percent of the initial GDP. Furthermore the excess is positive (1.34 percent) providing evidence for the existence of a high-growth recovery phase phase of the cycle. On the other hand, recessions seem to be linear with an excess close to zero.

The second and third lines show the estimates of the business cycle statistics but computed for the subsamples before and after 1984.1 which is the date of the structural break in volatility of US output growth documented by McConnell and Perez Quiros (2002) and Kim and Nelson (1999a). After the break, expansions are longer (they last 32 quarters instead of 17) but the duration of recessions remains at about 3.7 quarters due to the long 2008-2009 recession. Also the amplitude of expansions is larger (25.6 percent as compared with 19.6 percent) while that of recession is smaller (they go from -2.1 percent to -1.6 percent). For the interest of this paper, one important feature that has dramatically changed sign is the excess of expansions going from a positive number (1.77 percent) before 1984.1 to a negative number (-0.17 percent) after that date. Thus, expansions have gone from having a steep beginning and flat end to have a smooth beginning and sharper end.[4]

The effect of the loss of the high-growth recoveries of output on the job market deserves a final remark. According to Schreft, Singh and Hodgson (2005), the weakness of output growth during the recoveries since the nineties contributes to the sluggish pace of job creation in these recoveries. The jobless recoveries documented by Groshen and Potter (2003) are examined in Figure 6 which shows the average (monthly) growth rates of total nonfarm payrolls (all employees) for the first year of the expansions that follow the recessions that appear in the horizontal axis. According to this figure, the average monthly growth rates of employment during the first year of the recoveries from the most recent recessions is negative which stands in sharp contrast to the vigorous rebound

[4] Using bootstrap procedures in industrial production series, Camacho, Perez Quiros and Saiz (2008) provided evidence of the loss of the high growth recovery phase in most OECD countries.

in employment during earlier recoveries.

2.2 Formal analysis

In this section, we use several econometric techniques to test for the existence of a high-growth recovery phase in the US business cycles. According to Sichel (1994), we can start by regressing growth rate of GDP, y_t, on a dummy variable taking a value of 1 if period t corresponds to a recession as described by the NBER dating committee, $NBER_t$, and a dummy variable which is equal to 1 if period t is one of the first two quarters of an expansion, TS_t:

$$\widehat{y}_t = \underset{(0.06)}{0.96} - \underset{(0.13)}{1.48} NBER_t + \underset{(0.17)}{0.46} TS_t, \quad (1)$$

where standard deviations are in parenthesis. These results imply that the normal growth rate in expansions is 0.96 percent. This growth rate falls to -0.52 percent in recessions (when the variable $NBER_t$ takes value equal to 1) but rises to 1.42 percent in the two first quarters of the expansions. Hence, the estimations in expression (1) provide evidence of the existence of a phase of high growth when expansions start.

Building on these estimates, we could include the possibility of a change in the third phase before and after the structural break in volatility. For that, we enlarge the mode by including a dummy variable which is equal to 1 for periods after 1984.1, B_t:

$$\widehat{y}_t = \underset{(0.06)}{0.96} - \underset{(0.13)}{1.48} NBER_t + \underset{(0.20)}{0.78} TS_t - \underset{(0.35)}{1.06} TS_t B_t. \quad (2)$$

For the period before 1984.1, the growth rate in the two first quarters of expansions rises to 1.74 percent which implies almost twice as much of the normal growth rate of expansions. However, for the period of low volatility the economy grows only at 0.68 percent at the beginning of expansions. Therefore, these results present evidence for the loss of the high-growth recovery phase after the structural break in volatility.[5]

[5] To establish robustness, we repeat all the computations by using: (i) the recessionary indicator obtained from

Although suggestive, the previous results are subject to a very basic criticism. These estimations assume that the sequence of expansions and recessions as captured by the variable $NBER_t$ are completely exogenous and available to the analyst in real time. These assumptions are not realistic for two main reasons. First, there is a typical lag in the publication of recession dates by the NBER. For example, the dating committee took almost two years to publish the date of the last trough in November 2001. Second, the dating committee uses information on the growth rate of GDP to establish the dates of peaks an troughs and, therefore, the sequence of recessions is an endogenous variable.

To get around these problems we allow the empirical model to determine when the economy is located on the different phases of the cycle. For this purpose, we use a variant of the Markov-switching model proposed by Hamilton (1989) in which the phases of the cycle are identified by an unobservable variable, s_t. According to Boldin (1996), s_t is allowed to take three values which are associated with the three phases of the the business cycle previously defined: expansion (when $s_t = 0$), recession (when $s_t = 1$), or third phase (when $s_t = 2$). Furthermore, we assume that these three states translate into three different average GDP growth rates so that we can write

$$y_t = \mu(s_t) + \varepsilon_t \tag{3}$$

with $\varepsilon_t \sim N(0, \sigma^2)$.[6] Thus, the economy presents three average growth rates of GDP depending on the value taken by the state variable s_t. So, if the data follow the economic intuition behind the idea of business cycles we should observe that $\mu(2) > \mu(0) > \mu(1)$.

The last element that needs to be specified is the transition matrix governing the unobserved

the BBQ algorithm; and (ii) break in volatility dates from 1982.1 to 1989.4. All the results were qualitatively similar to those presented in the paper.

[6] According to Camacho and Perez Quiros (2007) we omitted autoregressive parameters since they were not significant in any of the specifications proposed in the empirical analysis. Errors from this specification are not serially correlated.

Markov chain s_t. Let the probabilities of staying in each state be as follows

$$prob(s_t = 0|s_{t-1} = 0) = p(0)$$

$$prob(s_t = 1|s_{t-1} = 1) = p(1)$$

$$prob(s_t = 2|s_{t-1} = 2) = p(2).$$

To apply this model to our analysis we need to design the entries in the transition matrix of the unobserved Markov chain so that the third phase does not follow an expansion, that a recession does not follow the third phase and that an expansion does not follow a recession. This amounts to imposing the following conditional probabilities:

$$prob(s_t = 2|s_{t-1} = 0) = prob(s_t = 1|s_{t-1} = 2) = prob(s_t = 0|s_{t-1} = 1) = 0. \tag{4}$$

The first column of Table 2 presents the results of estimating the previous model which has been labeled as MS1. The entries show that the data moves between three states characterized by growth rates of 0.72 percent, -0.71 percent and 1.47 percent, which could be interpreted, respectively, as the expansionary, recessionary and high-growth recovery phases of the cycle. Notice these estimations are in close agreement with the estimates displayed in expression (1) which were obtained under the assumption that the sequence of expansions and recessions was known.

Next, we include in the estimation the fact that there is a structural break in volatility by allowing the variance of the residuals to be different before and after 1984.1. That is, we assume

$$\varepsilon_t \sim N(0, \sigma_t^2) \tag{5}$$

where $\sigma_t^2 = \sigma_1^2$ if $t \leq 1983.4$ and $\sigma_t^2 = \sigma_2^2$ if $t \geq 1984.1$. According to the results obtained in (2), we allow for different growth rates for the three states before and after the date of the structural brake. This way, the average growth rate of GDP in state s_t and subsample j will be denoted $\mu_j(s_t)$ where $j = 1$ if $t \leq 1983.4$ and $j = 2$ if $t \geq 1984.1$.

The estimations of the model with volatility break are presented in the second column of Table 2, labeled as MS2. According to these estimates, augmenting the model improves significantly the value of the log-likelihood function (from -77.5 to -58.9). A likelihood ratio test rejects the hypothesis of equal models with a p-value of 0.00. To identify the states of the Markov switching process as business cycle phases, we use Figure 7 which shows the filtered probabilities of the state variable being in each of the three states. In the top chart, the probabilities of $s_t = 0$ are close to 1 except around those quarters identified as recessions by the NBER and rebound to one a bit after the troughs. The middle chart reveals that the probabilities of $s_t = 1$ are close to 1 on those quarters identified as expansions by the NBER and they are close elsewhere. Finally, the probabilities of $s_t = 2$ are significantly different from 0 only on the first quarters of expansions. Tentatively, we will call these states as expansions ($s_t = 0$), recessions ($s_t = 1$), and third phase ($s_t = 2$).

These estimates also allow us to compute the expected duration of the three phases of the cycle. For a Markov chain, the expected duration of state s_t is $1/[1 - p(s_t)]$. Thus, the expected duration of expansions, recessions and the third phase are, respectively, 14.2, 3.8, and 2.5 quarters approximately. The expected duration of expansions is much larger than that of recessions while the third phase only covers the two quarters following the end of recessions. In addition, it is worth noting that the expected duration of the third phase that characterizes the beginning of the expansions coincides with the duration that was used to examine the existence of a high recovery phase in Figures 2 to 4 and to construct the dummy variable TS_t which is related to the existence of the third phase.

We now compare the estimations for the periods before and after the structural change in volatility. The estimations for the high volatility subsample (estimated variance of 0.79) imply that the growth rate of expansions is 1.07 percent while in recessions the economy grows at -0.35 percent. During the third phase, the growth rate of GDP rises to 1.70 percent which is higher than the average growth rates of expansions and the average growth rate of the entire sample. However, these estimations present a different situation after the structural brake date (estimated variance of 0.21). During expansions the expected growth rate is now 0.86 percent while during recessions

US output is expected to grow -0.60 percent. Furthermore, the most dramatic difference appears in the growth rate during the third phase. In the period of low volatility, GDP is expected to grow at 0.44 percent which is not only lower than the growth rates of expansions but also lower than the average of the period. Thus, together with the volatility reduction, recoveries from recessions have changed from being periods of rapid growth to periods of lower than average growth. Noticeably, the appearance of these two phenomena, the volatility reduction and the loss of the high-growth phase of the cycle, have coincided in time.[7]

The economic consequences of business cycle recessions on the level of US output are immediate: the effects of those recessions occurred since the nineties have become more permanent. Many authors linked the high-growth recovery phase with the ability of the economy to return to its growth path making recessions a pure transitory phenomenon which reinforces the view of GDP as having a stationary (instead of stochastic) trend. Our evidence shows that not only this phase of rapid growth has disappeared but that when entering the expansionary phase of the cycle, US output grows at a lower rate than average. Thus, after the mid eighties, this makes it difficult for GDP to rapidly return to the pre-recessionary level and leads to a change in the form of the recoveries from being V-shaped to L-shaped after the mid eighties.

Before ending this section, we document the business cycle properties of employment along the lines provided for GDP. Column MS3 of Table 2, shows the estimates of the Markov-switching model with different means for the periods of low and high volatility but using employment data. Furthermore, Figure 8 is for employment the equivalent to Figure 7 for GDP and shows the filtered probabilities of employment being in each of the three states. As with GDP we observe how the unobserved state variable roughly coincide with the NBER referenced expansions and recessions whereas the third phase characterizes the first months of expansions. In these three business cycle phases, employment was estimated to grow at monthly rates of 0.28, -0.26, and 0.18 in the period prior to the break in volatility whereas these estimates become 0.17, -0.20 and -0.01 after that

[7] Excluding the 2008-2009 recession from the sample would lead to qualitatively similar results.

date. As in the case of output growth, the recoveries since the volatility reduction are characterized by very low and even negative growth rate in employment.[8]

3 Recoveries and the Great Moderation

In this section, we present evidence that links the loss of the third phase of the cycle with the occurrence of the Great Moderation. It is well known that output growth volatility has diminished after the mid-eighties. However, Table 3 helps us to (re-)establish some stylized facts related to the Great Moderation. The average of GDP growth rate is 0.77 dropping to -0.52 percent during recessions and rising to 1.01 percent during expansions (the difference is statistically significant with a p-value of 0.00). However, the average growth rate before 1984, 0.82 percent, is not statistically different from that after 1984, 0.69 percent (p-value of 0.15). With respect to the standard deviation, it is 0.94 in recessions which is not statistically different than that in expansions, 0.83 (p-value of 0.30). Unlike the averages, though, there are statistically significant differences in the volatility before 1984.1, 1.14, and after that date, 0.62 (p-value of 0.00). In line with McConnell and Perez Quiros (2000), the null hypothesis of equal variances is rejected with the supremum, exponential, and average tests (p-values of 0.00) and the date of the structural brake is 1983.4.

Just for the sake of completeness, Table 3 also shows similar statistics for employment. Comparing expansions and recessions, the means of employment growth rates are statistically different whereas the variances are not. This table also shows the results of the supremum, exponential and average tests of structural change in the variance of monthly employment growth as used in McConnell and Perez Quiros (2000). The p-values of the three tests are 0.00 indicating that the null hypothesis of equal variances is overwhelmingly rejected. Of remarkably interest is the break date that marks the volatility reduction in 1983.12 which coincides with the volatility break date

[8] For this estimation, we impose the break in volatility to occur on 1983.12. As shown below on Table 3, this is the date estimated by structural break tests in the volatility of employment.

of output growth suggested in the literature.

Let us now examine to what extent the loss of the high-growth recovery phase and the volatility reduction in output growth are related. To answer this question we propose the following two exercises. First, we study whether changes in the estimated expected growth rates of US GDP have contributed significantly to the reduction in volatility. To perform such an exercise, we compute the estimated expected growth rate for each quarter as the average growth rate of each state multiplied by the probability of being in each state.[9] We compute a series for this expected growth rate using the estimated coefficients for each subsample together with the evolution of the probabilities of being on each state for each quarter of the sample. The estimated series is shown on Figure 9 which reveals a clear reduction in volatility after 1984.1. To check whether this reduction is statistically significant, we compute the supremum, exponential and average tests of structural change in the variance of this series. All these tests show p-values of 0.00 and therefore we reject the hypothesis of equal variances. Thus, there is a structural change in the variance of the estimated expectation of the series of GDP growth.

Second, we check to what extent the loss of the third phase of the business cycle is able to explain the reduction in the volatility of the GDP growth rates. For this purpose, we perform the counterfactual exercise of simulating time series that mimic the business cycle characteristics which were estimated in the Markov-switching model MS2 displayed in Table 2.[10] However, these simulated time series are generated with diminishing variance but without the observed changes in the behavior of the third phase. To start with the analysis, we generate two sets of 1,000 time series of simulated growth rates. The first set of 1,000 series tries to simulate the low volatility subsample and includes 106 draws (the number of observations between 1984.1 and 2010.2) of shocks from a normal distribution with a variance of 0.21 as in the subsample after the structural

[9] According to our empirical model, GDP growth would be this expected value plus a white noise. Thus, what we call third phase is built implicitly on the expected value of GDP growth and not on the noise.

[10] We acknowledge that, as a conterfactual exercise, the analysis could not be free from the Lucas' critique.

break. These draws are added to generated shifting means with the estimated mean growth rates for the three states as measured by the coefficients $\mu_2(0)$, $\mu_2(1)$, and $\mu_2(2)$ equal to 0.86, -0.60, and 0.44, respectively. The changes among the three states are assumed to be governed by random draws whose dynamics is governed by transition probabilities of $p(0) = 0.93$, $p(1) = 0.74$, and $p(2) = 0.60$.

The other set of 1,000 series intends to simulate an scenario with a high variance of shocks but without the existence of a third phase of the business cycle. Thus, each of these series includes 124 draws (the number of observations between 1953.1 and 1983.4) of shocks from a normal distribution with a variance of 0.79 as in the first subsample before the structural break in volatility. In this case, these shocks are added to simulated shifting means but, instead of being generated with the mean growth rates estimated for the first subsample (1.07, -0.35, and 1.70, respectively), we construct shifting means with the business cycle characteristics of the second subsample. With these computed means we seek to isolate the reduction in volatility from the change in the dynamics among the three phases of the cycle. To construct such means, we look at the differences between the growth rates of the three phases of the cycle in the low volatility subsample. After 1984.1 the difference in growth rates between expansions and recessions is 1.46 percentage points (that is, 0.86 percent in expansion minus -0.60 percent in recessions). In addition, the difference between the growth rate in the third phase and the growth rate in recessions is 1.04 percentage points (that is, 0.44 percent in the third phase minus -0.60 percent in recessions). Thus, during the Great Moderation, the ratio of the difference in growth rates of the third phase as compared with recessions and the difference of expansions as compared with recessions is 0.71 (1.04 divided by 1.46).

Clearly, the estimated growth rate in the third phase for the period before 1984.1, $\mu_1(2) = 1.70$, does not satisfy the same factor of proportionality with respect to the growth rates of expansions ($\mu_1(0) = 1.07$) and recessions ($\mu_1(1) = -0.35$). Before 1984.1, the difference in growth rates between expansions and recessions is 1.42 (that is, 1.07 percent in expansions minus -0.35 percent in recessions) while the difference in growth rates between third phases and recessions is much larger and equal to 2.05 percentage points (that is, 1.70 percent in the third phase minus -0.35 percent in recessions). Now we want to find the growth rate in a hypothetical third phase whose difference with the growth rate in recessions is scaled down by a factor of 0.71 with respect to the difference in growth rates between expansions and recessions, as it happens after 1984.1. This difference between growth in the third phase and growth in recessions would be 0.71 of 1.42 percent, or 1.00 percentage points. This means that the growth rate of such hypothetical third phase should be 0.65 percent (i.e. -0.35 percent plus 1.00 percent) instead of 1.70 which is the actual growth in the third phase prior to the volatility reduction. Call this constructed growth rate $\widetilde{\mu}_1(2)$.

We then generate the second set of 1,000 time series of simulated growth rates by using the draws of shocks with high variance of 0.79 plus the shifting mean growth rates for the three states as measured by the coefficients $\mu_1(0) = 1.07$, $\mu_1(1) = -0.35$, and $\widetilde{\mu}_1(2) = 0.65$. As before, the change of states is governed by the estimated transition probabilities $p(0) = 0.93$, $p(1) = 0.74$, and $p(2) = 0.60$. The final set of 1,000 simulated time series is found by enlarging the 1,000 generated series for the first subsample with the 1,000 constructed series for the second subsample.

A formal way of evaluating the empirical impact of the elimination of the third phase of the cycle on the reduction in the volatility of the series of GDP growth rates is to test for a structural break in the variance in each of the 1,000 generated series. We sequentially apply the structural break in variance tests to these replications by assuming that we do not know the moment of the break and keep the maximum. In these time series, the null of no structural break in the variance cannot be rejected in about 70% of cases by using the supremum test, in 40% of cases using the exponential test, and in 30% of cases using the average test. In addition, in about 40 percent of the simulations where a structural break is found, the estimated break is more than two years away from the true change in volatility. Clearly, if the rapid recovery were eliminated from the first subsample of the time series the structural break in the variance would have probably never be found.[11]

4 The role of inventory management

The previous sections have documented two major stylized facts of the US business cycle dynamics after the Second World War. First, there has been a change towards a greater stability as defined by a sudden reduction in the volatility of growth rates. Second, business cycles no longer show the high-growth phase that used to characterize the beginning of expansions which also exhibit sluggish developments in the job market. The simultaneous occurrence of these two facts, at about the mid 80s, and the analysis developed in the previous section suggest that they may have a connection. In this section, we provide evidence to support the idea that these two facts emerged from changes in business practices related to inventory management.

4.1 Inventories, sales and the third phase

We now pursue the idea that the disappearance of the high-growth recovery phase has been associated with a change in the behavior of inventory investment and not of sales. Figures 10 and 11 present, respectively, the contribution to GDP growth of both sales and inventory investment during recessions and for different quarters of expansions together with the average contribution in expansions.[12] Comparing these figures with Figure 2, we can see how the sales contribution to GDP growth does not exhibit the high-growth recovery phase which was evident for GDP. The average contribution of sales at the beginning of the expansions is very similar to the overall average for the expansion as a whole. On the contrary, the contribution of inventories is unusually high on the first two quarters of the expansion. While the average contribution in expansions is 0.07 percentage points, the average contribution during the first two quarters of the expansions is

[11] We repeated the experiment by excluding the 2008-2009 recession and we obtained very similar results.

[12] Following a suggestion of one referee, we use as inventories' contribution the residual of the regression of output on sales. Using growth accounting leads to similar results.

0.55. This points towards the hypothesis that the existence of a third phase of rapid recovery in US GDP growth is linked to inventory investment instead of associated with the dynamics of sales.

To analyze further this result, let x_t be the contribution of sales to GDP growth. We could run a similar regression as in (1) to test the relation of the third phase with sales and inventory investment in a more formal way. The estimation of such a regression provides the following results:

$$\widehat{x}_t = \underset{(0.05)}{0.94} - \underset{(0.18)}{1.01} NBER_t - \underset{(0.15)}{0.06} TS_t. \tag{6}$$

This expression indicates that the contribution of sales to GDP growth rate in expansions is 0.94 percentage points while in recession (when the variable $NBER_t$ takes value 1) the contribution is reduced to -0.07 percentage points. However, unlike the estimation in (1), the estimated coefficient of the dummy variable TS_t is small and is not statistically significant in this case. Thus, the data shows that for the contribution of sales to GDP growth for the first two quarters of each expansion are not different from the rest of the expansion itself.

If instead we run the regression with the contribution of inventory investment, variable z_t, the result is

$$\widehat{z}_t = \underset{(0.03)}{0.02} - \underset{(0.09)}{1.39} NBER_t + \underset{(0.12)}{0.52} TS_t. \tag{7}$$

That is, inventory investment is unusually important in GDP growth during the first two quarters of the expansions. Although the contribution of inventories to growth is very low and not statistically significant in expansions, it grows to 0.58 and becomes highly significant if we only consider the first two quarters of expansions.

4.2 Inventories, sales and the Great Moderation

Table 3 shows that sales in expansions exhibit significantly higher growth rates than those of recessions. However, the variance within recessions is not significantly different from the variance within expansions. According to the structural break in volatility tests, sales does not seem to exhibit any break point (supremum, exponential, and average tests with p-values of 0.30, 0.11

and 0.07, respectively). By contrast, this table reveals that the contribution of inventories does exhibit a break in volatility in the mid eighties as in the case of US output growth. Accordingly, the evolution of inventories instead of the evolution of sales seems to be behind the candidate explanations for the Great Moderation of output growth.

To analyze further the connection between the rates of growth of sales, the two-state business cycles, the third phase, and the Great Moderation, we run a Markov-switching model with an unobserved state variable with three states (expansion, recession and third phase). Although we did not account for a significant reduction in the variance of sales, to facilitate comparisons with GDP growth rates we allow for a structural break in the variance in 1984.1, and for the switching means to be different before and after the volatility break.[13] The estimates of this model, labeled as MS4, appear in Table 2. Figure 12 presents the filtered probabilities of each state. With this figure, we can identify the first two states with expansions and recessions respectively. This is because the probabilities that the variable $s_t = 0$ are high in quarters identified as expansions by the NBER and because the estimated growth of sales when $s_t = 0$ is 1.13 before 1984.1 and 0.85 after this date. Furthermore, the probabilities that the variable $s_t = 1$ are high in quarters identified as recessions by the NBER and sales are expected to grow at lower rates of 0.20 (before 1984.1) and -0.01 (after that date). By contrast, the quarters for which $s_t = 2$ is more likely are quite disperse, without any persistence and difficult to interpret. In fact, the estimated probability of staying in the third state, $p(2)$, is negligible which corroborates a lack of persistence of this state for sales. According to these results, sales do not seem to be behind either the break in volatility of output growth or the loss of the rapid recoveries observed since the mid eighties.

We now consider the contribution of inventories to GDP growth. Let z_t be the part of GDP growth attributable to inventory investment. Regressing this variable on a constant, the dummy variable $NBER_t$ determining the recessionary quarters, and the dummy variable B_t discriminating

[13] Estimates of a Markov-switching model that does not allow for break in volatility show qualitatively similar results.

between observations before and after 1984.1, we obtain the following estimation:

$$\widehat{z}_t = \underset{(0.05)}{0.12} - \underset{(0.12)}{0.54} NBER_t - \underset{(0.08)}{0.08} B_t + \underset{(0.20)}{0.29} NBER_t B_t. \tag{8}$$

This estimation shows that although inventories contributed to 0.12 percent of GDP growth during expansions in the high volatility period, they now only contribute 0.02 percentage points in the expansions after the Great Moderation. Similarly, while inventories reduced GDP growth by 0.54 percentage points in recessions before 1984.1, now they contribute to reducing GDP growth by only 0.21 percentage points during recessions.

In order to better understand the role of inventories on the third phase of the business cycle we repeat the exercise presented in Table 2 for GDP, employment and sales using the contribution of inventories to output growth. When we allow for a three-state switching mean that changes with the reduction in volatility we obtained that the filtered probabilities for the three estimated states remain almost constant after the volatility break which is a consequence of the clear change in the data generating process of inventories after the break. To overcome this drawback, Table 2 displays the results of the model for the contribution of inventories to GDP, labeled MS5, which imposes that the within states mean does not change with the reduction in volatility.[14] The estimates of this model reveals that the contribution of inventories to output growth in expansions, in recessions and in the third phase are 0.01, -1.42, and 0.65 respectively. However, Figure 13 shows that in the beginning of the expansions prior to the Great Moderation there is a significant contribution of inventories to the rapid recovery observed in GDP growth rates. However, the rapid recovery phase is not detected after the volatility reduction.

[14] The p-value of the null that the within states mean does not change after the volatility reduction is 0.11. This reinforces the result outlined in expression (8) that the dummy of the volatility break does not significantly change the mean.

4.3 Economic interpretation

So far, in this section, we have shown that although sales and GDP share the dynamic of recessions and expansions, sales do not exhibit either the high-growth recoveries from the recessions until the eighties, or the sudden reduction in volatility experienced by GDP growth rates in the mid eighties. The explanation of these two phenomena appears to be found in the behavior of inventory investment which also present the business cycle features observed in GDP growth rates.

Two main reasons to hold inventories have been proposed in the literature. The first reason to hold inventories is the so-called stockout avoidance theory, stated in Kahn (1987), and has been recently examined by Kahn et al. (2002), and Bils and Kahn (2000). Within this theory, production must be decided upon before demand is known, and if demand is correlated over time, firms will find it profitable to accumulate inventories anticipating future high demand. Thus, as firms tend to overproduce in response to positive demand shocks, this theory predicts output to be more volatile than sales and inventory investment to be positively correlated with sales. According to Kahn (2008), the second theory that rationalizes the use of inventories has to do with smoothing production. Within this theory, firms try reduce costs by smoothing production. This can be achieved by reducing the need to maintain a inventory stock positively correlated with the level of sales to satisfy the demand of clients. Under this theory, output tend to be less volatile than sales.

Figure 14 shows the rolling variance estimates of GDP growth and the contribution of sales to GDP growth. Figure 15 presents the rolling correlation estimates between the contributions to GDP growth of sales and inventory investment. Both series are computed using a six year rolling window. These figures show that output has gone from being more volatile than sales to be equally or less volatile. Furthermore, the correlation between sales and inventory investment has gone from being mostly positive to be negative. Interestingly, both changes have occurred in the mid eighties, right after the beginning of the Great Moderation and the loss of the high-growth recovery phase. This may explain that firms changes their motivation to hold inventories from avoiding stockouts to smoothing production.

Kahn (2008) states that the change in inventory management has been motivated by the improvements in the production and information technologies observed in the mid eighties. Improvements in technologies of information and communication have allowed firms to externalize the production process making this production process more flexible to market conditions. In line with this feature, this author documented the developments of just-in-time production processes since the mid eighties. Furthermore, improvements in the information technologies (bar codes, digital technologies, client fidelization programs, and the like) allow firms to know in a more timely fashion changes in the tastes and needs of their buyers.

Interestingly, the causes that motivate the changes detected in output and employment dynamics can also be related. Groshen and S. Potter (2003) connected the sluggish employment growth observed in the post-1990 recoveries to technological changes, reorganization of production and local or international outsourcing. Schreft, Singh, and Hodgson (2005) showed that one common feature of the jobless recoveries was the greater use of jut-in-time employment practices which allow firms to more easily adjust output in the short term without hiring permanent workers.

5 Conclusions

For many economists, the Great Moderation is interpreted as good news. As cycles are expected to be smoother, the negative effect of recessions would also be smaller. However, the Great Moderation did not imply that the business cycle or the pain they can cause were diminished. This paper presents evidence that the high growth recoveries observed after the mid eighties are no longer present in the post-1990 expansions. Recoveries, that were “V-shaped”, have become “L-shaped”. Hence, although some recessions are now not as deep as they were until the eighties, it takes the economy longer to recover and they are followed by sluggish growth in GDP and by slow job creation. Many economists which viewed the rapid recoveries from recessions as evidence in favor of transitory effects of recessions, would interpret this result as if the effect of recessions have become permanent.

We have also shown evidence that links both phenomena to changes in the behavior of inventory investment. Rather than sales, inventory investment share the volatility reduction and the loss of the rapid growth recoveries observed in GDP. Before the middle of the 80s inventories contributed to amplify business cycles increasing the volatility of production over sales while after the mid 80s inventory investment reduced the volatility of production over sales. Thus, inventory management seems to have switched from trying to avoid stockouts to allow a smoother production process. A part of the explanation of this change in attitude towards inventory management could arrive from the generalization of practices linked to the information technologies. Thus, firms do not need to maintain costly inventories to satisfy their demand but can order their products to other firms down the production line. Outsourcing practices together with the introduction of technological improvements like the bar codes and digital technology have reduced production lags. Furthermore improvements in information technology have provided firms with more knowledge of changes in consumer tastes and needs. All these changes reduce the need to hold inventories to avoid stockouts and the opportunity costs associated with not servicing the demand. According to Groshen and S. Potter (2003) and Schreft, Singh, and Hodgson (2005), these changes in information technology and management practices may also explain the jobless recoveries.

References

[1] Ahmed, S., Levin, A.,Wilson, A., 2004. Recent U.S. macroeconomic stability: Good policies, good practices, or good luck? Review of Economics and Statistics 86, 824-32.

[2] Bils, M., Kahn, J., 2000. What inventory behavior tells us about business cycles. American Economic Review 90, 458-481.

[3] Boldin, M., 1996. A check on the robustness of Hamilton's Markov switching model approach to the economic analysis of the business cycle. Studies in Nonlinear Dynamics and Econometrics 1, Replications 1.

[4] Camacho, M., Perez Quiros, G., 2007. *Jump-and-rest* effect of US business cycles. Studies in Nonlinear Dynamics and Econometrics 11, Article 3.

[5] Camacho, M., Perez Quiros, G., Saiz, L., 2008. Do European business cycles look like one? Journal of Economic Dynamics and Control 32, 2165-2190

[6] Campbell, J., Mankiw, G., 1987. Are output fluctuations transitory? Quarterly Journal of Economics 102, 857-880.

[7] Cheung, Y, Chinn, M., 1999. Further investigation of the uncertain unit root in GNP. Journal of Business and Economic Statistics 15, 68-73.

[8] Clarida, R., Galí, J., Gertler M., 2000. Monetary policy rules and macroeconomic stability: Evidence and some theory. The Quarterly Journal of Economics 115, 147-180.

[9] Clark, T., 2009. Is the Great Moderation over? An empirical analysis. Economic Review, Federal Reserve Bank of Kansas City Fourth Quarter, 5-42.

[10] Davis, S., and Kahn, J., 2008. Interpreting the Great Moderation: Changes in the volatility of economic activity at the macro and micro levels. Journal of Economic Perspectives 22, 155-80.

[11] Dynan, K., Elmendorf, D., Sichel, D., 2006. Can financial innovation help to explain the reduced volatility of economic activity? Journal of Monetary Economics 53, 123-150.

[12] Friedman, M., 1993. The plucking model of business fluctuations revisited. Economic Inquiry 31, 174-177.

[13] Groshen E., Potter S., 2003. Has structural change contributed to a jobless recovery?. Current Issues in Economic and Finance 9(8) August.

[14] Hamilton, J., 1989. A new approach to the economic analysis of nonstationary time series and the business cycles. Econometrica 57, 357-384.

[15] Harding, D., Pagan, A., 2002. Dissecting the cycle: A methodological investigation. Journal of Monetary Economics 49, 365-381.

[16] Herrera, A., Pesavento, E., 2005. The decline in U.S. output volatility: Structural changes and inventory investment. Journal of Business and Economic Statistics 23, 462-472.

[17] Kahn, J., 1987. Inventories and the volatility of production. American Economic Review 77, 667-679.

[18] Kahn, J., 2008. Durable goods inventories and the Great Moderation. Federal Reserve Bank of New York Staff Reports 325.

[19] Kahn, J., McConnell, M., Perez Quiros, G., 2002. On the causes of the increased stability of the U.S. economy. Economic Policy Review 8, 183-202.

[20] Kim, Ch., Murray, Ch., 2002. Permanent and transitory components of recessions. Empirical Economics 27, 163-183.

[21] Kim, Ch., Nelson, Ch., 1999a. Has the U.S. economy become more stable? A bayesian approach based on a Markov-switching model of the business cycle. The Review of Economics and Statistics 81, 608-616.

[22] Kim, Ch., Nelson, Ch,. 1999b. Friedman's plucking model of business fluctuations: Tests and estimates of permanent and transitory components. Journal of Money, Credit, and Banking 31, 317-334.

[23] McConnell, M., Perez Quiros, G., 1998. Output fluctuations in the United States: What has changed since the early 80s? Federal Reserve Bank of New York Staff Reports 41.

[24] McConnell, M., Perez Quiros, G., 2000. Output fluctuations in the United States: What has changed since the early 80s? American Economic Review 90: 1464-1476.

[25] Sichel, D., 1994. Inventories and the three phases of the business cycle. Journal of Business and Economic Statistics 12, 269-277.

[26] Schreft, S., Singh, A., Hodgson, A., 2005. Jobless recoveries and the wait-and-see hypothesis. Federal Reserve Bank of Kansas City Economic Review Fourth Quarter, 81-99.

Table 1. Business cycle features

Period	Duration		Amplitude (%)		Excess (%)	
	expans.	recess.	expans.	recess.	expans.	recess.
53.1-10.2	20.77	3.70	20.92	-1.95	1.34	-0.14
53.1-83.4	17.57	3.71	19.58	-2.10	1.77	-0.25
84.1-10.2	32.00	3.67	25.60	-1.62	-0.17	0.14

Note. We do not considered either the expansion with trough in 53.3 or the expansion with peak in 09.2 since they are very short lived in the sample.

Table 2. Markov-switching estimates

	MS1	MS2	MS3	MS4	MS5
$\mu_1(0)$	0.72 (0.07)	1.07 (0.17)	0.28 (0.02)	1.13 (0.09)	0.01 (0.03)
$\mu_1(1)$	-0.71 (0.19)	-0.35 (0.26)	-0.26 (0.03)	0.20 (0.17)	-1.42 (0.33)
$\mu_1(2)$	1.47 (0.11)	1.70 (0.33)	0.18 (0.03)	-1.17 (0.34)	0.65 (0.13)
$\mu_2(0)$		0.86 (0.06)	0.17 (0.01)	0.85 (0.07)	
$\mu_2(1)$		-0.60 (0.23)	-0.20 (0.04)	-0.01 (0.26)	
$\mu_2(2)$		0.44 (0.22)	-0.01 (0.04)	0.20 (0.48)	
σ_1^2	0.48 (0.05)	0.79 (0.14)	0.05 (0.04)	0.45 (0.06)	0.29 (0.05)
σ_2^2		0.21 (0.03)	0.03 (0.01)	0.23 (0.03)	0.15 (0.02)
$p(0)$	0.93 (0.02)	0.93 (0.02)	0.97 (0.01)	0.95 (0.02)	0.97 (0.01)
$p(1)$	0.68 (0.10)	0.74 (0.09)	0.89 (0.03)	0.79 (0.08)	0.01 (0.01)
$p(2)$	0.86 (0.04)	0.60 (0.17)	0.90 (0.03)	0.00 (0.00)	0.62 (0.16)
$\ln(L)$	-77.5	-58.9	771.32	-23.46	34.16

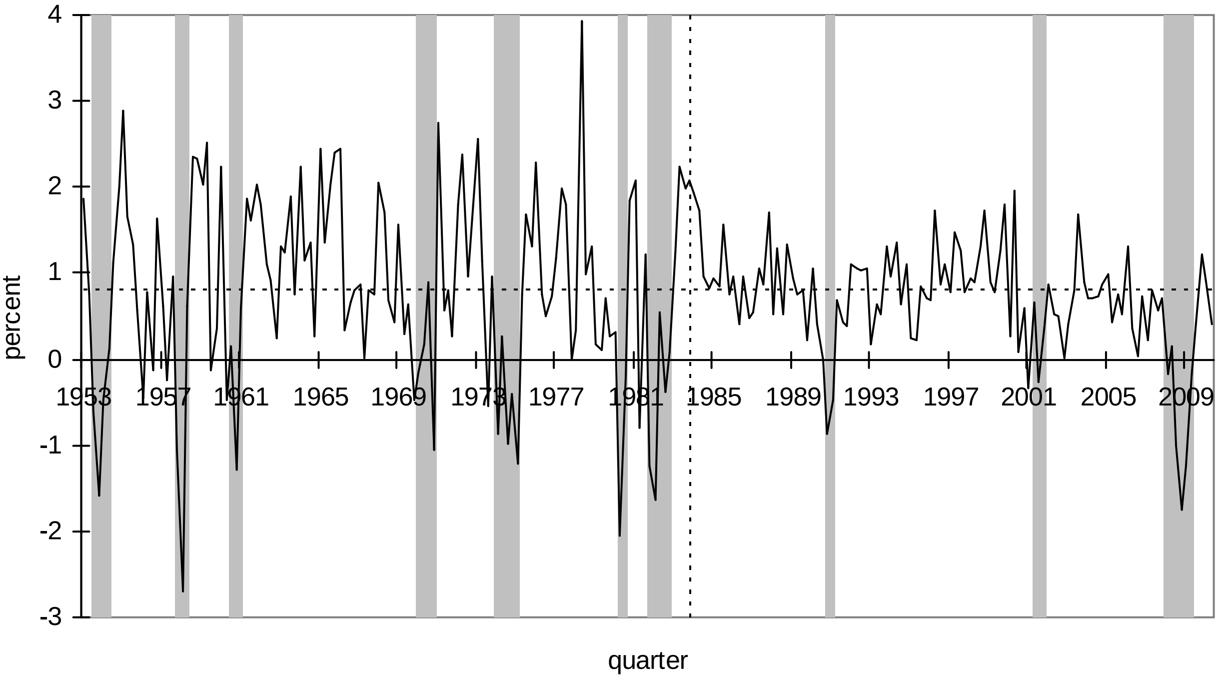
Note. The columns labelled MS1 and MS2 refer to different specifications for GDP growth rate, with and without structural change in 1984.1. The columns labelled MS3, MS4 and MS5 refer to the monthly growth rates of employment, the quarterly growth rates of sales, and the quarterly contribution of inventories to output growth, respectively.

Table 3. Statistics for GDP and components

	GDP	Employment	Sales	Inventories
Business cycle facts				
Mean				
total	0.77	0.92	0.76	0.01
recessions	-0.52	-1.44	-0.16	-0.36
expansions	1.01	1.37	0.94	0.01
test$^{(1)}$	0.00	0.00	0.00	0.00
before	0.82	0.89	0.81	0.01
after	0.69	0.96	0.64	0.01
test$^{(1)}$	0.15	0.39	0.06	0.43
Standard deviation				
total	0.94	1.96	0.77	0.55
recessions	0.83	1.86	0.80	0.66
expansions	0.74	1.63	0.62	0.50
test$^{(2)}$	0.30	0.26	0.03	0.02
before	1.14	2.30	0.83	0.65
after	0.62	1.47	0.58	0.38
test$^{(2)}$	0.00	0.00	0.03	0.00
Change in volatility: Tests of structural change				
date	83.4	83.12	91.4	87.3
supremum$^{(3)}$	0.00	0.00	0.30	0.11
exponential$^{(3)}$	0.00	0.00	0.11	0.04
average$^{(3)}$	0.00	0.00	0.07	0.03

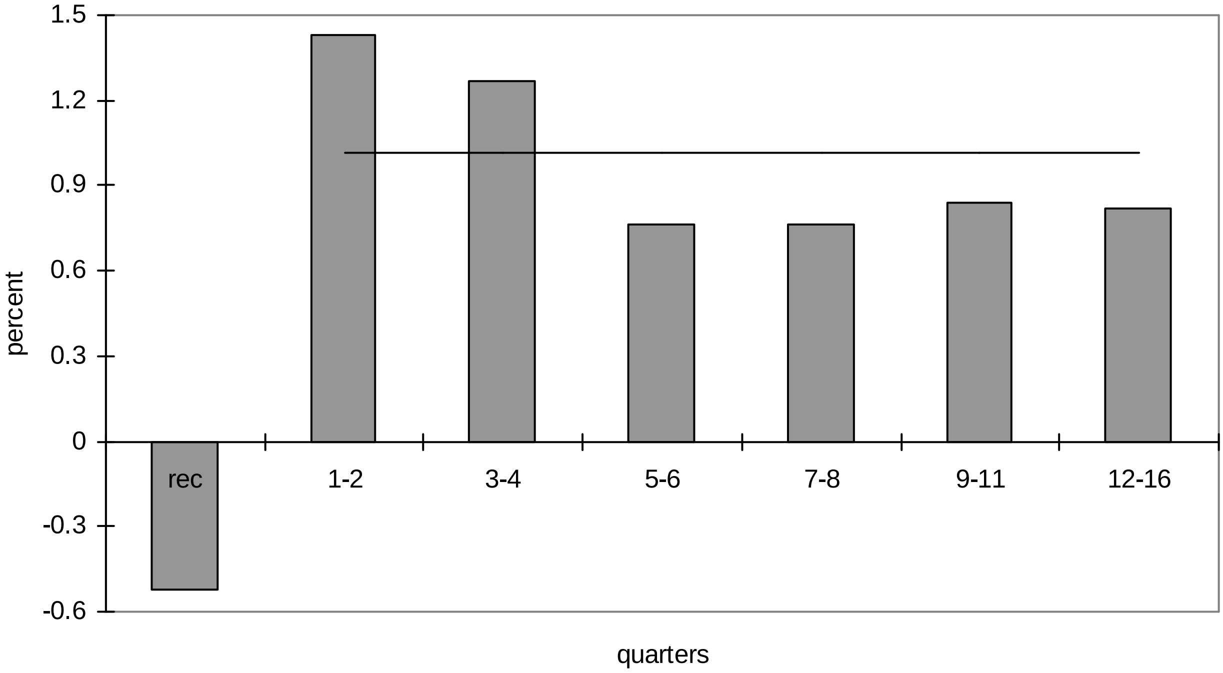
Note. Before refers to data prior to 1984.1. The *p*-values refer to the following null hypothesis: (1) means are not different, (2) Barlett test for equal standard deviations, (3) McConnel and Pérez Quirós tests of no change in volatility.

Figure 1: GDP growth rates 1953.1-2010.2



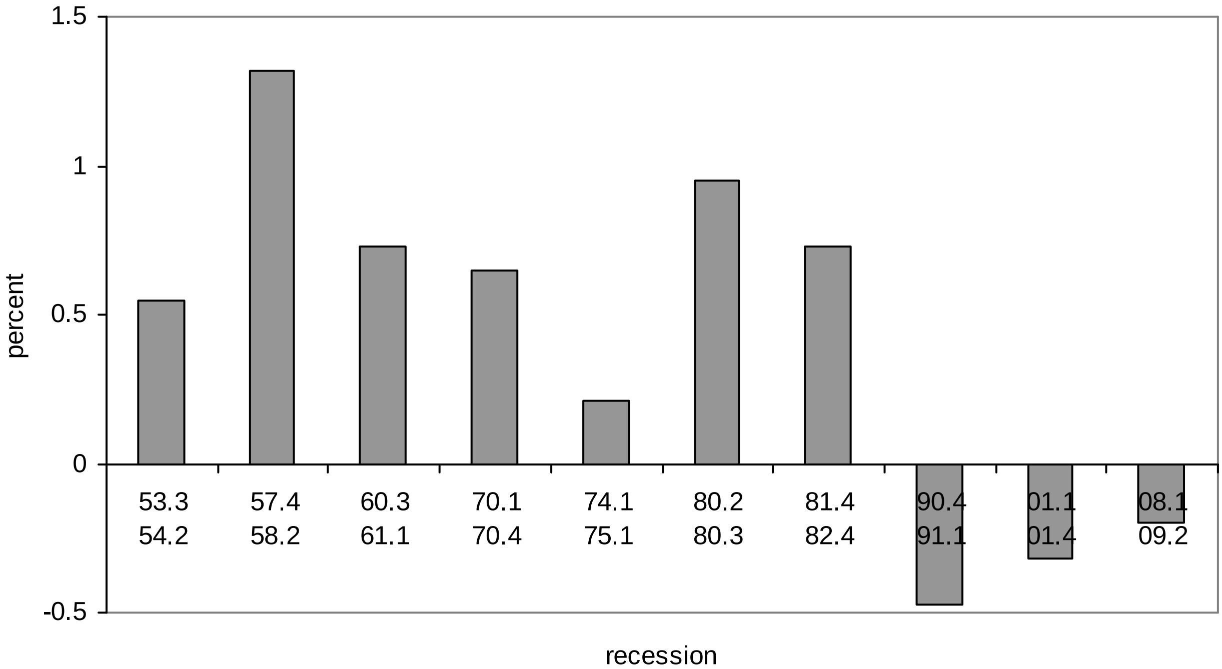
Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to 1984.1. The horizontal discontinuous line represents the average growth rate of the whole sample.

Figure 2: Growth rates of GDP for different quarters of the cycle



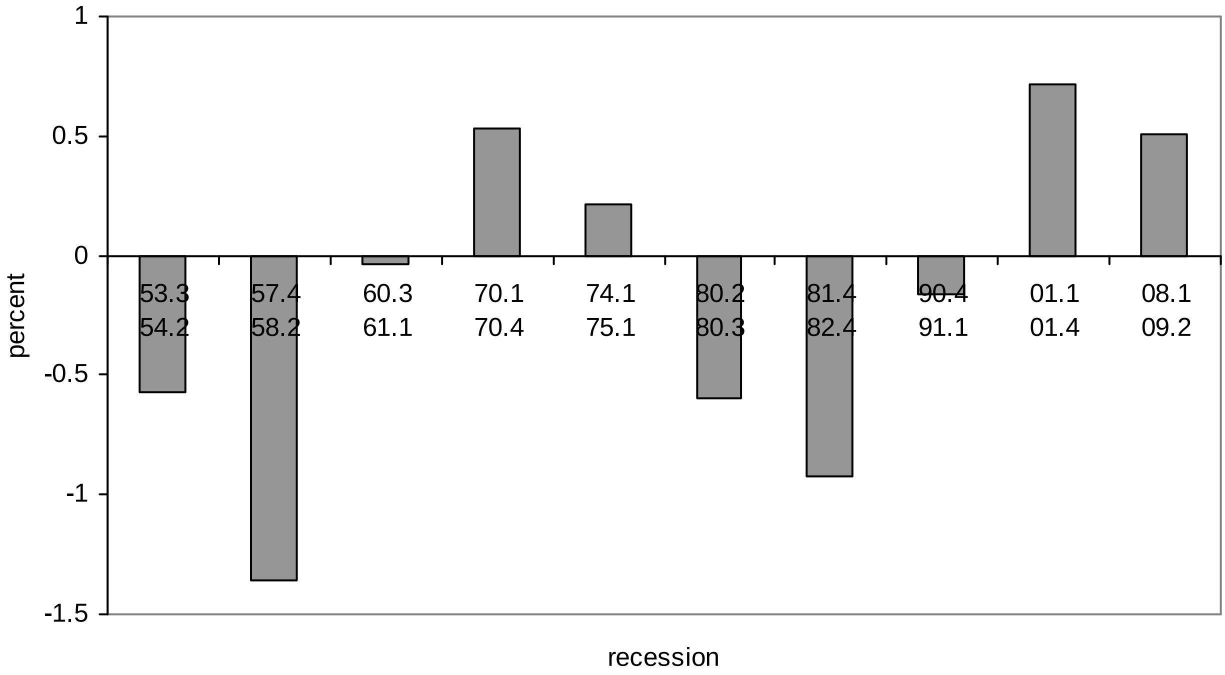
Note: Average (quarterly) growth rates of GDP for recessions and for different quarters in expansions.

Figure 3: Relative growth rate of GDP in the first two quarters of expansions



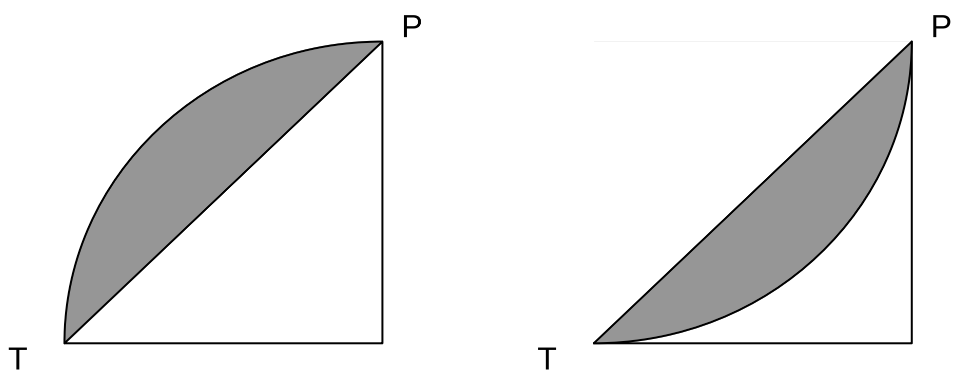
Note: Average (quarterly) growth rates of GDP for the first two quarters of expansions that follow the recessions that appear in the *X*-axis minus the average growth rate of expansions.

Figure 4: Relative growth rate of GDP in the first two quarters of recessions



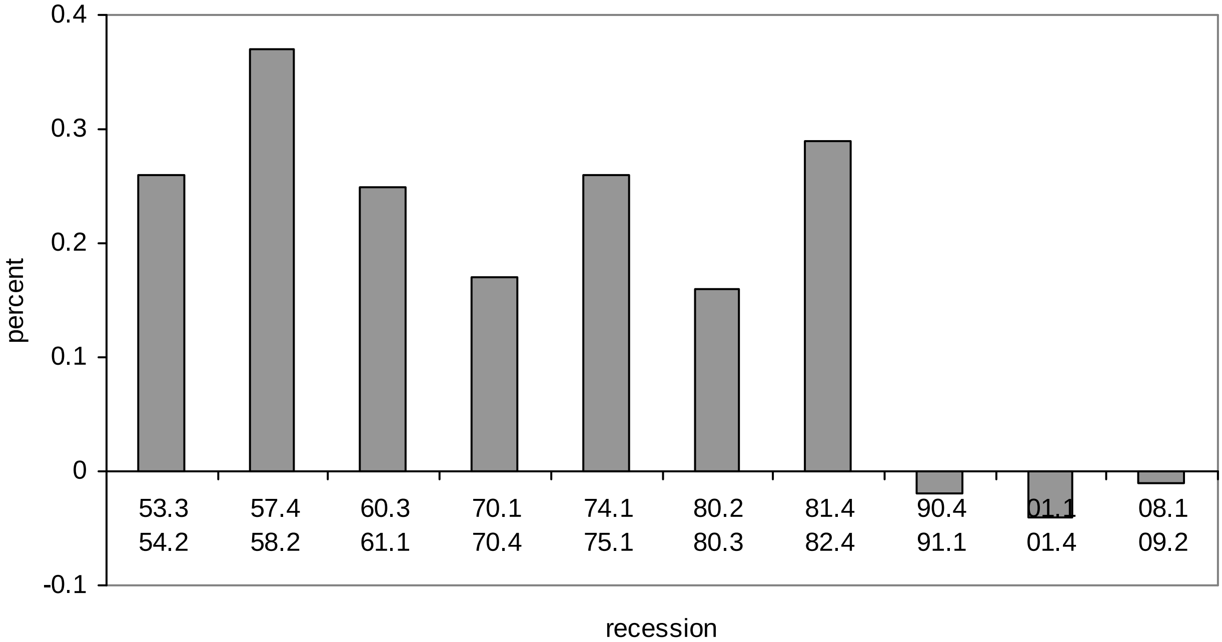
Note: Quarterly average growth rates of GDP for the first two quarters of the recessions that appear in the horizontal axis minus the average growth rate of recessions.

Figure 5: Stylized cycles



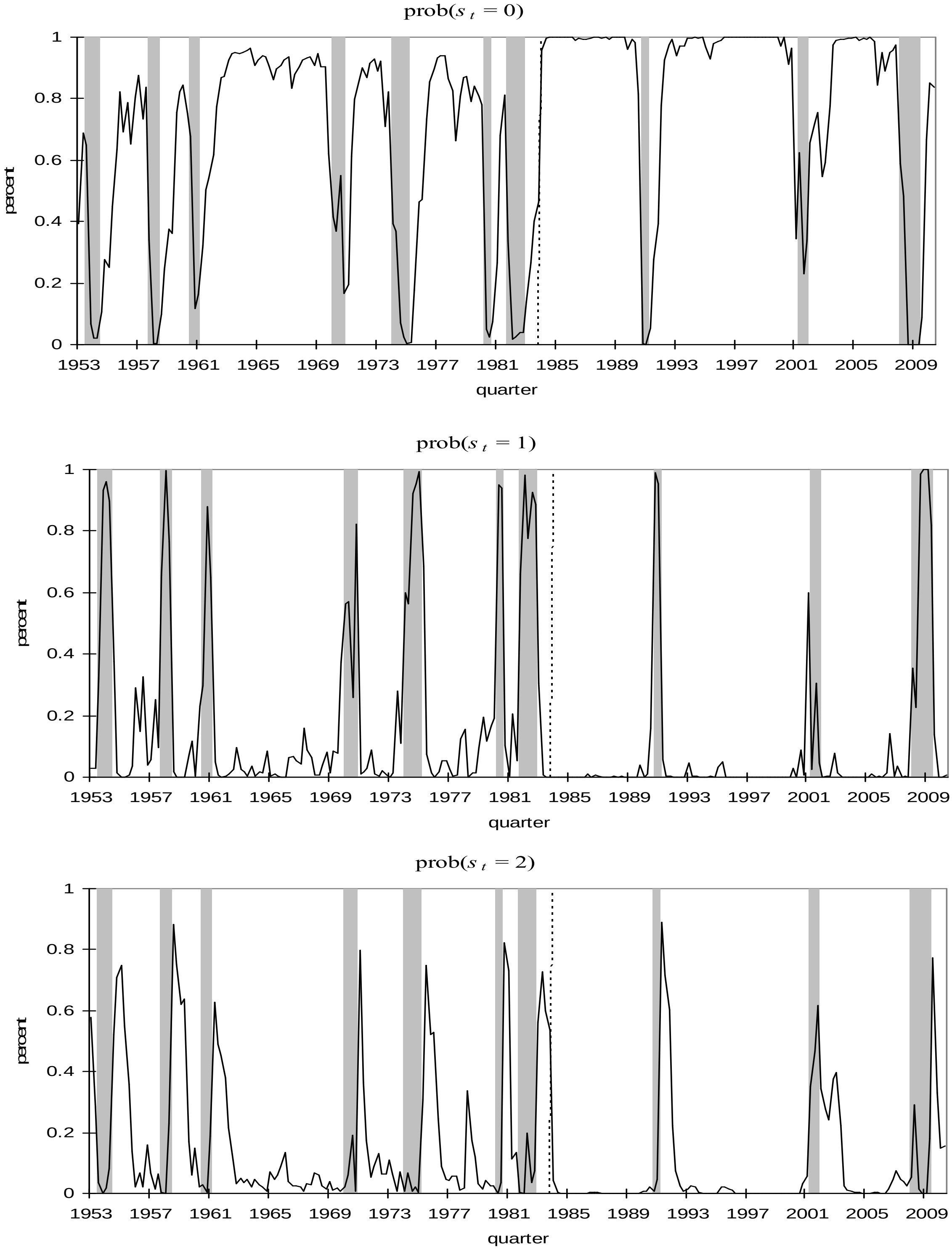
Note: The letter P refers to the peak of the cycle while the letter T refers to the trough.

Figure 6: Growth rate of employment in the first year of expansions



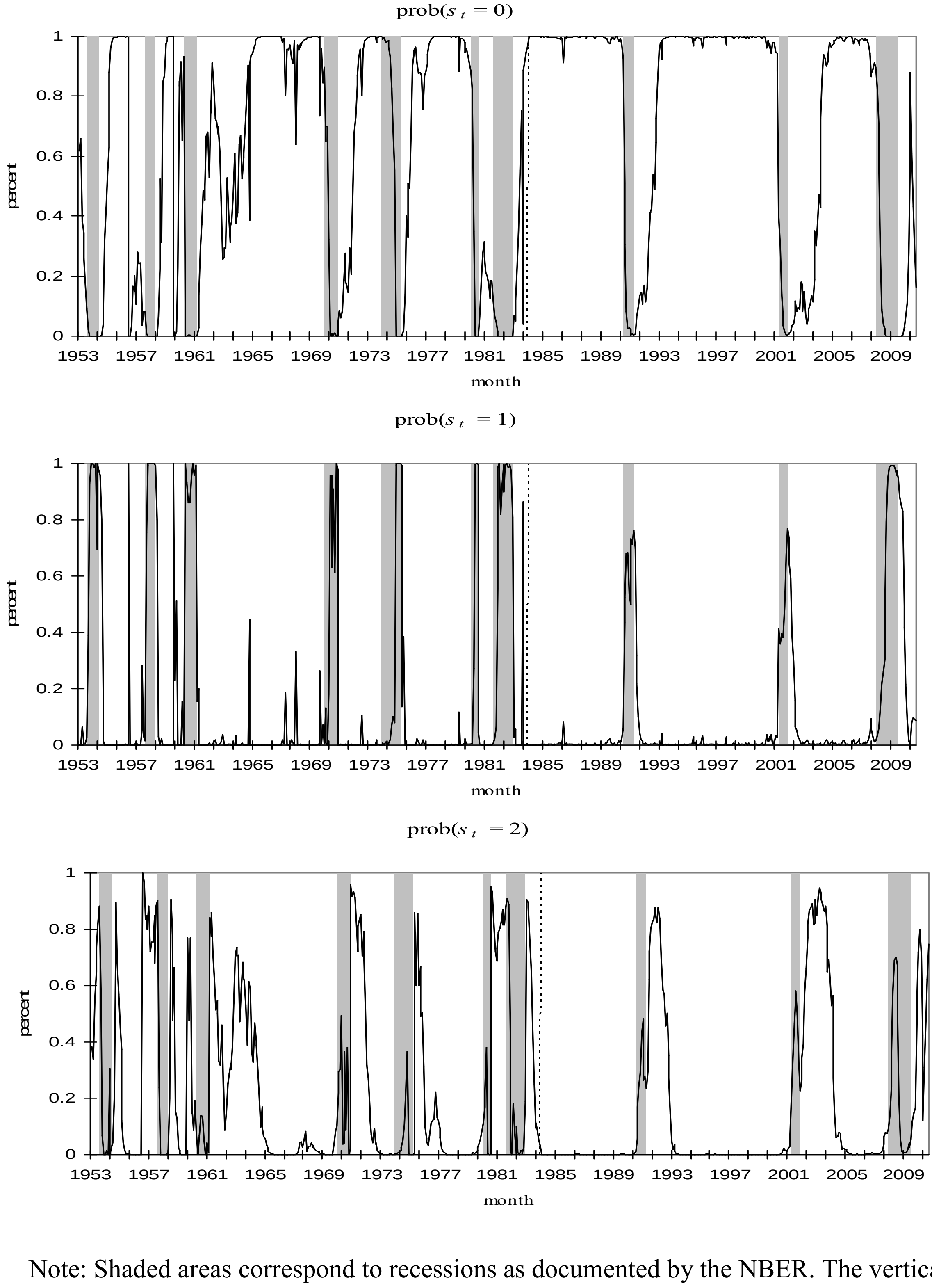
Note: Average (monthly) growth rates of employment for the first year of expansions that follow the recessions that appear in the horizontal axis.

Figure 7: Filtered probabilities for the growth rate of GDP



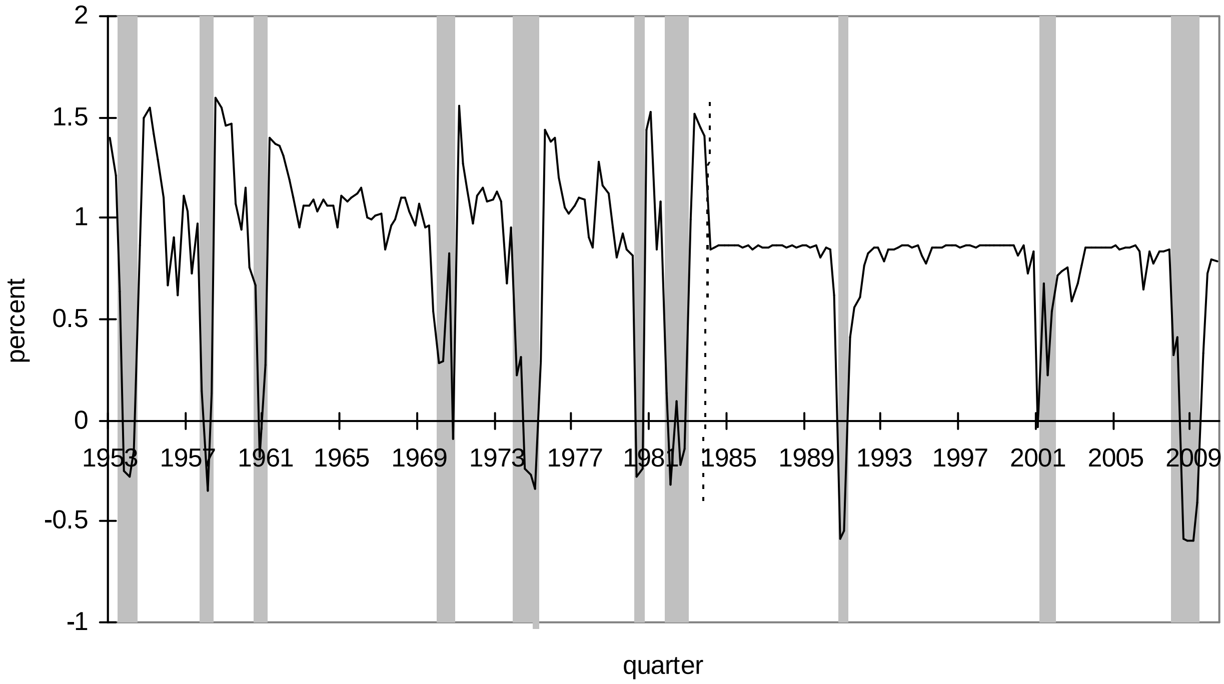
Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to 1984.1.

Figure 8: Filtered probabilities for the growth rate of employment



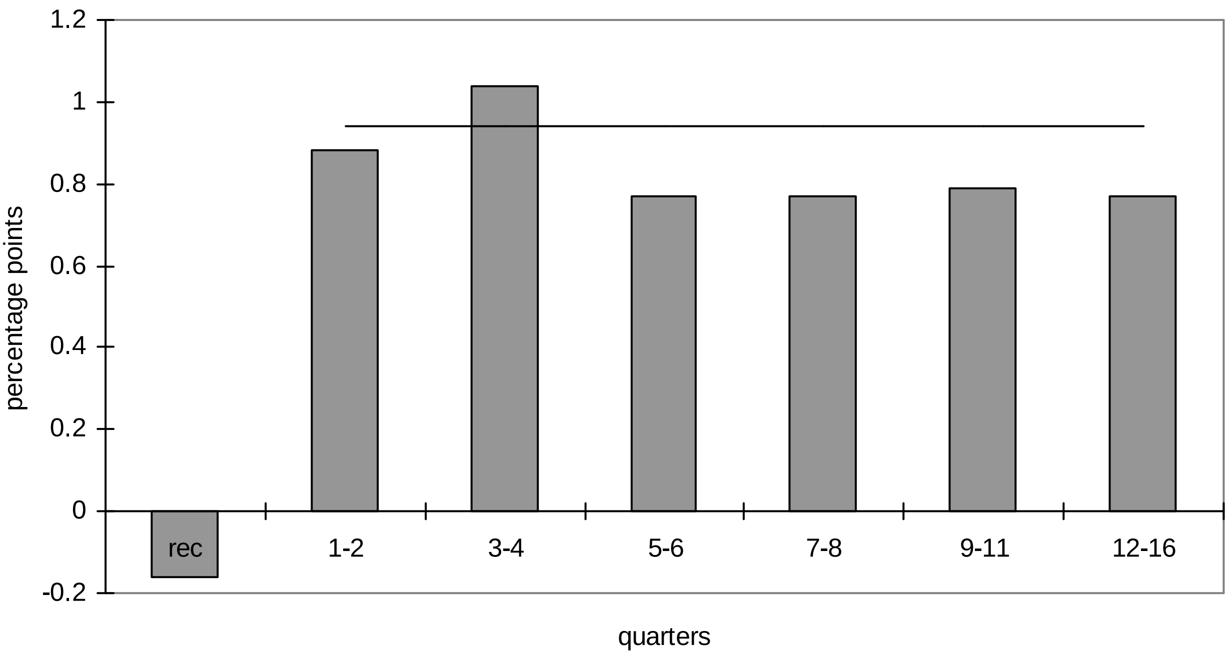
Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to 1984.01.

Figure 9: Estimated GDP growth rates



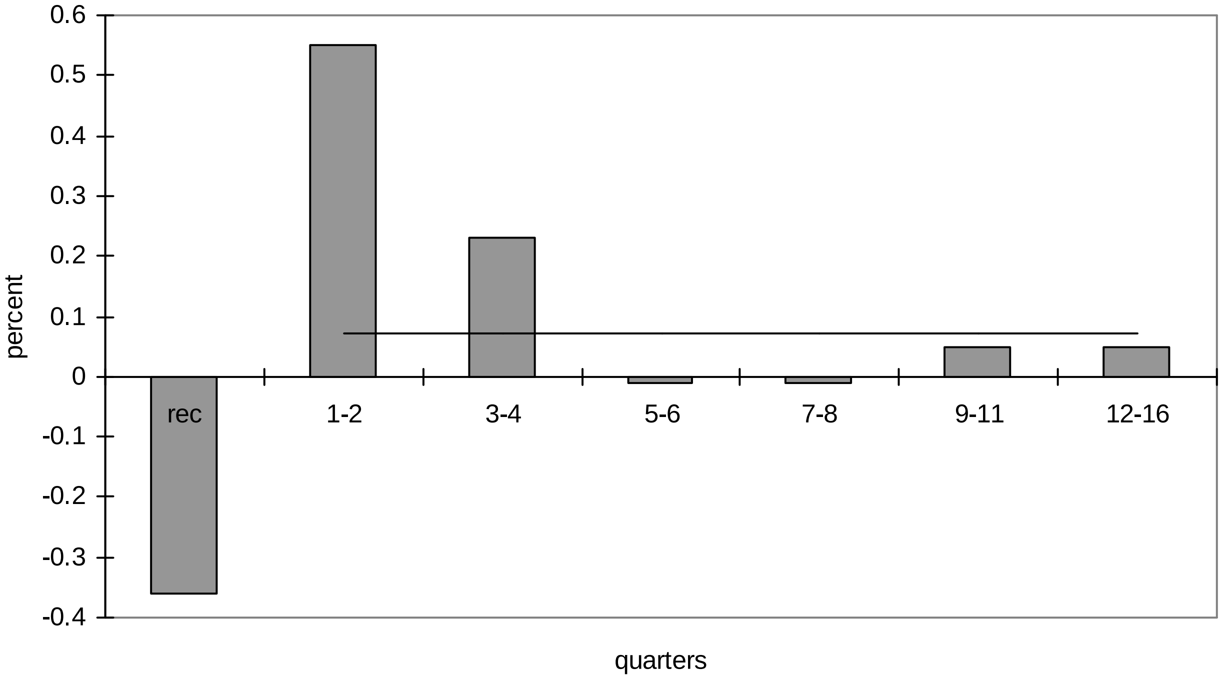
Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to 1984.1.

Figure 10: Average contribution of sales to GDP growth



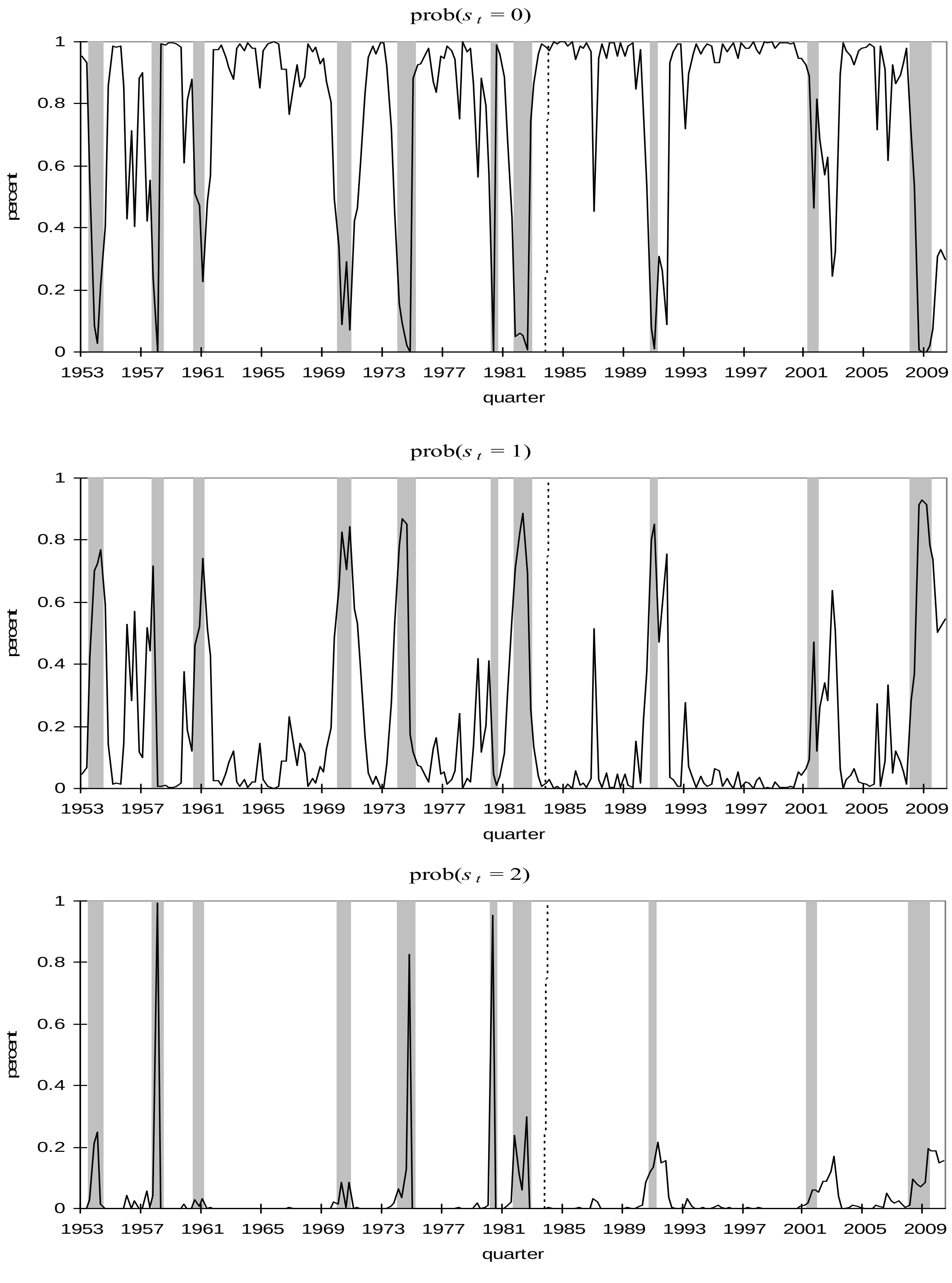
Note: Average contribution of sales to GDP growth for recessions and for several quarters in expansions.

Figure 11: Average contribution of inventories to GDP growth



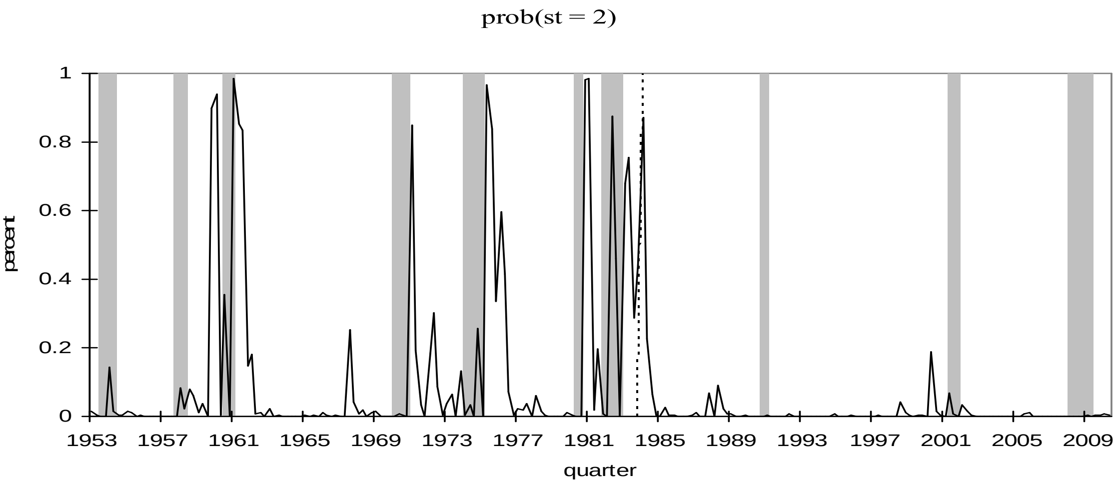
Note: Average contribution of inventories to GDP growth for recessions and for different quarters in expansions.

Figure 12: Filtered probabilities for the growth rate of sales



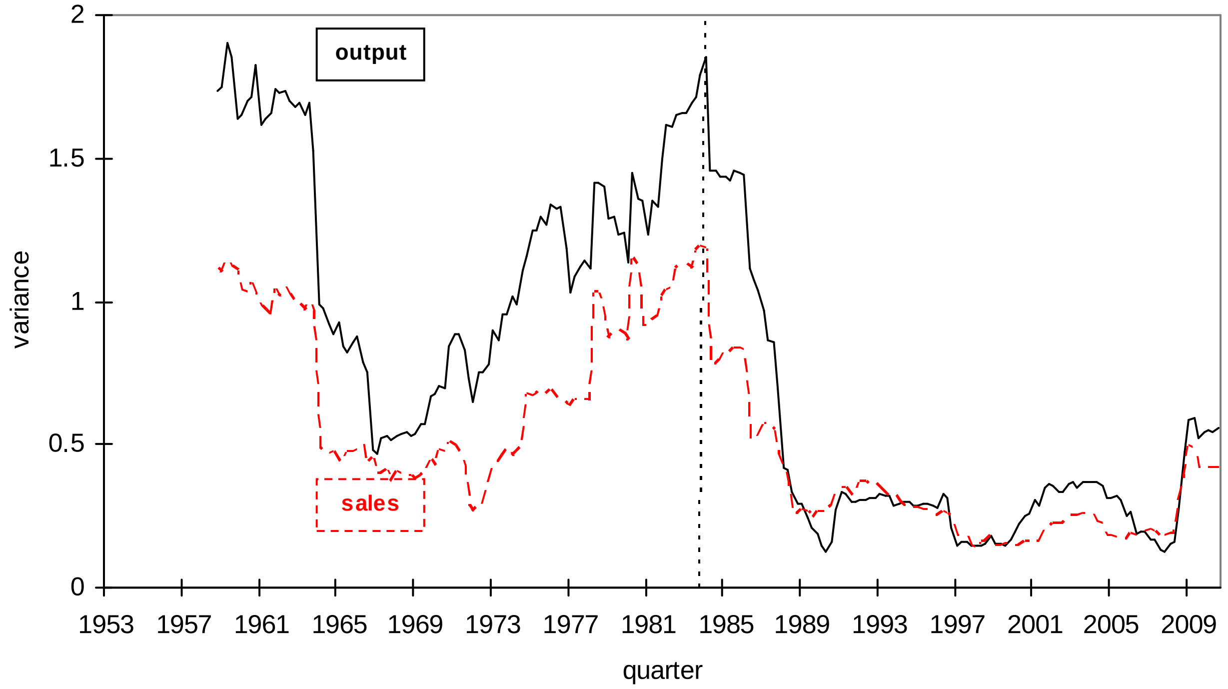
Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to 1984.1.

Figure 13: Filtered probabilities for the growth rate of Inventories



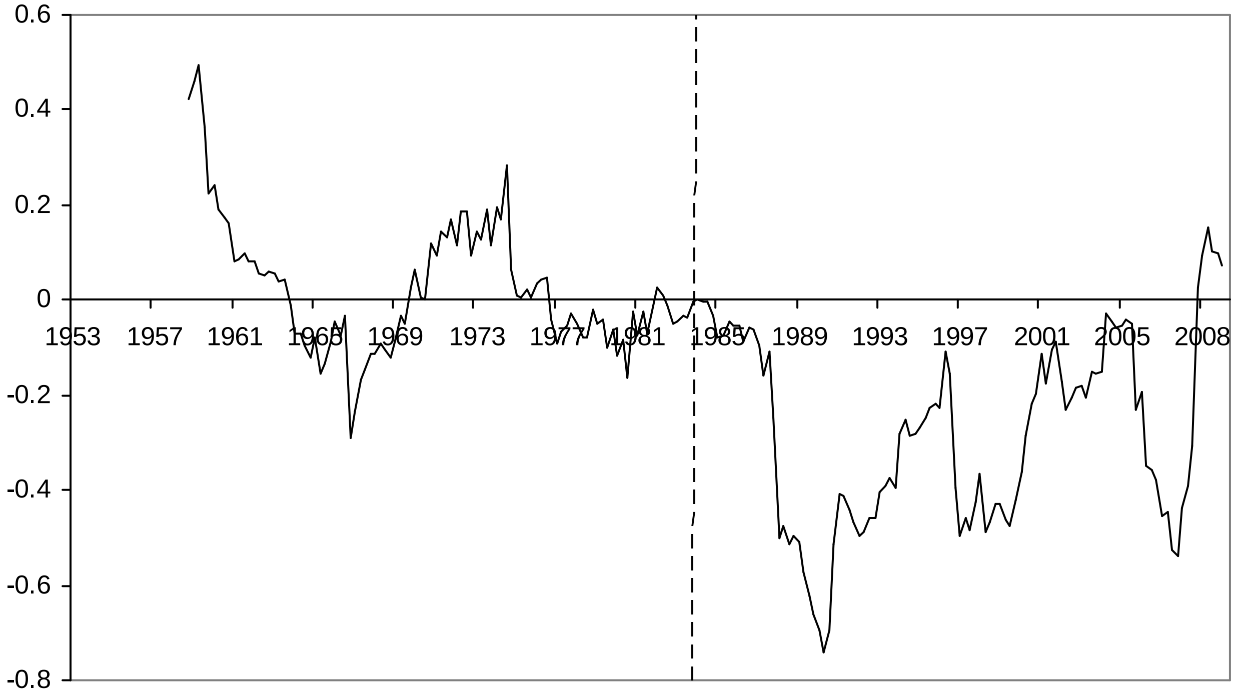
Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to the structural break date.

Figure 14: Variances of GDP growth rates and contributions of sales



Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to 1984.1.

Figure 15: Correlations between contributions of sales and inventory investment



Note: Shaded areas correspond to recessions as documented by the NBER. The vertical discontinuous line refers to 1984.1.