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Dipartimento di Statistica "G. Parenti" – Viale Morgagni 59 – 50134 Firenze - www.ds.unifi.it

Regime Switching: Italian Financial Markets over a Century

Margherita Velucchi

Università degli Studi
di Firenze

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Margherita Velucchi*

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Abstract

The frequency of crashes and the magnitude of crises in international financial markets are growing more severe over time. Recent financial crises are not singular events portrayed in recent accounts, rather, they erupt in circumstances that are very similar to the economic and financial environments of the earlier eras. This paper analyzes the Italian stock market in two very peculiar periods (1901-1911 and 1993-2004): the "Second" and the "Third Industrial Revolution". We use Markov Switching Models to test whether the Italian stock market volatility has increased in the long run and if it can be represented by different volatility regimes. We find that volatility regimes exist; that Banking sector has a central role and "New Economy" sectors perform quite well while traditional sectors do not, in both periods.

Keywords: Markov Switching Models, Volatility Regimes, Second and Third Industrial Revolutions

1 Introduction

Economists often compare financial crises developed in different contexts to investigate whether the crises are growing more frequent and more severe over time

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(Delargy and Goodhart, 1999; Eichengreen and Bordo, 2004; Bordo and Murshid 2001; Bordo et al., 2001). The comparison of crises in economic, institutional, geographic and, especially, historical different contexts may seems to be bold, but the evidence that "history matters" is definitely not new in economics. In fact, many authors suggest to focus on the comparison between pre-1914 crises and 1990s crises showing that some of the "peculiarities" of modern financial markets resemble what happened just a century ago (Delargy and Goodhart, 1999; Eichengreen and Bordo, 2004). Wilson, Sylla and Jones (1990) stress the relationship between increased volatility, panics and crashes testing whether, in the long run, increased volatility precedes, coincides with or follows crises; Bordo (1986) analyzes comparatively the relationships between crises, stock market behavior and the money supply; Delargy and Goodhart (1999), Bordo Eichengreen (2004), Bordo and Murshid (2001), Bordo et al. (2001), focus on financial markets behavior in the long run, suggesting a comparison of financial crises to test whether the frequency of crashes and the magnitude of crises are growing more severe over time. In particular, Delargy and Goodhart (1999) compare the Asian financial crisis in 1997 with late 19th. century crises. They find that the economic and financial environments of the two eras are very similar claiming that the Asian crisis had its roots in private sector over-expansion as it happened in the pre-1914 crises[1]. Eichengreen and Bordo (2004) compare the Argentina-Barings crisis of 1890 with the 1990s crises. They partially confute Delargy and Goodhart (1999) showing that crises are more frequent today but not more severe (twice as prevalent today) and that losses and recovery from such crises were not faster before 1914.

According to this literature, we propose a long run analysis of Italian stock market in two very peculiar periods (1901-1911 and 1993-2004): the "Second" and the "Third Industrial Revolution" in Italy. Indeed, the "Second" and the "Third industrial revolution" are both characterized by strong changes in the structure of the economy due to important technological innovations (electricity and information technology, respectively) and by a large expansion of the stock market. We use volatility modelling to study the Italian financial market over a century and to investigate whether there has been an increase in volatility and whether some relationship between innovative and traditional sectors can be identified.

Volatility modelling literature has been flourishing since the seminal papers on

[1]They analyze real demand, external relationships and domestic financial conditions in USA (1873,1890-1891, 1893, 1907), Italy (1893, 1907), Austria (1873), Australia (1893), Argentina (1873) in the late 19th and early 20th century comparing them to the economic environment of the Asian Tigers of the 1990s.

ARCH (Engle, 1982) and GARCH (Bollerslev, 1986) have been published. Since then an impressive number of generalizations have been suggested (Nelson 1991, Rabemananjara, Zakoïan, 1993; Glosten, Jagannathan and Runkle, 1993; Zakoïan, 1994; Engle and Kroner, 1995; Ballie, Bollerslev and Mikkelsen, 1996) to take into account asymmetries of the series and to provide a systematic comparison of volatility models. A different strand of literature, maintaining the time-varying volatility assumption of GARCH models, is represented by the Markov Switching approach (Hamilton, 1989, 1994; Hamilton and Susmel, 1994). Markov Switching models, modelling the series as a mixture of regimes (high and low returns and/or volatility periods), turn out to be particularly interesting to answer the questions concerning financial markets comparison in the long run. In this approach, the parameters are viewed as the outcome of a discrete-state Markov process and they are known to accurately capture typical stock market patterns such as jumps and crashes (Billio and Pelizzon, 2000; Kuo and Lu, 2005; Mills and Wang, 2003; Gallo and Otranto, 2006).

In this paper we use a Markov Switching approach to analyze stock market volatility in Italy in two periods: the first decade (1901-1911) and the last decade (1993-2004) of 20th century. We use a univariate 2-state Markov Switching model to analyze the behavior of the market, then we investigate the roots of the increased volatility focusing on sector indices. We expect to sketch high and low volatility regimes and to identify the "leading sectors", at least in terms of under/over performing sectors. Then, a Multivariate extension of the 2-state Markov Switching Model is used to stress the existence of relationships between the series and whether these relationships changed over time.

This paper is structured as follows: a brief description of the economy and of the stock market evolution in both periods is given in section 2, the model is introduced in section 3, section 4 describes the data and section 5 discusses the results. Section 6 concludes.

2 A Secular Overview on Italian Economy

According to many scholars, recent international financial crises are not events developed in new account; rather, they resemble old financial crises, especially the pre-1914 crises (Delargy and Goodhart, 1999; Eichengreen and Bordo, 2004). Recent financial crises erupted in circumstances that are very similar to the economic and financial environments of the former era, at least in some important features. This section sketches the main aspects of the Italian economy in the first

and the last decade of the 20th. century to stress their analogies over the century.

2.1 The First Decade: 1901-1911

At the end of 19th. century, Italy has not completed the *industrialization process* and its economic development is still behind the most industrialized countries (Castronovo, 1995). Notwithstanding, during the first decade of the 20th. century, Italy reaches the most advanced countries: between 1897 and 1907, the GDP rate of growth (compound average) is 2.5%, the average annual industrial production rate of growth is 5.5% and the average fixed investment rate of growth is 10.5% (Cotula, Garofalo, 1995). This decade is also characterized by the introduction of some important technological innovations and new sectors. Telegraph in 1894, for example, increases enormously the speed of financial transactions, favoring the integration of local stock markets (especially Milano and Genova) and the expansion of Borsa di Milano, while the introduction of electricity and new chemical products (like fertilizers, dye stuff and explosives) help the emerging of the new capital intensive firms obtaining adequate funds by the financial system. This period is commonly known as the *Italian industrial revolution*. Between 1895 and 1907, the good performance of economic indicators is accompanied by a large stock market boom. The number of quoted firms at Borsa di Milano increases from 30 to 171 (Table 1), showing a peak of 45 new entrants in 1905 (Siciliano, 2001). This is not simply an increase in number of quoted firms, because they are qualitatively very important for the Italian economy (De Luca, 2002). The largest Italian firms are quoted at Borsa di Milano and all the sectors characterizing the "New" and the "Old Economy" are represented. In 1903, 72% of the Italian share capital is quoted and almost all the increases in capital are realized by stock market new emissions (Siciliano, 2001, Baia Curioni, 2000). However, although the early 20th. century shows a very positive trend of the Italian economy, in 1907 one of the worse financial crises of its history takes place[2]. Table 2 shows that returns are constantly increasing up to 1905, then a downturn behavior starts changing completely the Italian financial system: from a well developed mix of *market-oriented* and *bank-oriented* system to a pure *bank-oriented* system that lasted until 1980s (Baia Curioni, 1995; Bonelli, 1971, Confalonieri, 1982; La Francesca, 2004).

[2]Siciliano (2001) shows that the boom before the 1907 stock market crisis has been the largest of the century and that the loss after the crash has never been completely re-absorbed. Between 1905 and 1907, Italian stock market loses 80% of its value: if we compare the market index price over a century starting with 1905 (=100), the value at 2000 is around 15.

Table 1: Number of Quoted Firms in 1901-1911:

Year	Quoted Firms
1897	30
1898	33
1899	46
1900	59
1901	60
1902	70
1903	72
1904	91
1905	134
1906	148
1907	171
1908	169
1909	168
1910	157
1911	159

Table 2: I70 index returns(1901-1911):

Year	I70 returns
1901	$+3.7\%$
1902	$+7\%$
1903	$+15.7\%$
1904	$+13.7\%$
1905	$+7.7\%$
1906	-9.7%
1907	-11.6%
1908	-13.7%
1909	-1.5%
1910	$+0.9\%$
1911	-4.8%

2.2 The Last Decade: 1993-2004

The Italian economic structure of the last decade 1993-2004 is characterized by strong institutional changes (the role of Europe and the introduction of euro) and by the privatization policy of the late nineties. The "globalization" phenomenon and the information technology sectors ("New Economy" sectors) role represent a deep structural change of the economy, whose effects are often compared to those of the Second Industrial Revolution. The effect of the "New Economy" revolution on the Italian stock market is represented by many high technology and capital intensive quoted firms, ensuring very high returns. However, the decade is characterized by frequent and successive waves of international financial crises involving almost all western stock exchanges: the 1992 collapse of Europe's fixed

parities, the 1994 collapse of the Mexican peso, the 1997-1998 East Asian crisis, Russia, Brazil and the 9-11, 2001 terroristic attack (De Long, 2001).
The economic growth of the last decade is not as high on average as that of the first decade of the century but, focusing on the stock market, if we isolate the period between the beginning of 1999 and the end of 2000, we obtain an expansion that resembles the 1905-1907 boom. During the last decade, Borsa di Milano experiences particularly high returns between 1996 and 2000, almost doubling the European average (Table 4). Since 1998, the number of firms quoted at Borsa di Milano increase after a decade of negative trend(Table 3): more than 50% of the new firms quoted are small and young and none of them belong to any group already quoted at Borsa di Milano (De Luca, 2002). High returns persist until the autumn of 2000. Since that moment, all international stock markets begin to suffer huge losses that reduce substantially the gains obtained during the previous years. The Mib30 annual return is +5.4% in 2000 and -25.1% and -23.7% in 2001 and 2002, while it appear to be positive after 2002 (+14.9 % and +17.4 % in 2003 and 2004, respectively).

Table 3: Number of Quoted Firms in 1993-2004:

Year	Quoted Firms
1993	259
1994	260
1995	254
1996	248
1997	239
1998	243
1999	270
2000	297
2001	294
2002	295
2003	279
2004	278

3 The Model

The Hamilton's seminal paper in 1989 suggested Markov switching techniques as a method for modelling time series. In the Hamilton approach, the parameters are viewed as the outcome of a latent discrete-state Markov process based on the fact that variables can be subject to occasional, discrete shifts in mean and/or variance. This approach has been widely used to describe and forecast financial time series

Table 4: Mib30 returns (1993-2004):

Year	Mib30 returns
1993	+37.4%
1994	+3.3%
1995	-6.9%
1996	+13.1%
1997	+58.2%
1998	+41%
1999	+22.3%
2000	+5.4%
2001	-25.1%
2002	-23.7%
2003	+14.9 %
2004	+17.4 %

(Rockinger, 1994; Van Norden and Schaller, 1993) while several others contributions and extensions of the original Hamilton's model have been developed and applied to different fields of the economic activity showing its high flexibility and forecast ability (Billio and Pelizzon, 1997; Khabie-Zeitoun et al., 2004; Jeanne and Masson, 1999; Kuo and Lu, 2005; Mills and Wang, 2003; Gallo and Otranto, 2006).

In a financial related context, regime-switching models refer to a situation in which stock market returns (and/or volatility) are drawn from two different distributions, where known stochastic processes determine the likelihood that each return (and/or volatility)is drawn from a given distribution.
Consider a random variable s_t that can assume only integer values $\{0, 1, ..., N\}$. Suppose that the probability that s_t equals some particular value j depends on the past only through its most recent value s_{t-1}:

$$P\{s_t = j \,|s_{t-1} = i, s_{t-2} = k, ...\} = P\{s_t = j \,|s_{t-1} = i\} = P_{ij}. \qquad (1)$$

This process is described as a N-state Markov Chain with transition probabilities $\{p_{ij}\}_{i,j:1,2,...,N}$. The transition probability gives the probability that state i will be followed by state j. Let s_t be a two states Markov Chain and consider the following:

$$y_t = \mathbf{x}_t'\beta_1 + \sigma_1\varepsilon_t, \ \textit{if}\ s_t = 0 \qquad (2)$$

$$y_t = \mathbf{x}_t'\beta_2 + \sigma_2\varepsilon_t, \textit{if}\ s_t = 1$$

where
$\varepsilon_t \sim i.i.d.N(0, \nu^2)$
and
$s_t = \begin{cases} 0 \textit{ if return and/or volatility is low} \\ 1 \textit{ if return and/or volatility is high} \end{cases}$
Denote the transition probability matrix as $\mathbf{P} = \{P_{i,j}\}$:
$P(s_t = 0, s_{t-1} = 0) = P_{00}$,
$P(s_t = 1, s_{t-1} = 0) = P_{10} = 1 - P_{00}$,
$P(s_t = 1, s_{t-1} = 1) = P_{11}$,
$P(s_t = 0, s_{t-1} = 1) = P_{01} = 1 - P_{11}$.
A related question is when the turning point is likely to occur. Therefore, it is useful to know the average *duration* h of the states (regimes):

$$E(h_i) = (1 - P_{ij}), i, j : 0, 1, j \neq j \tag{3}$$

Let us now introduce the stochastic process ξ_t such that $\xi_t = (1, 0)$ if $s_t = 0$ and $\xi_t = (0, 1)$ if $s_t = 1$. Then we have

$$E\left[\xi_t \left| s_t = i\right.\right] = Pe_i$$

and

$$E\left[\xi_{t+1} \left| \xi_t\right.\right] = Pe_i$$

if and only if $\xi_t = e_i$, hence

$$E\left[\xi_{t+1} \left| \xi_t\right.\right] = P\xi_t$$

If the process is governed by regime $s_t = j$, then the conditional density of $\mathbf{y}_t$ is assumed to be

$$f(\mathbf{y}_t \left| s_t = j, \mathbf{Y}_{t-1}; \theta\right.) \tag{4}$$

where $\mathbf{Y}_t = (y_1, ..., y_T)$ and $\theta = (\beta_j, \sigma_j, P_{i,j})', i, j : 0, 1$.
Let η_t be the collector of all conditional densities, with $N = 2$,

$$\eta_t = \left[\begin{array}{c} f(y_t \left| s_t = 0, y_{t-1}; \theta\right.) \\ f(y_t \left| s_t = 1, y_{t-1}; \theta\right.) \end{array} \right] = \left[\begin{array}{c} \frac{1}{\sqrt{2\pi\sigma_1}} \exp\left\{\frac{-(y_t - x_t'\beta_1)^2}{2\sigma_1^2}\right\} \\ \frac{1}{\sqrt{2\pi\sigma_2}} \exp\left\{\frac{-(y_t - x_t'\beta_2)^2}{2\sigma_1^2}\right\} \end{array} \right] \tag{5}$$

Let us collect the conditional probabilities $P(s_t = j \,|\mathbf{Y}_t; \theta)$ for $j : 0, 1$ in a two-dimensional vector $\widehat{\xi}_{t+1|t}$ whose *j*-th. element represents $P(s_{t+1} = j \,|\mathbf{Y}_t; \theta)$. The optimal inference and forecast $\forall t$ can be found by iterating on the following pair of equations:

$$\widehat{\xi}_{t|t} = \frac{(\widehat{\xi}_{t|t-1} \odot \eta_t)}{\mathbf{1}'(\widehat{\xi}_{t|t-1} \odot \eta_t)} \tag{6}$$

$$\widehat{\xi}_{t+1|t} = \mathbf{P} \cdot \widehat{\xi}_{t|t} \tag{7}$$

where η_t represents the (2×1) vector whose *j*-th element is the conditional density, $\mathbf{P}$ is the (2×2) transition matrix, $\mathbf{1}$ is a (2×1) vector of $1s$ and $\odot$ denotes the element-by-element multiplication. Given $\widehat{\xi}_{t|\tau}$, if $t > \tau$, $\widehat{\xi}_{\cdot}$ represents the *smoothed inference* for some future period, while if $t < \tau$, $\widehat{\xi}_{\cdot}$ represents *smoothed inference* about the regime the process was in at date t based on data until date τ. Smoothed inference can be calculated using the EM algorithm developed by Kim (1993). The process is completely described by

$$y_t = \mathbf{x}_t' \beta_j + \sigma_j \varepsilon_t, j : 1, 2, t : 1, 2, ...T, \varepsilon_t \sim i.i.d.N(0, \nu^2) \tag{8}$$

$$\mathbf{P} = \{P_{ij}\}, i, j : 1, 2 \tag{9}$$

$$\theta = (\beta_j, \sigma_j, \mathbf{P}), i, j : 1, 2 \tag{10}$$

then the maximum likelihood estimates for the transition probabilities satisfy[3]

$$\widehat{P}_{ij}^{l+1} = \frac{\sum_{t:2}^{T} P(s_t = j, s_{t-1} = i \,|\mathbf{Y}_T \,, \widehat{\theta})}{\sum_{t:2}^{T} P(s_{t-1} = i \,|\mathbf{Y}_T \,, \widehat{\theta})} \tag{11}$$

and

$$\widehat{\beta}_j^{l+1} = \left[\sum_{t:1}^{T} \widetilde{x}_t(j) \widetilde{x}_t(i)'\right]^{-1} \left[\sum_{t:1}^{T} \widetilde{x}_t(j)' \widetilde{y}_t(j)\right]$$

where

$\widetilde{x}_t(j) = x_t \sqrt{P(s_t = j \,\big|\mathbf{Y}_T, \widehat{\theta})}$

$\widetilde{y}_t(j) = y_t \sqrt{P(s_t = j \,\big|\mathbf{Y}_T, \widehat{\theta})}$

[3]See Appendix at the Chapter 22 in Hamilton (1994) for further discussion.

4 The Data

We use the daily price series of seven sectors for the first decade of 20th. century (Figure 1) and the daily price series of ten sectors for the last one (Figure 2; the sectors composition do not change very much during a century but some new sectors were introduced. The data consist of 3164 observations for the first period (January,2, 1901- December, 29, 1911) and 3071 observations for the last period (January,2, 1993 - February, 28, 2004), respectively. Index 70 and Mib30 are used to proxy the market behavior in both periods, calculated on the 70 and 30 most capitalized firms of the stock market, respectively[4]. The daily returns are calculated as the change in the logarithm of the closing prices of two successive days. Financial sector of the last decade has been splitted in two series, the first being the Banking sector and the second being the mean of the three most important financial sectors (Banking, Insurance, Financials Holdings). The Finance sector can indeed explain better the dynamics of the financial sector as a whole, even if it is less volatile than the Banking sector itself.

Table 5 and Table 6 provide summary statistics of data. The returns vary consistently both across sectors and across time from 18.28% (Food) in the first decade and 34.26% (Chemical Products) in the last one to -35.52% (Chemical Products) in the first and -30.93% (still Chemical Products) in the last decade. Both indices, as expected, show lower returns (from 6.25% and -7.77% to -6.72% and -8.11%, respectively). However, the volatility of the sectors of the first decade appear to be smaller than that of the last decade. Chemical Products sector is the most volatile among the first decade sectors while Cars, Media and Food are the most volatile sectors of the last decade. All series are not normally distributed and show evidence of skewness and leptokurtosis.

Table 5: Summary Statistics (1901-1911)

	Max	Min	St.Dev.	Skewness	Kurtosis	Jarque Bera (p-value)
Food	18.28	−17.36	0.86	1.09	217.37	0.000
Textiles	2.12	−6.82	0.29	−5.49	114.31	0.000
Banking	2.82	−2.62	0.35	−0.75	14.14	0.000
Chemical Products	16.21	−35.52	1.40	−5.38	159.78	0.000
Electrical Equipments	6.99	−5.38	0.64	0.29	20.25	0.000
Mining	6.81	−4.87	0.76	0.08	8.80	0.000
Transports	7.76	−2.78	0.42	1.61	42.32	0.000
I70	6.25	−6.72	0.43	−1.37	57.18	0.000

[4]The I70 index collects historical data since January, 1888 (Baia Curioni, 2000). The Mib 30 historical index is provided by Borsa Italiana (www.borsaitalia.it)

Table 6: Summary Statistics(1993-2004)

	Max	Min	St.Dev.	Skewness	Kurtosis	Jarque Bera (p-value)
Food	8.77	−27.14	1.72	−2.57	41.16	0.000
Textiles	5.44	−9.66	1.34	−0.46	6.49	0.000
Finance	6.70	−8.49	1.35	−0.45	5.87	0.000
Banking	6.95	−9.32	1.41	−0.42	6.55	0.000
Chemical Products	34.26	−30.93	1.64	0.54	117.33	0.000
Electrical Equipments	9.43	−8.43	1.67	−0.09	5.33	0.000
Mining	8.05	−10.45	1.54	−0.18	5.53	0.000
Cars	7.82	−9.62	1.76	−0.14	5.42	0.000
Transports	11.73	−14.26	1.34	−0.03	13.84	0.000
Media	22.78	−11.07	1.77	0.72	16.63	0.000
Public Utilities	6.75	−13.53	1.62	−0.31	5.70	0.000
Mib30	7.77	−8.11	1.52	−0.06	4.63	0.000

5 The Results

Table 7 and Table 8 show the results of a 2-states univariate Markov Switching Model on both returns and volatility[5] for sector and global indices. The results show the existence of a regime 0 with low returns and high volatility and a regime 1 with high returns and low volatility (Brock, Lakonishok, LeBaron, 1992). On average, the last decade appears to be more volatile than the first one, confirming that the volatility has increased (Eichengreen and Bordo, 2004) and, even if Mib30 shows both regimes with positive means, the volatility of regime 1 increased almost by four times in a century. The Chemicals in the first decade and the Food sector in the last one appear to be under performing (lowest returns and highest volatility among each period' sectors)[6] but some sectors of the first decade of the 20th. century show a negative mean also for the low volatility regime (Textiles and Mining). In particular, the results of Mining confirm historiography suggesting that it is one of the sectors driving the crash and one of the roots of the persisting crisis (Bonelli, 1971; Baia Curioni, 2000). The "New Economy" sectors are performing well: Electric Equipment in the first decade and Media and Public Utilities[7] in the last one.

Table 12 and Table 13 report the expected durations in both regimes. As ex-

[5]The parameters of the models are estimated by maximising the conditional log-likelihood function evaluated using Hamilton's (1989) recursive procedure. All models are estimated using GAUSS codes and testing the robustness of the estimates by using different sets of initial values.

[6]The result of Food is strongly influenced by the Parmalat crack: the Food sector loses almost 70% from December, 11 to the end of 2003, until Parmalat is excluded by the Mib30.

[7]Note that, in the last decade, Public Utilities sector contains the phone and mobile phone industry.

pected, low volatility regimes are more persistent than high volatility ones across time and sectors (Van Norden and Schaller, 1993). In particular, the regimes are more persistent during the last decade. Notice that, for example, the Mib30 expected duration of the high volatility regime during the last decade of the 20th. century is the same as the I70 expected duration of the low volatility regime of the first decade (33 days). Banking shows the highest expected duration among the sectors of the first decade of the 20th. century (25 days duration of the low volatility regime), which is still very low compared to that of the last decade, since no sector shows a duration lower than 33 days between 1993 and 2004. This implies that between 1901 and 1911 the transition from a state to the other occurred for a short period of time, confirming Bonelli (1971) about the uncertain situation in the Italian stock market during the 1907 crisis: it is the starting point of a depression that lasted until 1914.

Table 7: Maximum Likelihood estimates (standard error in parenthesis) based on data for daily Italian Stock Market sector indices, t: Jan.,2, 1901-Dec., 29, 1911:

	μ_0	μ_1	σ_0	σ_1	P_{00}	P_{11}	LogL
Food	-0.002 (0.008)	0.064 (0.121)	5.286 (0.589)	0.161 (0.008)	0.60 (0.049)	0.95 (0.006)	-274.78
Textiles	-0.064 (0.021)	0.011 (0.0006)	0.319 (0.021)	0.011 (0.0006)	0.55 (0.032)	0.85 (0.011)	-3531.32
Banking	-0.050 (0.026)	0.017 (0.004)	0.45 (0.032)	0.036 (0.001)	0.85 (0.020)	0.96 (0.005)	-2490.21
Chemical Products	-0.150 (0.272)	0.021 (0.013)	14.228 (1.521)	0.419 (0.018)	0.62 (0.006)	0.95 (0.048)	-1250.69
Electrical Equipment	0.010 (0.006)	0.024 (0.038)	1.320 (0.079)	0.059 (0.003)	0.83 (0.018)	0.93 (0.007)	-1037.50
Mining	-0.015 (0.039)	-0.004 (0.011)	1.297 (0.073)	0.160 (0.009)	0.93 (0.011)	0.96 (0.006)	-196.84
Transport	-0.033 (0.050)	0.03 (0.006)	0.749 (0.078)	0.077 (0.003)	0.74 (0.038)	0.95 (0.008)	-1638.91
I70	-0.048 (0.072)	0.007 (0.006)	1.055 (0.131)	0.078 (0.004)	0.77 (0.036)	0.97 (0.005)	-1762.97

For a good specification of the model, tables from 9 and 11 use specification tests of the Markov regime-switching model proposed by Hamilton (1996), testing for serial autocorrelation and ARCH effects.

As an illustration of switching behavior, a plot of the smoothed probability to be in a high volatility regime (give that at time $t-1$ the sector was in the high

Table 8: Maximum Likelihood estimates (standard error in parenthesis) based on data for daily Italian Stock Market sector indices, t: Jan.,2, 1993-Feb.,28, 2004:

	μ_0	μ_1	σ_0	σ_1	P_{00}	P_{11}	LogL
Food	-0.520	0.035	18.347	1.701	0.85	0.99	-2526.99
	(0.428)	(0.030)	(3.924)	(0.077)	(0.061)	(0.003)	
Textiles	-0.186	0.099	4.376	1.046	0.95	0.98	-2000.23
	(0.094)	(0.024)	(0.409)	(0.044)	(0.020)	(0.004)	
Finance	-0.036	0.046	3.979	0.891	0.96	0.98	-2005.77
	(0.049)	(0.023)	(0.265)	(0.041)	(0.009)	(0.004)	
Banking	-0.015	0.046	4.634	0.967	0.96	0.98	-2080.53
	(0.068)	(0.026)	(0.469)	(0.086)	(0.011)	(0.006)	
Chemical Products	-0.005	0.041	3.900	0.886	0.96	0.98	-2064.83
	(0.061)	(0.025)	(0.276)	(0.046)	(0.005)	(0.011)	
Electronic Equipment	-0.038	0.044	5.610	1.232	0.97	0.99	-2529.72
	(0.061)	(0.029)	(0.424)	(0.081)	(0.008)	(0.004)	
Mining	-0.087	0.060	6.048	1.477	0.88	0.97	-2459.17
	(0.133)	(0.030)	(0.734)	(0.092)	(0.030)	(0.009)	
Transport/Tourism	-0.039	0.024	5.397	1.240	0.98	0.98	-2748.77
	(0.030)	(0.026)	(0.277)	(0.065)	(0.005)	(0.006)	
Cars	-0.040	0.040	5.326	1.114	0.98	0.98	-1994.81
	(0.030)	(0.032)	(0.236)	(0.047)	(0.007)	(0.005)	
Media	0.018	0.048	7.785	1.104	0.97	0.99	-2496.18
	(0.021)	(0.102)	(0.051)	(0.501)	(0.008)	(0.003)	
Public Utilities	0.020	0.146	4.256	1.225	0.98	0.98	-2599.98
	(0.022)	(0.056)	(0.221)	(0.068)	(0.006)	(0.005)	
Mib30	0.012	0.048	4.289	1.213	0.97	0.99	-2384.97
	(0.059)	(0.030)	(0.251)	(0.056)	(0.007)	(0.004)	

volatility regime) is displayed for each sector and global indices. When the graph displays sharp spikes at irregular intervals, suggesting that the transition from the low to the high volatility regime occurs for a very short period of time, that sector is categorized as one having *weak regimes*. The graphs show the existence of weak regimes especially for Food (1901-1911), Chemicals (1901-1911) and Food (1993-2004).

The smoothed probabilities representation is coherent with the timing of crashes in both periods, showing the highest transition probability from regime 1 to regime 0 immediately before 1901, 1905, 1907 and before 1994, 1997 and 2001.[8]

Let us now introduce the results of the multivariate 2-state Markov Switching model. Table 14 and 15 show the transition probability matrices for the first and the last decade of the 20th. century. The multivariate analysis confirms that the low volatility regime is more persistent than the higher one independently of the

[8]The Food sector is strongly influenced by the Parmalat crack. In particular, if the last two months are excluded from the sample, the volatility is reduced by 50%, the returns of the high volatility regime become positive (from -0.52 to 0.13) while the expected duration of the high volatility regime increases from 6.7 to 10 days. Results are available upon request.

Table 9: Specification tests (1901-1911)

	Food	Textiles	Banking	Chemicals	Electric Eq.	Mining	Transport	I70
Serial correlation: regime 0	5.596	10.897	24.871	5.598	5.207	19.490	4.747	46.395
	(0.935)	(0.538)	(0.015)	(0.935)	(0.951)	(0.077)	(0.966)	(0.000)
Serial correlation: regime 1	27.301	3.349	2.953	0.457	29.800	0.291	6.223	4.325
	(0.007)	(0.993)	(0.996)	(0.997)	(0.003)	(0.997)	(0.904)	(0.977)
ARCH effects: regime 0	10.637	4.903	0.070	1.502	17.723	1.446	10.596	6.535
	(0.031)	(0.297)	(0.999)	(0.826)	(0.001)	(0.836)	(0.031)	(0.163)
ARCH effects: regime 1	7.258	4.924	3.601	1.287	17.652	1.241	13.931	23.303
	(0.123)	(0.295)	(0.463)	(0.864)	(0.001)	(0.871)	(0.008)	(0.000)

Note: LM ARCH test statistic with 4 lags and Ljung–Box 12–lag autocorrelation test statistic. P-values in parenthesis

Table 10: Specification tests (1993-2004)

	Chemicals	Mining	Banking	Electronic Eq.	Transport	Food	Textiles	Cars
Serial correlation: regime 0	7.800	7.275	2.903	96.977	6.684	89.020	13.531	5.052
	(0.801)	(0.839)	(0.996)	(0.000)	(0.878)	(0.000)	(0.332)	(0.956)
Serial correlation: regime 1	0.395	10.966	1.668	30.353	2.263	8.674	12.185	4.065
	(1.000)	(0.532)	(1.000)	(0.002)	(0.999)	(0.731)	(0.431)	(0.982)
ARCH effects: regime 0	3.851	1.789	9.305	1.651	2.612	1.442	6.335	8.954
	(0.427)	(0.775)	(0.054)	(0.800)	(0.625)	(0.837)	(0.176)	(0.062)
ARCH effects: regime 1	3.877	3.896	5.314	4.071	2.469	5.488	6.174	15.354
	(0.423)	(0.420)	(0.257)	(0.397)	(0.650)	(0.241)	(0.187)	(0.004)

Note: LM ARCH test statistic with 4 lags and Ljung–Box 12–lag autocorrelation test statistic. P-values in parenthesis

decade (P_{00}=55%, P_{11}=86% and P_{00}=71%, P_{11}=91%, respectively), showing also the higher stability of the regimes in the last decade.

From the multivariate analysis, linear relationships between sectors across the regimes over a century can be detected (Table 16 and 17). The correlations between sectors of the first decade are lower than those of the last one, independently of the regimes. As expected, the correlation increases as the volatility increases, in both the first and the last decade of the century. Banking shows the highest correlations with all other sectors over the century, confirming its central role in the Italian economy.

From Table 16, some relationships can be stressed, like those between Food and Textiles, Chemicals and Food and Chemicals and Transports (from 0.20 to 0.25, from 0.16 to 0.26 and from 0.15 to 0.24, respectively) showing the impact of chemical innovations on food industry and transports as well as the link between two of the most relevant traditional sectors (food and textiles). Electrical Equipment sector shows an increasing correlation with Food (from 0.10 to 0.24), with Banking (from 0.07 to 0.14) and with Transports (from 0.15 to 0.24), showing the

Table 11: Specification tests (1993-2004): cont'd

	Media	P. U.	Finance	Mib30
Serial correlation: regime 0	8.688	7.777	8.184	14.507
	(0.729)	(0.802)	(0.771)	(0.270)
Serial correlation: regime 1	7.505	4.992	8.906	0.315
	(0.823)	(0.958)	(0.711)	(1.000)
ARCH effects: regime 0	4.193	1.513	0.564	8.603
	(0.381)	(0.824)	(0.967)	(0.072)
ARCH effects: regime 1	3.833	1.539	7.812	6.468
	(0.429)	(0.820)	(0.099)	(0.167)

Note: LM ARCH test statistic with 4 lags and Ljung–Box 12–lag autocorrelation test statistic. P-values in parenthesis

Table 12: Durations in days (1901-1911)

	d_0	d_1
Food	2.6	20
Textiles	2.3	7.1
Banking	6.7	25
Chemical Products	2.6	20
Electric Equipments	1.2	16.7
Mining	2.5	14.3
Transport	3.8	20
I70	4.3	33.3

central role of Electricity during the Second Industrial Revolution. Finally, the Mining, the Food and the Textile sectors show quite strong relationships among themselves and the Banking sector, increasing from the low to the high volatility regime. This conclusion is supported by the results of the factor analysis in Baia Curioni (2000) that identifies Banking, Mining, Textiles and Food as the main roots of risk of this period.

Table 17 shows that the correlations between sectors during the century increase, as expected (Eichengreen, Bordo, 2004). Focusing on the last decade, the correlations from the low to the high volatility regime increase. For example Public Utilities and Banking correlation increases from 0.37 to 0.70 and Media and Electronic Equipment increases from 0.55 to 0.62. Banking is still strongly linked to the other sectors and this is particularly interesting if related to the recent Italian Cirio and Parmalat crack and FIAT 2003 crisis. Concerning the "New Economy" sectors, we might stress that Public Utilities shows a high correlation with Media and Electronic Equipment in both regimes (from 0.53 to 0.55 and from 0.70 to 0.68, respectively) identifying the sub-group of over performing sectors of the last decade.

Table 13: Durations in days (1993-2004)

	d_0	d_1
Food	10	33.3
Textiles	20	100
Finance	25	100
Banking	25	50
Chemical Products	25	50
Electronic Equipments	33.3	100
Mining	7.7	33.3
Transport	50	50
Cars	50	50
Media	33.3	100
Public Utilities	50	50
Mib30	33.3	100

Table 14: Multivariate Transition Probability Matrix (1901-1911)

States	**0**	**1**
0	0.55	0.45
	(0.050)	(0.065)
1	0.14	0.86
	(0.081)	(0.003)

From the results, a comparison between 1901-1911 and 1993-2004 periods can be established. The central role of the Banking system in the Italian economy persists over the century, financing the the most innovative sectors ("New Economy"sectors) of both periods, even if with alternate results as shown by the Mining case between 1901 and 1911, culminated with the nationalization of the sector in 1905. Certainly, the "New Economy" sectors in both periods have a good performance in the Italian financial market: Electric Equipment in the first decade and Public Utilities, Media and Electronic Equipment in the last decade of the

Table 15: Multivariate Transition Probability Matrix (1993-2003)

States	**0**	**1**
0	0.71	0.29
	(0.034)	(0.073)
1	0.09	0.91
	(0.040)	(0.002)

Table 16: Correlation Matrix (1901-1911)

Regime 0	Textiles	Food	Transport	Electricity	Banking	Mining	Chemicals
Textiles	1	0.25	0.20	0.08	0.17	0.07	0.10
Food		1	0.22	0.24	0.31	0.03	0.26
Transport			1	0.20	0.03	0.09	0.24
Electricity				1	0.14	0.07	0.15
Banking					1	0.22	0.07
Mining						1	0.03
Chemicals							1
Regime 1	Textiles	Food	Transport	Electricity	Banking	Mining	Chemicals
Textiles	1	0.20	0.19	0.12	0.01	0.02	0.09
Food		1	0.43	0.10	0.03	0.12	0.16
Transport			1	0.15	0.007	0.06	0.15
Electricity				1	0.07	0.07	0.08
Banking					1	0.20	0.21
Mining						1	0.08
Chemicals							1

century perform better than the remaining sectors, especially the traditional ones (Textiles and Food in both periods).

6 Conclusion

Looking for the roots of the increased volatility in the Italian stock market over the long run, we compare two high volatility periods representing the Second and the Third Industrial Revolution (1901-1911 and 1993-2004), both characterized by the introduction of strong technological innovations and by high volatility in the financial market. We use Markov Switching Models - volatility models where the conditional variance switch across a number of states and the dynamics of the switches are driven by a latent Markov Chain. We test the existence of returns and volatility regimes (high and low) and we describe the effects of regimes switches in the Italian stock market both at a sectoral and aggregate level over the century. The last decade appears to be more volatile than the first one, confirming that the volatility has increased (Eichengreen and Bordo, 2004): the volatility of the high volatility regime increased almost by four times in a century. As expected, low volatility regimes are more persistent than high volatility ones both across time and sectors (Van Norden and Schaller, 1993). In particular, the regimes have become more persistent during the last decade.

From a sectoral point of view, some similarities across time can be established. The results show that the so called "New Economy" sectors - Electricity for the first decade and Electronic Equipment, Media and Public Utilities for the last

Table 17: Correlation Matrix (1993-2004)

Regime 0	Food	Cars	Chemicals	Electronic Eq.	Mining	Textiles	P.U.	Media	Transport	Finance	Bank
Food	1	0.46	0.35	0.37	0.34	0.46	0.40	0.28	0.42	0.46	0.58
Cars		1	0.48	0.50	0.43	0.61	0.54	0.38	0.49	0.60	0.65
Chemicals			1	0.47	0.33	0.48	0.45	0.32	0.38	0.51	0.99
Electronic Eq.				1	0.25	0.58	0.68	0.62	0.51	0.82	0.63
Mining					1	0.42	0.35	0.22	0.40	0.56	0.49
Textiles						1	0.61	0.48	0.55	0.66	0.62
P.U.							1	0.55	0.43	0.92	0.70
Media								1	0.41	0.61	0.49
Transport									1	0.57	0.54
Finance										1	
Bank											1
Regime 1	Food	Cars	Chemicals	Electronic Eq.	Mining	Textiles	P.U.	Media	Transport	Finance	Bank
Food	1	0.52	0.60	0.48	0.47	0.49	0.61	0.31	0.47	0.62	0.26
Cars		1	0.67	0.59	0.49	0.56	0.65	0.45	0.46	0.68	0.41
Chemicals			1	0.66	0.55	0.61	0.75	0.50	0.51	0.77	0.99
Electrical Eq.				1	0.46	0.57	0.70	0.55	0.47	0.80	0.41
Mining					1	0.46	0.60	0.40	0.45	0.79	0.31
Textiles						1	0.63	0.47	0.43	0.65	0.40
P.U.							1	0.53	0.37	0.94	0.37
Media								1	0.33	0.58	0.24
Transport									1	0.58	0.28
Finance										1	
Bank											1

decade - perform well in both periods with stable regimes. On the contrary, traditional sectors, like Textiles and Food, strongly under perform, showing weak regimes. The Banking sector maintains a crucial role over the century, showing high volatility and strongly persistent regimes in both periods.

Finally, from the multivariate approach we can discuss the correlation dynamics between the series, across the regimes. The correlations increase over time, showing an increase of the linkages between sectors. As expected, the Banking sector have a central role in both periods, showing high correlations with all sectors independently of the regimes. Indeed, Banking is very important for the Italian economy, financing the "New Economy" sectors in both periods (Media, Public Utilities and Electronic Equipment, and Electrical Equipment and Chemicals, respectively).

A final observation may be advanced on the basis of this long run analysis on Italian financial market. The extraordinary evolution in financial markets improved very poorly the reactions after the shocks which, in turn, increased dramatically

over a century. The Italian financial market is not less risky than a century ago; it is more reactive and sensitive to international shocks but it is still fragile and banking oriented.

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Figure 1: Time Series of Seven Sector Indices: Sample Jan.2, 1901- Dec.29, 1911. 3164 Observations. Log-scale.

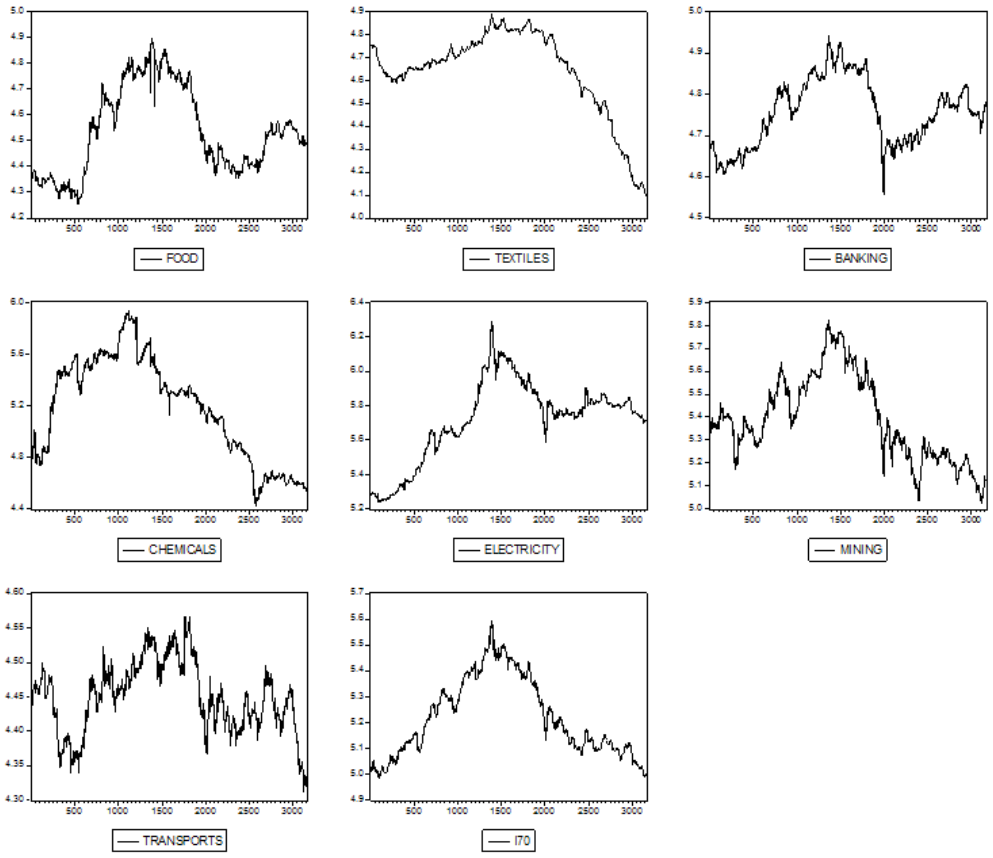

Figure 2: Time Series of Ten Sector Indices: Sample Jan.2, 1993- Feb.,28, 2004. 3071 Observations. Log-scale.

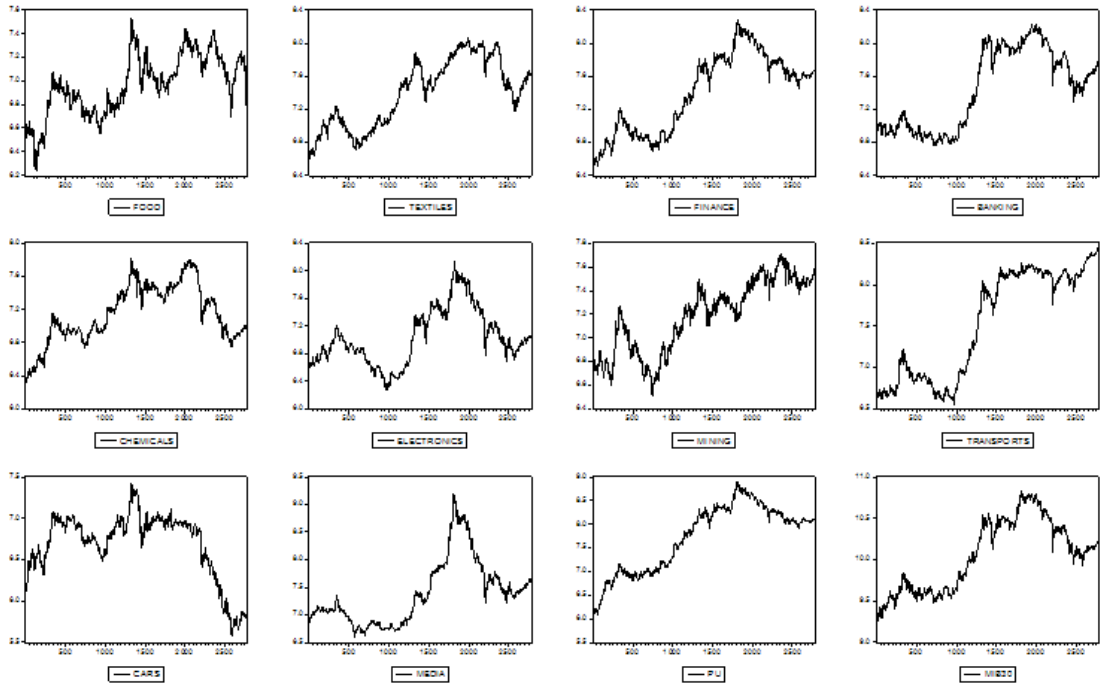

Figure 3: Smoothed probability (state 0): 1901-1911

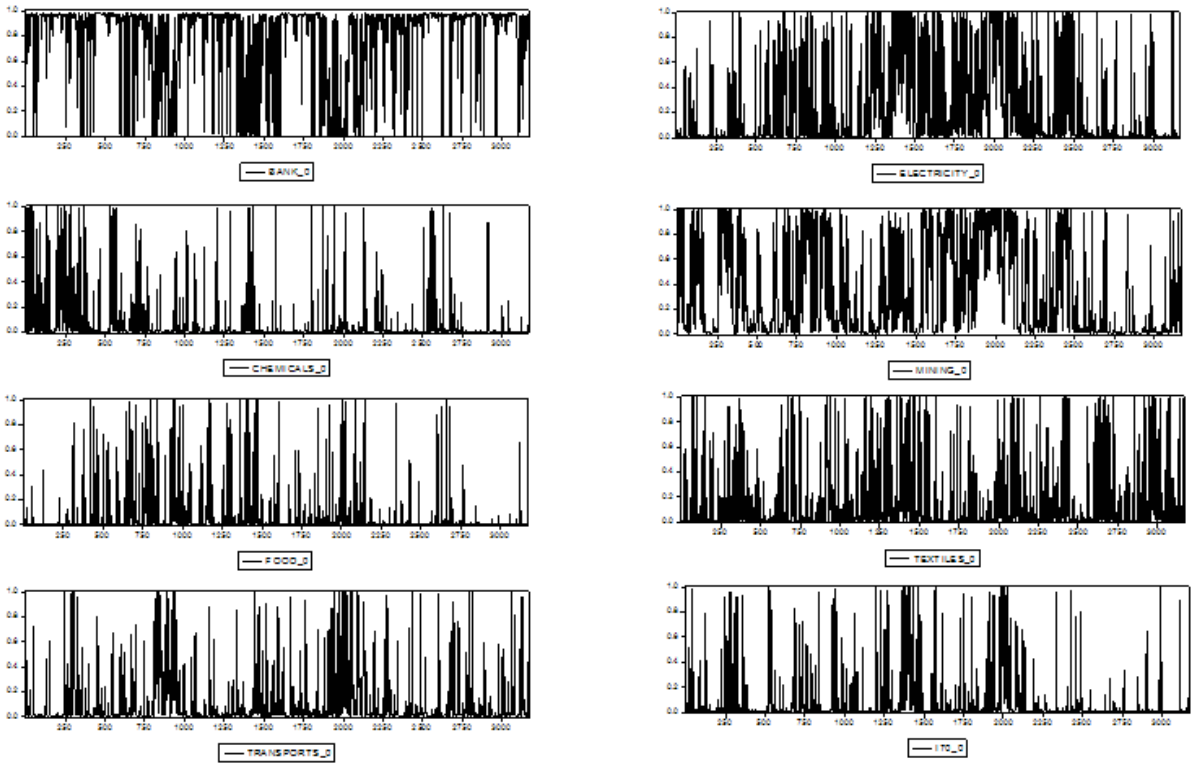

Figure 4: Smoothed probability (state 0): 1993-2004

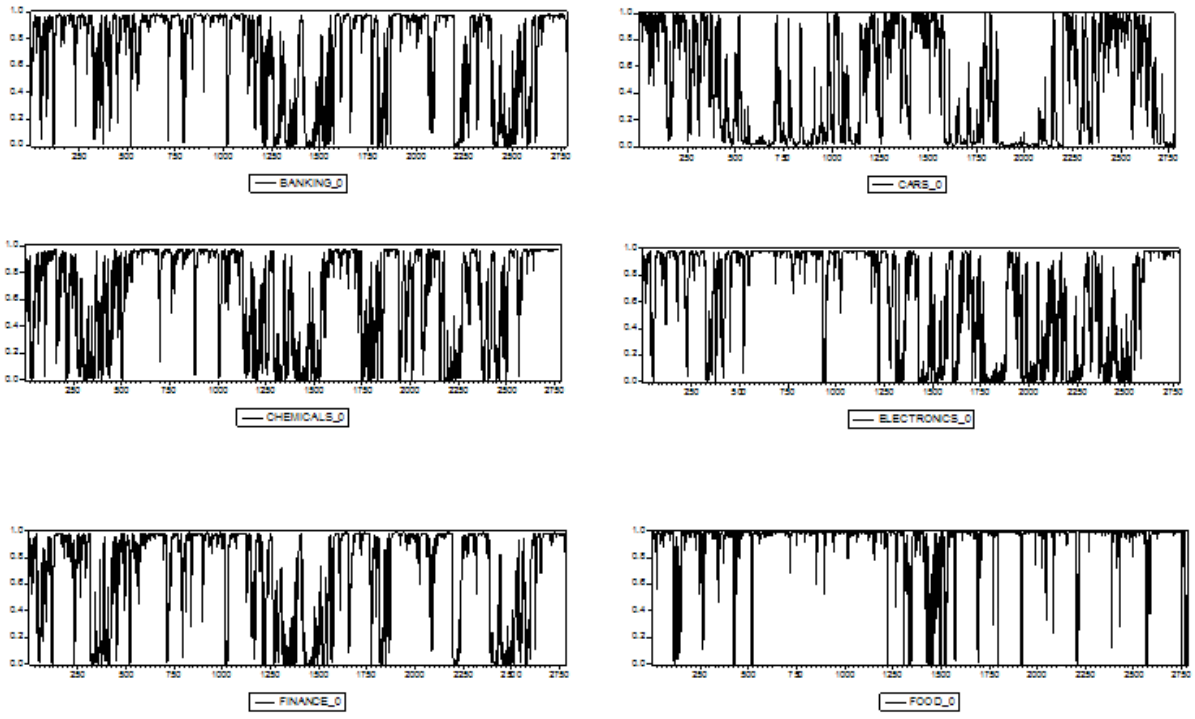

Figure 5: Smoothed probability (state 0): 1993-2004 (cont'd)