A Nonlinear Markov Switching Approach to Characterize the Cyclical Asymmetric Dynamics of the German Manufacturing Industry

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Abstract

The manufacturing industry has gained significant importance in creating sustainable growth and development policies, particularly after the devastating impacts of the recent global financial crisis on real sector. Especially advanced economies aim to strengthen their economies and achieve a more stable growth in a sustainable framework by eliminating the ongoing effects of the crisis. The study examines the asymmetric cyclical dynamics of the manufacturing industry for the German economy, which is one of the leading economies in the manufacturing sector across the world. This paper documents the presence of state-dependent asymmetric behaviors and heteroskedasticity across the cyclical phases in German manufacturing industry by employing Markov regime switching models. Besides, the empirical results provide the smoothed probabilities, the transition probability estimates along with identifying the different regime classifications. Revealing these results provides a further understanding for policy makers and investors in order to design more effective policies in the decision-making process.

Keywords: Markov Switching Models, Manufacturing Industry, German Economy

JEL Classification: C32, L60

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1. Introduction

Developments that occurs in advanced economies shape the course of the world economy to a greater extent, with their leading position in the world economy. Monitoring the dynamics of the large economies carefully has become a further necessity for policy makers where they have a decisive role in the shaping of economic policies all around the globe.

Dramatic effects of the 2008 global financial crisis on the real economy has caused for a further questioning of the financial sector's domination on the real sector. Neglecting the important role of the real sector on the sustainable growth has weakened the competitiveness power of developed economies in the global market. Consequences of the crisis show the inaccurancy of the growth policies that are strongly based on international capital flows, which create a fragile economic structure, and therefore, the necessity for effective industrial policy has widely come up again. In this context, the developed economies have begun to focus more on sustainable growth policies that are based on strengthened to protect increase their competitive advantages against the vulnerable and unstable economic structure that is caused by uncontrolled capital flows. Therefore, the reforms related to sustainable manufacturing industry has become one of the central policy areas in terms of sustainable global growth. Recently, the European Union has put into place a strategy re-called the renaissance of European industry[3] in order to revive the EU economy and direct it into a sustainable growth path after the crisis. This strategy, which is being implemented under the Europe 2020 Strategy is a development plan that also takes the post-crisis effects into account and includes the policies based on innovation, environmentally friendly new technologies and productivity growth to foster the manufacturing sector. This industrial strategy for the modernization of Europe's industrial base increases competitiveness and affects not only the economies in the union, but also many economies out of the EU. Germany is the European Union's largest and the world's fourth-largest economy. German economy leads EU's industry 4.0 application for manufacturing industry to achieve innovation and productivity growth. In addition, it is also the 4th biggest economy in the leading manufacturing economies in the world.[4] Although China remains as a world leader in creating manufacturing value added, Germany has still the biggest competitiveness power being the 1st economy on the rankings for the competitive industrial performance[5] with having higher technology feasibilities. German economy has also an important place in the world trade as being the world's 3rd largest exporter and importer economy in parallel to its strong position in manufacturing production.[6]

Germany, which already has a leading position among the manufacturing economies, aims to increase the competitiveness of its economy in the market with the reforms in the manufacturing industry that is called as the fourth industrial revolution. Because of its leading position with its structure based on production and trade, the developments occurring in the German economy shape significantly the economic policies of other countries that interacts by affecting the structure of the global supply and demand. In this context, analyzes that examine the dynamics of the production structure in the German manufacturing industry provide a

[3] See for more information, Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions for a European Industrial Renaissance, COM(2014)014 final, 22 January 2014 (http://eurlex.europa.eu/legal-content/EN/TXT/PDF/ ?uri=CELEX:52014DC0014&from=EN)

[4] See Unido statiscical estimates on leading manufacturing economies share in world MVA (at constant 2010 prices). (http://www.unido.org/Data1/IndStatBrief/World_Leading_MVA.cfm?print=no&ttype=W6&Country=GER&Group=)

[5] See Unido Statistical estimates, (http://www.unido.org/Data1/IndStatBrief/Basic_Information.cfm?print=no&ttype=C1&Country=GER&Group=)

[6] According to World Trade Organization Trade Profiles Publication (2015)

guiding perspective for policy makers in the process of creating national economic policies for any economy in the. In light of these developments, this study examines the cyclical dynamics of the German manufacturing industry by using monthly manufacturing production indices to provide a detailed understanding on the asymmetric behaviors of the German production structure that is highly employed in creating solid economic policies.

Identifying economic fluctuations and cyclical properties of manufacturing industry has been studied for many different countries depending on various contex and methods. Sala and Farré [21] examine the cyclical characterization of Spain manufacturing industry in their extensive study by following Harding and Pagan[15] methodology. They both investigate asymmetric behaviors in 16 manufacturing industries in terms of duration, amplitude, deepness and steepness co-movement relations among industries of the Spanish economy using quarterly IPI data. Their results determine that although Spanish manufacturing industries exhibit different attitudes in their cyclical phases, there is no significant asymmetries in their deepness and steepness behaviors except for the food industry in its own behavior. For the U.S manufacturing industry, Chang and Hwang [8] detect cyclical turning points for 74 U.S. manufacturing industries and examine their comovement tendencies along with the characterization of their asymmetric behaviors between cyclical phases over the overall business cycle. They also examine the effects of macroeconomic shocks on industry phase shifts, such as oil prices, and financial conditions. Similar to the previous work, they also utilize the non-parametric Harding and Pagan [15] methodology for the period between 1972:1 and 2011:4 along with Bry and Boschan [6] algorithm for quarterly data. Their findings determine substantial asymmetry among the turning points of business cycle phases of these 74 manufacturing industries in U.S and the importance of the macroeconomic shocks to drive industrial phase shifts. Korenok, Mizrach and Radchenko [17] examine the behaviors of GDP and the sectors as components of GDP, mainly focusing on the manufacturing sector that is separeted as durables and nondurables manufacturing sectors, and the sub-sectors of this manufacturing classification for the U.S. They employ Markov switching model along with the Bayesian estimation approach on determining sectoral asymmetries for the dates between January 1967 to December 1997 by using aggregate quarterly data on sectoral output. According to their findings, there is highly strong asymmetry in the manufacturing sectoral phases, whereas they detect a fairly weak asymmetry behavior for the aggregate GDP and the services sector. Baycan [4] examines the cylical asymmetric dynamics for the capacity utilization rates of the Turkish manufacturing industry, which includes the textile and apparel sub-industries among of the other ones, by using nonlinear Markov switching methods together with the Expectation Maksimization (EM) algorithm for monthly Turkish manufacturing industry capacity utilization rate data from February 1991 to August 2015. The study reveals the strong asymmetry across the cyclical phases over the capacity utilization rates of the Turkish manufacturing industry.

On the other hand, although there is a wide literature that examines the dynamics of the German economy, they mostly deal with the applications of the leading indicator methodology and the co-movement analyses among time series variables or co-movement behaviors among different countries. Bandholz and Funke [3] search for a leading indicator for economic activity of Germany in their paper by utilizing a dynamic factor model with and without regime switching in the framework of Markov switching models and Kalman filtering method. Artis, Krolzig and Toro [2] investigate the existence of a common European business cycle by using both the indices of industrial production and GDP in the framework of univariate and multivariate nonlinear Markov regime switching models for nine European countries including Germany. Their results present the evidence of the existence for a common business cycle in Europe that consisting of three phases. The results also document three phases over the business cycles in the individual European economies, except for Germany. Artis, Kontolemis, Osborn

[1] conduct a study that examines the existence and characteristics of classical cycles in industrial production for the G7 economies together with the most major European countries by utilizing nonparametric Bry and Boschan [6] method. The results obtained from analysis emphasize that business cycles show mostly asymmetric and comovement properties and there are strong links between the business cycle states across countries. Den Reijer [12] examines the deviation cycles in the manufacturing industry by applying the Christiano-Fitzgerald band-pass filter in order to measure the cyclical fluctuation and identify the cylical properties like dating turning points, amplitude, steepness and duration dependence for each country across low and high growth phases for nine OECD countries, including Germany. In addition, the study examines the international linkages of the cyclical movements in the manufacturing industries among these nine countries and investigates leading properties of the manufacturing industry cycle.

To our best knowledge, there is no study in the field that characterizes the non-linear asymmetric dynamics of the German manufacturing industry employing the Markov regime switching models. Utilizing these models provides distinct information on the cyclical behaviors of the examined variable of a time series considering its superiority to indicate asymmetric behaviors with respect to the changes in each regime. Considering the great importance of recognizing regime changes and asymmetric behaviors across the phases in decision making process for policy makers, this study provides a useful insight about the dynamic behaviors of the German manufacturing industry to make inferences for its production pattern. Moreover, the globalization process has led to considerable economic instability across the world. This situation causes major policy changes in any time and any country due to the volatile structure of the global economy. Such policy changes may create structural breaks in national and global economies that result in regime changes. Therefore, to monitor these external potential changes that may cause macroeconomic shocks is highly important to consider consistent policies for national economies in respect to policy makers and investors. In the light of these needs, this paper employs nonlinear regime switching Markov models that allow to change both the mean and variance parameters to investigate the asymmetric characteristics of the German manufacturing industry at monthly frequencies by using Expectation Maximization (EM) algorithm.

2. The Model and Data

Early approaches on linear econometric modeling that has been utilized in time series analysis are incapable of capturing the nonlinearity and asymmetric behaviors in macroeconomic time series. Such restricted analyses does not yield useful results considering the time series nature that subject to structural breaks that are caused by sudden policy changes. Such policy changes or unexpected developments in economies causes regime shifts among different business cycle phases that are subject to regime changes through time, which show asymmetric characteristics over the cyclical phases. Considering these nonlinear characteristics, Markov switching class of models allow for a more realistic framework to analyze macroeconomic series.

Although early studies (see among others, Mitchell [19] Burns and Mitchell [7] and Neftci [20]) imply the asymmetry in time series behaviors, the seminal paper of Hamilton [13] is enable to model the nonlinear characteristics of the variables among different phases by allowing the transitions between regimes and asymmetric behaviors. Markov switching framework allows to model the periodic shifts[7] in the model parameters through the transition process of different phases that causes the change of the values in parameters. In Markov switching framework, regime changes process are driven by an unobservable stochastic state

[7] See for further information, Kim & Nelson [16]

variable. Therefore, the path of the state variable and the parameters through time are to be inferred from the data . (Kim and Nelson, [16])

This is the first study that characterizes the cyclical properties of the manufacturing industry in Germany by employing Markov regime switching models in the related literature.

Let y_t represents for the German manufacturing industry that can be formulated as the sum of the terms n_t and z_t, which denote the Markov trend and the Gaussian component, respectively.

(1) $$y_t = n_t + z_t$$

The Markov trend (n_t) is consists of,

(2) $$n_t = \alpha(s_t) + n_{t-1},$$

where $s_t \in \{1,\ldots,M\}$ is a latent Markov processes that determines the state of the German manufacturing industry and M represents the number of regimes, and $\alpha(s_t) = \alpha_i$ for $s_t = i$, $i \in \{1,\ldots,M\}$.

Consequently, the Markov regime switching dynamics formulate a probability rule for the transition among different states, which show the probability of moving from one regime to another that is driven by an invisible state variable under Markov process. The unobserved stochastic state variable, s_t, follows a first-order Markov-process, where the current state depends only on the most recent one.

The probability rule is shown as,

(3) $$P[s_t = j | s_{t-1} = i, s_{t-2} = k, \ldots] = P[s_t = j | s = i] = p_{ij},$$

which explains the probability condition that state i will be followed by state j indicated by p_{ij} and $i, j, k \in \{1,\ldots,M\}$. By rules of probability, we have $\sum_{j=1}^{M} p_{ij} = 1$.

The second term in Equation (2), which is the Gaussian component, is given by:

(4) $$z_t = z_{t-1} + \phi_1(z_{t-1} - z_{t-2}) + \cdots + \phi_r(z_{t-r} - z_{t-r-1}) + \varepsilon_t$$

where $\boldsymbol{\varepsilon_t / \sigma(s_t) \sim NID}(0,1)$ and is unaffiliated of $\boldsymbol{n_{t+h}}$, $\forall \boldsymbol{h} \geq 0$. By differencing Equation (1) and (4) we reach to the following equation as,

(5) $$\Delta \boldsymbol{y_t} = \boldsymbol{\alpha(s_t)} + \phi_1(\boldsymbol{z_{t-1} - z_{t-2}}) + \cdots + \boldsymbol{\phi_r(z_{t-r} - z_{t-r-1}) + \varepsilon_t}\ .$$

This model has a distinct ability to characterize the regimes regarding different regime parameters. Considering the presence of structural breaks in the German manufacturing industry due to the abrupt policy changes, which is frequently caused by the instability in the global economy, the study employs a hidden Markov model with no lag, which implies the autoregressive terms in Equation (4) are set to zero[8].

After applying hidden Markov specification, we obtain the differenced series as,

(6) $$\Delta y_t = \alpha(s_t) + \varepsilon_t\ .$$

We estimate the models using EM algorithm together with the nonlinear filter to find the maximum likelihood estimates of the model parameters following Hamilton's [14] application on Markov models. As it is stated in the study of Billio *et. al* [5] the EM algorithm is an convergence method for maximization of the likelihood function in case of models with missing observations, which cause to weak chosen of starting values of the parameters. It provides an optimization for the distributed parameters towards a plausible region. Notice that we do not impose any restrictions on model parameters and infer the states through statistical estimation

[8] See Chauvet [9] for an hidden Markov application on Brazilian economy.

in the process of transformation of the data. The EM algorithm is further described in Dempster, Laird and Rubin [11] and Krolzig [18].

The study employs seasonally adjusted manufacturing industry production indices at monthly level that covers the periods between January 2005 and December 2015. The data is taken from the Eurostat short term business statistics at constant prices (2010=100) and based on the NACE Rev. 2. classification. Following Stock and Watson [22] high frequency movements in the different series of total manufacturing production index are smoothed out by taking twelve-month differences of the annual month-to-month growth rates in logarithms.

3. Empirical Results

The study focuses on explaining the asymmetric characteristics of the German manufacturing industry and providing a realistic inside about the German production structure according to how it behaves over its cyclical phases. To that end, we examine nonlinearity, detect the number of regimes, identify the regime dependent mean and variances, find the transition and smoothed probabilities, and document regime classification with respect to each identified regime.

In order not to yield the misleading results of the model, we first examine the presence of the unit roots in the monthly manufacturing production series by use of the Augmented Dickey-Fuller the Phillips Perron tests. Stationarity is provided after taking twelve-month averages of the annual month-to-month growth rates for the German manufacturing production series. After then, we start to analyze the asymmetric characteristics of the German manufacturing industry over the cyclical phases.

The results are presented in Table 1 for the selected Markov regime switching model that both mean and variance parameters change according to different regimes that are driven by an unobservable state.

Table 1. MSMH(3) – AR(0) Results for Monthly German Manufacturing Industry

	German Manufacturing Industry
log-L	-208.25923
LRP	0.000
α_0	-7.52924
	(0.8385)
α_1	0.262758
	(0.1223)
α_2	3.42051
	(0.1913)
σ_0	3.05135
	(0.5994)
σ_1	0.868136
	(0.08766)
σ_2	1.33051
	(0.1340)
p_{00}	0.925186
	(0.07164)
p_{01}	0.0184466
	(0.01828)
p_{12}	0.0389014
	(0.02698)
AIC	3.8300
SC	3.7059
HQ	3.6210

Notes: The sample period is from January 2005 to December 2015. LRP denotes the upper bound for the p-value of the likelihood ratio test of linearity based on Davies [10]. Standard errors are reported in parenthesis.

Table 1 provides the estimated values of the mean and variance parameters that differs depending on each regime, transition probabilities, AIC, HQ and SIC model selection criteria test results, Likelihood Ratio statistics, and the Davies upper bound p-values for the German manufacturing industry. Likelihood ratio statistics and information criteria tests are employed to define the number of states and to examine heteroskedasticity with respect to each different regime. The asymptotic standard errors are given with the numbers in parenthesis.

According to the Davies upper bound values, linearity is rejected in support of the nonlinear model. The strong asymmetry is reported by the value of the upper bound, various significant mean and variance estimates and the regime probabilities that indicate the persistence of staying in the same state.

The information criteria tests and modified likelihood ratio values provide the model and state specifications by comparing a 3 state model versus a 2 state specification. The results suggest three states model specification with regime dependent mean and variance parameters, MSMH(3), for the state dependent dynamics of the German manufacturing industry. As it is stated in Baycan [4] and Yilmazkuday and Akay [23], among others, a three state specification decomposes the positive growth regime into moderate and high growth regimes for the fluctuations of the German manufacturing industry, and therefore, it enables us to obtain further distinguishing informations about the characteristics of the manufacturing industry.

We also examine the nonlinear dynamics for heteroskedasticity of the German manufacturing industry. As shown in Table 1., test results prove the presence of regime dependent variances. The variance parameters values reveal volatility degree in German manufacturing industry in the low, moderate and high growth regimes. The low growth regime for the manufacturing industry has the highest volatility by the rates of 3.05% compared to the moderate and high growth regimes of the manufacturing industry, where the volatility rates for moderate and high growth regimes are 0.86% and 1.33%, respectively. Besides, the average growth rate of the German manufacturing industry in the low growth regime is 7.52%, which points out a sharp drop in the recessionary period. For the moderate and hight growth states in the German manufacturing industry, the average growth rates are 0.26% and 3.42%, respectly.

Furthermore, the study clarifies the duration and persistence of staying in each particular regime by using the estimated transition probabilities. The related results are given in Table 2 and Table 3.

Table 2. Average durations and percentages of staying in the same state

	Manufacturing Industry	
	Percentage	Average Duration
Regime 0	14.67%	14.00
Regime 1	45.83%	27.50
Regime 2	42.50%	25.50

Note: Regime 0 refers the low growth state, Regime 1 refers the moderate growth state, regime 2 refers the high growth state for the manufacturing industry.

Table 3. Estimated transition probabilities of staying in the same state

	Manufacturing Industry
Regime 0	0.92519
Regime 1	0.98155
Regime 2	0.96110

Note: Regime 0 refers the low growth state, Regime 1 refers the moderate growth state, regime 2 refers the high growth state for the manufacturing industry.

Table 2 shows that the average durations for low, moderate and high growth regimes are 14, 27.50, and 25.50 months, while the average percentages are 14.67%, 45.83% and 42.50%, respectively. According to the values in Table 3, the probabilities of staying in the same exact regime for the following month are 0.92, 0.98, 0.96, respectively. Among these three different

regimes, the moderate growth regime for the manufacturing industry has the longest average duration and the highest percentage for persistence. These results reveal that the average durations and percentage values for staying in the same state in German manufacturing industry exhibit asymmetric characteristics with respect to different cyclical phase. Although there is not substantial asymmery between moderate and high growth state, there is strong asymmetry between the low growth state and the other two expansionary growth states.
Figure 1 also shows the smoothed probabilities and the fitted values for the German manufacturing industry, which identify economic fluctuations with respect to the regime classifications.

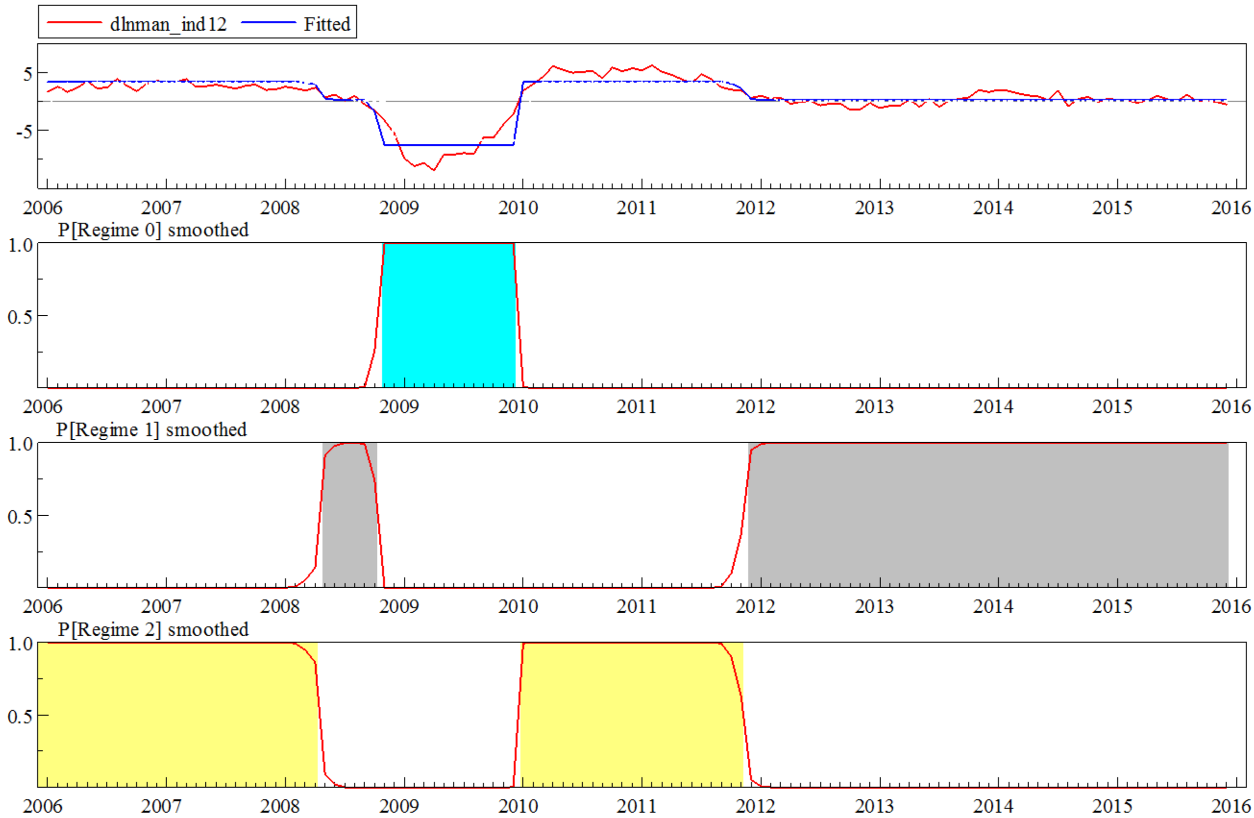

Figure 1. Smoothed Probabilities of Low, Moderate and High Growth States for the German Manufacturing Industry and Fitted Values

The smoothed probabilities identify one recession regime, which lasted 14 months for the period between 2008(11) and 2009(12). This period implies deep effects of the 2008 financial crisis on the German manufacturing industry with sharp declines for the average growth rates. After the recession phase, German manufacturing industry enters into a rapid recovery process by staying 23 months in high growth state for the period of 2010(1)-2011(11). Subsequently, it shifts to the moderate growth state where it stays for its longest period with 49 months, from 2011(12) to 2015(12). The results exhibit that German manufacturing industry tends to stay in moderate growth state, which is the least risky state among the three states compared their volatility degree.

4. Conclusion

The rising role of the industrial sector on sustainable growth and development in global economic agenda, especially after the recent global crisis, has led the economies to give heavily importance on the industrially driven policies. As a leading manufacturing economy globally, German economy and its industry-based structure are highly worth to investigate due to their strong potential spillover effects towards other market economies. This study investigates the cyclical asymmetric dynamics of the German manufacturing industry by employing nonlinear Markov regime switching model specifications that are able to capture nonlinear asymmetric behaviors across the cyclical phases of the German manufacturing industry. The study utilizes Expectation Maksimization(EM) algorithm together with nonlinear filtering to estimate model parameters to provide more maksimum likelihood estimate values without imposing any further restrictions. The study examines nonlinearity, determines the number of regimes, provides regime classification and investigates the regime dependent heteroskedasticity with respect to different regimes of the German manufacturing industry to reveal the manufacturing-based structural behaviors. Revealing this information about the characteristic properties of the German manufacturing industry enables the policy makers to create more consistent policies and to make relatively right investment decisions. The results document the highly existence of asymmetric behavior across the cyclical phases with three different states for the German manufacturing industry. Besides, the study employs the estimated transition probabilities to determine the duration and persistence of staying in each particular identified regime for the German manufacturing industry.

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