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Global Recessions and Booms: What do Probit models tell us?

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Global Recessions and Booms: What do Probit models tell us?*

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Abstract

We present non-linear binary Probit models to capture the turning points in global economic activity as well as in advanced and emerging economies from 1980 to 2016. For that purpose, we use four different business cycle dating methods to identify the regimes (upswings, downswings). We find that especially activity-driven variables are important indicators for the turning points. Moreover, we identify similarities and differences between the different regions in this respect.

Deutsche Zusammenfassung:

Das Papier analysiert nicht-lineare binäre Probit-Modelle, um Wendepunkte der Weltkonjunktur sowie in fortgeschrittenen und aufstrebenden Volkswirtschaften von 1980 bis 2016 zu bestimmen. Zur Identifikation der Regime (Auf- und Abschwung), verwenden wir vier verschiedene Konjunkturzyklusbestimmungsmethoden. Als Ergebnis ergibt sich, dass vor allem aktivitätsgetriebene Variablen wichtige Indikatoren der Wendepunkte sind. Die Determinanten der Wendepunkte lassen Unterschiede und Gemeinsamkeiten in den unterschiedlichen Regionen erkennen.

Keywords: Global GDP, Probit, turning points

JEL Classification: C34, C35, E32,

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1. Introduction

One of the greatest challenges of empirical business cycle research is the timely detection and modelling of business cycle turning points. In the US and the euro area, there are the Business Cycle Dating Committees of the NBER and the CEPR, respectively, which date the turning points in the dynamics of economic activity. However, at a global level - be it world-wide, advanced economies, emerging market economies - such dating does not exist and the business cycle analysis is quite limited. To detect as well as model the turning points in a global context, we make use of the dynamic and non-linear bivariate Probit models.

Dynamic Probit models estimate a multi-regime variable directly with the help of one or more economic variables (e.g. Haltmaier 2008, Christiansen et al. 2014 for the US, Boysen-Hogrefe 2012 for the euro area, Abberger & Nierhaus 2010 for Germany, Fornari & Lemke 2010 for a set of countries).[1] The application of probit models requires the definition of a binary variable that distinguishes expansions from recessions. There are various ways to specify the upswings and downswings to construct the binary variable. These include simple rules of thumb (e.g., two consecutive declines in quarterly GDP growth as indicative of a recession) or more formal rules like the Bry-Boschan-algorithm (e.g. Harding 2008).

There are only few papers on turning points in global economic activity. Ferrara & Marsilli's (2014) approach builds on a Factor-Augmented Mixed Data Sampling model of various countries and sectors worldwide. Ravazzolo & Vespignani (2015) also concentrate on growth rates and evaluate the quality of world steel production compared to Kilian's index of global economic activity and the index of OECD world industrial production. Stratford (2013) uses *linear* models to investigate several global indicators' ability to nowcast world trade and world GDP. He finds that the indicators are most helpful during periods of large swings in world growth. However, their usefulness fluctuates greatly over time. The only paper which addresses turning points directly and on a global level within a non-linear framework is Camacho & Martinez-Martin (2015). They propose a two-state *Markov-switching* dynamic factor model to produce short-term forecasts of world GDP and to compute business cycle probabilities.

[1] An alternative would be Markov Switching models which define and estimate two or more regimes where the evolution of economic activity is regime-dependent (see, e.g., Hamilton 1989). A comparison of both model types with regard to business cycles may be found in Layton & Katsuura (2001).

Our analysis differs in several aspects from these papers. First, and in contrast to Ferrara & Marsilli (2014), Ravazzolo & Vespignani (2015) and Stratford (2013), we concentrate solely and directly on turning points of global GDP growth. Second, we use Probit models to capture the turning points on a global level. So far, these methods have been predominantly applied to a national level. Third, we use several business cycle turning point dating methods to evaluate the models. Fourth, the indicator variables are included individually, not as factors as in Camacho & Martinez-Martin (2015) and Ferrara & Marsilli (2014).

Our results reveal that lagged GDP growth rates and activity-based variables are the best indicators of upswing and downswing periods. The emerging market economies are the hardest to model. The remainder of the paper is structured as follows. Section 2 describes the independent and dependent variables used. Following this, section 3 introduces the Probit models and presents their results. Section 4 summarises and concludes.

2. Data

We use seasonally-adjusted quarterly data for the sample 1980Q1-2016Q4. World activity is measured by real quarterly world GDP, derived from a PPP-weighted aggregation of national GDP data based on national sources. We also distinguish between real quarterly GDP for advanced economies and emerging economies (see Appendix A for details).

The independent variables considered can be grouped as follows:

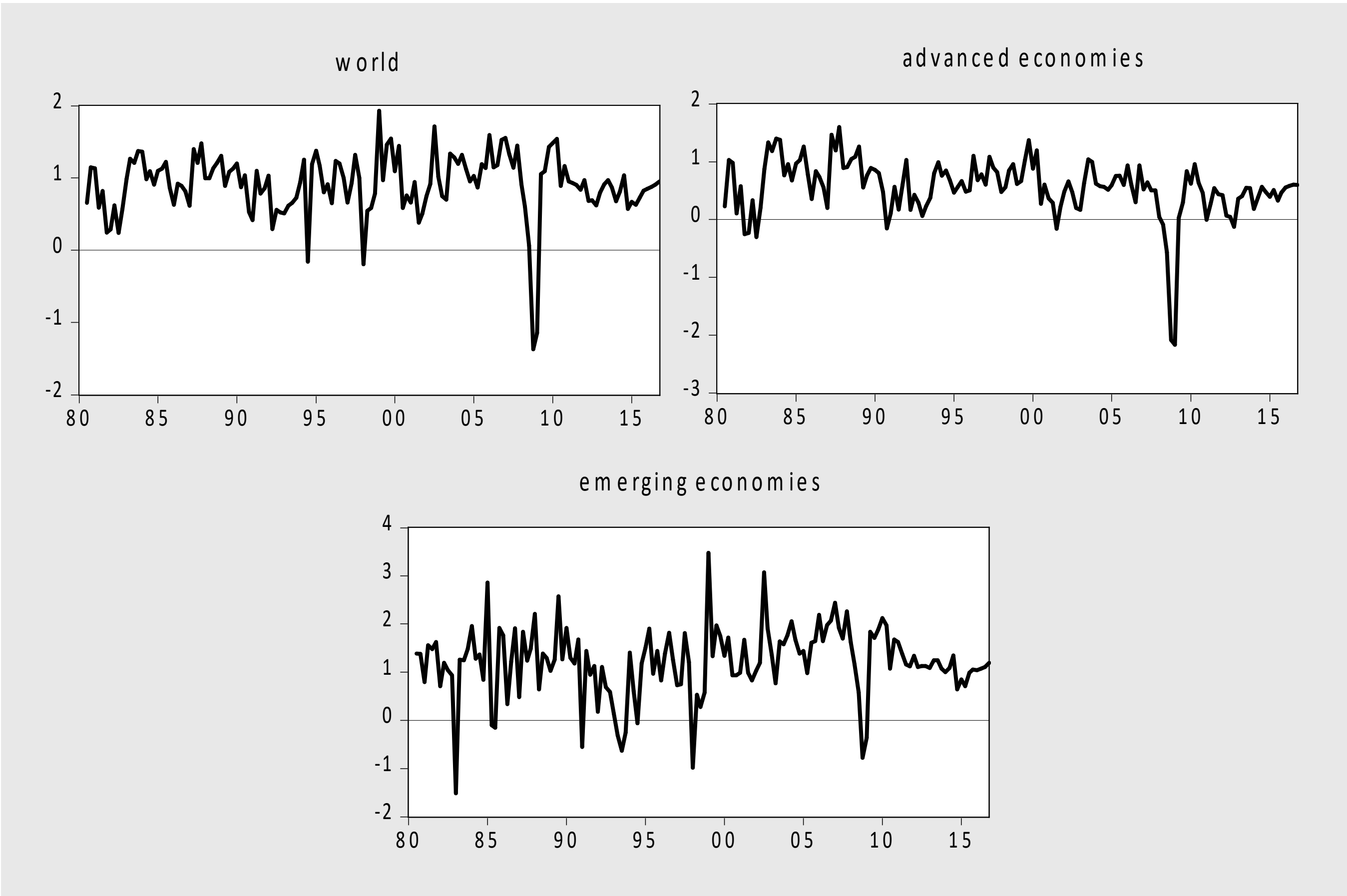
- *Activity data*: industrial production in OECD countries and emerging market economies, world steel production (see Ravazzolo and Vespignani, 2015), the Kilian index of real world economic activity, the Goldman Sachs Global Leading Indicator, the Composite Leading Indicator by the OECD, a global factor derived by Delle Chiaie, Ferrara and Giannone (2017) and the Conference Board US Leading Economic Index.
- *Survey data*: consumer confidence in OECD countries and the US.
- *Financial data*: the US term spread (10years minus 3 month), the US BBB bond spread, S&P500, M1 and M3 for OECD countries.
- *Commodity prices*: oil prices in USD and indices of metal prices and non-oil commodity prices.

The results reported in section 3 concentrate, however, on those independent variables that turned out to be statistically significant in the various specifications selected and in line with economic reasoning.

Chart 1 plots quarterly world, advanced economy and emerging economy real GDP growth from 1980Q1 to 2016Q4. We distinguish two types of periods with different mean growth rates: (i) negative or slightly positive, but low growth rates; (ii) periods of robust growth (either briefly following recessions or on a more prolonged basis). The only common recession in all three country groupings is the great recession 2009 which affected global economies, AEs as well as EMEs, although the latter to a lesser extent.

In what follows, our aim is to use model-based techniques and judgmental approaches to detect these alternative episodes, and thereafter to estimate probabilities of staying in a regime or moving to a different one.

Chart 1: Real GDP – world, advanced and emerging economies
(quarter-on-quarter percentage change)



Sources: IMF, ECB and author's calculations.

3. Probit models

3.1. Methodology

One methodology commonly used to analyse turning points in economic activity is the Probit method. A textbook treatment may be found in Verbeek (2012). Recent business cycle applications are, inter alia, Chauvet & Potter (2010), Christiansen et al. (2014), Nyberg (2014), Fossati (2015), Hsu (2016), and Proaño (2017). In our case, a value of the binary variable of "0 signals a "downswing" whereas the value "1" indicates an "upswing". The objective of the analysis is to assess with what probability the variable changes its value at a specific date.

Formally, the probit method can be represented as follows:

$$(1) \qquad P_i = \Pr(Y_i = 1 \mid X_i, \beta) = \int_{-\infty}^{X'\beta} \frac{1}{\sqrt{2\pi}} e^{-0,5u^2} du = \Phi(X', \beta),$$

where P_i represents the probability that a specific event (e.g. an upswing) will occur; $\Phi(.)$ is the distribution function of the standard normal distribution (the so-called probit function); u stands for the normally distributed residuals. X_i is the vector of the independent variables, in our analysis specifically the potential variables that explain an upswing or a downswing or, more specifically, a turning point. The β coefficients of the independent variables of this non-linear estimation approach can only be determined by iteration. To estimate these coefficients, we use the Newton-Raphson method with Marquardt steps to obtain parameter estimates. The standard errors are estimated by the inverse of the estimated information matrix. The latter is computed with the help of the observed Hessian.

A precondition for the empirical application of probit models is the specification of the binary variable. As there is neither an official business cycle dating available at the global level nor for advanced or emerging economies as a whole (as, for example, for the US from the NBER), we rely on our own dating. For that purpose, we use four variants in what follows:

- "Acceleration" is defined as 1 if there is an acceleration in year-on-year real GDP growth in at least three out of five quarters (measured on a centred rolling basis), and 0 otherwise (*p_yoy*),
- "High growth" is 1 in any period if the centred five-quarter moving average quarterly growth rate in real GDP is above the 40^{th} (35^{th}) percentile of the series, and 0 otherwise (*p_pct40*(*35*)),

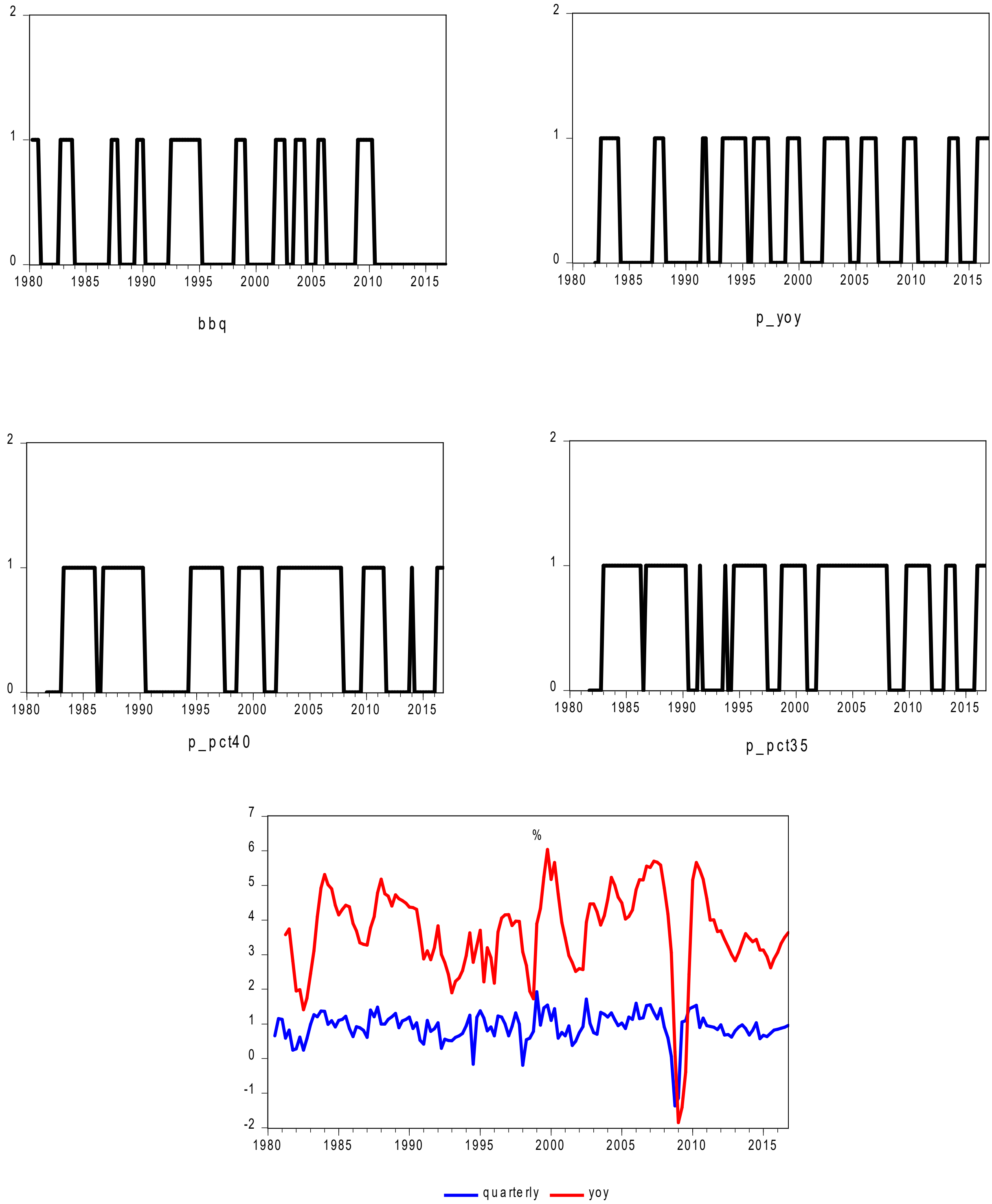
- "Bry/Boschan" is a quarterly analogue to the Bry-Boschan algorithm to detect turning points in time series (*bbq*) (see Bry & Boschan, 1971; Harding & Pagan, 2002). This methodology identifies a turning point by using the definition that a peak happens at time *t* if y(t-k),..,y(t-k+1) < y(t) > y(t+1),…,y(t+k), where *k* is the so-called symmetric window parameter (turnphase). It needs to be set. For for quarterly data, usually k=2.

Chart 2 shows the four binary variables together with the quarterly and year-over-year growth rates for the world economy. The chart illustrates that all indicators capture the worldwide recession in 2009 quite well. Since then, however, the picture is mixed. Whereas the Bry-Boschan index does not show signs of an upswing, the other three variables indicate some, but no clear-cut, hints of an acceleration in growth since about 2013. The problem in getting an unambiguous assignment is evident in the growth figure in the lower right part of the chart. It shows that after 2010 the growth rates declined in the first years (until 2013). Afterwards they exhibit ups and downs, but increased on a quarterly and annual basis since 2015.

Charts 2a and 2b in Appendix B contain the same information for the advanced and emerging economies. All binary indicators point to an improved economic situation in the advanced economies in the last few years. This pattern is also apparent in the rising annual growth rates. In contrast, two out of the four indicators for the emerging countries do not show any signs of a turning point in the direction of an upswing. The year-over-year method and the one where we calculate the cut-off rate with the 35^{th} percentile present evidence of a turning point in 2016. What is also evident is that the year-over-year growth rates in the advanced economies declined to a lesser extent compared to the emerging world in the Great Recession. In the former, growth rates declined to around -5%, while they did not turn into negative territory in the latter.

In what follows, we describe in detail the results for the best model(s) of one indicator and refer to similarities and differences of the others in footnotes and separate paragraphs. Our preferred indicator is the year-over-year procedure as it looks especially at turning points and yields in most of the cases– economically and statistically – the most promising results.

Chart 2: Global GDP growth and the binary variables



Note: quarterly: quarterly growth rate of real GDP; yoy: year-over-year growth rate of real GDP. p_yoy: 1 if there is an acceleration in year-on-year real GDP growth in at least three out of five quarters, and 0 otherwise; p_pct40(35): 1 in any period if the centred five-quarter moving average quarterly growth rate in real GDP is above the 40th (35th) percentile of the series, and 0 otherwise; bbq: quarterly analogue to the Bry-Boschan algorithm.

3.2. Results

3.2.1. Global GDP

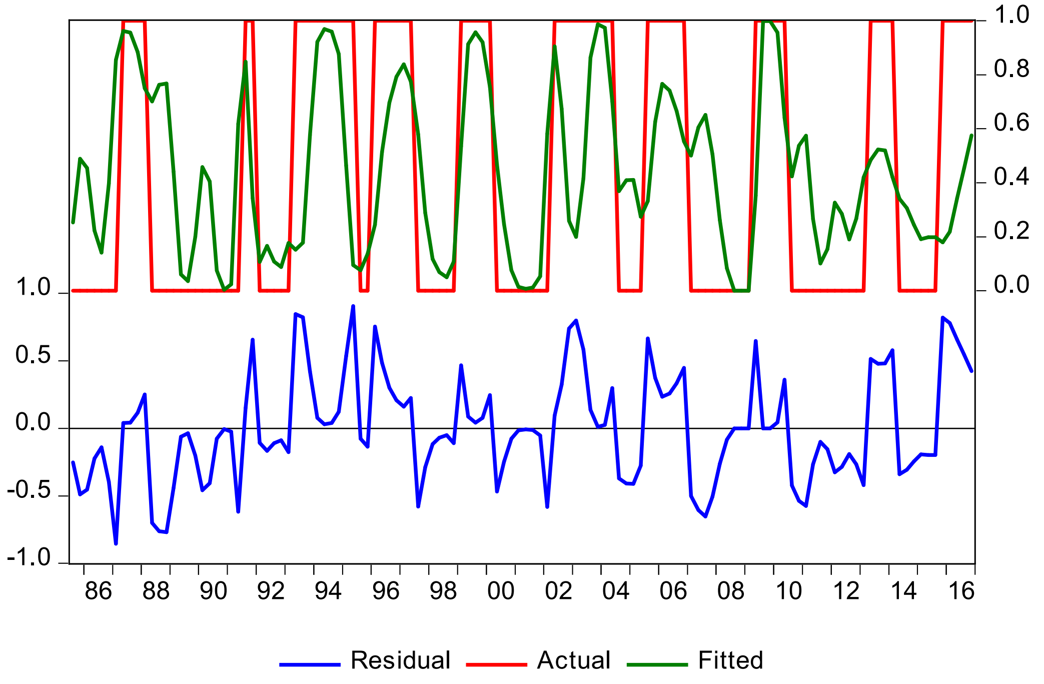
The explanatory variables in the best Probit model include the contemporaneous and lagged Goldman Sachs Global Leading Indicator.[2] This is also true for the other binary variables. The equation reads as

$$(2) \qquad p\_yoy = -\underset{(5.2)}{1.16} + \underset{(3.7)}{0.66}\, gs\_gli_t + \underset{(3.0)}{0.51}\, gs\_gli_{t-1}$$

Note: Sample: 1985q3-2016q4; observations with dependent variable = 0: 71; observations with dependent variable = 1: 55; absolute z-statistic in parentheses below coefficients; McFadden R^2 = 0.31; SE = 0.40; SSR = 20.1; LR = 53.5 (0.0).[3]

As can be seen from the residual analysis (see Chart 3), the model is quite a good predictor of the turning points. Most residual fluctuations are located at the regime edges, i.e. the model becomes restless around the turning points and, therefore, signals that a regime change is approaching. One "unpleasant" aspect is, however, the false signals during the downswing phases in the beginning and the middle of the 1990s and during the upswing phase at the beginning of the new century. Here, the model user would have erroneously suspected a regime change, even though none materialized (type-2 error).

Chart 3: Residual analysis: global



[2] Alternative models which do, however, not perform as good, only include lagged GDP growth rates or OECD consumer confidence (results available upon request).

[3] SE: standard error of regression; SSR: sum of squared residuals; LR: Likelihood Ratio statistic on the overall significance of the model (p-value in parentheses).

Table 1 highlights once again the model's goodness of fit and its uncertainty. In this table, the 126 total observations are broken down by deciles. The columns labeled “Risk deciles” depict the high and low value of the predicted probability for each decile. Also depicted is the actual and expected number of observations in each group, as well as the contribution of each group to the overall Hosmer-Lemeshow (H-L) statistic—large values indicate large differences between the actual and predicted values for that decile. If the predicted values for the binary value are in the 1st-5th or the 8th-10th decile, the model performs rather well in discriminating between the two different regimes (upswing or downswing). Most of the forecast errors are in the 7th decile. In this decile, if the model user were to assume that a predicted value of greater than 0.5 signals an upswing or a value of smaller than 0.5 a downswing, he would achieve a hit probability of only about 50 %, i.e. in this decile he could basically toss a coin and then decide based on the outcome which regime is present. However, overall, the null that the observed and expected values are the same across all the deciles cannot be rejected, as indicated by the Hosmer-Lemeshow test (p-value > 90 %). This test groups observations on the basis of the predicted probability that y = 1.

Table 1: Forecast quality: global

	Risk deciles		**Dep=0**		**Dep=1**		Total obs.	H-L value
	Low	High	Actual	Expect	Actual	Expect		
1	0.00	0.06	12	11.74	0	0.26	12	0.27
2	0.07	0.14	12	11.76	1	1.24	13	0.05
3	0.14	0.20	8	9.87	4	2.13	12	2.01
4	0.20	0.29	10	9.75	3	3.25	13	0.03
5	0.29	0.41	9	8.37	4	4.63	13	0.13
6	0.42	0.49	7	6.60	5	5.40	12	0.05
7	0.50	0.58	6	5.93	7	7.07	13	0.00
8	0.61	0.75	4	3.92	8	8.08	12	0.00
9	0.75	0.91	3	2.30	10	10.70	13	0.26
10	0.91	1.00	0	0.52	13	12.48	13	0.54
		Total	71	70.77	55	55.23	126	3.34 (0.91)

Note: Hosmer-Lemeshow test whether the observed and expected proportions are the same across the deciles; p-value in parentheses.

These conclusions are underscored by Table 2. Here, an assessment based on the model is correct if the predicted probability is below the cut-off value of C = 0.5 in the case of y = 0 or above 0.5 in the case of y = 1. It is obvious that in 76.2 % of the cases the model prediction is correct (the specificity, i.e. the correct y = 0 observations, is 81.7 %; the sensitivity, i.e. the correct y = 1 observations, is 69.1 %). For comparative purposes, the right part of Table 2 shows the results of a model with a constant probability, which arises when one estimates the model only with a constant. It reveals that our preferred model is over 49 % better (calculated as the percent of incorrect predictions corrected by the equation, i.e. (0.778-0.563)/(1-0.563)) than the model with constant probability, which generates 56.3% correct values.

Table 2: Classification table: global

	Estimated equation		**Constant probability**	
	Dep = 0	Dep = 1	Dep = 0	Dep = 1
p(Dep=1) ≤ 0.5	59	16	71	55
p(Dep=1) > 0.5	12	39	0	0
% correct	77.8		56.3	

Note: White cells indicate correct forecasts, grey cells indicate incorrect predictions. Correct: predicted probability ≤ C = 0.5 and act. y=0 or predicted probability > C = 0.5 and act. y=1.

For the other classification schemes of upswings and downswings, the statistical properties and the economic interpretation are not as good as for p-yoy.[4] However, they all lead to an improvement compared to a model with constant probability.

3.2.2. Advanced economies

For the advanced economies, the optimal Probit model consists of lagged GDP growth rates and the Goldman Sachs Global Leading indicator (see Equation 3).[5] This is also true for the other binary variables. The inclusion of a leading indicator in the detection of turning points is in line with Haltmaier (2008) who finds that in six of the eight considered OECD countries at least one (monthly) lag of the leading indicator is significant. Moreover, it is also significant in her panel setup. Financial variables, especially the yield spread, and narrow monetary aggregates which often are found helpful in this respect for (individual) advanced economies and within the Probit methodology (see, e.g., Fornari & Lemke, 2010; Boysen-Hogrefe, 2012) do not enter our preferred specification. Our best equation reads as

$$(3) \qquad p\_yoy\_ae = -\underset{(3.5)}{1.07} + \underset{(3.6)}{2.00}\, gdp\_ae_{t-1} - \underset{(3.0)}{1.59}\, gdp\_ae_{t-2} + \underset{(4.8)}{0.84}\, gs\_gli_t$$

Note: Sample: 1985q2-2016q4; observations with dependent variable = 0: 68; observations with dependent variable = 1: 59; absolute z-statistic in parentheses below coefficients; McFadden R^2 = 0.33; SE = 0.40; SSR = 19.7; LR = 58.2 (0.0). Explanations see Equation 4.

[4] Results available upon request.

[5] A model with only three lags of GDP growth performs slightly worse than the one presented (results available upon request).

The residual analysis in Chart 4 shows a slightly better behaviour compared to the results for the global economy. The model reveals again the problems during the downswing at the end of the 1980s and beginning of the 1990s, but behaves quite well in the other episodes.[6] At the end of the sample (2015/16) our preferred model indicates a steadily improving economic situation.

Chart 4: Residual analysis: advanced economies

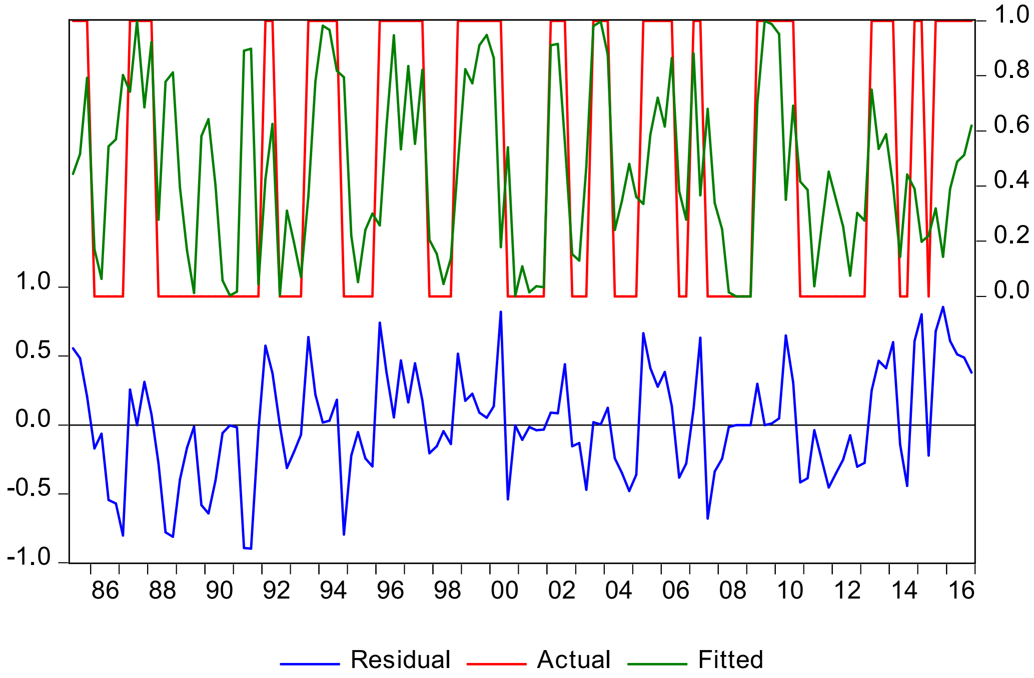


Table 3 compares the fitted expected to the actual values by group (ten deciles) and calculates the Hosmer-Lemeshow test statistic. This test of goodness-of-fit shows that, in general, the model behaviour is quite good. There are some problems in the 5th decile in which the accuracy is only slightly above 50 %. In general, however, differences between "actual" and "expected" are not too large. Therefore, we do not reject the model as providing a sufficient fit to the data.

[6] The latter is also true for the Bry-Boschan model. The "High growth" specification, in contrast, exhibits problems at the end of the 1990s and beginning of the new century (results available upon request).

Table 3: Forecast quality: advanced economies

Risk deciles	Low	High	Dep=0 Actual	Dep=0 Expect	Dep=1 Actual	Dep=1 Expect	Total obs.	H-L value
1	0.00	0.04	12	11.86	0	0.14	12	0.14
2	0.04	0.14	12	11.89	1	1.11	13	0.01
3	0.15	0.24	12	10.41	2	2.60	13	0.17
4	0.25	0.34	9	8.50	3	3.50	12	0.10
5	0.35	0.40	7	8.12	6	4.88	13	0.41
6	0.42	0.53	5	6.80	8	6.20	13	1.00
7	0.54	0.63	4	5.00	8	7.00	12	0.34
8	0.64	0.79	4	3.47	9	9.53	13	0.11
9	0.80	0.91	4	1.90	9	11.10	13	2.73
10	0.91	1.00	0	0.49	13	12.51	13	0.51
		Total	68	68.44	59	58.56	127	5.5 (0.70)

Note: Hosmer-Lemeshow test statistic that the observed and expected proportions are the same across the deciles; p-value in parentheses.

Table 4 reveals that in 78 % of all cases our model delivers the right classification (specificity: 82 %; sensitivity: 73 %). Compared to a model with constant probability which has 53 % correct values, this is an improvement of more than 50 %.

Table 4: Classification table: advanced economies

	Estimated equation		**Constant probability**	
	Dep = 0	Dep = 1	Dep = 0	Dep = 1
p(Dep=1) ≤ 0.5	56	16	68	59
p(Dep=1) > 0.5	12	43	0	0
% correct	78.0		53.5	

Note: White cells indicate correct forecasts, grey cells indicate incorrect predictions. Correct: predicted probability ≤ C = 0.5 and act. y=0 or predicted probability > C = 0.5 and act. y=1.

The model with the binary variable specified by "High growth (40)" performs slightly better in discriminating between regimes and with regard to the overall fit of the model. In contrast, the results of all others binary variable specifications are worse than the one presented.

3.2.3. Emerging markets

All in all, the emerging market economies were the hardest to model. As with the advanced economies, the best model includes lagged quarterly GDP growth rates, but in the emerging market case together with industrial production in emerging markets (see Equation 4). This result is in line with Baumann et al. (2018) who use a three regime classification to analyse emerging market economies with a Markov Switching framework. Overall, we have 140 observations, of which 77 belong to regime 0 and 63 to regime 1. The model has the lowest R^2 and the highest standard error of all the regional models considered.

$$(4) \qquad p\_yoy\_ee = -\underset{(4.6)}{1.47} + \underset{(2.6)}{0.42}\, gdp\_ee_{t-1} + \underset{(1.9)}{0.17}\, ip\_ee_t + \underset{(1.8)}{0.16}\, ip\_ee_{t-1}$$

Note: Sample: 1982q1-2016q4; observations with dependent variable = 0: 77; observations with dependent variable = 1: 63; absolute z-statistic in parentheses below coefficients; McFadden R^2 = 0.12; SE = 0.50; SSR = 28.7; LR = 23.9 (0.0). Explanations see Equation 4.

Chart 5 and Tables 5 and 6 summarize the statistical properties of the model. At the sample end (2016), the model indicates a slow movement in the direction of a possible regime turning point from downswing to upswing. The Hosmer-Lemeshow test on the equality of observed and expected values is significant (p-value: 0.13). With more than 70% correct predictions, our model is better than the one with constant probability which in turn does only forecast correctly in 55 % of all cases.

The "Bry-Boschan" and the "high growth" regime classifications include the Goldman Sachs global leading indicator instead of industrial production. This corresponds to the preferred model in the multinomial logit case of Baumann et al. (2018). In terms of predictive accuracy, the best model is "high growth" which, in both cases (cut-off of 35 or 40) has about 80 % of correct classifications (specificity: between 50 % and 60 %; sensitivity: > 90 %). The improvement relative to the model with only a constant (which has 70 % of correct predictions) is between 32 % and 41 %.

Chart 5: Residual analysis: emerging markets

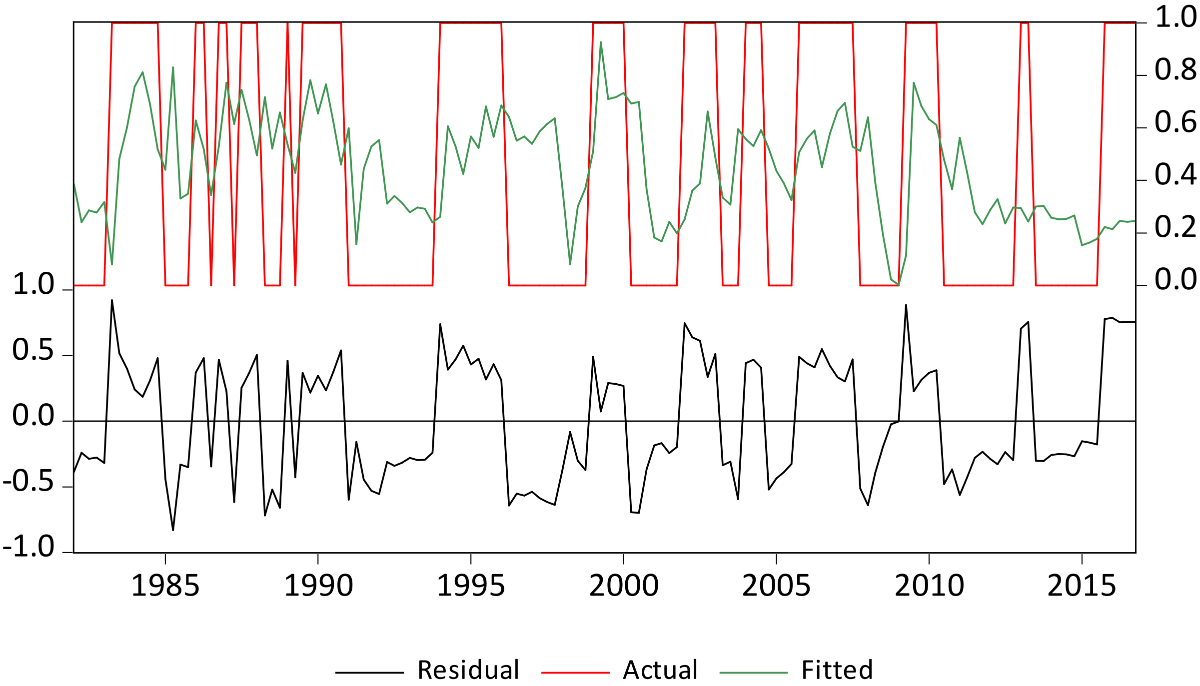


Table 5: Forecast quality: emerging markets

Risk deciles			Dep=0		Dep=1		Total obs.	H-L value
	Low	High	Actual	Expect	Actual	Expect		
1	0.00	0.21	11	12.10	3	1.90	14	0.73
2	0.22	0.26	8	10.60	6	3.40	14	2.61
3	0.26	0.30	12	9.98	2	4.02	14	1.42
4	0.31	0.37	13	9.30	1	4.70	14	4.38
5	0.37	0.46	10	8.18	4	5.82	14	0.97
6	0.48	0.53	4	6.86	10	7.14	14	2.35
7	0.53	0.58	6	6.27	8	7.73	14	0.02
8	0.59	0.63	5	5.47	9	8.53	14	0.07
9	0.63	0.70	5	4.68	9	9.32	14	0.03
10	0.70	0.93	3	3.26	11	10.74	14	0.03
		Total	77	76.69	63	63.31	140	12.6 (0.13)

Note: Hosmer-Lemeshow test statistic that the observed and expected proportions are the same across the deciles; p-value in parentheses.

Table 6: Classification table: emerging markets

	Estimated equation		**Constant probability**	
	Dep = 0	Dep = 1	Dep = 0	Dep = 1
p(Dep=1) ≤ 0.5	55	19	77	63
p(Dep=1) > 0.5	22	44	0	0
% correct	70.7		55.0	

Note: White cells indicate correct forecasts, grey cells indicate incorrect predictions. Correct: predicted probability ≤ C = 0.5 and act. y=0 or predicted probability > C = 0.5 and act. y=1.

4. Summary, conclusions

In this paper, we tried to shed light on the question what determines the turning points of world GDP on the one side and advanced as well as emerging economies on the other from the beginning of the 1980s onwards. For that purpose, we constructed different binary variables to capture upswings and downswings to integrate and explain them with the help of Probit models. It seems that world and advanced economy activity can be captured better than that in emerging markets. This could be due to the poor data quality. The most important variables in these exercises are lagged GDP growth rates and activity-based indicators.

Interestingly, the yield spread does not yield significant results in detecting turning points. However, against the background that we neither have yield data on a global level nor for advanced and emerging economies as a whole, this is not too surprising.

It might be interesting to combine our approach with the Markov-Switching methodology to identify the turning points. These models might also be helpful to decide whether the two-regime case is really the correct one or whether we should take more than two regimes into account. This is left to a separate paper, see Baumann et al. (2018).

Appendix A: Data used

Activity data:

- real GDP growth, national accounts at country level weighted using PPP shares of world total, ECB and WEO databases
- the EME GDP aggregate is based on ECB data after 1995, which are linked up to IMF International Financial Statistics data (in year-on-year growth rates) before 1995
- industrial production in OECD countries, index excluding construction, OECD
- industrial production in emerging market economies (EMEs) excluding construction weighted using PPP shares of EMEs total, country statistical offices
- world crude steel production in thousand tonnes, World Steel Association
- index of world economic activity, based on Kilian (2009)
- composite leading indicator, OECD total, OECD
- global leading indicator from Goldman Sachs. This leading indicator is derived from ten component series, namely (i) Korean exports, (ii) GS industrial metals index; (iii) US initial jobless claims, (iv) G4 consumer confidence, (v) Japanese inventory-to-sales ratio, (vi) AUD and CAD trade weighted index, (vii) Belgian and Dutch manufacturing confidence survey, (viii) Global PMI new orders less inventories, (ix) Baltic Dry Index, (x) Global PMI. The aggregate cyclical series is constructed by weighting the double-smoothed components with equal (10%) weight, see also O'Neill et al (2002) and Stupnytska et al (2010).
- global factor of economic activity, based on Delle Chiaie, Ferrara & Giannone (2017)
- leading economic index for the US, Conference Board

Survey data:

- consumer confidence, OECD total, OECD
- consumer confidence, US, OECD

Financial data:

- term spread US, the 10-year Treasury Note yield minus the 3-month Treasury Bill yield, Federal Reserve Board
- bond spread US, the Baa corporate bond yield minus the 10-year Treasury Note yield, Federal Reserve Board
- stock price index, S&P500 composite, Standard & Poor's
- monetary aggregates, OECD M1 and M3, OECD

Commodity prices:

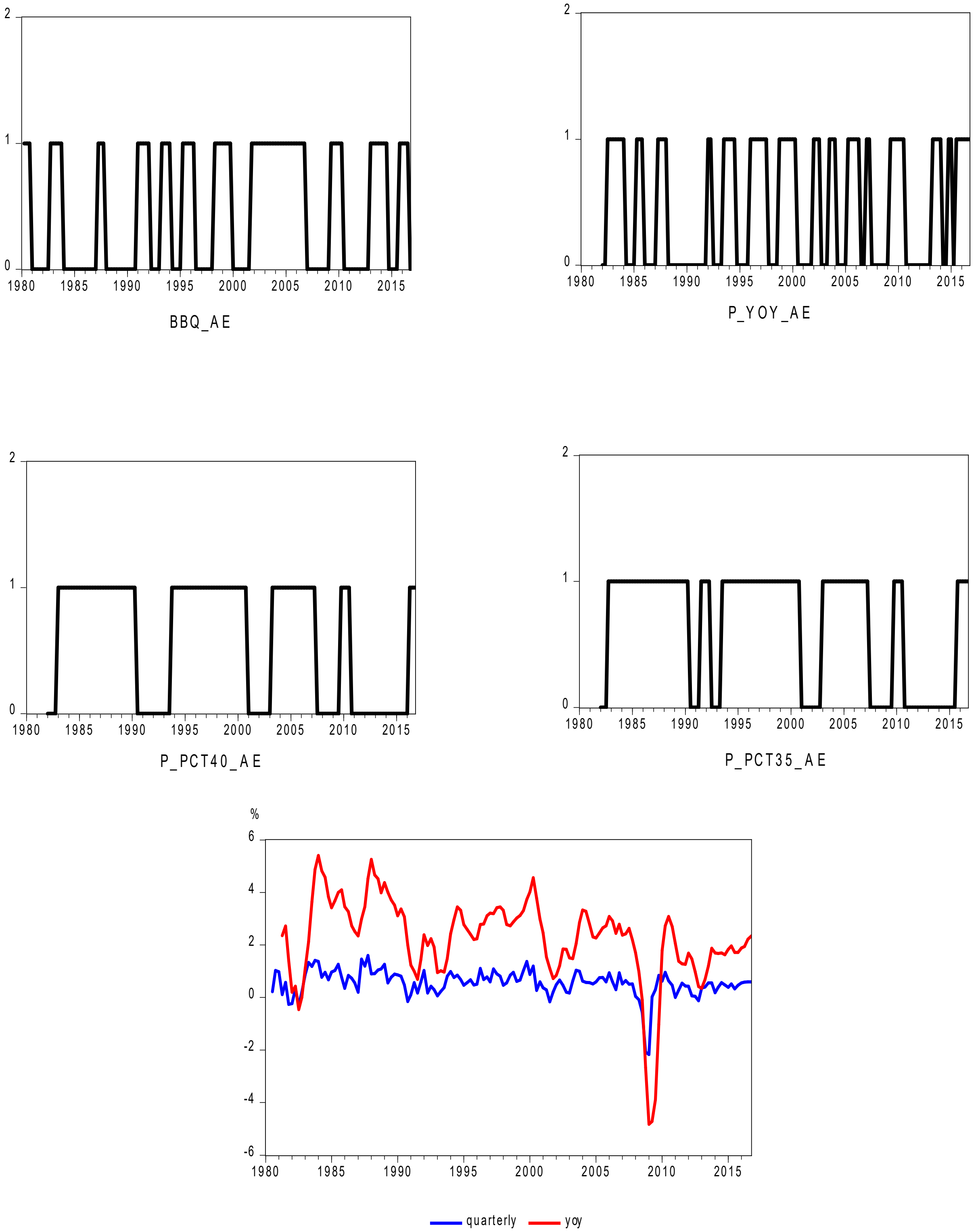
- Brent crude oil prices in US-dollars, IMF
- metal price index, IMF
- non-oil commodity prices, IMF

Classification of advanced (AEs) and EMEs:

- AEs include: US, Japan, UK, Canada, euro area, Switzerland, Sweden, Denmark, Poland, Czech Republic, Romania, Hungary
- EMEs include: China, India, South Korea, Russia, Brazil, Mexico, Argentina, Turkey

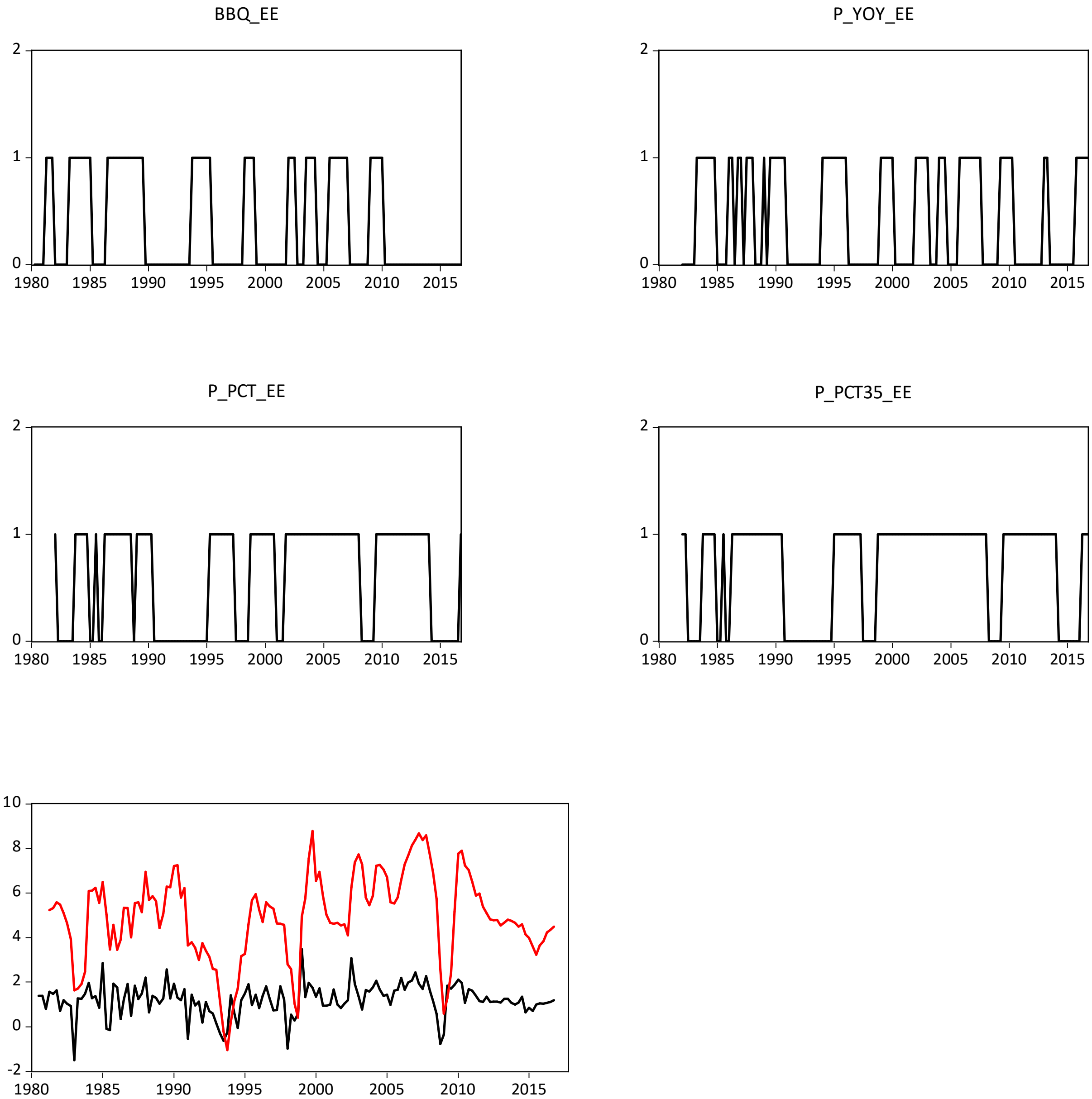
Appendix B: Additional charts

Chart 2a: GDP growth and the binary variables: advanced economies



Note: quarterly: quarterly growth rate of real GDP; yoy: year-over-year growth rate of real GDP. ae: advanced economies; p_yoy: 1, if there is an acceleration in year-on-year real GDP growth in at least three out of five quarters, and 0 otherwise; p_pct40(35): 1 in any period if the centred five-quarter moving average quarterly growth rate in real GDP is above the 40th (35th) percentile of the series, and 0 otherwise; bbq: quarterly analogue to the Bry-Boschan algorithm.

Chart 2b: GDP growth and the binary variables: emerging economies



Note: quarterly: quarterly growth rate of real GDP; yoy: year-over-year growth rate of real GDP. ee: emerging economies; p_yoy: 1 if there is an acceleration in year-on-year real GDP growth in at least three out of five quarters, and 0 otherwise; p_pct40(35): 1 in any period if the centred five-quarter moving average quarterly growth rate in real GDP is above the 40th (35th) percentile of the series, and 0 otherwise; bbq: quarterly analogue to the Bry-Boschan algorithm.

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