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Contents

Abstract

Modern central banks have adopted a 'risk management' approach in assessing and presenting risks to macroeconomic stability. This paper seeks to contribute to the improvement of central banks' current strategies for Central and Eastern European countries, first by assessing the potential size of macroeconomic risks, and secondly by empirically relating these risks to certain selected financial variables. Our results suggest that risks to GDP and the Price Level are significantly higher than commonly supposed based on a normal distribution of their cyclical components. However, relating these risks to the selected financial variables generated mixed results and is rarely significant in economic terms. We conclude that central banks currently risk underestimating the probability of large deviations in GDP and Price Level from their trends. A combination of financial variables and the inclusion of international financial variables could result in more significant results than the ones used separately in this study, when looking for useful indicators of such events.

JEL: E44, E52, E58.
Keywords: central bank policy, financial imbalances, GDP-at-risk, CPI-at-risk.

Összefoglalás

A modern jegybankok „kockázatkezelési" megközelítést alkalmaznak a makrogazdasági stabilitás kockázatainak értékelésében és bemutatásában. A tanulmány a kelet- és közép-európai jegybankok jelenlegi gyakorlatának tökéletesítését javasolja először azzal, hogy értékeli a makrogazdasági kockázatok mértékét, majd azzal, hogy ezeket a kockázatokat megkísérli empirikus kapcsolatba hozni néhány pénzügyi mutatóval. Eredményeink szerint a GDP és az árszint kockázatai szignifikánsan nagyobbak, mint amekkorát rendszerint sugallnak, amikor normál eloszlás feltételezésével mutatják be ezek ciklikus komponenseit. Ugyanakkor a kockázatoknak az általunk választott pénzügyi változókkal való empirikus kapcsolatának vizsgálata vegyes eredményt adott, és az eredmények közgazdasági értelemben ritkán szignifikásak. Arra a következtetésre jutunk, hogy a jegybankok jelenlegi gyakorlatukkal azt kockáztatják, hogy alábecsülik a GDP és az árszínvonal saját trendjüktől való nagymértékű eltérésének valószínűségét. Pénzügyi változók kombinációja és nemzetközi pénzügyi változók szerepeltetése szignifikánsabb eredményt adhatna, mint a jelen tanulmányban egyenként vizsgált változók, amikor az ilyen eseményeket előrejelző mutatókat keresünk.

1 Introduction

Inspiration for this study came from the recent discussions about the appropriate central bank strategies in the era of the so-called 'Great Moderation', which took place well before the recent financial crisis erupted in 2007. These debates were fuelled by a surprising development in the macroeconomy: while central banks were able to achieve price stability by the 1990s, this was accompanied by elevated asset price volatility and larger financial imbalances. That is to say, it might be possible that macroeconomic and financial stability was not guaranteed by focusing exclusively on achieving and maintaining price stability.[1] Some went even further by saying – in the spirit of Hyman Minsky – that stability itself facilitates the build-up of fragilities which lead to future instability.[2]

The literature on assessing the role of asset prices/financial imbalances (henceforth referred to APFI) has taken multiple directions. One strand of the literature analysed monetary policy using an augmented version of the standard policy model which allows reaction to APFI directly, over and above their impact on the inflation forecast. The results suggest that – in addition to their direct impact on the inflation forecast – it is better to react to APFI using an extended Taylor-rule which includes APFI variables.[3] Another model-based analysis is provided by Bordo et al. (2002), who conclude that optimal monetary policy is conditional on the nature of shocks and the state of the economy, and cannot be summarised in a simple reaction function.

Another line of research is based on empirical exercises, instead of policy-oriented models. Borio et al. (2002a, 2002b and 2009) try to detect 'unusual' developments in (several combination of) APFI variables, and relate them to episodes of financial instability. What they effectively do is to look at 'configurations' of variables which increase the financial vulnerability and instability of the economy. Their method is a variant of the early warning indicators. They find that unusually strong, sustained growth in combinations of certain variables provides useful early warning signs for policymakers in relation to macroeconomic and financial instability. In Borio and Lowe (2004), this method is extended to the information content of the same set of explanatory variables on macroeconomic stability, i. e. output and inflation, rather than financial stability. The authors look at significant deviations from the output gap (below more than minus one percent gap) or a decline in inflation as dependent variables.

A different empirical analysis is given in Cecchetti (2006). His work starts by demonstrating that large Price Level gaps and GDP gaps are more likely and larger than usually supposed by using normal distributions. Thus, welfare-improving macroeconomic policies should seek to prevent such large deviations. While he looks at 'very bad' realisations of these macroeconomic variables, Borio and Lowe (2004) look at 'bad', but not necessarily 'very bad' realisations of the same macroeconomic variables. Next, Cecchetti looks for evidence as to whether these 'very bad' outcomes can be attributed to developments in certain asset prices. He chose housing prices and stock price indices as APFI variables and linked 'extreme' developments in such – i. e. deviations from their own trends by more than a specified threshold – leading to 'macroeconomic risks', with some time lag. While Cecchetti looked at the 17 'old' OECD countries (with long time series dating back to the 1970s), Gochoco-Bautista (2008) carried out a similar analysis for eight Asian countries, for similar APFI variables, again dating back to the 1970s sometimes, and in other cases just to the 1980s.

[1] 'While large asset price fluctuations are by no means a new phenomenon, a distinctive feature of the last two decades is that prolonged build-ups and sharp collapses in asset markets have taken place amidst a decline in consumer price inflation and a more stable macroeconomic environment in most of the industrialized world.' IMF (2000): Chapter III 'Asset prices and the business cycle', p. 77.

[2] Borio et al. (2009), p. 30.

[3] Cecchetti et al. (2000).

In this paper, I undertake an analysis similar to that of Cecchetti and Gochoco-Bautista. My aim is to see if APFI variables can be used as indicators of macroeconomic risks in Central and Eastern European (henceforth CEE) countries. If it turns out that fat tails in the macroeconomic variables are more common than hitherto supposed by central banks, then booms and busts are more costly than previously thought and a strategy seeking to pre-emptively cool down the economy even if the inflation forecast prepared in line with the present models (i. e. disregarding APFI variables) may be welfare improving. In order to implement such a pre-emptive strategy, however, central banks need to have appropriate indicators to detect such booms, well in advance before the busts and early enough to be able to react to them.[4]

In the rest of this paper, I will first look at the macroeconomic risks in CEE countries as proposed by Cecchetti (2006) and followed by Gochoco-Bautista (2008). This is followed by the core section of this paper, where I look at certain financial variables and their ability to explain or indicate 'extreme' developments in the macroeconomic variables. Finally, I present the conclusions and discuss in what ways the results could be used by the central bank to improve monetary strategy.

[4] The optimal tools are not discussed here as these require a separate study. It is to be noted that this subject is also a hotly debated one; opinions spreading from using the traditional policy rate to not using it at all, instead using prudential policies. See Cecchetti (2005) p. 19.

2 Macroeconomic risk measures for CEE countries

In defining and measuring macroeconomic risks, I have applied Cecchetti's method[5] to data on CEE countries. The basic idea is the following: macroeconomic risks are defined as 'extreme'[6] realisations of basic macroeconomic indicators. The most common such indicators for central banks are GDP and inflation (or changes in the Price Level). Risks to these variables were defined as the worst fifth or tenth percentiles of their realisations. As Cecchetti points out, a similar concept is used in the financial industry called Value-at-Risk (VaR). In the financial industry, this concept is used to define tolerable risks taken by institutions, branches or individual traders, etc. Essentially, based on the model/historical data used by the financial institution, VaR defines potential loss over a given horizon.[7] With VaR, financial institutions do not measure the expected size of the likely loss should the negative 5th or 10th percentile outcome materialise. That would be measured by the expected tail loss (ETL). By calculating VaR, financial institutions determine the likely loss which will not be exceeded in 95 or 90 percent of the cases. They are not particularly interested in how much worse the actual outcome could be: in the case of a bankruptcy, it is not important how much an institution is bankrupt. By contrast, central bankers are not indifferent in terms of the expected tail loss, and thus we will look at ETL as well.

By now, it is widely recognised that financial data do not follow a normal distribution: instead, they are better approximated with fat-tailed distributions. Financial market practitioners use extreme value methods to better approximate tail risks. One such widely used method is the Hill-index.[8] In calculating Hill-index, one does not suppose a normal distribution; instead, a fat-tailed distribution such as Student-t is used. The expected tail loss is calculated directly from the empirical values of the tail outcomes, instead of the distribution of all the realisations. These are thought to approximate the likely risks better than using a normal distribution, which only looks at the expected mean and the variance.[9]

In a macroeconomic context, GDP-at-risk and CPI-at-risk are defined as a certain percentile of the distribution of the cyclical component of the GDP and CPI series. The cyclical component, also called the GDP and CPI gap is defined as the difference between the seasonally adjusted quarterly realisation of (log) real GDP and (log) Price Level indicator and its own trend. This trend is constructed with applying Hodrick-Prescott filter to the seasonally adjusted data. Using this series, we can calculate the 5th percentile of the distribution of the cyclical components of both GDP and the CPI price level using both normal and Student-t distributions. For the latter, we used the Hill-index as explained above.

We chose eleven CEE countries for which data was available for the relevant time period. These countries share certain similarities for the purposes of this analysis: these were transition economies with roughly similar level of economic and financial development, which differentiates them from both 'old' OECD and Asian countries. None of them are primary commodity producers – we excluded Russia – and all of them are/were converging to the EU and EMU, both in terms of incomes and institutions. We had to define a time period for the analysis, which adequately represents 'normal' periods,

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[5] Cecchetti (2006) pp. 1-7.

[6] The use of quotes are justified by the fact that 'extreme' qualifier depends on the supposed/empirical probability. The same realisation could be seen as 'extreme' if we suppose normal underlying distribution, and less so if it is supposed that it follows a more fat-tailed distribution such as Student-t. In this section, our aim is precisely to show that certain negative outcomes are less 'extreme' than previously thought, because the often tacit supposition of a normal distribution cannot be justified.

[7] In finance, it is usually a portfolio that is analysed. Portfolio considerations are not relevant for our macroeconomic risks measures as we look at GDP-at-risk and CPI-at-risk separately.

[8] For internationally coordinated regulatory purposes (i. e. covered by BIS or EU), institutions must calculate VaRs using 99 percentile confidence for a 10-trading day horizon and the resulting potential loss should be covered by 3 times the regulatory capital. This 'rule of thumb' multiplication factor is intended to cover – among others - the fat tail, as authorities could not find reliable analytical methods to precisely calculate the risks of fat tails. That is, instead of using an extreme value method, they multiplied the capital requirement resulted from using non-fat-tailed distribution.

[9] A detailed explanation of Hill-index calculation used in this paper can be found in the Appendix.

i. e. which is not characterised by 'transformational crisis'. Data availability and the above considerations resulted in time series starting variously from 1993–1998 and spanning to 2009 Q1.[10] We were interested in improving monetary policy strategy in the usual sense, in the sense of seeking to achieve and maintain price stability, and were not directly interested in financial stability issues per se.[11] The effect of the present global financial crisis is not visible in the dataset used, although it captures economic developments up until the moment when the crisis finally hit the CEE countries.

Table 1 shows the results of the macroeconomic risks estimations carried out separately for the individual countries.[12] It can be seen that for some countries the normal and Student-t distributions suggest reasonably similar risks (GDP-at-risk for Poland or CPI-at-risk for Bulgaria, Croatia, Czech R., etc.). However, for most countries the two measures show significantly different risks. In case of Hungary for example, the normal distribution suggests that in 5 percent of the cases, the GDP-at-risk (or negative deviation from the trend) is about 2.2 percent or worse. However, using the Student-t distribution suggests that in 5 percent of all the cases this negative deviation from the trend is more than 8%. The Jarque-Bera normality test suggests that out of 11 countries, a non-normal distribution is likely in the case of 9 countries for GDP and in the case of 7 countries for CPI (and for one more country at a significance level of 10%).[13] It is known, however, that the Jarque-Bera test has low power in small samples. For this reason, we also made a normality test on the pool of the above data.

Table 1

Macroeconomic Risks measures by country, with normal and Student-t distribution and Jarque–Bera normality test

Country	Bulgaria	Croatia	Czech R.	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovakia	Slovenia
Empirical standard deviation											
of GDP	0.014872	0.023871	0.018065	0.035942	0.013092	0.035552	0.030066	0.013207	0.036931	0.021977	0.017509
of CPI	0.022279	0.009394	0.013457	0.044564	0.019599	0.039789	0.087289	0.02664	0.135808	0.019326	0.019512
GDP-at-risk under different distributions											
Normal	−0.02446	−0.03927	−0.02972	−0.05912	−0.02154	−0.05848	−0.04946	−0.02173	−0.06075	−0.03615	−0.0288
Student-t	−0.0939	−0.0697	−0.05275	−0.10495	−0.08266	−0.22448	−0.08779	−0.02661	−0.0869	−0.06417	−0.11055
CPI-at-risk under different distributions											
Normal	−0.03665	−0.01545	−0.02214	−0.07331	−0.03224	−0.06545	−0.14359	−0.04382	−0.2234	−0.03179	−0.0321
Student-t	−0.04222	−0.01893	−0.0255	−0.28138	−0.04612	−0.25123	−0.55114	−0.1682	−0.39656	−0.0412	−0.05698
p-value of Jarque-Bera normality test											
for GDP	0	0.000364	0.581005	0	0	0	0	0.552775	0	0.000001	0.00000
*, ** significant at 10% or 5% level	**	**		**	**	**	**		**	**	**
for CPI	0.208304	0.057449	0.000129	0	0.30004	0.000007	0.00000	0	0.00000	0.27847	0.01366
*, ** significant at 10% or 5% level		*	**	**		**	**	**	**		**

[10] See the Data Appendix for details.

[11] We acknowledge that a strict separation of main tasks of monetary policy as seeking macroeconomic stability (price and GDP growth stability) and financial stability is impossible in practice and the present crisis is a useful reminder to this fact. See Borio (2006).

[12] See appendix for charts on GDP-at-risk and CPI-at-risk for visual representation of the results.

[13] Cecchetti found non-normality in 11 of 17 countries for GDP and 10 of 17 countries for CPI in OECD countries. As Levin noted, most of the extreme values in Cecchetti's sample were realisations in the 1970s; newer data exhibited fewer extremes until the recent crisis (Levin, 2006). In our case, most of the extreme value of GDP is due to the slowing down of the economies recently. For 8 Asian countries, Gochoco-Bautista found non-normality in 7 countries for CPI and in 4 countries for GDP.

Table 2
Pool estimation for GDP gap and CPI gap for the CEE countries

	GDP?_CYC	CPI?_CYC
Mean	2,02E-03	0,002864
Median	−0,000117	−0,001917
Maximum	0,132746	0,278762
Minimum	−0,114424	−0,296205
Std. Dev.	0,021627	0,042354
Skewness	0,297264	−0,339613
Kurtosis	7,854843	20,85005
Jarque-Bera	619,0066	8256,34
Probability	0,00000	0,00000
Sum	1,25102	1,778361
Sum Sq. Dev.	0,289982	1,112211
Observations	621	621
Cross sections	11	11

Table 2 shows the distributional properties of the pooled series. According to the pooled normality test, normality can be rejected at any meaningful significance level as p-values are extremely low for both GDP and CPI, although some caveats still apply. Using estimation results in future monetary strategy based on past data is appropriate only to the extent that we are confident that i) past realisations are sufficiently good predictors of future realisations, and ii) both the future and the past of the country sample is sufficiently homogeneous. This result is based on past observable data, which involves the effects of past policy reactions as well.

In summarising the results of this section, we can say that it is likely that GDP and CPI-at-risk are significantly different from a normal distribution. As it is currently customary to present macroeconomic risks with fan charts or quadratic loss functions imposing normal distributions, our results warn us that most likely we underestimate the likelihood and/or size of bad macroeconomic outcomes and we habitually present overly optimistic risk scenarios.[14] This part of our work complements similar results obtained for the 'old' OECD and Asian countries by Cecchetti and Gochoco-Bautista, and could be used in presenting more accurate risk scenarios to the monetary policy committees and the public in general. It is to be noted that the result of this section can be used independently of the rest of the paper as well; that is, independently from whether these bad outcomes are caused by APFI variables to be analysed in the next section or not. In the next section, we look at the latter issue.

[14] The Bank of England was the leading bank to publish uncertainty around its baseline projection using fan charts. See Bank of England (internet): The *Inflation projection: understanding the fan chart,* p. 31 section Choice of distribution for details. As BoE illustrates uncertainty by constructing skewed distribution using 'two half' normal distributions ('two piece normal' method), it still underestimates fat tails. Moreover, the Bank of England represents the central projection by the mode, instead of the mean. A side effect of this is to give even less weight to tail risks. A similar 'two-part method' was used by the Magyar Nemzeti Bank until recently. At the end of 2010 the MNB changed to symmetric fan charts (see MNB 2004). The Czech National Bank (2008) and, by now, Riksbank also use symmetrical normal distribution. It is to be noted that not all inflation targeting central banks make and publish quantitative estimations about risks around the central projections.

3 Asset prices/financial imbalances and macroeconomic risks

In the previous section, we concluded that fat-tailed distributions are likely for CPI and GDP gaps, but we did not say anything about their possible causes. In this section, we look at the possible links between asset price/financial imbalance indicators and 'extreme' GDP or CPI developments. The underlying idea is that APFI developments can result in unsustainable processes, whereby financial fragility builds up, while this may not captured in the inflation forecasts. As the unsustainable process comes to an end, the process reverses itself resulting in a costly boom-bust or overheating-overcooling cycle. Central banks may seek to dampen such inefficient fluctuations caused by APFI variables. Thus, if we find that certain variables cause these amplifications, then we may find ways to affect their behaviour and to thereby smooth macroeconomic developments.

Again, I follow Cecchetti (2006) and Gochoco-Bautista (2008), but with a difference. The main difference between my work and theirs is that I have chosen different APFI variables. While both authors used stock exchange and housing price indices, I have used four other variables: the real effective exchange rate, the nominal effective exchange rate, the nominal interest rate and loans. The reason for this choice is that the earlier literature and casual observation of CEE countries showed that stock exchanges and housing prices played a smaller role in the macroeconomy during the period under review. Nonetheless, the latter has recently started to attract attention in the run-up to and during the 2007–2009 financial crises in some CEE countries. For example, Borio and Lowe (2002b) found an important difference between developed (31 countries) and emerging (13 Asian and Latin American) countries in terms of which financial variables have explanatory power in banking crises. They found that in the developed group stock indices and credit developments had explanatory roles (in combination) but the exchange rate did not, whereas in the developing group of countries the exchange rate and credit developments (in combination) were more likely to lead to financial/banking crisis.[15] They also mentioned the potentially important role of real estate prices in emerging countries, but had to omit these prices due to data limitations.

Thus, in CEE countries, which in many APFI-related respects are closer to developing countries, we might expect that the exchange rate plays a more important role than the stock exchange index. The fact that in the CEE countries much fewer companies are listed on the stock exchanges than even in similarly developed emerging market countries is another reason why we left out stock exchanges from our analysis. We decided to use both the nominal and real effective exchange rates because, due to sluggish price and expectation adjustments, the nominal and real exchange rates can show different patterns for extended periods. The lack of sufficiently long comparable time series also prevented us from using real estate prices, but in the future it would be important to analyse these data as well. Moreover, nominal interest rates may also be too low or too high, depending on the conditions prevailing on the international and domestic markets and the stance of monetary policy. Finally, the development of loans is an obvious candidate as a useful indicator.

In the rest of this section, I show the estimation results of the effects of the APFI variables listed above on the various moments of the GDP gap and Price Level gap, or their cyclical components. Gaps or cyclical components are defined as deviations from their own trend, as measured by the Hodrick–Prescott filter. The following four tables show the results of estimations for the gap **(Table 3),** variance of the gap (square of gap) **(Table 4)** and the expected tail loss (the size of the gap when it is large) **(Table 5)** for GDP and Price Level, as in Cecchetti (2006). For explanatory variables I use the 4, 8 and 12 percent one-sided deviations of APFI variables from their own trends 4, 8 and 12 quarters in advance. In the case

[15] Borio and Lowe (2002b) use 'signals', instead of 'leads' or 'causes' of crisis. This is probably due to their method: they use the signalling approach borrowed from the 'early warning systems' literature. Our method is called 'direct estimation' method in that literature, but we – following Cecchetti (2006) and Gochoco-Bautista (2008) and Borio and Lowe (2004) – use it not only or exclusively to open financial crises, but macroeconomic risks or instabilities as well.

of the interest rate a negative deviation, while in the other three cases positive deviations are seen as 'booms'. In **Table 6,** I report the results of a pool probit regression on the same macroeconomic variables using the same APFI variables as before, following Gochoco-Bautista (2008). Interpretation of the results is not easy, because we are looking for boom and bust patterns, and the same variable can be significant in both, either one or the other, or neither of the phases, with a certain time lag. And, just as in the other cases, we do not have a good theory of lag lengths, so – in line with the literature – we somewhat arbitrarily decided to use 4-, 8- and 12-period lags in the context of quarterly data.

In equation (1), I estimate the effect of APFI variables which exceed various thresholds from their own trend several periods earlier on the gap (deviation from trend) of the GDP and Price Level. The estimated equation is following:

$$x_{it} = a + b\, d_{it-k}(\alpha) + \varepsilon_{it}; \quad (1)$$

where $x_{i,t}$ denotes the GDP gap or Price Level gap at time t for country i, $d_{i,t}-k(\alpha)$ stands for dummy APFI variables in excess of α percent at time $t-k$ for country i, while $\varepsilon_{i,t}$ is the error term. Table 3 reports the estimates of parameter b of equation (1).

In **Table 3** and the subsequent tables, thresholds are in the lines (left column). Inside the table, the upper values are parameters while the numbers below show p-values of their significance. Bold values are significant at 5%, and italic ones at 10% confidence levels. The table reads as follows: take the example of the real exchange rate. In Table 3, it is shown that the real effective exchange rate significantly increases the negative Price Level gap when it exceeds its own trend by 4, 8 and 12% thresholds after 8 quarters or lags. The size of the effect is the following: when the real exchange rate increases by more than 4 percent above its own trend, the negative GDP gap became even more negative by 1.5 hundredths of a percent 8 quarters later. If the exchange rate exceeds its own trend by more than 8 percent, the negative gap will exceed 3 hundredths of a percent 8 quarters later. The increase in the nominal effective exchange rate increases the positive Price Level gap after 8 lags. This latter result is not intuitive: it may be caused by a common underlying factor and/or the chosen period is too short and only the boom period is covered. In most, but not all cases where it is significant (4 and 12 quarters later for GDP and 8 and 12 quarters later for the CPI gap), the interest rate (where negative deviation from its own trend is seen as a 'boom') is associated by increasing negative GDP and Price Level gaps at all thresholds. Large positive deviation of loans from its trend results in significantly negative value of the GDP gap at 8 quarters at all thresholds. The Price Level gap is positively affected on both the 8- and 12-quarter horizons at all thresholds.

The above results are not very significant in economic terms. That is, although we have some statistically significant results, these are quantitatively smaller than in the OECD (Cecchetti, 2006) or Asian (Gochoco-Bautista, 2008) countries. In addition, in the latter group of countries, the effects are more consistent, i. e. the signs of the parameters are generally the same across time lags, but far from always.

In equation (2), I estimate the effect of the same APFI variables on the variance of the gap of GDP and Price Level:

$$(x_{it})^2 = a' + b'\, d_{it-k}(\alpha) + \upsilon_{it}; \quad (2)$$

where $x_{i,t}$ denotes the square of the GDP gap or Price Level gap at time t for country i, $d_{i,t}-k(\alpha)$ is the dummy for APFI variables at time $t-k$ for country i, while $\upsilon_{i,t}$ is the error term.

Table 4 reports the estimation results for b' in equation (2). The only difference from the previous estimation is that the dependent variable is the square of the GDP and Price Level gap, rather than the gap itself.

Table 3
Effects of selected financial variables on GDP and Price Level gaps

Impact of Asset Price Movements on the							
	Output Gap Lag of Asset Price(k)				Mean of the Price Level Lag of Asset Price(k)		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.00297	−0.00168	*−0.00600*	4	0.00324	**−0.01550**	0.00423
	0.34110	0.59360	*0.06340*		0.51900	**0.00050**	0.29930
8	*−0.01190*	0.00032	**−0.01548**	8	**−0.02376**	**−0.03186**	**0.02083**
	0.07380	0.96100	**0.02070**		**0.02530**	**0.00050**	**0.01360**
12	−0.01672	−0.00077	−0.00670	12	0.00181	**−0.04995**	0.00563
	0.11310	0.94140	0.52990		0.91470	**0.00060**	0.67610
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.00379	−0.00359	0.00318	4	0.00378	**0.01447**	−0.00213
	0.15830	0.17050	0.24330		0.36790	**0.00010**	0.53670
8	−0.00688	−0.00608	**0.01459**	8	*0.01299*	**0.03902**	−0.00482
	0.11940	0.16160	**0.00110**		*0.05720*	**0.00000**	0.39470
12	**−0.01871**	**0.01537**	**0.02913**	12	**0.08990**	**0.04972**	**−0.03363**
	0.00840	**0.02700**	**0.00000**		**0.00000**	**0.00000**	**0.00020**
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**−0.00149**	−0.00007	**−0.00089**	4	0.0008	**−0.0033**	**−0.0010**
	0.00000	0.84520	**0.01620**		0.1180	**0.0000**	**0.0066**
8	**−0.00148**	−0.00008	**−0.00089**	8	0.0008	**−0.0033**	**−0.0010**
	0.00010	0.82130	**0.01620**		0.1112	**0.0000**	**0.0066**
12	**−0.00148**	−0.00009	**−0.00090**	12	0.0008	**−0.0033**	**−0.0010**
	0.00010	0.79850	**0.01470**		0.1060	**0.0000**	**0.0063**
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.00112	**−0.00946**	−0.00346	4	0.00200	**0.01256**	**0.00568**
	0.56310	**0.00000**	0.10480		0.46960	**0.00000**	**0.00750**
8	*−0.00486*	**−0.01224**	−0.00062	8	−0.00157	**0.01750**	**0.00856**
	0.07610	**0.00000**	0.82810		0.68640	**0.00000**	**0.00250**
12	−0.00441	**−0.01442**	0.00414	12	*−0.00916*	**0.02237**	**0.00994**
	0.23180	**0.00010**	0.27180		*0.07730*	**0.00000**	**0.00720**

Note: **Bold** means significant at 5%, *italic* 10% level.
The table shows the estimation result of *b* of the following equation:

$$x_{it} = a + b\, d_{it-k}(\alpha) + \varepsilon_{it};$$

$$where\ d_{it-k} \begin{cases} = 1, when\ apfi\ variable\ exceeds\ \alpha\ threshold\ \ k\ period\ earlier \\ = original\ value\ of (log\ transformed) apfi\ variable\ otherwise \end{cases}$$

Thresholds are vertically below the financial (apfi) variables and calculated as percentage deviations from HP trends (negative direction in the case of interest rate, positive otherwise).
Lags of (HP filtered) dependent macroeconomic variables are indicated horizontally in number of periods of quarterly data.

Table 4
Effects of selected financial variables on the variance of the GDP and Price Level gap

Impact of Asset Price Movements on the							
	Output Gap Lag of Asset Price(k)				Volatility of Price Level Lag of Asset Price(k)		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	0.00000	0.00000	0.00000	4	0.00000	0.00000	0.00000
	0.48310	0.48310	0.48310		0.94350	0.94350	0.94350
8	0.00000	0.00000	0.00000	8	0.00000	0.00000	0.00000
	0.68290	0.68290	0.68290		0.88730	0.88730	0.88730
12	0.00000	0.00000	0.00000	12	0.00000	0.00000	0.00000
	0.73570	0.73570	0.73570		0.98830	0.98830	0.98830
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	0.00000	0.00000	0.00000	4	0.00000	0.00000	0.00000
	0.79210	0.79210	0.79210		0.89180	0.89180	0.89180
8	0.00000	0.00000	0.00000	8	0.00000	0.00000	0.00000
	0.94940	0.94940	0.94940		0.78500	0.78500	0.78500
12	0.00000	0.00000	0.00000	12	0.00000	0.00000	0.00000
	0.93610	0.93610	0.93610		0.69570	0.69570	0.69570
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	0.00001	0.00001	0.00001	4	−0.00027	−0.00027	−0.00027
	0.84660	0.84660	0.84660		0.70420	0.70420	0.70420
8	0.00002	0.00002	0.00002	8	−0.00024	−0.00024	−0.00024
	0.76850	0.76850	0.76850		0.74030	0.74030	0.74030
12	0.00002	0.00002	0.00002	12	−0.00020	−0.00020	−0.00020
	0.79620	0.79620	0.79620		0.77650	0.77650	0.77650
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**0.00007**	**0.00007**	**0.00007**	4	−0.00039	−0.00039	−0.00039
	0.00180	**0.00180**	**0.00180**		0.13220	0.13220	0.13220
8	0.00000	0.00000	0.00000	8	−0.00002	−0.00002	−0.00002
	0.69490	0.69490	0.69490		0.81830	0.81830	0.81830
12	0.00000	0.00000	0.00000	12	−0.00001	−0.00001	−0.00001
	0.54780	0.54780	0.54780		0.83380	0.83380	0.83380

Note: **Bold** means significant at 5%, *italic* 10% level.
The table shows the estimation result of b' of the following equation:

$$(x_{it})^2 = a' + b'\, d_{it-k}(\alpha) + v_{it};$$

$$where\ d_{it-k} \begin{cases} = 1, when\ apfi\ variable\ exceeds\ \alpha\ threshold\ \ k\ period\ earlier \\ = original\ value\ of\ (log\ transformed)\ apfi\ variable\ otherwise \end{cases}$$

Thresholds are vertically below the financial (apfi) variables and calculated as percentage deviations from HP trends (negative direction in the case of interest rate, positive otherwise).
Lags of (HP filtered) dependent macroeconomic variables are indicated horizontally in number of periods of quarterly data.

Here, I find that in general the variance of the gap of the macroeconomic variables is not significantly affected by our APFI variables. For the OECD countries, housing price indices proved significant at a 5% level in affecting the variance of the GDP gap, but not the Price Level gap. Stock exchange indices did not prove significant in affecting the variance of either of the macroeconomic variables in the OECD countries. (For the Asian countries no variance test is available in Gochoco-Bautista's paper).

Next, we look at the estimated tail losses (ETL) of GDP and Price Level. As explained above, our interest here is how bad the GDP or CPI gap could be, if they turn out to be really bad.

The estimated equation is:

$$x_{it} = a + b_0\, d_{it-k}(\alpha) + b_1 tail(\beta)_{it} + b_3 d_{it-k}(\alpha) x\; tail(\beta)_{it} + \eta_{it}; \tag{3}$$

where $x_{i,t}$ denotes, as before, the GDP gap or Price Level gap at time t for country i, while $d_{i,t} - k(\alpha)$ is dummy for APFI variables at time $t-k$ for country i. $tail(\beta)_{i,t}$ is a dummy for the GDP or Price Level gap, taking the value of 1 if in the β tail (left hand side – 5, or 25 percentiles for GDP and right hand side – 75 or 95 percentiles – for CPI) of its own distribution. Finally, $\eta_{i,t}$ is an error term. I report the estimation results for the b_3 parameter, which measures the estimated tail loss when the GDP or Price Level gap is at its extreme after several quarter lags that the relevant APFI variable exceeded a critical threshold. Note that b_2 picks up those realisations, where these bad realisations are not preceded ('explained') by the APFI variables exceeding the critical thresholds. **Tables 5a** and **5b** show the estimation results for expected tail losses (ETL) for GDP and CPI: in **Table 5a** the results are presented for estimations where the tail begins at 25 percentiles (left hand) for GDP and 75 percentiles (right hand) for CPI, while in **Table 5b** the relevant values are 5 and 95 percentiles.

With respect to the 25th and 75th quantiles **(Table 5a),** the real and nominal effective exchange rates result in significantly positive Price Level gaps at several thresholds and lags, but are mostly insignificant with respect to the GDP gap. The decrease in the nominal interest rate below the relevant thresholds increases the positive GDP gap (8 and 12 quarters later), and suggests a significantly more negative Price Level gap. Loans adversely affect the estimated tail loss for GDP at nearly all lags and thresholds, while resulting in a significant increase in the positive Price Level gap. (For the OECD countries, Cecchetti finds an economically as well as statistically significant negative effect of both an equity and housing boom on both output and (negative) price level gap. For Asian countries, this kind of estimation is not available; instead, a pool probit regression has been applied; see below).

As for the 5th and 95th quantiles there are very few realisations in the tails, which means few interpretable results; hence the many ones and zeros in the **Table 5b.** The real and nominal effective exchange rates are significant only in very few cases and show no consistent pattern. This is also largely the case with the interest rate. Only loans show some consistency and seem to affect the probability of a positive Price Level gap after 4 and 8 lags (see **Table 5b**).

It is important to note that I looked at positive Price Level gaps, which is in contrast to Cecchetti (2006), but is in line with Gochoco-Bautista (2008).

Table 5a
Effects of selected financial variables on the estimated tail loss of the GDP and Price Level gap
(25th and 75th percentiles)

Impact of Asset Price Movements on the							
	Estimated tail loss of Output Lag of Asset Price(k)				Estimated tail loss of Price Level Lag of Asset Price(k)		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.00474	0.00025	−0.00869	4	**0.05725**	**0.04337**	**0.03732**
	0.41200	0.96820	0.17510		**0.00000**	**0.00000**	**0.00000**
8	0.00313	0.01573	*−0.02232*	8	**0.07884**	*0.03445*	**0.06432**
	0.80050	0.25440	*0.07150*		**0.00020**	*0.06550*	**0.00010**
12	0.01023	0.02979	0.01506	12	0.05371	0.02074	*0.04720*
	0.61610	0.10910	0.51200		0.10890	0.48820	*0.05920*
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.00658	**−0.01068**	−0.00875	4	**0.08177**	**0.02681**	**0.01801**
	0.20440	**0.03540**	0.11910		**0.00000**	**0.00010**	**0.01440**
8	−0.00774	**−0.02665**	**−0.01862**	8	**0.12358**	**0.02854**	0.01871
	0.31670	**0.00080**	**0.03150**		**0.00000**	**0.00900**	0.12820
12	−0.00710	−0.01829	0.01570	12	**0.15452**	−0.01831	−0.01179
	0.56720	0.34730	0.67730		**0.00000**	0.32470	0.63950
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	*0.00159*	**0.00382**	**0.00405**	4	**−0.01060**	**−0.00206**	**−0.00167**
	0.06420	**0.00000**	**0.00000**		**0.00000**	**0.01770**	**0.00510**
8	*0.00164*	**0.00384**	**0.00414**	8	**−0.01063**	**−0.00208**	**−0.00167**
	0.05690	**0.00000**	**0.00000**		**0.00000**	**0.01650**	**0.00510**
12	*0.00166*	**0.00386**	**0.00416**	12	**−0.01067**	**−0.00210**	**−0.00167**
	0.05360	**0.00000**	**0.00000**		**0.00000**	**0.01550**	**0.00510**
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**−0.01291**	**−0.01492**	**−0.01208**	4	**0.01987**	**0.01440**	−0.00497
	0.00120	**0.00050**	**0.01030**		**0.00020**	**0.01110**	0.21630
8	**−0.01249**	**−0.01361**	**−0.01952**	8	**0.04012**	**0.02550**	−0.00006
	0.01360	**0.01130**	**0.00130**		**0.00000**	**0.00030**	0.99030
12	−0.00694	−0.00983	**−0.01945**	12	**0.06243**	**0.02489**	−0.00474
	0.30090	0.15780	**0.01280**		**0.00000**	**0.00480**	0.47260

Note: **Bold** means significant at 5%, *italic* 10% level.
The table shows the estimation result of b_3 of the following equation:

$$x_{it} = a + b_0\, d_{it-k}(\alpha) + b_1 tail(\beta)_{it} + b_3 d_{it-k}(\alpha) x\, tail(\beta)_{it} + \eta_{it};$$

$$where\ d_{it-k} \begin{cases} = 1, when\ apfi\ variable\ exceeds\ \alpha\ threshold\ \ k\ period\ earlier \\ = original\ value\ of\ (log\ transformed) apfi\ variable\ otherwise \end{cases}$$

and

$$tail(\beta)_{it} \begin{cases} = 1, when\ \ x_{it}\ variable\ in\ its\ \beta = 25\%\ lower\ (GDP)\ or\ upper\ (CPI)\ tail \\ \qquad = \ zero\ otherwise \end{cases}$$

Thresholds are vertically below the financial (apfi) variables and calculated as percentage deviations from HP trends (negative direction in the case of interest rate, positive otherwise).
Lags of (HP filtered) dependent macroeconomic variables are indicated horizontally in number of periods of quarterly data.

Table 5b
Effects of selected financial variables on the estimated tail loss of the GDP and Price Level gap
(5th and 95th percentiles)

Impact of Asset Price Movements on the							
	Estimated tail loss of Output Gap Lag of Asset Price(k)				Estimated tail loss Price Level Lag of Asset Price(k)		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**0.07463**	*0.04688*	0.03175	4	**0.09091**	0.01587	0.00000
	0.00570	*0.07730*	0.23540		**0.00110**	0.55290	1.00000
8	0.07143	0.07143	**0.14286**	8	**0.14286**	0.00000	0.00000
	0.22810	0.20830	**0.01160**		**0.01860**	1.00000	1.00000
12	0.00000	0.00000	0.00000	12	0.00000	0.00000	0.00000
	1.00000	1.00000	1.00000		1.00000	1.00000	1.00000
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**0.05882**	**0.08140**	0.01205	4	**0.11364**	**0.05952**	**0.06098**
	0.01470	**0.00030**	0.60710		**0.00000**	**0.00750**	**0.00020**
8	0.06061	**0.09091**	0.00000	8	**0.22857**	*0.06250*	0.03125
	0.11770	**0.01240**	1.00000		**0.00000**	*0.08350*	0.23040
12	0.08333	0.00000	0.00000	12	**0.58333**	0.00000	0.00000
	0.19470	1.00000	1.00000		**0.00000**	1.00000	1.00000
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	0.01770	**0.04546**	**0.06376**	4	**0.04985**	**0.03165**	0.01424
	0.14280	**0.00010**	**0.00000**		**0.00000**	**0.00900**	0.17600
8	*0.02029*	**0.04478**	**0.06601**	8	**0.04913**	**0.03115**	0.01404
	0.09010	**0.00010**	**0.00000**		**0.00000**	**0.00950**	0.17910
12	*0.01983*	**0.04361**	**0.06431**	12	**0.04789**	**0.03333**	**0.02055**
	0.09380	**0.00010**	**0.00000**		**0.00000**	**0.00490**	**0.04630**
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**0.07018**	**0.07792**	**0.04930**	4	**0.06024**	**0.06757**	0.02174
	0.00000	**0.00000**	**0.00540**		**0.00030**	**0.00010**	0.14760
8	**0.08434**	**0.07407**	**0.05128**	8	**0.08537**	**0.10127**	0.01316
	0.00050	**0.00160**	**0.03220**		**0.00030**	**0.00000**	0.51570
12	0.04546	0.04546	0.04651	12	**0.13636**	**0.09091**	0.00000
	0.17420	0.15460	0.14970		**0.00000**	**0.00510**	1.00000

Note: **Bold** means significant at 5%, *italic* 10% level.
The table shows the estimation result of b_3 of the following equation:

$$x_{it} = a + b_0\, d_{it-k}(\alpha) + b_1 tail(\beta)_{it} + b_3 d_{it-k}(\alpha) x\; tail(\beta)_{it} + \eta_{it};$$

$$where\ d_{it-k} \begin{cases} = 1, when\ apfi\ variable\ exceeds\ \alpha\ threshold\ \ k\ period\ earlier \\ = original\ value\ of (log\ transformed) apfi\ variable\ otherwise \end{cases}$$

and

$$tail(\beta)_{it} \begin{cases} = 1, when\ \ x_{it}\ variable\ in\ its\ \beta = 5\%\ lower\ (GDP)\ or\ upper\ (CPI)\ tail \\ \qquad\qquad = \ zero\ otherwise \end{cases}$$

Thresholds are vertically below the financial (apfi) variables and calculated as percentage deviations from HP trends (negative direction in the case of interest rate, positive otherwise).
Lags of (HP filtered) dependent macroeconomic variables are indicated horizontally in number of periods of quarterly data.

Next, we turn to a simple panel probit regression (4) and ask the following question: to what degree is the probability of a negative GDP gap tail risk and a positive Price Level gap tail risk affected in the margin by occurrences of APFI booms? The following equation has been estimated:

$$\Pr(x_{it} = 1|d_{it-k}) = F(\beta_0 + \beta_1 d_{it-k}) \tag{4}$$

where $y_{i,t}$ is a dummy variable that takes the value 1 if the GDP gap or Price Level gap is in the tail of its own distribution, otherwise the dummy equals 0. $x_{i,t-k}$ denotes the APFI variables at time $t-k$ for country *i*. $Pr(x_{it}=1|d_{it-k})$ is the conditional probability of x_{it}, i. e., what is the probability of the GDP at time *t* for country *i* being in the tail, given that the APFI variable exceeds the relevant threshold.

The leads and thresholds for filtering the APFI variables are the same as before. We use both the 25th and 75th percentiles **(Table 6a)** and the 5th and 95th **(Table 6b)** for the GDP gap and Price Level gaps. Here, the macroeconomic variables are y and on the left hand side one finds the standard CDFs of *x*, the APFI variable.

In case of 25th and 75th quantiles, there are few significant results for nominal and real exchange rates. Interest rate undershooting results in a higher probability of a negative GDP and Price Level gap at 4 and 8 quarters lag. Loans positively affect the probability of a Price Level gap in the case of quite a few lags and thresholds, while negatively affecting the GDP gap at a 4-quarter lag, but positively at a 12-quarter lag at 8 and 12 percent thresholds.

For the 5th and 95th percentiles, the results are summarised in **Table 6b.** Real exchange rate and nominal exchange rates do not seem to be significant except the real exchange rate effect on the likelihood of a negative Price Level gap at all thresholds after 8-quarter lags. Interest rate undershooting seems to increase the probability of a negative Price Level gap at several thresholds and lags. Loans positively affect the probability of a Price Level gap at all thresholds after 8 and 12 lags.

Parameters of probit regressions are not to be interpreted as marginal effects on the dependent variable. To better illustrate the degree to which the probability of the occurrence of the tail event changes in response to the APFI variable exceeding certain thresholds, we compiled **Table 7a** for the 25th and **Table 7b** for 5th percentiles.[16]

The numbers in brackets are probabilities of the tail events of the GDP or the Price Level gap when the APFI variable is not in its 5th/95th or 25th/75th percentile tail respectively: that is, the bracketed term is the constant of the probit regression recalculated as probability. The bracketed numbers are the estimated probabilities of the APFI variables when not in the tail of their distribution (constant time normal distribution), while the number without brackets are the probabilities of the same variables when in their own tails (constant plus beta times normal distribution). The signs and significance levels are taken from the probit estimations, as reported in **Tables 6a** and **6b.** When the probability is significant, the bracketed number should be smaller than the non-bracketed one.

Using 25th and 75th percentiles, only loans resulted in significant and meaningful estimates: loans marginally increase the positive Price Level gap at all thresholds. Significant inverse effects of interest rates are visible for both the GDP and Price Level gap (see **Table 7a).**

At the 5% level **(Table 7b),** again only the effect of loans seems to be meaningful, where it is positive and significant at nearly all thresholds and after all lags. To a lesser extent, and somewhat inconsistently, the interest rate variable affects inversely the Price Level gap.

[16] Bartus (2005) discusses methods to translate probit regression parameters to marginal effects.

Table 6a
Probit estimation: APFI-s impact on the probability of macroeconomic risks
(25th and 75th percentiles)

Panel probit: Impact of Asset Price Movements on the							
	25th quantile of Output Gap Lag of Asset Price(k)				**75th quantile of Price Level Lag of Asset Price(k)**		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.29535	**−0.74516**	*−0.34857*	4	0.07037	**−0.46896**	*0.33177*
	0.12260	**0.00090**	*0.08160*		0.67160	**0.01710**	*0.05760*
8	−0.43523	**−4.18927**	−1.24406	8	*0.63267*	**−1.29578**	0.18493
	0.31870	**0.00970**	0.11580		*0.06530*	**0.03400**	0.65880
12	0.13772	**−4.63571**	−1.04924	12	0.82535	**−5.40196**	0.55121
	0.81500	**0.00330**	0.27740		0.15340	**0.00050**	0.34370
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**−0.49092**	**−0.51215**	**−0.55803**	4	−0.08111	−0.26504	0.21603
	0.00990	**0.00790**	**0.00890**		0.60180	0.11150	0.19370
8	−0.25636	*−0.64002*	*−0.81395*	8	0.14062	−0.08130	0.42838
	0.37430	*0.06680*	*0.07920*		0.55570	0.75300	0.13640
12	*−2.63562*	−0.35773	−1.15375	12	−0.39473	−0.58770	1.12159
	0.06040	0.52640	0.39090		0.38090	0.24280	0.11090
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**−0.07183**	**−0.06886**	−0.00741	4	**−0.15011**	**−0.06868**	0.03236
	0.00110	**0.02060**	0.84900		**0.00000**	**0.00050**	0.31930
8	**−0.07238**	**−0.06963**	−0.01013	8	**−0.14933**	**−0.06842**	0.03254
	0.00110	**0.01970**	0.79530		**0.00000**	**0.00050**	0.31840
12	**−0.07138**	**−0.07187**	−0.00870	12	**−0.15108**	**−0.06938**	0.03438
	0.00130	**0.01640**	0.82440		**0.00000**	**0.00040**	0.29420
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**−0.57129**	−0.10678	0.15086	4	0.13552	0.18816	**0.35686**
	0.00000	0.40120	0.24140		0.24410	0.11660	**0.00390**
8	**−0.71619**	−0.10192	**0.38856**	8	*0.25784*	**0.45274**	**0.55635**
	0.00050	0.57190	**0.02830**		*0.08810*	**0.00450**	**0.00130**
12	**−0.78900**	0.02996	**0.50105**	12	**0.44418**	**0.67203**	**1.07073**
	0.00360	0.89710	**0.03600**		**0.01990**	**0.00080**	**0.00000**

Note: **Bold** means significant at 5%, *italic* 10% level.
The table shows the estimation results of coefficient of:

$$\Pr(x_{it} = 1|d_{it-k}) = F(\beta_0 + \beta_1 d_{it-k})$$

$$where\ x_{it} \begin{cases} = 1, the\ macro\ variable\ is\ in\ instail\ (left\ for\ GDP\ and\ right\ for\ CPI) \\ = zero\ otherwise \end{cases}$$

$$where\ d_{it-k} \begin{cases} = 1, when\ apfi\ variable\ exceeds\ \alpha\ threshold\ \ k\ period\ earlier \\ = zero\ otherwise \end{cases}$$

Thresholds are vertically below the financial (apfi) variables and calculated as percentage deviations from HP trends (negative direction in the case of interest rate, positive otherwise).
Lags of (HP filtered) dependent macroeconomic variables are indicated horizontally in number of periods of quarterly data.

Table 6b
Probit estimation: APFI-s impact on the probability of macroeconomic risks
(5th and 95th percentiles)

Panel probit: Impact of Asset Price Movements on the							
	5th quantile of Output Gap Lag of Asset Price(k)				95th quantile of Price Level Lag of Asset Price(k)		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.3176	−0.3449	−0.2523	4	−0.5330	**−6.0401**	0.2484
	0.4349	0.3997	0.5187		0.1591	**0.0103**	0.3205
8	−1.7010	−2.3304	−0.3545	8	0.1942	**−7.0211**	−0.5514
	0.4893	0.3942	0.7437		0.7084	**0.0013**	0.5812
12	−1.9223	−2.5595	−0.0572	12	−0.7649	**−7.1238**	−0.3126
	0.4558	0.3407	0.9634		0.6337	**0.0010**	0.7889
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	0.1441	−0.2779	−0.3078	4	−0.1716	−0.0334	*0.3699*
	0.6037	0.4498	0.4440		0.5136	0.8914	*0.1000*
8	0.0471	0.1347	−1.0226	8	0.0563	0.2464	0.2652
	0.9211	0.7783	0.5053		0.8790	0.4695	0.5072
12	−1.8076	0.8711	−0.9528	12	−2.4223	0.0088	−1.1904
	0.4602	0.1823	0.7074		0.2185	0.9890	0.4959
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**−0.0635**	−0.0629	−0.0524	4	**−0.1198**	**−0.0614**	*0.1332*
	0.0321	0.1784	0.3988		**0.0000**	**0.0120**	*0.0514*
8	**−0.0632**	−0.0621	−0.0507	8	**−0.1197**	**−0.0611**	**0.1380**
	0.0331	0.1857	0.4172		**0.0000**	**0.0125**	**0.0461**
12	**−0.0630**	−0.0614	−0.0493	12	**−0.1196**	**−0.0620**	**0.1428**
	0.0341	0.1928	0.4327		**0.0000**	**0.0112**	**0.0414**
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	−0.2481	**−0.7254**	0.1575	4	0.2837	**0.3907**	**0.5930**
	0.3210	**0.0417**	0.4779		0.1008	**0.0273**	**0.0010**
8	−0.0759	−1.8684	−0.2055	8	*0.3798*	**0.6550**	**0.9069**
	0.8115	0.1277	0.5863		*0.0723*	**0.0019**	**0.0000**
12	−0.1411	*−2.1448*	0.0776	12	0.4046	**0.9497**	**0.9616**
	0.7447	*0.0840*	0.8569		0.1246	**0.0001**	**0.0005**

Note: **Bold** means significant at 5%, *italic* 10% level.
The table shows the estimation results of coefficient of:

$$\Pr(x_{it} = 1 | d_{it-k}) = F(\beta_0 + \beta_1 d_{it-k})$$

$$where\ x_{it} \begin{cases} = 1, the\ macro\ variable\ is\ in\ instail\ (left\ for\ GDP\ and\ right\ for\ CPI) \\ = zero\ otherwise \end{cases}$$

$$where\ d_{it-k} \begin{cases} = 1, when\ apfi\ variable\ exceeds\ \alpha\ threshold\ \ k\ period\ earlier \\ = zero\ otherwise \end{cases}$$

Thresholds are vertically below the financial (apfi) variables and calculated as percentage deviations from HP trends (negative direction in the case of interest rate, positive otherwise).
Lags of (HP filtered) dependent macroeconomic variables are indicated horizontally in number of periods of quarterly data.

Table 7a
Probabilities
(25th and 75th percentiles)

Panel probit: Marginal Impact of Asset Price Movements on the							
	25th quantile of Output Gap Lag of Asset Price(k)				75th quantile of Price Level Lag of Asset Price(k)		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	(0.2440) 0.1614	**(0.2748) 0.0895**	*(0.2809) 0.1765*	4	(0.2369) 0.2592	**(0.2700) 0.1397**	*(0.2651) 0.3837*
		neg	neg			neg	poz
8	(0.2373) 0.1250	**(0.2550) 0.0000**	(0.2729) 0.0323	8	*(0.2350) 0.4642*	**(0.2599) 0.0262**	(0.2766) 0.3416
		neg			poz	neg	
12	(0.2352) 0.2795	**(0.2523) 0.0000**	(0.2708) 0.0485	12	(0.2376) 0.5443	**(0.2519) 0.0000**	(0.2762) 0.4829
		neg				neg	
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**(0.2503) 0.1221**	**(0.2712) 0.1310**	**(0.2857) 0.1305**	4	(0.2426) 0.2180	(0.2663) 0.1870	(0.2689) 0.3446
	neg	neg	neg				
8	(0.2381) 0.1664	*(0.2601) 0.0998*	*(0.2738) 0.0785*	8	(0.2374) 0.2830	(0.2573) 0.2317	(0.2727) 0.4300
	neg	neg	neg				
12	*(0.2345) 0.0004*	(0.2553) 0.1549	(0.2687) 0.0383	12	(0.2407) 0.1359	(0.2578) 0.1079	(0.2763) 0.7012
	neg						
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**(0.2244) 0.2035**	**(0.2436) 0.2225**	(0.2712) 0.2688	4	**(0.2034) 0.1636**	**(0.2432) 0.2222**	(0.2881) 0.2992
	neg	neg			neg	neg	
8	**(0.2241) 0.2030**	**(0.2432) 0.2219**	(0.2709) 0.2676	8	**(0.2032) 0.1636**	**(0.2430) 0.2221**	(0.2883) 0.2995
	neg	neg			neg	neg	
12	**(0.2241) 0.2033**	**(0.2425) 0.2206**	(0.2710) 0.2682	12	**(0.2023) 0.1624**	**(0.2425) 0.2213**	(0.2886) 0.3005
	neg	neg			neg	neg	
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**(0.2766) 0.1222**	(0.2669) 0.2330	(0.2606) 0.3118	4	(0.2300) 0.2732	(0.2440) 0.3066	**(0.2504) 0.3759**
	neg						poz
8	**(0.2556) 0.0848**	(0.2615) 0.2295	**(0.2597) 0.3991**	8	*(0.2313) 0.3168*	**(0.2428) 0.4034**	**(0.2622) 0.4681**
	neg		poz		poz	poz	poz
12	**(0.2472) 0.0705**	(0.2580) 0.2678	**(0.2648) 0.4492**	12	**(0.2318) 0.3864**	**(0.2451) 0.4929**	**(0.2629) 0.6687**
	neg		poz		poz	poz	poz

Note: **Bold** means significant at 5%, *italic* 10% level.
Signs and significance levels are taken from the probit regressions.
The bracketed numbers are marginal effects of the APFI variables when not in the tail of their distribution (constant time normal distribution), while the other numbers are the marginal effects of the same variables when in their own tails (constant plus beta times normal distribution). The signs and significance levels are taken from the probit estimations.

Table 7b
Probabilities
(5th and 95th percentiles)

Panel probit: Marginal Impact of Asset Price Movements on the							
	5th quantile of Output Gap Lag of Asset Price(k)				95th quantile of Price Level Lag of Asset Price(k)		
Real effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	(0.0309) 0.0144	(0.0336) 0.0148	(0.0362) 0.0202	4	(0.0511) 0.0151	**(0.0483) 0.0000**	(0.0517) 0.0838
						neg	
8	(0.0292) 0.0002	(0.0315) 0.0000	(0.0347) 0.0150	8	(0.0468) 0.0691	**(0.0447) 0.0000**	(0.0556) 0.0160
						neg	
12	(0.0289) 0.0001	(0.0311) 0.0000	(0.0344) 0.0303	12	(0.0473) 0.0074	**(0.0444) 0.0000**	(0.0553) 0.0282
						neg	
Nominal effective exchange rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	(0.0279) 0.0385	(0.0335) 0.0174	(0.0364) 0.0178	4	(0.0492) 0.0340	(0.0513) 0.0479	*(0.0492) 0.0998*
							poz
8	(0.0291) 0.0323	(0.0312) 0.0419	(0.0349) 0.0023	8	(0.0470) 0.0528	(0.0495) 0.0803	(0.0540) 0.0898
12	(0.0289) 0.0001	(0.0305) 0.1580	(0.0342) 0.0028	12	(0.0463) 0.0000	(0.0509) 0.0518	(0.0549) 0.0026
Nominal interest rate							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	**(0.0256) 0.0220**	(0.0294) 0.0254	(0.0338) 0.0301	4	**(0.0321) 0.0243**	**(0.0449) 0.0394**	*(0.0579) 0.0751*
	neg				neg	neg	poz
8	**(0.0256) 0.0220**	(0.0294) 0.0255	(0.0339) 0.0302	8	**(0.0320) 0.0243**	**(0.0449) 0.0394**	**(0.0581) 0.0759**
	neg				neg	neg	poz
12	**(0.0256) 0.0220**	(0.0294) 0.0255	(0.0339) 0.0303	12	**(0.0320) 0.0243**	**(0.0447) 0.0391**	**(0.0582) 0.0768**
	neg				neg	neg	poz
Loans							
Threshold (alfa)	4	8	12	Threshold (alfa)	4	8	12
4	(0.0332) 0.0186	**(0.0393) 0.0065**	(0.0316) 0.0446	4	(0.0398) 0.0709	**(0.0395) 0.0861**	**(0.0359) 0.1136**
		neg				poz	poz
8	(0.0301) 0.0253	*(0.0320) 0.0001*	(0.0363) 0.0227	8	*(0.0423) 0.0894*	**(0.0407) 0.1383**	**(0.0398) 0.1986**
					poz	poz	poz
12	(0.0300) 0.0216	*(0.0302) 0.0000*	(0.0347) 0.0411	12	(0.0445) 0.0975	**(0.0404) 0.2128**	**(0.0463) 0.2357**
		neg				poz	poz

Note: **Bold** means significant at 5%, *italic* 10% level.
Signs and significance levels are taken from the probit regressions.
The bracketed numbers are marginal effects of the APFI variables when not in the tail of their distribution (constant time normal distribution), while the other numbers are the marginal effects of the same variables when in their own tails (constant plus beta times normal distribution). The signs and significance levels are taken from the probit estimations.

4 Summary and conclusions for monetary strategy

In this study, we looked at some indicators of financial imbalances and investigated whether these played a role in macroeconomic risks. We have adapted Cecchetti's (2006) and Gochoco-Bautista's (2008) work to Central and Eastern European Countries. In the first part of the study, we looked at the behaviour of critical macroeconomic indicators, the GDP and Price Level gaps, to see if they could be safely represented by a normal distribution. We found that instead these could be better approximated by some fat-tailed distributions such as Student-t. This means that occurrences of significantly worse GDP and CPI gaps are more frequent, or extreme outcomes are worse than what is suggested by the normal distribution. That is, central banks concentrating only on the mean and variance of the critical macroeconomic variables are risking larger macroeconomic gaps than they are aware of. With the same preferences and knowing this, they would probably react differently to the otherwise unchanged information base. It is important to remember, however, that our ability to statistically detect leptokurtic (fat tailed) series is very limited, not to mention how to handle them. By definition, rare events with large impacts are rare, and develop in somewhat unexpected ways.

In the second part, we tried to find empirical links between developments in the selected APFI variables and various macroeconomic risk indicators. We found mixed results. Some of the statistically significant results are not significant in economic terms. Others could not be interpreted easily or contradict our expectations. The best results were seen across various estimations for loans, but even in that case the results were not consistent. This mixed result can be explained by various ways. We may need better indicators or more significant variables leading to macroeconomic risks. For example, we concentrated on domestic indicators, while the countries under investigation are highly integrated and subject to developments in foreign markets in terms of liquidity and risk appetite. Use of variables adequately capturing these exogenous effects could also improve our results.[17] Moreover, instead of looking at explanatory variables individually, combinations of variables could improve our results.

[17] Alessi and Detken (2009) found global liquidity as one of the most significant early warning indicators of financial distresses, including the present crisis.

Appendix

CALCULATION OF GDP-AT-RISK AND CPI-AT-RISK

In the paper, we compare two GDP-at-risk and CPI-at-risk values to show the difference between the one calculated by using a normal distribution and the other by using a fat-tailed distribution. We have chosen 5 percent VaR level in both cases in accordance with usual practice. Moreover, it has been shown that the distribution of financial market data can be satisfactorily approximated by the Student-t distribution. We use the (reciprocal) of the Hill-index value to determine the degree of freedom of the Student-t distribution. Of course, one could use other parameters as well for the cut-off value or the level of VaR or other distributions than Student-t to approximate fat-tailed distribution.

For calculating the fat-tailed GDP-at-risk and CPI-at-risk figures, we use an adaptation of the Extreme Value Theory, which is extensively applied in financial markets. It involves the calculation of a tail index. The most common among such indices is the so-called Hill index. The Hill index seeks to model the extreme values of a particular distribution. As such, it does not model the whole distribution, only the 'tails'. The calculation is based on the following equation:

$$\tau_{n,m}^{H} = \frac{1}{m-1}\sum_{i=1}^{m-1} \ln X_i - \ln X_{n-m,n} \quad \text{where m} > 1$$

Where X is the variable whose Hill index we are interested in. X_i denotes value which separates the 'tail' from the rest of the distribution, representing the smallest or largest 10% of the distribution. The value of m is the number of observations in the tail. $X_{n-m,n}$ stands for the values in the tail. Finally, n is the total number of observations.

A crucial choice in applying the formula is to determine where the tail begins. In large samples it is estimated, while in small samples the usual practice is to apply a rule of thumb. Here, we arbitrarily took the smallest or largest 10 percent of all values as extreme values.[18] In other words, first one has to determine 10% of the smallest (or largest) values. One has to calculate the log differences between each extreme value beyond the cut-off value (which separates the tail from the rest or the distribution) and the cut-off value itself. The sum of these differences is divided by the order of the tail (i. e. the number of extreme values), which gives the average log difference between the tail realisation and the cut-off value. The resulting figure is the tail index, or Hill index, the reciprocal of which is the number of the moments of the tail (in the literature sometimes this reciprocal value is called the tail or Hill index).

The only remaining step is to multiply the one-sided 5% level Student-t value by the standard deviation of the cyclical components of the CPI and GDP. The normal distribution based GDP-at-risk and CPI-at-risk figures are usually calculated simply by multiplying the standard deviation of the cyclical components of the relevant series by – 1,645, which is the normal distribution at one-sided 5% level.

Due to short time period, the Hill index calculation is based on 4-6 observations, depending on the length of the series of the particular country. The Jarque–Bera normality test of the whole sample of approximately 600 data points have weak power if calculated country by country (less than 60 data points by country). Thus, a pool analysis is necessary to assess the appropriateness of the normality assumption of the distribution of the GDP and CPI data.

[18] There are other rules, see for example LeBaron et al. (2004). We follow Cecchetti for the ease of application and to ensure comparability with his results.

DATA APPENDIX

Data sources:

We used the database collected by Benczúr et al. (2005); in most cases the range spans from 1991 Q1–2005 Q1. Benczúr et al. generously provided us with the extended set of series, which spans until the end of 2008 or 2009 Q1 prepared for updating their study. We wish to thank them for making available this unique, most useful data set which stands out for its coverage and comprehensiveness in terms of time span, number of macroeconomic variables and CEE countries.

Filtering data:

In this study we used the Hodrick–Prescott method to decompose the trend and cycle components of the time series. One reason for that was that it is the easiest to use for a relatively short time series. The alternative, Baxter–King method is suitable for longer series. Another reason is that most authors use the H-P filter and so it is more useful for international comparison.

However, one must bear in mind that the results based on this particular method may not be robust to the alternatives. It has been shown in the context of the Central and Eastern European countries (Darvas and Vadas, 2005), that choice of a particular method for filtering trend and cycle components has a significant effect on the results – including Hodrick-Prescott as well. They found that not a single method could be recommended as the single best one. Instead, they proposed a combined methodology.

Seasonal adjustment:

For developed countries, data are readily available in seasonally adjusted versions as well. For CEE countries this is usually not the case. Benczúr et al. (2005) used X11 method for analysing business cycle properties of CEE countries. Darvas and Szapary also used X11 method for CEE economies before filtering for trend and business cycles and analysing cyclical co-movements of the EMU and selected CEE economies. Darvas et al. (2005) used SEATS/TRAMO for comparing the performance of various filtering methods for CEE countries. We also decided to apply SEATS/TRAMO as it was available freely in the Demetra program package.

Among its strengths – beside it user friendly interface – one finds its capability to manipulate a large number of time series together, in a more or less automated fashion. However, despite of the intention of the creators and supporters of the program package, no commonly available dataset was available at the time of writing for the various holiday and other workday adjustments applicable to different countries. Thus, we had to mark those days ourselves using internet resources for national holidays. Although we tried to do our best, such a treatment is far from being flawless and involves a high risk of making mistakes in preparing the raw data. Nonetheless, we found it more appropriate to use the best technique available even if it is not flawless, rather than to rely on an outmoded one, however convenient it may have been.

In addition to deciding on the group members of a relatively homogeneous pool of countries, we also had to decide on the time periods. One choice could be to use idiosyncratic periods for each country which could be seen as 'normal' ones, i.e. the following 'non-normal' period of systemic transformation. As not all countries went though the systemic transformation at the same time, that choice would result in heterogeneous chronological periods. The drawback of this choice would be that the effects and shocks from the external environment could be different, and thus, we would mistakenly attribute these to varying internal factors. Given the fact that these countries are very open, this could be as serious a problem as those arising from using one-fits-all time period for countries with different periods of 'normalcy'. Alternatively, had we used only the common chronological part of the idiosyncratic periods, it would have resulted in too much sacrifice in the number of total data points. Thus, we tried to arrive at a compromise by choosing a period when overly wild variations in the CPI and GDP series had disappeared, after the effects of the systemic transformation. Our decision resulted in a somewhat arbitrary choice of periods, informed mainly by the series themselves, rather than by deep knowledge of the particulars of each country's recent economic history.

The above considerations resulted the following periods for the earlier dataset:

GDP figures	CPI figures
BUL: Q1:1998 - Q1:2009	Q1:1998 - Q3:2008
CRO: Q1:1998 - Q4:2008	Q1:1998 - Q3:2008
CZR: Q1:1994 - Q1:2009	Q1:1993 - Q3:2008
EST: Q1:1993- Q1:2009	Q1:1993 - Q3:2008
HUN: Q1:1995 - Q1:2009	Q1:1993 - Q3:2008
LAT: Q1:1993 - Q1:2009	Q1:1993 - Q3:2008
LIT: Q1:1993- Q1:2009	Q1:1993 - Q3:2008
POL: Q1:1994 - Q1:2009	Q1:1993 - Q3:2008
ROM: Q1:1994 - Q1:2009	Q1:1993 - Q3:2008
SLK: Q1:1993 - Q1:2009	Q1:1993 - Q3:2008
SLV: Q1: 1993 - Q1:2009	Q1:1993 - Q3:2008

Russia: was not considered as homogenous with the above group of countries due to its size and economic structure (as an oil and mineral exporter, etc.).

CHARTS APPENDIX

Chart A1
Cyclical components of CPI and GDP

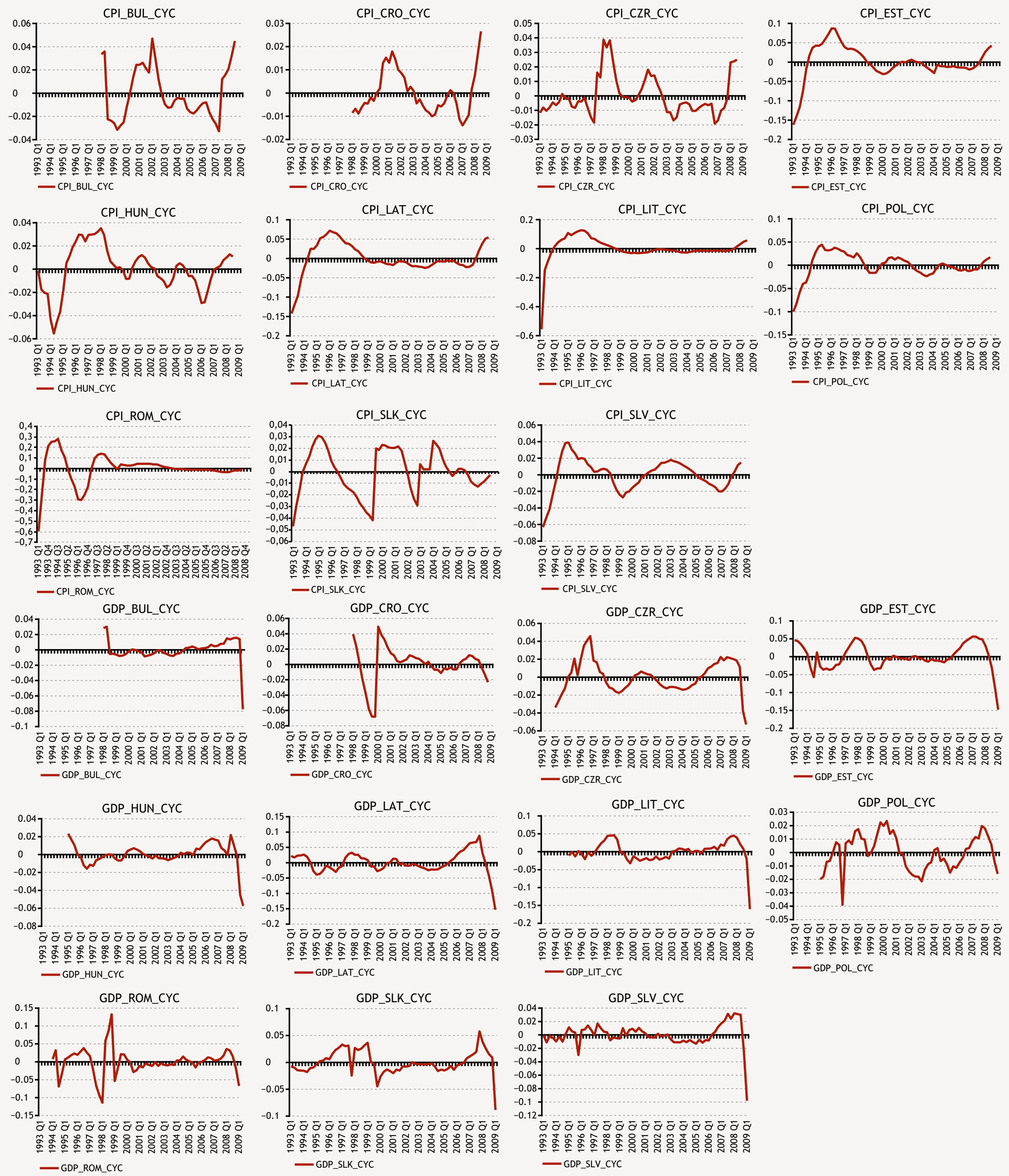
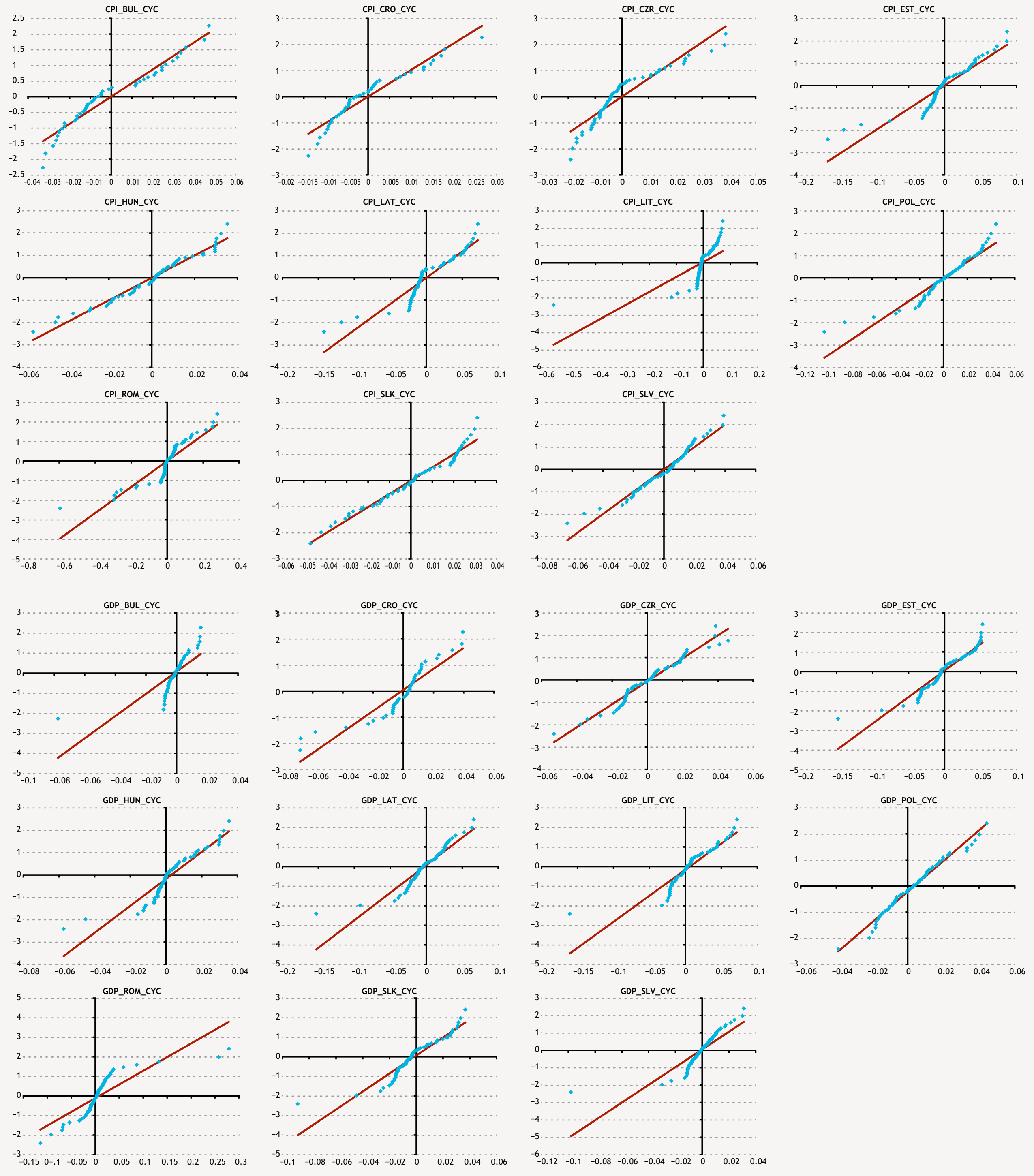
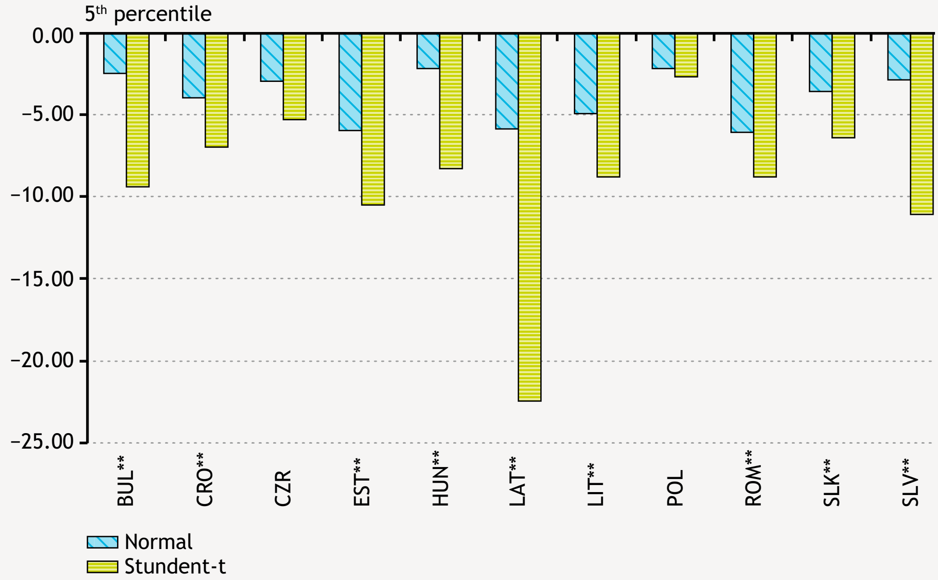


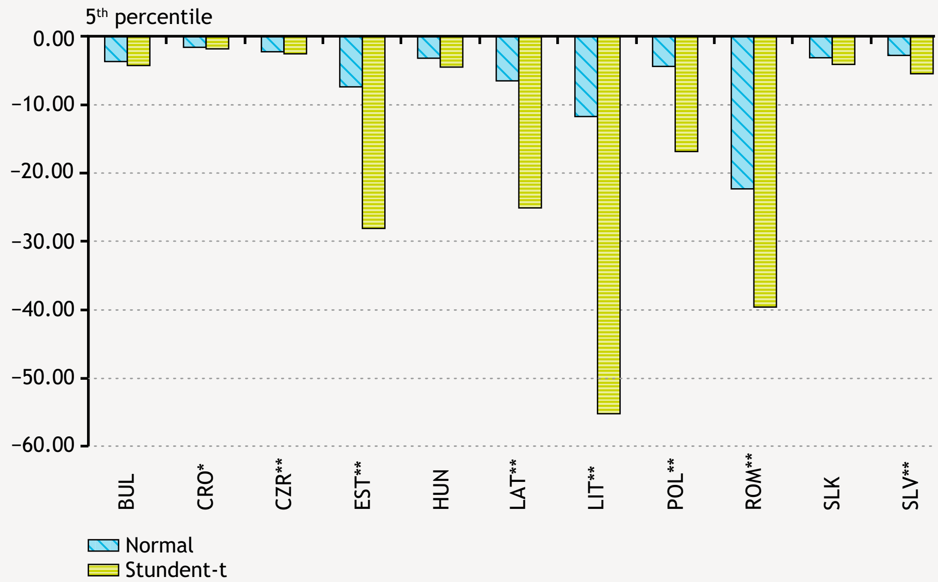
Chart A2
QQ-plots relative to normal distribution for cyclical components of CPI and GDP



Memo: fat tails show up in a shape above normal on right down and below normal on right up.

Chart 3
GDP-at-risk (above) and CPI at Risk (below) and (variously 1993, 1998–2009 Q1)





** The Jarque–Bera test significant at 10%.*
*** The Jarque–Bera test significant at 5%.*

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