What Does Drive European Price Levels 'Up' and Down'? – A 'Robust' Search for Determinants

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Abstract

The article is aimed at the problem of determinants of comparative price levels in the EU. We presents a thorough search for determinants using the Bayesian approach is employed (Bayesian model averaging, BMA) so that model uncertainty issue associated with determinants can be addressed properly. Our dataset covering the period 1997–2011 and 26 members of the EU consist of a broad range of variables already utilized in empirical studies and new ones associated with broadly defined institutional environment. Base results confirm the importance of some 'traditional' determinants such as labour costs and output gap and broadly defined environment (institutional factors) including a monetary regime. An extension of the basic model so that a potentially differentiated impact of determinants in old and new EU member states can be accommodated does not provide sufficient evidence for this hypothesis.

Keywords: comparative price level (CPL), price convergence, new EU member states, determinants, BMA

JEL Classification: E31, F15, F31, P22, O11

1 Introduction

There have been many attempts to analyse factors (determinants) of price convergence across Europe, mainly during first years of the existence of Euro. Since then a general interest has faded out. The on-going financial crisis has revealed many problems and aspect of a common currency and indirectly highlighted the importance of an adequate price-productivity ratio may be a key to the success. Prices are one of the two key mechanisms that allow individual economies taking part in a monetary union to deal with both internal and external shocks. Therefore, there are several research questions that can and should be explored. In this paper we try to shed some light on the process of nominal (price) level convergence in EU countries due to the on-going integration process.

Nominal (or price) convergence is inextricably intertwined with real convergence both from a theoretical and an empirical point of view. As income levels of individual countries tend to grow over time, their internal (and external) price level(s) change. One of the stylized fact is that the less developed a country is, the faster the growth of GDP (income convergence) and price changes can be expected. This economic phenomenon rests upon theoretical contributions from the 1930's/1960's/1980's (mainly the so-called Harrod-Balassa-Samuelson effect). An important characteristic of the European Union (and the Euro Area) is that not only some EU members, but also some current euro area members have not achieved their '*steady state*' which means that income growth

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and price (level) adjustments will definitely take place in the foreseeable future (apart from 'natural adjustments' reflecting day-to-day changes in the surrounding economic environment).

The importance of price convergence seems to have been confirmed by the on-going Sovereign debt crisis (SDC) in the Euro area (EA). A high level of convergence of business cycles and converged price levels are essential in a monetary union such as the Euro area. Even though the single European currency has enabled easier and quicker comparisons across EA/EU countries, it has also revealed huge differences between individual countries (and markets). More than 14 years have not been enough to close existing gaps. Similar business cycles and price levels are main building blocks pinning down potential inflation pressures and asymmetric impacts stemming from one-fits-all monetary policy of the ECB. The existence of countries with different inflation rates in a monetary union (e.g. a group of converging countries) poses a problem regarding both the effectiveness and impacts of the single monetary policy. In addition, a recent experience has clearly shown implications of inflation differentials for countries using one currency (REER differentials and consequently a level of competitiveness). A loss of competitiveness seems to be at heart of the on-going Sovereign (Debt) Crisis in several EA countries, together with financial (banking) sector.

Empirical illustrations have become an integral part of almost every piece of research work. Good empirics are rather a challenging task given a large number of problems, starting with a choice of the methodology, over model settings to a selection of variables and criteria for model selection. At the end of such an exercise the best model is selected and inference and/or forecasting are done. However, due to complexity of the real environment, a particular choice or a particular model may not fully reflect the reality (the underlying uncertainty is simply ignored or put aside). Therefore, an approach trying to deal with uncertainty has been gaining ground, putting emphasise on a full evaluation of all possible models for a particular application, the so-called model averaging.

There have been many applications of model averaging, mainly in highly 'controversial' fields of modern economics such as economic growth or (international) finance. The essential problem of them (many more) is related to so-called open-endedness – they do not possess a house-resembling structure, i.e. some parts can coexist and a rejection or unconfirmability does not affect the validity of others. As a result, empirical testing of hypotheses within such fields typically follows a strategy when a set of standard variables is used together with a set of some problem-related (specific) ones. Alternative (other) combinations are usually not taken into account in the exercise.

A very similar case to the economic growth literature is the nominal (price) convergence literature that highlights few important determinants (for example real income) along a large set of 'auxiliary' variables stemming from various theoretical papers. Therefore, it is an 'ideal' candidate for applications of model averaging techniques (such as BMA or its alternatives) capable of dealing with the model uncertainty. The novelty in this paper is that we applied the BMA approach to price convergence in an economic-growth-studies manner compared to a vast amount of studies based on the frequentist approach (e.g. Blatná (2011); Čihák, and Holub (2005); Dreger *et al.* (2007); Wolszczak-Derlacz, and De Blander (2009); Wolszczak-Derlacz (2010)). We search for determinants of this dynamic process and therefore, all problems may emerge that have been just described.

The remainder of this paper is structured as follows: Section 2 reviews basic definitions, and some stylized facts related to nominal (price) convergence. Section 3 briefly outlines main characteristics of the Bayesian approach. Section 4 presents and discusses results of our analysis. Finally, Section 5 concludes and offers some guidance for further research.

2 Price convergence – some theoretical notes

Comparative price level (CPL) is a price level that is expressed as a fraction of the price level of a country or an integration group. In the case of European countries, CPL can be based on the average of EU-27 (it will be EU-28) or for analytical purposes also as the average of EU-15 countries or various euro area averages. CPL in year t for country i (expressed against a country/a group of countries j) is given as:[3]

$$CPL_{t,i} = \frac{ER_{t,i}^{PPP}}{ER_{t,i}} = \frac{ER_{t,i}\frac{P_{t,j}}{P_{t,i}}}{ER_{t,i}} \tag{1}$$

where $ER_{t,i}^{PPP}$ is the PPP exchange rate for country i in year t, and $ER_{t,i}$ is the spot exchange rate in year t for country i. Values of CPL for the same reference (benchmark) country are thus directly comparable. If a CPL is above 100, it indicates that the country is relative more expensive compared to an average and vice versa.

Most commonly used macroeconomic indicators of price convergence are those calculated in international comparison programmes (ICP) of prices and values of the World Bank that has a long tradition[4] or its European part (ECP) organized by Eurostat and OECD. Both these projects are aimed at obtaining (calculating) volume and value indicators that are comparable over time and across countries.[5] Such data are more robust compared to those from comparisons based on spot exchange rate calculations affected by many determinants.

Theoretically, adjustments of price levels can be attributed to changes of two main economic variables (i.e. they occur via two main so-called channels). Therefore for a country with any type of floating exchange rate regime holds: first, the so-called *price channel* represents higher inflation rates in the country compared to a 'reference' country (or a group of countries) and secondly, through exchange rate appreciation (the so-called *exchange rate* channel). A problem for catching-up countries or countries undergoing structural adjustments would be the existence of a common currency that closes completely one of the previously mentioned channels (e.g. in catching-up countries for example (some) Mediterranean countries, Slovenia or Slovakia). An implication can be a long-run surge in inflation rates (both officially measured and/or hidden ones) with repercussion for competitiveness – changes in relative prices (and consequently unit labour costs) and real effective exchange rate. These seem to be one of the reasons for the current turmoil in the Euro area (mainly in Mediterranean countries) and they create challenges for the conduct of monetary policy. Nevertheless, even for some candidate countries with pegged/fixed exchange rate regimes (such as *currency boards* in Bulgaria or Lithuania) implications are similar up to the point that they still have the (outside) option to adjust their exchange rate to alleviate any potential pressures through a change of its parity.[6] Having

[3]CPL is a relative measure since it expresses a price level for a particular good/service ('basic heading') in terms of the reference country; here we keep the EU-15 average = 100 (= j) and as it is usual, the subscript j is omitted.

[4]Since the late 1960's the ICP had been guided by the Statistical Division of the United Nations (nomUNSDStatistical Division of the United Nations) as a part of the global initiative with the aim of providing of worldwide comparable GDP data; since 1993 it has been carried out by the World Bank (see Žďárek (2006); for the history of the project see e.g. World Bank (2008)). Results of the most recent ICP 2011 Round are being finalised and will be released at the end of 2013.

[5]While the WB publishes internationally comparable indicators in PPP (ICP), its European counterparts (Eurostat/OECD) publish indicators in PPS (ECP); Purchasing Power Standard is equivalent to PPP but it is based only on averages of prices for European countries (now EU-28), while PPP can be based on the average prices of OECD countries or the US prices.

[6]However, it is a question whether they would do so since repercussions of such a step are hard to predict and

stated that, it is obvious why nominal convergence and analyses of nominal convergence process have been, are and will be interesting for a wide range of policy-makers: prediction of demand and supply determinants of nominal convergence make inflation forecasts more reliable, enable to estimate potential pressures stemming from prices and other nominal values, and allow to assess effects on real exchange rates and competitiveness.

2.1 Is there anything special about prices (price differentials) in the EU?

Both real and nominal convergence are affected by a wide range of factors that are associated with the domestic (country-specific) environment including *inter alia* macroeconomic policies, a phase of a business cycle, etc. (see Čihák, and Holub (2005); Égert (2007)) and external environment (e.g. preparations for an EU accession or the Single Market Programme), in particular effects of the on-going globalization process including outsourcing, offshoring, reallocation of production (changes in production chains) within and outside the EU, see Alho *et al.* (2008). Changes ('adjustments') of individual prices, price ratios/relations and price levels are a widely observed economic phenomenon, in converging economies across countries, especially for so-called tradable goods (for some evidence in the EU see empirical studies for example Faber, and Stockman (2007) or Dreger *et al.* (2007).[7]

On the other hand, evidence on goods known or labelled as non-tradable – i.e. those whose prices (price levels) are mainly determined by domestic determinants such as taxation (mainly VAT, indirect taxes), wages, regulation and trade barriers has been rather scarce and ambiguous. However, there is no exact definition of tradable and non-tradable which may thus offer a potential explanation for those results.[8] An alternative explanation is that they can be viewed as a piece of rather early evidence of the Single Market and thus, they can bear a mark of first years of the life of the Euro in the Single Market (see below).

Observed price differences in the Euro area (EA) in the early 2000 were generally larger than those in US regions, i.e. showing the very opposite)[9] and mostly related to 'traditional' type of shops but country-specific (based on data until 2002, see EC (2004)). Nevertheless, there have been many signs of reduced price differentials, mainly in the 1990s after the Single Market Programme had been brought to life (for further details see e.g. ECB (2002); Mathä (2003)).[10] Conversely, it does not seem to be real to expect no differences in the EU/EA environment at all because of simple reasons such as natural and structural factors or market conditions (EC (2002)). While the last one can be at least partially remedied by anti-monopoly policy (regulations trying to restore free markets for as many goods and services as possible), the first and second (such as consumers' preferences, 'searching & matching costs', cost of transport, packaging, the size of a market, etc.) are in most of the day-to-day situations pre-determined (consumers' tastes, *home bias* in consumption, level of technology, etc.).

potentially 'lethal'.

[7]There have been also studies that have cast doubt on nominal convergence even for some of these goods, see Lutz (2004) for car prices or for rates of inflation of EU countries Buseti *et al.* (2006).

[8]For example the World Bank uses the label non-tradable for goods and services including energy, housing, public utilities, services and transport (see World Bank (1991)). These are a result of natural characteristics, trade restrictions and/or trade costs, etc.

[9]Contradicting the results of a study by Rogers *et al.* (2001); most likely due to a construction of price indices for euro area members based on an EIU database (the EIU CityData).

[10]That seems to be a reason for a large number research projects and regular price assessments having been carried out by the European Commission (EC) since the early 2000s (for example personal cars, see below). An updated version of such an assessment is EC (2006) that lists a number of problems and shows room for nominal convergence.

However, the very existence of price (level) gaps because of any reason can be an important source of demand/supply inflation shocks and inflation rates in a monetary union.[11] As a result, persistence of different inflation rates may lead to problems with competitiveness of domestic firms, affecting the balance of payments and consequently, domestic (branches of) banks and the sovereign with non-zero probability of triggering a financial crisis. On the other side, a hypothesis has been put forward that increasing intra-EU trade will mitigate or even reverse nominal (price) convergence, and therefore it will lead to more diverse national prices (price levels), see Baldwin (2006). In addition, one should not forget the influence of factors such as the economic integration process, or these linked to the on-going Great Recession.

2.2 Determinants of price convergence

Changes of comparative price levels (CPLs) in a national economy (denoted i) can be simply written with help of an equation as (see Lewis, 2007):

$$\Delta CPL_{t,\,i} = ER_{t,\,i} + \pi_{t,\,i} \tag{2}$$

where $ER_{t,\,i}$ is the change in an exchange rate and $\pi_{t,\,i}$ is the rate of domestic inflation of country i for given year t.[12] The relative importance of both channels depends on the regime of exchange rate in a given country. If there is a fixed type of exchange rate arrangement, any adjustment is carried out through the inflation channel (i.e. a positive/negative inflation differential), in the case of a floating type of exchange rate arrangement, total changes of CPLs are given by a mixture of both channels and thus, their individual (relative) proportion and importance may vary. If there is any type of inflation target set by a monetary authority (being the case in the Czech Republic, Hungary and Poland in NMS or euro area countries), it is simultaneously determined an upper limit for inflation channel for a year (at least weakly due to possibility of not meeting a target in a year).[13]

This decomposition shows that there are two main determinants of CPLs and their changes: the so-called price channel that affects the comparative price level in an economy and reflects a higher/lower annual rate of domestic inflation. This results from changes of economic structure (for example so-called selective inflation in case of BS effect), demand and supply factors, on-going process of deregulation of administered prices, changes of taxes (for example changes due to harmonization within the EU), etc. The other channel, the so-called exchange channel affects the comparative price level is given by changes (appreciation) of exchange rate. However, changes of exchange rate may be influenced by both short-lived (i.e. temporary) and long-lived (i.e. fundamental) factors. While transitory factors may lead to temporary disturbances and changes of exchange rate (for example set interest rates in economy resulting in important interest rate differentials), fundamental factors are supposed to be more relevant (for example changes of labour productivity).

Sectoral differences of labour productivity are supposed to be resulting from the Balassa-Samuelson

[11] Another being a limited/distorted function of the so-called dynamic Penn effect, see Ravallion (2010).

[12] Having observations for a given country, the equation 2 does not hold true. It is due to changes of methodology and existence of mismeasurement (a discrete approximation of a continuous process). Therefore, for most of empirical studies using real data it is supposed that the exchange rate term takes into account not only changes of exchange rate, but also errors occurring by measurement.

[13] A decomposition of real CPL changes is thus possible; for an illustration see e.g. Žďárek (2008).

effect (a supply side effect) well established in the neoclassical economic theory. Other explanations focus on factors associated with changes of real income of an economic subject due to different price of elasticity of consumption stemming from levels of disposable income and their changes (see e.g. Bergstrand, 1991), effects due to a relative endowment of inputs in a country ('factors of production', i.e. their relative abundance or relative scarcity, see e.g. Bhagwatti, 1984). There are a large number of other variables which (may) have impact on national price level (so-called structural factors) discussed and often empirically tested in the literature (see Čihák, and Holub (2005)[14]; Kleiman, 1993[15]; Nestić (2005)[16]).

2.3 A brief review of literature

Theoretical and empirical studies focused on price (nominal convergence) have used two main sources of information about price movements – macroeconomic indicators such as CPLs or microeconomic indicators (individual prices); both of them have advantages and disadvantages ('biases'), for a review see e.g. Dreger *et al.* (2007). This paper utilizes CPLs, i.e. macroeconomic indices mainly due to data availability. A study by Dreger *et al.* (2007) investigated effects of a EU enlargement and its consequences for price convergence. Comparative price levels (CPL) indices for 1999–2004(2005) and 25 EU countries were utilized in a panel regression employing factors obtained from Principal Component Analysis (a proxy for 'catching-up' and another for 'competition'). Main conclusions are that competition and real convergence matter most, however, effects differ among old and new member states, commodities and in the period before and after the enlargement Their results also confirmed σ and β convergence of price levels. Because of a large number of studies, this review is primarily aimed at reviewing studies related to European (Union) reality.

Allington *et al.* (2005) focus on first effects of the Euro adoption on price convergence (changes in CPL) for EU-15 countries between 1995 and 2002. A change in the convergence process was found and it was attributed to the Euro.

Wolszczak-Derlacz (2006) (with minor modifications similar to Wolszczak-Derlacz (2008) combines both macroeconomic indices (CPL) and the EIU City Data for EU-15 countries between 1990 and 2005. She confirms both β and σ convergence (via OLS and GMM regressions) and calculates a speed of convergence (13.3% p.a.) and a half-live (5.2 years) for CPLs, $\approx$ 29% p.a. and 2.4 years for the EIU data respectively. She also presents results for tradables and non-tradables separately: 35.5% p.a. and 2 years, 16.1% p.a. and 4.3 years respectively.

Funke, and Koske (2008) work with individual prices of 90 commodities based on HICP from January 1995 to March 2005 (monthly data) for EU-15, NMS10 and EU-25. Fewer commodity groups showed price convergence for NMS10 than EU-15 and half-lives were higher (median prices for EU-25 $1.4 - 2.3$ years, for EU-15 $1.5 - 3.2$ and for NMS10 $1.0 - 1.8$ years). The speed of convergence

[14]The empirical testing of determinants of the national price level based on ECP dataset show that the highest relative importance has level of real income, taxation, labour productivity, etc.

[15]Taxation may give rise to increasing prices in domestic economy (in case of shift of tax burden to consumer while having accommodative monetary policy). Influence of government expenditures on prices is supposed to be given by the necessity to finance higher government expenditures either by higher taxes and/or higher ineffectiveness of government' production and distribution of goods and services in comparison with private sector.

[16]Data stemming from European part of ICP for 1999 confirmed the importance of government revenues and expenditures and labour productivity as the most important factors for determining comparative price level in a given economy.

for NMS10 countries is rather high and it may have been affected by exchange rate regimes (mostly managed float). Even though a standard estimate of a half-life is between $3 - 5$ years (see Rogoff (1996)), recent studies have found a significantly faster speed of convergence (a shorter half-life) in the case of price differentials (see Wolszczak-Derlacz (2006).

Bergin, and Glick (2007) employ data from the EIU CityData as well, however, they use a sample of 70 countries and 108 towns around the world between 1990 and 2005 (101 tradable and 30 non-tradable goods and services). Main focus is on price differentials (dispersion of prices) measured via MSE (mean square error) regressed together with standard 'trade' variables such as distance, boarder, common language, tariff barriers, exchange rate volatility and a variable linked to a currency crisis and a participation in a monetary union. Price dispersion diminished over the time period, however, a detailed analysis showed a significant decrease in the first period (1990–1997) and an increase in the other (1997–2005). That resembles the letter 'U', but if only developed countries are included, their price dispersion decreased throughout the period.

Schwarz (2012) focuses on price dispersion (mean square error and standard deviation) using of the EIU City Data as well, but only for a sample of 'European' and some CIS countries over the period 1990–2009. It is tested whether entrepreneurship (and thus entrepreneurial activity) helps explain existing price differentials among cities if other standard determinants (such as boarder) affecting price differentials are accounted for. Since institutional quality may be of importance (quality of institutions) for making the existing price differentials more or less attractive for potential arbitrageurs, WGI (Worldwide Governance Indicators) is used as a proxy for the institutional quality in individual countries. If WGI was employed in a regression together with distance and population density in cities (a proxy for a degree of market competition), all variables turned to be statistically significant. It may be that this additional variable (WGI) captures some unexplained variance in prices or a part of the variance attributed to the boarder effect.

Wolszczak-Derlacz, and De Blander (2009) analyse price dispersions of both individual and aggregated prices (double-weighted) for EU-15 countries and three selected NMS (their capitals – Budapest, Prague and Warsaw) in 1995–2006. σ-convergence is confirmed for 31 out of 157 individual prices for NMS. The impact of the 2004 EU enlargement is analysed as well, however, no results are shown due to a rather short time span. Nevertheless, they considered the enlargement as a gradual process starting in mid-1990 and for this hypothesis price convergence is confirmed.

Fischer (2009) analyses prices of only one commodity (washing machines) in 17 EU countries (the core 12 euro area members and the Czech Republic, Denmark, Hungary, Poland, Slovakia and the United Kingdom) over the period 1995—2005 (two and four-month data). Panel unit root tests do reject the convergence hypothesis (utilizing the Phillips, and Sul (2007)'s $\ln t$ *test*). In addition, this study also reveals the existence of five clusters in the sample (EA^+), in most cases consisting of both EA and non-EA members since 1999 (1997) which leads him to the conclusion of zero impact of the Euro on price level convergence; however, a standard test of variances (alike to a F-test) does provide evidence in favour of σ-convergence for the Euro area.

Staehr (2010) analyses price convergence in short and long run with help of CPL for GDP in NMS10 countries over 1996—2008 by employing VECM and Johansen-Fisher panel cointegration method. His model tries to capture effects of selected determinants such as productivity growth and balance of current account (price and exchange rate channels). The results show rather small effects of income levels or productivity differentials; however, capital flows affect significantly both real and nominal convergence (both primary and secondary effects).

Staehr (2011) examines the dynamic Penn Effect (Ravallion (2010)) that represents a relationship between income and price levels. He employs dynamic panel data methods (the MG (case of homogeneity) and PMG (case of heterogeneity) estimator) on the data for NMS10 over 1995–2009. The results show a strong price convergence responding to differences in long-run income and price trends in five countries (Bulgaria, Latvia, Lithuania, Poland and Romania). As a result, an external shock leading to out-of-equilibrium in an economy has a different impact and significant gaps between price and income levels may persist for a relatively long period.

Blatná (2011) analyses price convergence of EU countries with the help of methods for cluster analysis (the Ward method, Euclidian distances). Using data for CPL (1995–2008) and other thirteen economic indicators four clusters are identified: the Czech economy belongs to the third cluster together with seven other countries. Another finding confirms a previously known fact (see e.g. Žďárek (2008)) that old and new EU member states respond differently and an empirical analysis should account for that.[17]

3 Search for determinants – Bayesian Model Averaging

A potentially serious problem of empirical studies tackling the challenge of finding relevant determinants of convergence processes, i.e. explanatory variables for conditional models of nominal convergence (similar to real convergence though) is both the choice of a particular model and/or a selection of variables to use. The inability to refute one concept against its competitors has resulted in a large number of empirical studies based on different approaches utilizing zillions of variables ('sink' estimations) with results having not given any better answer to the problem yet ('open-endedness', see Brock, and Durlauf (2001) that seems to be of a general nature in (and not exclusively) the still expanding economic growth literature, but not only there). As a result of this so-called model uncertainty, methods applying various forms of model averaging have started gaining the ground.[18] A 'natural' starting point for a number of studies have used Bayesian (also 'full' *Bayesian Model Averaging*, BMA) or 'pseudo-Bayesian' approaches (such as the so-called Bayesian averaging of classical estimates (BACE), Limited Information Bayesian Model Averaging (LIBMA) or Bayesian Maximum Likelihood Estimates (BAMLE), see below) or two directly comparable methods in the frequentist approach: (*a*) the so-called Frequentist Model Averaging, FMA (Moral-Benito (2012a)) and

[17]There are some other studies: Žďárek (2008) estimates a panel regression when trying to find determinants of price convergence in NMS countries; he finds that the most important determinant of price level to be GDP per capita, a proxy for openness and public finance's indicators. A detailed decomposition price level indices is in Žďárek, and Šindel (2008); Žďárek (2011) examines convergence process in NMS countries with a brief coverage of first effects of the on-going financial crisis.

[18]There are three main components of the model uncertainty (see e.g. Amini (2012)): a) uncertainty about theory (which determinants are essential?), b) uncertainty about heterogeneity (are parameters identical across observations?), and c) uncertainty about functional form (which variables do enter linearly and which non-linearly in the model?).
Apart from model uncertainty, there are many issues: parameter heterogeneity, outliers, measurement error, missing data, cross-section dependence, etc. see e.g. Durlauf *et al.* (2005) or Durlauf *et al.* (2009a). Methods of dealing with parameter uncertainty (such as EBA – Extreme Bound Analysis – that reports an upper and lower bound for estimates of parameters (usually two standard deviations, i.e. $\langle \hat{\beta}_{v,\,i} \pm 2\sigma_v \rangle$) or an alternative comparing the left and right side of a distribution (CDF's) for a particular β_v see Sala-I-Martin (1997)); however, both are subject to criticisms due to (1) their relative 'strictness' (a high rejection probability), (2) a relatively high likelihood of non-identification of 'true' determinants, or stepwise estimated models based on comparisons of selected statistical tests, for details see e.g. Durlauf *et al.* (2009a). The Bayesian approach seems to be a logical extension.

(somewhat better and less developed) (*b*) Mallows model averaging (MMA that is asymptotically equivalent to least squares estimators for homoscedastic errors, see Amini, and Parmeter (2012)) or a recently introduced method for a heteroscedastic errors setting – Jackknife Model Averaging (JMA, see Hansen, and Racine (2012)) to verify old results and/or to offer 'a more realistic' ('systematic') picture regarding determinants of real convergence (such as Sala-I-Martin *et al.* (2004)'s BACE or a full BMA for European regions Crespo-Cuaresma *et al.* (2009)).[19] A reason being the natural limit for the number of cross sections (countries, regions) and therefore, the inability to address these issues in ways the micro-econometric studies (empirical literature) have done. This could also be the reason why most studies apply more than one method when trying to find robust results. Nevertheless, to our best knowledge, there has not been any similar study for price convergence and/or including effects of the on-going financial crisis.[20]

The problem of choice of variables (determinants) for a model can be plainly illustrated with the help of equation (3):[21]

$$y_t = \xi M_t + \zeta A_t + \upsilon_t \tag{3}$$

where M_t is the set of 'standard' variables (regressors) usually included in an empirical exercise, A_t is the set of 'additional' (candidate) variables (regressors) employed by a researcher when conducting research.

However, there are only very few applications where a researcher would have a prior as to what variables should be included in each of these groups.[22] One particular problem of this approach is that the researcher may not be convinced about the 'value added' of variables included in M_t but there is the 'necessity' for utilizing them (any possible reason). Depending on the employed method (and assuming A_t fixed), either an estimator produces $\hat{\xi}$ and a distribution depending on the data generating process (DGP, i.e. frequentist approach) or a posterior density of ξ given the data, the prior supplied by the researcher and assuming a correct specification (linear model) is calculated. For a particular choice of a model ($L_\tau \in \mathcal{L}$), available data (D), a posterior pr can be specified as $pr(\xi|D, L_\tau)$. While there will be many theoretical arguments about what should be included in A_t, the key problem for any statistical inference – $\hat{\xi}$ or $pr(\xi|D, L_\tau)$ – will remain given the existence of uncertainty about the one 'true' (correct) model.

Since we are interested in determinants of price convergence (and their importance), i.e. the aim is at estimating a linear model such as (4) (and this problem is obviously similar to (3)), the key issues here is the 'right' choice of $\mathbf{X}_\tau \in \mathcal{X}$ (a set of variables/regressors/determinants):

$$z = \mathbf{1}\iota_\tau + \Gamma_\tau X_\tau + \vartheta_\tau \tag{4}$$

[19] An excellent introduction to (or a refresher of) the methodology is an article by Hoeting *et al.* (1999) or Raftery *et al.* (1997).

[20] However, our model specification does not allow us to model effects of the SDC explicitly and a full evaluation is left for future research.

[21] An example of this 'composition method' can be found in Sala-I-Martin (1997). Implications of a random (naïve) choice of explanatory variables.

[22] For example in the case of economic growth it seems almost natural to assume that a growth will depend upon an initial GDP level. Nevertheless, there are as many as 145 variables that have been found significant in various models over past decades (for an overview see Durlauf *et al.* (2005)) and a choice of other variables is (almost in all cases) subjective. Moreover, only a smaller number of them can usually be employed in empirical studies including BMA. For example Ciccone, and Jarocińsky (2010) use 67 variables. A potential set of variables for price convergence may be somewhat smaller though.

where ι_τ is a constant (a constant intercept across all models), $\mathbf{1}$ is a vector of n ones, $\mathbf{X}_\tau$ includes a list of K potential determinants for example of price levels ($\mathbf{X} = (x_1, \ldots, x_K)$), for each model L_τ there will be $K \geq K_j \geq 0$ determinants (regressors) that are centered : $X_\tau \mathbf{1} = \mathbf{0}$ without any unfavourable effect(s) since only the constant ι_τ is shifted, see (Liang *et al.*, 2008, p. 412), $\Gamma_\tau \in \mathcal{R}^{K_j}$ is a set of the relevant coefficients, and the error term (ϑ_τ) is assumed homogeneous and independently distributed : $\vartheta \sim \mathcal{N}[\mathbf{0}, \sigma^2 \mathbf{I}]$.

3.1 BMA approach

A 'direct' approach would utilize one linear model encompassing all potential determinants, which does not seem to be feasible because of multicollinearity and a limited number of observations in our dataset. Bayesian approach deals with the model uncertainty in a (cannonical) regression model differently: the correct model is modelled as an uncertain (and unobservable) variable. BMA makes use of all possible combinations of explanatory variables and produces results that are in the form of a weighted average over all of them.

Since there are many possible combinations of parameters for models, a model L_τ ($\tau = 1, \ldots, 2K$, where K is the number of variables (regressors)) is determined by a set of parameters ψ_τ which allows us to define explicitly the posterior for such parameters applying the Bayesian logic:

$$pr(\psi_\tau | z, X, L_\tau) = \frac{pr(z|\psi_\tau, L_\tau) pr(\psi_\tau | L_\tau)}{pr(z|L_\tau)} \tag{5}$$

where $pr(.|z, X, L_\tau)$ is the posterior probability and $pr(.|\psi_\tau L_\tau)$ is the likelihood and $pr(\psi_\tau|L_\tau)$ is a (model) prior.

For a model L_τ, being one particular model out of the model space $\mathcal{L}$, one can write the posterior model probabilities (PMP) following the Bayes rule:

$$pr(L_\tau | z, X) = \frac{pr(z|L_\tau, X) pr(L_\tau)}{pr(z|X)} \propto pr(z|L_\tau, X) pr(L_\tau), \tag{6}$$

In the Bayesian approach one of the key parts of the entire sequence of steps (chain) is attributed to the marginal likelihood (also called integrated likelihood, for explicit derivations see e.g. (Greene, 2011, ch. 16) or Koop (2003)) that is necessary in (6):

$$pr(z|L_\tau, X) = \int pr(z|\psi_\tau, L_\tau) pr(\psi_\tau | L_\tau) \mathrm{d}\psi_\tau \tag{7}$$

A transformation of (5) expressing explicitly the posterior probability and consequently, the model weighted posterior distribution for the statistics (ψ) is then:[23]

$$pr(\psi | z, X) = \sum_{\tau=1}^{2^K} pr(\psi | L_\tau, z, X) \frac{pr(L_\tau | X, z) pr(L_\tau)}{\sum_{r=1}^{2^K} pr(L_r | z, X) pr(L_r)} \tag{8a}$$

[23] The first and second moment for ψ (posterior mean and variance) can be also specified when applying $\mathsf{E}(.)$ operator to e.g. equation (8b).

or equivalently

$$pr(\psi|z,X) = \sum_{\tau=1}^{2^K} pr(\psi|z,X,L_\tau)pr(L_\tau|X,z) \tag{8b}$$

When looking for an answer whether a model L_τ generated the observed data, that is whether this model belongs to a set of models ($L_\tau, \tau = 1,\ldots,2^K$). Given our observations, the probability that L_τ is the true model is reflected in the posterior model probability (PMP). In calculations, BMA uses weights stemming from particular posterior model probabilities ($pr(L_\tau|z,X)$) conditional on data (z,X) and these 'normalised' probabilities lead to the following:

$$pr(L_\tau|z,X) = \frac{pr(z|L_\tau,X)pr(L_\tau)}{pr(z|X)} = \frac{pr(z|L_\tau,X)pr(L_\tau)}{\sum_{r=1}^{2^K} pr(z|L_r,X)pr(L_r)} \tag{9}$$

In order to compare individual models, both the Bayes factors and the posterior odds are employed. The calculation of the Bayes factors (10a) represents a comparison of two marginal likelihoods for two competing models, for example L_h and L_τ : ($^{pr(z|L_h)}/_{pr(z|L_\tau)}$), based on a comparison of their relative weights. The probability (posterior) odds $B(L_\tau\colon L_h)$ ($^{pr(L_\tau)}/_{pr(L_h)}$) summarize the comparison (pairwise) of two chosen models (10b) taking into account the Bayes factors and the prior odds:

$$B(L_\tau\colon L_h) \equiv \frac{pr(z|X,L_\tau)}{pr(z|X,L_h)} \tag{10a}$$

$$\frac{pr(L_\tau|z)}{pr(L_h|z)} = \frac{pr(z|L_\tau,X)}{pr(z|L_h,X)} \cdot \frac{pr(L_\tau)}{pr(L_h)} \tag{10b}$$

For interpretation of BMA results, one key characteristic is the posterior inclusion probability (PIP) of a regressor. It is defined as follows:

$$PIP_s \equiv \sum_{L_v:l_s=1}^{2^K} pr(L_\tau|z) \tag{11}$$

where $l_s = 1$ is the sign that a regressor s belongs in the model. There are recommendations as to which variables can be considered to be *very robust* ($PIP \rightarrow 1$), simply *robust* ($PIP \leq 0.5$) and which gives very little information (low PIP, often for $PIP < 0.5$) that a particular variable is not included in the true model or can be seen as a piece of evidence against that variable.

Since the sum in equation (8a) or (8b) increases (exponentially) with the number of included variables (K), Two solutions have been suggested to deal with increasing model space (see e.g. Amini (2012)) – *a*) the Occam's window algorithm and *b*) Markov chain Monte Carlo. The former has not gained too much popularity since its algorithm may result in biased results (for details see *op. cit.*) and therefore, the latter has become a standard tool. Algorithms such as MCMC (Markov chain Monte Carlo) are considered as a good approximation of the original problem (sampling happens from the same distribution (a Markov chain) whose characteristics tend to the equilibrium distribution with increasing number of steps; convergence may be slow depending on a utilized sampler (such as the Metropolis-Hastings algorithm), see Fernández *et al.* (2001) or for a brief review Amini (2012); Zeugner (2012)). Since our database consists of many variables collected from previous empirical studies and our newly defined variables (in total there are as many as 103 variables including additional dummy variables, however, the actually used number of variables is lower, see below), which means searching through all subsets of these variable amounting to the necessity to estimate 2^k models (potential combinations) in the full model space; that leads to the use of MC³ of Madigan, and York (1995) to reduce this immense computational burden.[24]

The marginal likelihood represents the probability of the data given the particular model L_τ, the prior (also the prior model probability, $pr(L)$) should reflect prior beliefs. It has to be evoked by a researcher since it embodies the probability of the model L_τ before utilizing any type of available data. If there is no prior, a solution is based on an uniform prior giving an equal probability to each model $p(l_\tau) \propto 1$; alternatives commonly used in the literature are: 'simple' priors such as BRIC or 'mixtures of g-priors such as Zellner's g prior, see below. Functional forms of the posterior and marginal likelihoods depend on a particular estimation (cross-section vs. panel setting, etc.).

BMA choice I. – priors on parameter

Since a particular choice of parameter g from a parameter space affects the number in a model included parameters (both their number and their size), there have been suggested many alternatives of treating g in the literature. Below we draw upon a summary shown in (Liang *et al.* (2008)) that distinguish the following:[25]

- *unit information prior* ($g \sim UIP$): for linear models is defined as $g = N$, i.e. the amount of information in the prior and in one observation is equal (Kass, and Wasserman (1995)); Liang *et al.* (2008) show that Bayes factors resembles the Bayesian information criterion (BIC) for two selected model (for example L_v nad L_w) as n increases ($n \to \infty$);
- *risk inflation criterion* ($g \sim RIC$): sets the rule as $g = K^2$, which uses for example Foster, and George (1994)'s study for calibration of the posterior model probability;
- *benchmark prior* ($g \sim BRIC$): defined as $g = \max(n, K^2)$ stems from Fernández *et al.* (2001)'s study, whose proposal is to utilize the best combination of $g \sim UIP$ and $g \sim RIC$ for predictions;[26].
- *local empirical Bayes* ($g \sim LEB$): where $g = \arg\max_g pr(z|L_\tau, X, g)$ that can be viewed as obtaining a particular g for each model (= locally). Some authors (e.g. George, and Foster (2000)) emphasise its role for g as utilizing information from the data (z, X) (for derivation see Liang *et al.* (2008)), however, Feldkircher, and Zeugner (2009) point out its counterintuitive impact on a prior because of the g's data dependency and problems with consistency of BMA;
- *global empirical Bayes* ($g \sim GEB$): where only one g is utilized for all models, estimated as an across-all-models-calculated average of the marginal likelihood of the data; however, it can be used only via numerical optimization George, and Foster (2000) (no close form solution exists).

[24] An alternative approach has been proposed by (Magnus *et al.* (2009)) who distinguish between 'key' (focus) variables and 'auxiliary' (doubtful) variables in a model. They use the so-called WALS method (a Weighted-Average Least Squares estimator) and Laplace priors for parameters and non-informative priors for the model that significantly reduces the amount of necessary computations; essentially, this estimator creates a Bayesian combination of frequentist estimators.

[25] An early review of utilized specifications of g-prior (twelve in total) can be found in Eicher *et al.* (2011).

[26] Another alternative is a prior $g = k^2$ suggested by Foster, and George (1994) that shrinks to $g = \max(n, K^2)$ under certain circumstances – possibly in growth regressions as for those studies do hold $k \gg n$ – or a prior resembling the Hannah-Quinn information criterion (H-Q) where $g = (\ln n)^3$

Mixtures of priors – hyper-g priors

The choice of a parameter prior (and a model prior as well) may affect results as shown for example by Fernández *et al.* (2001). This study utilizes twelve different priors and among them the unit informative prior ('BRIC', i.e. more informative prior, see above) setting $g = \max(N, k^2)$ with a uniform model prior performing better than any other prior in their study. However, a study by Feldkircher, and Zeugner (2009) shows improved performance of a hyper-g prior following recommendations in the study of Liang *et al.* (2008). This choice seems to be 'natural' given the standard regression framework – using the conjugate approach means a normal (conditional) prior on ψ_τ. Another type of mixtures of g priors is a class of Zellner and Siow's (Cauchy) priors, however, their main disadvantage is the nonexistence of a closed-form solution for their marginal likelihoods (see *ibid.*).

Hyper-g prior takes the form: $\varphi(g) = \frac{a}{a-2}(1+g)^{a/2}$, where $\varphi(g)$ will now represent the prior on g (potentially depending on dimension of n). This prior is recommended to use for $g > 0, a > 2$ (a represents prior beliefs). If the g prior is fixed, the posterior mean of Γ_τ (in equation (4)) for a particular model g represents a linear shrinkage estimator given a shrinkage factor $\frac{g}{1+g}$; adaptive data-driven shrinkages exist for mixtures of g (see Liang *et al.* (2008)).[27] A hyper-g prior leads to a mixture of normal distributions with fatter tails for the prior on the vector of coefficients (Ley, and Steel (2012)). Therefore, a reformulation of the hyper-g prior gives rise to shrinkage factors such as $\frac{g}{1+g} \sim Beta[1, \frac{a}{2} - 1]$, i.e. a Beta prior and appropriate beliefs on the hyperparameter a enable to replicate fixed-g cases (for example $a = 4$ leads to prior shrinkage that is uniformly distributed between 0 and 1); for further discussion see e.g. Ley, and Steel (2012).

Main advantages of the hyper-g prior are outlined in (Feldkircher, and Zeugner (2009); Feldkircher, and Zeugner (2012)): (1) the availability of its posterior distribution in closed form (for details and derivation see *ibid.* and it allows the data to 'choose'), (2) a reduction of sensitivity of the prior g to posterior mass, (3) g is adjusted towards less noisy data (the model specific g_τ and shrinkage factors do change during an estimation; more noisy data will result in lower g and more even distribution of PMPs),[28] (4) the room for a researcher to formulate any prior beliefs is not affected, and (5) the supermodel effect is non-existent (mass of posterior reflect only the best performing models generated by the data).

BMA choice II. – model priors

The other important factor affecting BMA analysis is the choice of a model prior. Obviously, that choice will depend on a problem and possibly on a researcher's prior. Often a uniform model is chosen that assigns the same weight to any model L_τ, i.e. $pr(L_1) = pr(L_2) = \ldots = pr(L_\tau) = \frac{1}{\mathcal{L}}$(which has two implications: the 'inclusion probability' a variable in the true model is $pr = 1/2$ and the probability that one variable is included in a model does not affect the 'inclusion probability' of other variables). An alternative that has been used in the literature are random Binomial priors (e.g. Sala-I-Martin *et al.* (2004) who assumes that $p < 1/2$ while preserving the other characteristics of the previous one) or Beta-Binomial priors (e.g. Ley, and Steel (2009)) or dilution priors dealing with the problem of previous priors assigning equal weights to all similar regressors in a set of utilized variables

[27] The shrinkage factor affects PMPs and how much differences in R^2_τ are reflected in differences between PMPs and PIPs. Flexible g priors (in hyper-g priors) lead to shrinkage factors to be around 0.95 on average, see Feldkircher, and Zeugner (2012).

[28] A hyper-g will offer less evidence for a particular model given the data compared to a fixed g that would offer a model-'winner' even under these circumstances.

(Moral-Benito (2012a)).

3.2 Problems of BMA

Durlauf *et al.* (2009a) or more recently Henderson *et al.* (2012) explicitly list issues of BMA models. Some of them have already been described (a choice of a prior and a model prior), others include conditional independence assumption (a problem of collinearity arises when different specifications of one variable (determinant) are in the set $\mathcal{X}$, solvable via reweighting), more generally described as redundant variables. Its solution and seriousness depend on a particular measure and a set of proxy variables (rather similar or dissimilar). One suggestion as how to deal with the issue (model uncertainty) in a systematic way can be found in Brock *et al.* (2003): (1) uncertainty in theory (solved via a 'classification of models'), (2) uncertainty about specification (linear, non-linear models, threshold effects, etc. necessary), (3) uncertainty in measurement ('what exactly to include in a model') and (4) uncertainty about heterogeneity (what countries area affected). A 'recipe' for the solution is to specify priors reflecting previous points (1) – (4) when model probabilities are allotted (see *ibid.*).

Another critique focuses on BMA's sensitivity to data (revisions) for 'agnostic' type of priors, which leads to rather significant changes in PIP, i.e. whether a determinant helps to explain the data. For example for the Sala-I-Martin *et al.* (2004)'s set of growth determinants Ciccone, and Jarociński (2010) carry out robustness checks and Monte Carlo Simulations confirming the presence of this problem even for moderate perturbations in the underlying dataset. This critique has been moderated by Feldkircher, and Zeugner (2012) who show evidence that most of the results' 'fluctuations' was due to change in the sample size (a reduction) of their PWT dataset and a specific type of utilized priors. Therefore, they propose employing hyper-g priors that are. Their study supplements Durlauf *et al.* (2009a) who suggest two possible ways of dealing with that: (a) methods less sensitive to such quite likely-to-observe patterns possibly via a new prior or (b) directly taking into account measurement errors.

Thirdly, the standard (full) BMA method does not account for potential endogeneity of regressors. As a result, some alternative in the pseudo-Bayesian approach have been suggested in the literature: they range from 'doing nothing' over using various lagged values of variables to a few modifications of BMA (FMA approach) allowing both for model uncertainty and endogeneity; for example in a panel context such as LIBMA (see Chen *et al.* (2011)) or BAMLE (see Moral-Benito (2012)), for a summary see Moral-Benito (2012a). However, there has not been reached a consensus between BMA and FMA on these issues so far, mainly because of pitfalls associated with the identification of endogenous variables and choice of instruments, comparability of likelihoods across models, etc. for details see *ibid.* Another problem may be heteroscedastic errors and/or the presence of outliers in a sample (mainly in the context of economic growth analyses or applications for financial markets). Doppelhofer, and Weeks (2011) have proposed a robust BMA allowing for parameter heterogeneity and outliers that makes use of a flexible mixture of distributions (encompassing normal distributions) creating 'fat tails'.

Fourthly, a potential problem when using BMA approach is a choice of sets of variable. This problem is often neglected though – 'jointness' of variables that can be tested via two statistics (see Błażejowski, and Kwiatkowski (2013)) – , i.e. whether two sets of variables are substitutes, complements or are not related at all in the model space. In addition to that in dynamic applications it is associated with the choice of lag lengths of variables.[29] Therefore, some authors have tried to bypass this by using a 'standard (frequentist) model' first to determine the 'right lag lengths' or by utilizing various lag lengths in an arbitrary (context-dependent) fashion sequentially (e.g. Babetský *et al.* (2012)). Therefore, due to previously listed reasons (and due to our focus on inference and not on forecasting) in our application no lags are included in the model and we leave this extension for further research.[30]

4 Empirical facts – our basic model

Since our dataset is rather limited both dimensions (both time and country dimension) given the composition of the EU and historical events (such as the establishment of independent NMS countries in the early 1990's), we decided to apply BMA in a panel data fashion (following a growing body of studies for real convergence, such as Crespo-Cuaresma *et al.* (2009) or Feldkircher (2012)). Even for the panel setting, we cannot (and will not) apply a standard 'growth' approach to search for determinants. Reason being the non-existence of growth-like dynamics (patterns) in our empirical application since there are 'natural' boundaries as to how far price levels can grow. In addition, we apply three-year averages of flow variables and stock variables are measured at the beginning of each period, i.e. we freely follow a recommendation of Moral-Benito (2012).[31] This gives us several non-overlapping periods and allows us to try to 'capture' an impact of the SDC (indirectly) even in this framework.

Having described the BMA methodology above and its potentially weak parts that seem to be a natural part of this relative new technique, we proceed to our model specification(s). As there has not been any only price-convergence-dedicated study that would have used this particular approach to date (no prior information), we will follow Feldkircher (2012) in his suggestions regarding choices of a prior and a model prior. The argument for this choice seems to be trivial – changes in comparative price levels (price convergence) share some similarities with economic growth that is they are affected by a host of determinants and our sample size (n) can be considered between small and medium. We would like to have a model answering our question (price convergence determinants) for a researcher who is rather 'agnostic' a priori, however, given problems of 'too agnostic' approaches shown in the literature (e.g. Ciccone, and Jarociński (2010)). Our choice of a prior will go towards a robust one that takes into account noise in the data. We also try to address (at least some) of aforementioned issues, however, some will remain an open research question due to our specific problem and dataset.

[29] There have emerged several issues (Babetský *et al.* (2012a)): (1) multicolinearity issues since BMA does not distinguish between lags of one variable when maximizing the objective function with implications for inference of such models, (2) an objective reason related to an increasing number of models in a model space (r variables with q lags), and (3) non-existence of a sequential procedure that would help select among models estimated with different lag lengths of one variable at a time.

[30] In addition, some authors have already argued in favour of including non-linear expressions in BMA models to improve inference and predictions. However, such an extension would rely on a choice of its functional form a priori, i.e. a relativisation of the 'agnostic' approach (for details see e.g. Henderson *et al.* (2012)). These authors (*op. cit.*) do this extension, however in the context of distribution free non-parametric methods (the conditional mean and the error term) – Local-Constant Least-Squares (LCLS) and Local-Linear Least-Squares (LLLS).

[31] We prefer shorter time averages given our rather limited time span since we focus on a problem of roughly similar nature to growth studies; there have been used four-year, five-year and ten-year averages in the economic growth literature. Moreover, five-year averages would leave us with only three observations (data for 2012 mostly not available, the same does hold for 1995 and before), when using lagged variables only with two.

Since main focus of this chapter is on determinants of price convergence, a linear regression model with fixed effects (FE) in the style of (4) is utilized. In order to avoid dealing with potential endogeneity and serial correlation no lagged dependent variable is included. The panel data (BMA) model takes the form: [32]

$$cpl_{ij,\,\Delta_t} = \mathbf{1}\iota_\tau + \Gamma_\tau X_\tau + \vartheta_\tau \tag{12}$$

where $cpl_{ij,\,\Delta_t}$ represents the relative percentage difference of comparative price levels for each period Δ_t over the time span (i.e. 1997–1999, ..., 2009–2011), the set of explanatory variables includes both 'growth' variables (those that are flow variables, see description of variables in Appendix) and 'level' variables (i.e. stock variables, we use the first year of each subperiod). Following the growth literature, one could split up the $\Gamma_\tau X_\tau$ into a 'benchmark' and an 'auxiliary' part but there is no main theory (such as the neoclassical growth model) and its alternatives *sensu stricto* as to what determinants should belong to each of them. Moreover, since we include j time fixed effects T_j our model reads:

$$cpl_{ij,\,\Delta_t} = \mathbf{1}\iota_{\tau'} + \Gamma_\tau X_\tau + T_j + \vartheta_{\tau'}. \tag{13}$$

where the variables have the same meaning like those in the equation (12).[33]

This particular approach is expected to help us to find out relative importance of price level determinants in the EU. It can be argued – using the logic explained above – that individual studies may not have captured the 'true' determinants due to *model uncertainty* (because of a rather short time span as well). A set of 103 potential variables ('determinants') of price levels has been identified, consisting both from previously used in literature or newly suggested. Apart from that a set of dummy variables is utilized as well. However, there are fewer 'real' determinants since some of our variables are simple transformations of one determinant, for example a proxy for openness. In addition, we follow a recommendation by Moral-Benito (2012) and other authors not to include too similar proxy

[32] There are several possible specification of the 'y' (CPL) variable: an average growth over a period, a (average) change over a period, a relative change over a period or simple a level. Due to limitations to our analysis (sample size) and the focus on convergence (a dynamic process), we will not use the last one. Because of our case is similar to economic growth models, we decided to use a similar approach to an estimation of growth determinants.

[33] Some studies have already employed different estimators for example *IV* type for growth regressions such as 2SLS by Durlauf *et al.* (2008), a RE estimator by Moral-Benito (2012), a reversible jump Markov chain Monte Carlo (RJMCMC, see Koop *et al.* (2012)), the two-stage BMA (2SBMA, with rather strict assumptions, see Lenkoski *et al.* (2012)) or its modified version – IVBMA (based on a conditional Bayes factor, see Karl, and Lenkoski (2012)). Another possibility is to run BMA in two separate stages or to check BMA results with a GMM-style estimation that would be somewhat difficult in our environment (26 × 5) though and its results may not be robust (we do not present them). Moreover, there has not been reached a consensus on this issue to date given rapid development in this area.
Unfortunately, we could not use the `R` package for IV estimation (`ivbma`) that offers perhaps the most promising version for IV within the BMA framework since it has not been extended for panel data models (and properties of such an estimator have not been derived). In addition, we considered a 'pseudo' BMA (LIBMA); in spite of our email correspondence with Dr. Ch. Tsangarides we did not manage to obtain his `Matlab` routine for *LIBMA* either but he promised that he would make it publicly available soon. We excluded determinants that could potentially lead to problems with endogeneity (for example exchange rates (bilateral or effective) and price indices).
Nevertheless, despite the fact that many advances in the IV methodology have been achieved over recent years, there are many potential pitfalls (a choice of instruments, lag selection, etc.) that cause 'problems' not only in our application. We are aware of these issues and take into account the fact that the usage of simple lags of variables in many macro empirical studies as 'instruments' has resulted in badly carried out IV estimations giving biased results (blown-up standard errors for weak instruments to name at least one). Importantly, problems with diagnostics of IV for BMA applications have not been settled to date together with other problems such as mixing of models. In addition, one cannot rely on standard tests for validity of instruments (Bayesian versions of the Sargan test or Cragg and Donald test, etc. are necessary) that create additional issues for IV BMA (validity of results), even though significant improvements have been achieved recently (see e.g. Lenkoski *et al.* (2012)). Therefore, we leave this extension of our empirical part for future research.

variables for one potential determinant of price levels (such as different various determinants for fiscal policy or the HBS effect); some tests have been proposed to deal with this problem, see below. Therefore, our estimation was done only for 38 determinants (33 'core' variables + 5 dummy variables) + time effects in our benchmark model.[34] Therefore, there are $2^{42} = 4.4 \times 10^{12}$ models in total to be evaluated. To reduce this immense computational burden, the MC³ sampler is utilized with 3×10^6 draws following a burn-in phase of 1×10^6 iterations which gives us a good approximation (correlation) of exact and MC³ PIP (≈ 0.99). Moreover, our prior is that the actual number of determinants is moderate (is equal to 11 regressors – a larger number given the inclusion of time effects (a panel); an alternative specification with 9 regressors does not have significant effects on our results), i.e. similar to the realm of GDP growth determinants – for example a (cross-sectional) growth model of Sala-I-Martin *et al.* (2004) use a prior model size = 7.[35]

In the case of model (12), the Bayesian method require a prior for ι, Γ_τ and σ^2 that is of key importance – the prior before employing data ($cpl_., X$) is assumed to follow $\mathcal{N}[\mu, \sigma^2]$ with specified values for mean (often conservative 0) and variance (depending on the data), following the Zellner's g definition (see Zellner (1986)). We will follow one of recommendations and place improper priors on the constant and the error term (its variance), that is they are assumed to be evenly distributed mirroring our lack of knowledge (complete prior uncertainty instead of the natural-conjugate approach for example à la Chipman *et al.* (2001)):

$$pr(\iota_\tau) \propto 1 \tag{14a}$$

$$pr(\sigma) \propto \sigma^{-1} \tag{14b}$$

As regards a model prior, a potentially large number of possible models hint at the use of an uninformative prior on the model space. In addition, a prior for Γ_τ (slope coefficient) has to be chosen. In the line with the literature, the standard formulation (a centered normal distribution, around zero) for BMA is chosen : $\sigma^2 = \left(\frac{1}{g} X'_\tau X_\tau\right)^{-1}$, where g expresses the level of uncertainty about values of the coefficients (large g being a sign of a great deal of uncertainty that they are zero):

$$\Gamma_\tau | L_\tau, \sigma^2, g \sim \mathcal{N}\left[0, \sigma^2 \left(\frac{1}{g} X'_\tau X_\tau\right)^{-1}\right] \tag{14c}$$

In our empirical exercise the hyper-g prior is utilized (two possibilities – UIP and BRIC with random (binomial) model priors) of Feldkircher, and Zeugner (2009) that is not fixed but estimated from our dataset. As a result, any inference conducted in models under this prior should be more robust (Feldkircher, and Zeugner (2012)). Moreover, a g prior (BRIC, uniform model prior, à la Fernández *et al.* (2001)). In addition, we include results of a g prior (BRIC, random model prior) and g-HQ prior (mimicking the Hannah-Quinn criterion, see Fernández *et al.* (2001)) as a robustness check.

Apart from labelling variables as very robust or robust (their $PIP > 0.5$, equivalent to $|t-\text{stat}| \approx$

[34] A full description of variables and their transformations is included in the Appendix A.1.

[35] Our choice was also driven by the dimensions of our panel specification and availability of data. Since we were aware of problems with variable sets mentioned above before running BMA we checked the correlation matrix of our variables and so that the `BMS` procedure would not stop due to non-singular matrices (collinearity). We also used 'jointness' tests described in Błażejowski, and Kwiatkowski (2013) and coded for `gretl` to check for variables that could be considered as strong substitutes/complements (in their description) that reduced our large set of variables.

1), their coefficient precision is evaluated following the suggestion in Masanjala, and Papageorgiou (2008) – it relates posterior mean to posterior standard deviation. For those in absolute value over 1.3 an asterisk (*) is added in Table 1 and they can be viewed as 'effective' following the approach of Masanjala, and Papageorgiou (2008).[36]

4.1 First results

Our results for the basic model are summarized in Table 1. Those determinants whose $PIP > 0.5$ are marked in bold.[37] Three model specifications are employed (labelled as *Model I–Model III*); however, results do not change significantly. This is confirmed by a model comparison shown in the Appendix 1. Across all models the same patterns can be seen (our preference is for model # II):[38]

a) a differential impact of subgroups of countries in the EU-27 is represented by the significance of a dummy for island economies (`island` such as Malta), and there is some link to countries whose central banks conduct inflation targeting `dINFTarget`, however, the former cannot be viewed as very strong (' effective');
b) there are two 'key' determinants according to our results, one being nominal compensations `ncomp` that represent both supply and demand factor (also viewed as a 'catching-up factor') and indirectly the importance of economic growth is highlighted by the relatively high value of output gap (`ogp` , i.e. a proxy for demand factors);
c) among twelve determinants shown in the table are also a four variables being a proxy for various aspects of a country's institutional environment, mainly related to the business environment in a country and the easiness of conducting business in such environment, i.e. they captures aspects relevant for competition forces (a part of the Heritage foundation's Index of economic freedom: freedom for business activities `f_business`, financial freedom `f_financial`, freedom from corruption `f_corruption`, and investment freedom `f_investment`);
d) conversely, our results do not much support (low values of PIPs) for traditional determinants of price levels found across the empirical literature such size and structure of markets, size of an economy or the effect of productivity growth, and government policies (such as tax revenues or expenditures or a measure of fiscal stance – only the variable for government expenditures `govfunc` is among the first twelve according the PIP) or a very limited for terms of trade (`tt`)

[36] Another approach has been proposed by Kass, and Raftery (1995) and used for example by Eicher *et al.* (2012). It distinguishes: *weak*, *positive*, *strong* or *decisive* effect of a variable based on its PIP: $50-75\%$, $95-95\%$, $95-99\%$ and $> 99\%$ respectively; however, there is no justification for either of them in the statistical / econometric literature that should be borne in mind by a user.

[37] We use `R` package `bms` that is more versatile (offers a larger set of potential specifications as regards priors on parameters and model priors). In addition, it shows better 'characteristics' according to Amini, and Parmeter (2012) compared with other BMA packages for `R`.
Model I follows a suggestion by Fernández *et al.* (2001) (g-prior = 'BRIC' and the uniform model prior), *Model II* a suggestion by Sala-I-Martin *et al.* (2004) (hyper-g prior = 'UIP', the random binomial model prior with imposed a prior model of size = 7), and *Model III* follows the same specification as the *Model II* only with hyper-g prior = 'BRIC'. We also utilized g-HQ prior = 'EBL' and uniform model prior and g-prior (BRIC, random model prior) – not shown in tables but available upon request from author – but their PIPs are shown in figure in Appendix.
We report the MCMC coefficients in our tables (in the analytical way for 5000 retained models are available upon request from author – those values are slightly higher compared to MCMC results; some authors prefer it to the former, e.g. Fernández *et al.* (2001)); for details see e.g. Zeugner (2012).

[38] Since there were rather high correlation between some variables in our sample, we run a robustness check for the same specification without these variables (household assets `hhfa` and bank lending to non-residents `blnr`). Both results do not differ significantly (both PIPs and their potential classification as 'effective') and therefore, we report only our full specification (results upon request from author).

or a measure of volatility (coefficient of variance, `cvx`) of exchange rate (NEER). In addition, there is no variable that would 'directly' represent for example GDP growth, a measure of openness or capital stock, wealth effects or differences between old and new EU members.

Table 1: Price level determinants – BMA results I., EU-27, 1995–2011

	Model I			Model II			Model III		
variable[a)]	PIP	Post mean	Post SD	PIP	Post mean	Post SD	PIP	Post mean	Post SD
`ncomp`	**1.000**	0.645⋆	0.104	**1.000**	0.624⋆	0.110	**1.000**	0.624⋆	0.110
`dINFTarget`	**1.000**	0.058⋆	0.011	**1.000**	0.056⋆	0.012	**1.000**	0.056⋆	0.012
`ogp`	**0.684**	0.004⋆	0.035	0.633	0.004	0.003	0.630	0.004	0.003
`island`	0.553	-0.021	0.000	0.558	-0.022	0.023	0.562	-0.022	0.000
`f_business`	0.376	0.000	0.001	0.373	0.000	0.001	0.375	0.000	0.001
`tnt`	0.274	0.082	0.149	0.272	0.076	0.143	0.272	0.076	0.143
`f_corruption`	0.189	0.000	0.000	0.195	0.000	0.000	0.193	0.000	0.000
`f_investment`	0.158	0.000	0.000	0.214	0.000	0.000	0.215	0.000	0.000
`govfunc`	0.142	-0.010	0.028	0.170	-0.011	0.030	0.169	-0.011	0.030
`f_financial`	0.172	0.000	0.000	0.169	0.000	0.000	0.176	0.000	0.000
`tt`	0.103	-0.066	0.229	0.140	-0.086	0.258	0.137	-0.084	0.256
`cvx`	0.083	-0.129	0.517	0.118	-0.170	0.583	0.120	-0.175	0.590

Note: model I (g prior BRIC, uniform), model II (hyper-g BRIC, random), model III (hyper-g UIP, random). Only first 12 determinants shown; full results are presented in the Appendix. ⋆ represents $|t - \text{stat}| > 1.3$, i.e. variable is 'effective'. a) Time dummies are highly significant but not shown.
Source: own calculation using `R` package `bms`.

It is rather difficult to compare our results with other empirical studies since there have been only few explicitly focused on determinants of price levels in the EU environment to date and none of them has utilized the Bayesian approach. Moreover, some of them aimed at estimating the speed of convergence (or half-life) and did not explicitly examine the question of determinants. Nevertheless, one of these studies (Dreger *et al.* (2007)) found three main determinants (PCA method utilized) for price levels a proxy for real convergence (catching-up) including compensations, openness and regulation. While results on catching-up factors were significant (similar to our results), those for the other two factors were rather mixed. No proxy (determinant) for wealth effects of financial markets, etc. was used. A study by Nestić (2005) includes real GDP, tax burden, government expenditures, labour productivity and apart from tax burden (mixed evidence), the remaining determinants are found significant. In our case effects of taxation (in broad sense) are not found to be a significant (important) determinant similarly to variables capturing government expenditures (more significant as measured by their PIP [$PIP < 0.5$] though) or changes in fiscal policy (structural deficit, `capb`). However, that may be due to high correlation of fiscal variables (revenues and expenditures) so that some of them could not be utilized at the same time (e.g. total revenues and expenditures).

4.1.1 BMA analysis – an extension

Since previous analysis has pointed out, perhaps somewhat surprisingly, the (insignificantly) different behaviour in NMS (a very low PIP for our NMS variable), in this section we try to shed some more light on determinants and their possibly differential effects for price level convergence. A 'natural candidate' for this purpose is the inclusion of interactions in our model. However, the issue with interaction effects in BMA context is associated with differences between the Bayesian and frequentist approach, i.e. the very existence of many potential models with combinations of parameters. That may lead to problems as shown for example in Chipman *et al.* (2001). Crespo-Cuaresma *et al.* (2009) suggest one possibility how to deal with interaction terms, however, this particular approach leads to the inclusion of interacted terms ('siblings') without their 'parents' and vice versa, which goes against the recommendation for the use of this model approach (see for example a classical study on this topic by Brambor *et al.* (2006)). Therefore, a modification – so-called Heredity prior – has been proposed by Feldkircher (2012) to deal with this and other potential problems.[39] This method is also utilized in the exercise. Our results with interaction terms are presented in Table 2 below.

Table 2: Price level determinants – BMA results II., EU-27, 1995–2011

	Model 1				Model 2				Model 3		
variable[a)]	PIP	Post mean	Post SD	variable[a)]	PIP	Post mean	Post SD	variable[a)]	PIP	Post mean	Post SD
`ncomp`	**1.000**	0.647*	0.102	`ncomp`	**1.000**	0.640*	0.106	`ncomp`	**1.000**	0.665	0.105
`dINFTarget`	**1.000**	0.057*	0.011	`dINFTarget`	**1.000**	0.055*	0.011	`dINFTarget`	**1.000**	0.056*	0.011
`ogp`	**0.712**	0.004*	0.003	`ogp`	0.602	0.004	0.003	`ogp`	0.551	0.003	0.003
`island`	0.544	-0.021	0.021	`island`	0.506	-0.019	0.021	`island`	0.479	-0.018	0.021
`f_business`	0.386	0.000	0.001	`f_business`	0.359	0.000	0.001	`f_business`	0.348	0.000	0.001
`tnt`	0.270	0.082	0.150	`tnt`	0.228	0.067	0.138	`tnt`	0.203	0.062	0.135
`f_corr`	0.179	0.000	0.000	`f_corr`	0.149	0.000	0.000	`f_corr`	0.130	0.000	0.000
`dirta#NMS`	0.437	-0.086	0.107	`ncomp#NMS`	0.464	-0.048	0.060	`ncomp#NMS`	0.498	-0.052	0.062
`ncomp#NMS`	0.404	-0.047	0.064	`dirta#NMS`	0.414	-0.085	0.115	`dirta#NMS`	0.415	-0.085	0.114
`tnt#NMS`	0.396	-0.192	0.245	`gfcfl#NMS`	0.191	0.024	0.055	`gfcfl#NMS`	0.189	0.024	0.055
`gfcfl#NMS`	0.350	0.050	0.073	`gspriv#NMS`	0.171	0.108	0.262	`gspriv#NMS`	0.187	0.118	0.272
`gspriv#NMS`	0.278	0.212	0.363	`nct#NMS`	0.163	0.006	0.013	`nct#NMS`	0.162	0.006	0.013

Note: model 1 (g prior BRIC, uniform), model 2 (hyper-g BRIC, random), model 3 (hyper-g UIP, random). Only first 12 determinants shown ($PIP > 0.5$); full results are presented in the Appendix. * represents $|t-\text{stat}| > 1.3$, i.e. variable is 'effective'. [a)] Time dummies are very significant but not shown. `f_corr` is the variable `f_corruption`.
Source: own calculation using `R` package `bms`.

Table 2 summarises main results for the same three model specifications as in the previous case but now with additional interaction terms for NMS countries (as defined above). There are no significant differences as regards individual determinants – their structure, significance (inclusion probability, PIP) are very similar to previous models without interactions; some have become less significant (for example `island`) and output gap `ogp` variables has lost its 'effective' status). Interactions have a lower inclusion probabilities ($PIP < 0.5$), only one is just on the frontier of 0.5 (`ncomp#NMS`) in model III and some other are in the range of $0.4-0.5$. However, this is not a surprising result given the fact that our estimation technique is quite 'demanding' in terms of the chance of an interaction to be included in a model. Our five most 'significant' are: the same four across specifications for nominal compensations,

[39] Let's assume that for simplicity there are two variables – X_1, X_2. A model can then consist of one or three variables or their combinations (X_1, X_2 and the linear combination X_1X_2): $Prob(\beth_{X_1X_2}|X_1,X_2) = \begin{cases} pr_{00}, & \text{if } (\beth_{X_1}\beth_{X_2}) = (0,0) \\ pr_{01} = \text{if } (\beth_{X_1}\beth_{X_2}) = (0,1) \\ pr_{10} = \text{if } (\beth_{X_1}\beth_{X_2}) = (1,0) \\ pr_{11} = \text{if } (\beth_{X_1}\beth_{X_2}) = (1,1) \end{cases}$
where $Prob(\beth_{X_1X_2}|X_1,X_2)$ is the probability of inclusion for the linear interaction and it depends on the inclusion of both its components. A structure is chosen via p that determines which combinations are used in the analysis. In this application the so called 'strong heredity principle' is used that leads to the inclusion of interaction ('siblings') terms only with their 'appropriate parents'. This eliminates all possibilities when one or both are missing. For further details see e.g. Feldkircher (2012).

direct taxation (`dirta`), gross fixed capital formation (`gfcfl`), private savings (`gspriv`) and one alternating – our proxy for the HBS effect (`tnt`) and net current transfers (`nct`). BMA method thus does not provide much support to a differential impact of individual determinants on old and new EU countries. There are some explanations such as the length of our time span, availability of variables that limit our analysis (for example most of the 'different years' in the 1990's cannot be included). As regards our second set of results and a comparison, the situation is even worse than in the first case. Empirical studies usually utilize a simple dummy variable for NMS countries and do not explore this aspect further. Since our results are rather close to 'inconclusive' than strongly in favour of any conclusion.[40]

4.2 Are there implications for monetary policy?

As regards determinants of price levels (and therefore their adjustments), there are both same old 'suspects' and also some new ones. While effects compensations of employees are confirmed, variables being a proxy for size, development such as GDP, population or taxation are not or rather weakly. Similarly, openness as it is traditionally measured (a fraction of GDP) do not have a very significant impact either ($PIP > 0.5$). Likewise, the importance of exchange rate movements, no matter how important theoretically, does not seem to find its (direct or indirect) empirical counterpart.

There are a large number of explanations why our results are somewhat surprising (different):

- our period is rather short and therefore, no stable linkages of determinants and price level may exist (compared with economic growth determinants); moreover, our period includes both the late 1990's (transformation phase) and late 2000's that are affected by the on-going financial crisis and other effects of events;
- our study is not a cross-sectional or a standard panel data estimation and there are no lagged variables included in our model;
- our methodology is more general compared to standard (frequentist) approaches, our set of determinants is broader and the aim of this exercise is different;
- exchange rate movements only reflect 'deeper' changes in structural characteristics of individual economies that are approximated by some well-known economic indicators. However, when using those directly, the real link and not its approximation may be revealed. The same may hold for real income that is usually viewed as a capturing-all proxy for various effects;
- regarding rather mixed results in case of effects of trade – it may be given by the fact that it may have lost its impact over years (a justification would point out an increase in the 1990's during the 'opening-up' period that did not continue on the same scale in the 2000's – measures of openness are practically flat after 2000 for a majority of EU-27 countries) or its impact is important for catching-up countries in the EU-27 but it is dissolved (not confirmed by our results though);
- the HBS effect – our results are more or less in the line with cross-sectional, time series or panel studies – some of them do find support for the effect, some do not or weak (due to a large number of factors – mainly, there may be a problem with the definition of tradable and

[40]Due to only negligible differences in results of this and previous exercise and space considerations, both our full and analytical results are available upon request from author.

non-tradable sector which varies in the literature). Therefore, it seems to be a very similar case with openness.[41]

On the other hand, there is some evidence (not very significant) that the broadly defined institutional environment matters, mainly in the form of administrative and bureaucratic activities that can easily hinder competition and its forces and/or create barriers for price convergence. Conversely, restrictions as regards transactions between domestic and foreign subjects are not found significant – either they were already removed (which could be the case in most of the EU-27 countries) or they are in the form that does not affect price changes (non-distortionary). Monetary policy has a limited scope here apart from affecting stability of financial environment in an economy and possibly via indirect linkages other parts of the economy.

Moreover, we can add some further comments on the BMA approach utilized in this thesis as well. Firstly, our empirical part was carried out for linear models only so there is still a lack of knowledge if one assumed non-linear linkages among a set of determinants (that could be investigated for example in the FMA approach). Secondly, our model did not contain any lagged variables (in spite of theoretical assumptions of mostly contemporaneous effects in our model environment – it seems to be plausible to assume that adjustments are realised within a year). However, as describe in the main text, this extension is associated with many not-easily-remedied problems. Thirdly, given a large number of potential determinants and mainly their possible specifications (for example variables capturing effects of foreign trade or productivity growth), it is not possible to include all of them into a set of determinants for a BMA application. This leaves a small amount of uncertainty as regards any findings and their robustness in terms of exact specifications of individual determinants (not about the determinant itself though). Fourthly, we investigated a one particular specification for the dynamic type of dependency, i.e. there is still some scope left for alternative specifications of our dependent variable for future research.

5 Conclusion

Price convergence is a part of the process of structural changes in the economy and is (inextricable) intertwined with on-going real convergence. It shares some characteristics such as convergence/divergence with it but it is also a specific process with its own specifics ('natural' limitations for changes of prices/price levels, i.e. convergence or divergence). Moreover, there are various definitions regarding 'adjustment processes' such as nominal convergence that includes adjustments of prices/price levels and wage levels of catching-up economies with an average. However, the main focus of this thesis is on the process of price convergence, i.e. adjustments of prices/price levels. Its importance has been well documented by the still on-going Great Recession (or SDC). Not sufficiently enough converged price levels in the Euro area seem to be at the heart of problems of some of its member states.

Our empirical illustrations were done for the European environment (the EU and its subgroups). This choice was done intentionally since it enables a researcher to investigate great many topics related to an integration group consisting of economies (independent countries) of different income levels –

[41] A support for our vanishing hypothesis is given by Bergin *et al.* (2006) or Égert (2007). Contemporaneous effects can be weak and since there are no lags in our model that may explain low PIPs of some of determinants.

more and less advanced countries including the Czech economy. Moreover, this integration group has gone through various steps of integration that has not finished so far, for example some of NMS countries are still expected to take part in the monetary union in the future and such an analysis as ours may help to tailor a country-specific path. In addition, it has been exposed to great many shocks and external effects. It also offers a reasonable basis of economic data that can be utilized.

Our research question was aimed at investigation of price levels determinants in the EU. Given a large amount of uncertainty as to what indicators should be used in an empirical study (the well-known *model uncertainty* problem), the Bayesian approach (BMA) was applied to the dataset. BMA is specifically aimed at this particular type of empirical analysis with great many potential determinants. It can be argued that the Bayesian approach is more robust, equipped to deal with many potential problems the other (frequentists) approach faces and offers 'better' estimates for many problem where the true model (and its parameterization, choice of variables, etc.) is not known. However, it is also affected by many assumptions and a particular chosen path and still deals with some issues since it is a relatively new approach.

The utilized set of determinants consists of variables (subsets) capturing both economic-related processes and those pertaining at least partially to non-economic determinants such as the institutional environment (broadly defined). To summarize, some determinants had already been identified and utilized in the literature (nominal compensations as the catching-up factor), while others not or not completely (for example variables trying to capture wealth effects). Our results confirm that the model uncertainty is a problem in this particular type of empirical exercises (price convergence) since we found only limited support for some traditional determinants (such as economic growth and labour costs) or any support at all (trade-related, productivity-related, etc.). As regards a broad institutional environment, inflation targeting and perhaps the existence of limited accessibility (island economies). A variable for NMS or many institutional aspects of an economy's environment were rather weakly significant measured by their PIPs. In addition, we tried to add another layer to the exercise by adding interaction dummies for NMS to address the question of differentiated impact of common variables on these states. Our results did not show a clear support to this hypothesis. However, we cannot rule out the possibility that it may have been due to our limited time span (including missing observations for some countries, etc.).

However, there are some limitations of our analysis and its results that one should keep back in their mind when thinking about implications. Our results can be interpreted as a first attempt that either shows a lack of explanatory power of standard variables and the need to search for alternative variables and/or their definitions or that one will have to use a different approach in order to model the link between price levels and their determinants. Our results also show that some of the individual time effects are very significant (i.e. 'effective', for the second period that bears results of the '11/9' event and the last period that is affected by the SDC) and their PIP are equal to one. They may reflect the effect of the on-going financial crisis or various shocks affecting European economies in the past or simply specific circumstances in the case of European integration process. Therefore, we prefer leaving this 'door' ajar, i.e. the question of price level determinants is very likely to be addressed in the future again.

A
Dataset

A.1 BMA – data

Regarding the set of determinants for BMA estimation, our inspiration follows both from the literature and previous text: based on the well documented relationship between price levels and GDP expressed in comparable units (such as PPP or PPS in the European case, see e.g. Dreger *et al.* (2007); Čihák, and Holub (2005); EC (2006)), GDP or a proxy for GDP is included in any empirical model. In addition, this observed pattern gives a motivation for researchers to consider other potential factor (determinants) influencing the process of nominal convergence. A wide range of variables that have been suggested in literature (for a review see Égert (2007)), see for example Čihák, and Holub (2005), which can be included as regressors in a model trying to find determinants influencing the comparative price level in an economy.[i] For example Dreger *et al.* (2007) work with only GDP, labour productivity, import penetration, and a proxy for competition (on a sectorial scale), and (market) regulation, however, these variables are ‘ selected’ in a PCA analysis. Nestić (2005) includes real GDP, tax burden, government expenditures, labour productivity. Because of a rather general type of our research we do not restrict ourselves only to previously used variables but we try to include both alternatives of standard variables and new variables that have not been used to date.

Our choice of determinants cannot follow the existing literature completely since many empirical studies have utilized individual prices of goods and services (e.g. the EIU CityData) and a corresponding gravity-type model or different model approaches such as PCA. Therefore, we split up possible determinants into several groups covering main parts of an economic environment both already included in empirical studies (in some form such as exchange rate volatility) and new variables in an attempt to explore the potentially large set of determinants that may have impact on price convergence:

- **Economic development**
  Because of increasing globalization and interconnectedness of national economies, traditional economic indicators the achieved level of economic development such as GDP have been losing their relevance for small and medium open economies. Therefore, there are various definitions (even though in the literature GDP has been preferred e.g. Dreger *et al.* (2007)) – GDP (growth of real GDP in constant prices);
- **Demand factors**
  A measure of output gap is also included (a percentage deviation of potential GDP) as output gaps persistently above a trend may indicate both a faster process of catching-up and a higher domestic demand that is expected to be reflected in CPL changes. Alternative definitions of aggregate demand (domestic demand real and final) and final domestic demand could be utilized as well. Moreover, we consider two more variables related to the demand side of an economy are utilized as well: gross fixed capital (GFC) that represents total capital accumulation since higher shares in GDP are expected to stimulate GDP growth and thus CPL growth and gross

[i] It is possible to divide them into three groups: natural, structural and political factors (Wolszczak-Derlacz (2008)). Natural factors are e.g. consumer’s tastes, culture, etc., structural factors are e.g. a market structure and finally, political factors are influences stemming from different political systems (the fiscal system, trade and non-trade barriers, etc.).

fixed capital formation (GFCF) following the same logic (both log levels and growth rates); both are calculated as growth over a period or as a level variable. Other variables included are nominal compensation per employee (`ncomp`) being a source of income (total economy, EU-15=100, growth rates) and nominal unit labour costs ULC (total economy, national currency, 2005 = 100, growth rates); however, due to the proximity of those determinants, only nominal compensations and GFC are used;

- **Market (space) factors**
  Two alternative variables are in our dataset that can be viewed as a proxy for market factors – natural logarithm of GDP in PPS per km^2, total employment (15–64 years) to total population of the same age per km^2, and total population per km^2. Since these measures provide similar information, we include only the first one. As an alternative view on market structure (producers' side) a measure of internal distance in a country is utilized `int_dis` based on Head, and Mayer (2002).[ii]
- **Sectoral determinants**
  A proxy for the Harrod-Balassa-Samuelson effect (*tntg*) is calculated as a change in the ratios of gross value added (GVA) in constant prices per employed person in tradable (industry) and non-tradable sector (agriculture, construction and commercial services).[iii]
- **Government determinants**
  An important economic agent almost in every economy is a governmental sector. Our database includes several variables capturing both revenue and expenditure side of a budget: (*a*) the revenue side is represented by indirect taxes, direct taxes and total revenues (a broader variables measures also other revenues) measured as a fraction of GDP in current prices (a simple average of levels), (*b*) expenditures of a government both total expenditures and variables based on the functional classification (COFOG) – total expenditures for main components such: public services, economic affairs, health, education, and social protection, all variables are measured as percentages of GDP in current prices, simple average of levels). Since they provide similar information, we include only total expenditures (the functional definition, `govfunc`);
- **Finance and wealth**
  Since finance and wealth related determinants have become important for business cycles and consumers and firms' behaviour (existence of 'credit booms', see e.g. Furceri, and Zdzienicka (2011) or Ito, and Chinn (2013)), a series of variables covering volumes of bank private credit (percentage of GDP), bank lending from non-residents (amounts outstanding, percentage of GDP), stock market capitalization (percentage of GDP) and remittance inflows (percentage of GDP); in addition, (natural logarithm of) stocks of financial assets for households (`hhfa`) as a proxy for wealth (since it includes other effect compared to private savings (all sectors apart from government based on the national accounts definition) as a proxy for disposable sources of private subjects (all as percentages of GDP, level variables) are in our dataset.
- **Open economy determinants**
  Some authors define 'openness' as a sum of exports and imports of goods only; our dataset contains both the previous definition and also a broader concept including both goods and

[ii] The formula for `int_dis` is $0.67 \cdot \sqrt{km^2/\pi}$.

[iii] Since there are no time series of GVA in constant prices for Malta covering the time span, we constructed them from GVA series in constant domestic prices supplied by the IMF and the World Bank using and employment data from Eurostat.

services, exports and imports separately and net exports (as percentages of GDP). Due to strong links between variables and for our purpose we use import shares in GDP and next exports (`open_*`). In addition, net current transfers `nct` and net primary income (`npi`) from the rest of the world are included as they represent an important source of income for many countries.

In addition to this set of determinants, three measures of exchange rate are considered: exchange rate volatility (based on yearly changes of national currencies against the Euro), coefficient of variance (based on yearly changes of national currencies against the Euro) and a weighted exchange rate – NEER (nominal effective exchange rate defined in a relative way to the rest of 36 industrial countries using double export weights EU-27, Turkey, Switzerland, Norway, USA, Canada, Japan, Australia, Mexico and New Zealand), lastly, indices of terms of trade (for goods and services separately and total index that is utilized, base 2005 = 100). However, due to potential endogeneity (prices vs. a measure of exchange rate), we utilize only a measure coefficient of variance `cvx` that is based on NEER (measured as standard deviation divided by average for our three-year periods);

- **Institutional environment/degree of competition**

  Probably the most difficult choice occurs when it comes to determinants (variables) for institutional framework in an economy. Since we are interested in effects of competition, and potential barriers hindering it such as regulation, bureaucracy, etc. a simple proxy is included. There are many alternatives such as indices of institutions for example published by the Fraser Institute, Heritage Foundation, Transparency International.[iv]

  Below we describe the HF index in brief whose parts are employed in our model (not all subindices are used). HF (2013) calculates the total index as a simple average across four main areas (all indices have a scale from 0–100, where the higher values for a country are recorded, the 'better' is this country in terms of an index, for details see HF (2013)):

  (1) 'Rule of Law' consisting of (I) Property Rights (capturing a level of law protection of individual's property rights and enforcement of individual and business rights and a level of their enforcement by a government; independence and a level of corruption in the judicial system, probability of being expropriated; (II) Freedom from Corruption (mostly based on CPI index of Transparency International.

  (2) 'Open Markets' including (i) Trade Freedom (being a measure of tariff and/or non-tariff barriers having negative effects imports and exports of goods and services of a country); (ii) Investment Freedom (a proxy for an easiness of being an entrepreneur moving their funds for investments without any restrictions of a government); (iii) Financial freedom (measures efficiency of the financial system and a level of public 'presence' (publicly owned banks, insurance companies, stock market, etc.) and interferences with transactions within the sector and with other sectors in the economy (regulation/limits for activities and

[iv] Both are similar to the HF index, however, they are focused on a limited number of indicators or published as 'one number' and there is no disaggregation into individual subindices for institutional quality represented by CPI index of the Transparency International (TI (2013)). The FI index is very similar to HF index since it consists of a set of indices: overall index and subindices capturing size of government, legal system and property rights, money system, international trade and regulation (for a description of indices see Gwartney *et al.* (2012). Its main disadvantage is availability: it has been calculated and published annually since 2000 (in a 5-year interval before), which is a clear obstacle for our estimation starting in 1995. Moreover, we utilize an index (`ito`) that is explicitly associated with open economy, i.e. a proxy for capital account openness, for details see Ito, and Chinn (2013).

transactions, code of conduct, conditions for an entry, etc.).

(3) Regulatory Efficiency contains three subindices (1) Business Freedom (related to business activities, i.e. the easiness of starting, running and closing an activity in terms of the administrative burden and efficiency of bureaucracy); (2)Labor Freedom (legal and regulatory aspects pertaining to a labour market such as minimum wages, employment protection laws and regulations, etc.) and (3) Monetary Freedom (measuring both price stability and public interventions in the price setting mechanism).

(4) The last component of the overall HF index is aimed at the position of a government – Limited Government (being approximated by the total presence of a government in an economy in economic terms: levels of public expenditures, transfers and consumption).

Why is it important to use a proxy for institutional factors? The notion of doing that may not be completely straightforward. Let us assume that for example the amount of time spent (less) with government bureaucracy should have a positive impact on prices. Conversely, in a country with a stronger regulation one should see a decrease in the HF index, even though fundamentals affecting prices may have remained at the same level. Similarly, a change in price controls that has been observed during the still on-going transition process is expected to lead to higher price levels in NMS countries. Similarly, a less efficient government would require a larger amount of resources for the same (or lower) range activities and provision of public services. A catching-up process is expected to 'help' organise public bureaucracy in a more efficient way with positive impact on levels of taxation and public expenditures. On the other hand, one could argue that in case of the EU-15, any type of regulation has already been removed for most of their prices, perhaps apart from some parts of service sector (utilities, i.e. network industries) such as energy and water supplies or telecommunications. As a result one would expect to see a higher level of competition in both wholesale and final markets and positive effects on prices (a reduction).

In addition to previously listed determinants, there is also a set of regional and 'effects-related' dummies: a dummy for NMS countries – all states in the region, EU dummy and a dummy for the Euro adoption, i.e. EMU entry[v] and finally, a dummy for countries with inflation targeting.[vi]. There is no separate dummy for the on-going financial crisis as it will be captured by time effects (due to the structure of our panel). In addition, a 'spatial' dummy islands is used as a proxy for being an island.[vii] The dataset covering period 1995–2011 and 26 countries of the EU (Luxembourg was omitted due to its time series being outliers) was obtained from various EUROSTAT databases, DG ECFIN (AMECO database, EC (2013)), IMF IFS database (IMF (2013b)) and World Bank database (WB (2013); WB (2013a)). Due to missing observation for some countries and some variables (mainly at the beginning of our analysed period) our panel is unbalanced.

[v] Two different approaches can be utilized: a simple dummy $d_i \in \langle 0, 1 \rangle$ (`dEU, dEMU`) that is used in the text or an alternative specification of a dummy variable representing the number of years being an EU or an EMU member (`yEU, yEMU`). However, if the latter is used, `NMS`, `dEU` and `dEMU` have to be excluded.

[vi] This variable is created on the basis of Debelle *et al.* (1998), Roger (2010), and own updates. Finland, Spain and Slovakia had started using inflation targeting framework but they stopped when joined the Euro Area. Other countries are (in the chronological order): the United Kingdom, Sweden, the Czech Republic, Poland, and Hungary.

[vii] Because of a rather short time span it was not possible to split the period into two parts such as one for the period before the Euro was introduced (1995–1998) and with the Euro in circulation (1999 onwards). However we tried to control for 'Euro effect' by inclusion of dummies for individual phases – its creation in 1999, the inclusion of Greece (1999) and new member states such as Slovenia (2007), Cyprus, Malta (2008), Slovakia (2009) and lastly Estonia (2011).

Since some time series in our database show signs of heteroscedascity we applied natural logarithm transformation and in case of outliers (we are suspicious of typing typos), mainly in the 'financial group' and financial flows, we use a `Stata` routine `bacon` to identify them together with Box-and-Whisker (plot) graphs. Identified outliers we used one rule to limit them (based on the interquartile range):

$x_{high} = x_{0.75} + (1.5(x_{0.75} - x_{0.25}))$
and
$x_{low} = x_{0.25} - (1.5(x_{0.75} - x_{0.25}))$.
These values were approximately equal to the 90% (or in some case 95%) quintile.

Table 3: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
cpl	0.03	0.06	-0.08	0.26	130
ogp	0.36	2.79	-9.91	8.66	130
rgdig	0.03	0.03	-0.05	0.11	130
gdpg	0.03	0.03	-0.05	0.10	130
gdpgg	0.05	0.03	-0.05	0.14	130
gdpgl	4.99	1.52	1.64	7.72	130
popg	0	0.01	-0.03	0.02	130
popl	15.98	1.36	12.83	18.23	130
gdp_ppskm	-0.45	1.09	-2.30	2.13	130
gfcfg	-0.01	0.05	-0.23	0.12	130
gfcfl	3.06	0.18	2.43	3.58	130
gfcg	0	0.06	-0.22	0.25	130
gfcl	3.09	0.21	2.32	3.67	130
tntg	-0.01	0.03	-0.07	0.12	127
hhfa	4.87	0.6	3.43	5.76	121
gfa	3.5	0.41	2.57	4.74	123
ncompg	0.05	0.05	-0.05	0.24	130
ulcg	0.03	0.04	-0.06	0.24	130
ervol	0.02	0.02	0.00	0.14	130
cvx	0.00	0.00	0.00	0.03	130
neerg	0.00	0.06	-0.49	0.09	130
ttg	0.00	0.01	-0.02	0.06	130
openbc	1.02	0.38	0.47	1.85	130
open_impbc	0.52	0.19	0.22	0.94	130
open_nxhdp	0.01	0.07	-0.19	0.19	130
npi	-1.7	3.34	-17.38	3.39	130
nct	0.04	1.54	-2.26	5.5	130
indta	2.58	0.15	2.18	2.93	130
dirta	2.37	0.39	1.56	3.42	130
taxbc	3.58	0.17	3.25	3.95	130
totrev	3.73	0.16	3.41	4.08	130
totexp	3.73	0.15	3.28	4.03	130
govfunc	3.8	0.15	3.44	4.11	126
ito	1.81	1.15	-1.17	2.44	130
prop_rights	71.08	18.23	30.00	90.00	130
f_corruption	62.05	20.06	28.00	100.00	130
f_fiscalf	60.35	15.18	30.3	89.40	130
C_government	38.17	18.11	0.00	70.80	130
f_business	76.21	10.16	54.2	100.00	130
f_labor	62.61	13.79	34.7	100.00	78
f_monetary	79.73	10.62	0.00	90.70	130
f_trade	80.64	6.82	46.8	87.60	130
f_investment	71.42	12.73	30.00	90.00	130

Continued on next page...

... table 3 continued

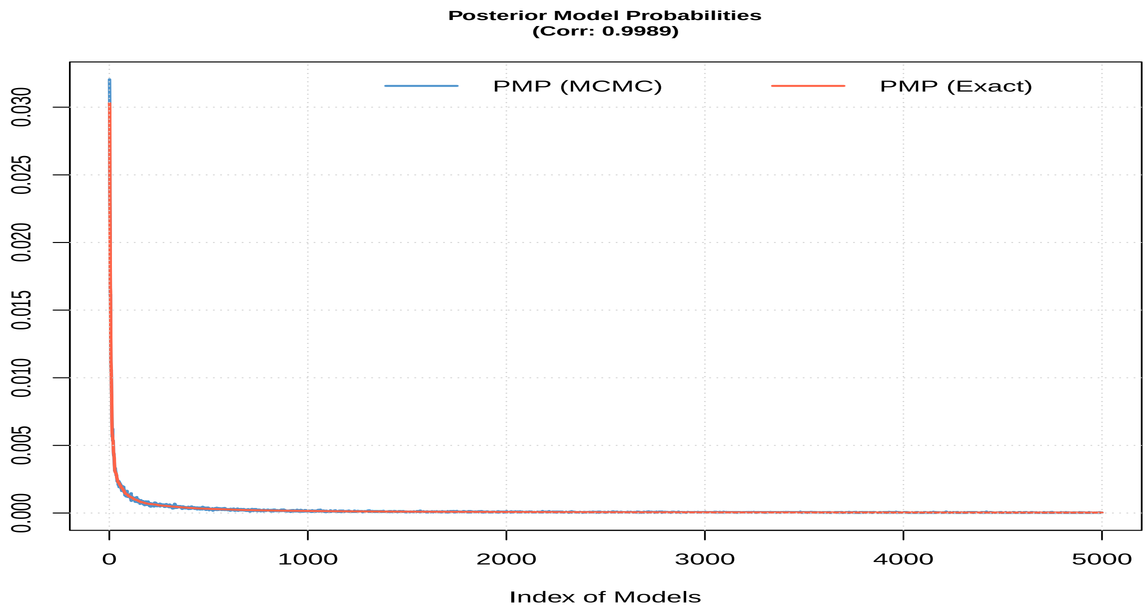
Variable	Mean	Std. Dev.	Min.	Max.	N
f_financial	69	14.67	30	90.00	130
dist_inc	4.7	0.77	1.9	5.71	130
pc	4.16	0.79	1.85	5.57	122
smcap	3.39	1.17	-3.51	5.51	129
sec_privatef	2.39	1.71	-1.97	5.34	109
sec_publicf	1.57	1.44	-2.41	4.09	124
debt_issuance	2.98	1.21	0.43	5.45	124
bdeposit	4.04	0.59	2.32	5.46	123
blnr	3.45	1.03	1	6.03	130
remi	0.09	0.32	-0.34	1.95	130
ti_full	-3.52	0.75	-5.81	-2.23	130
capb	-2.86	3.06	-17.44	4.76	130
gspriv	0.19	0.04	0.09	0.34	129
dINFTarget	0.17	0.38	0.00	1.00	130
dEMU	0.46	0.50	0.00	1.00	130
NMS	0.46	0.50	0.00	1.00	130
island	0.15	0.36	0.00	1.00	130
dEU	0.26	0.44	0	1.00	130
dcrisis	0.20	0.40	0.00	1.00	130
yEU	12.62	4.82	5.00	17.00	130
yEMU	7.42	6.91	0.00	15.00	130

Note: all values.
Source: own calculation based on sources given in previous text.

B

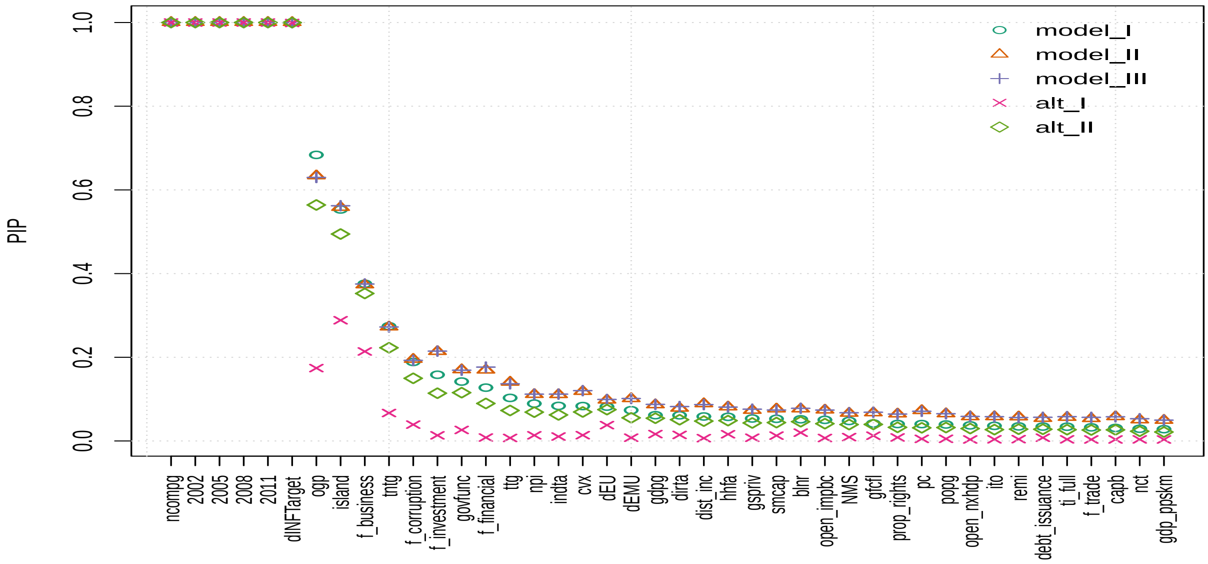
BMA – OUTPUTS

Figure 1: BMA – model convergence



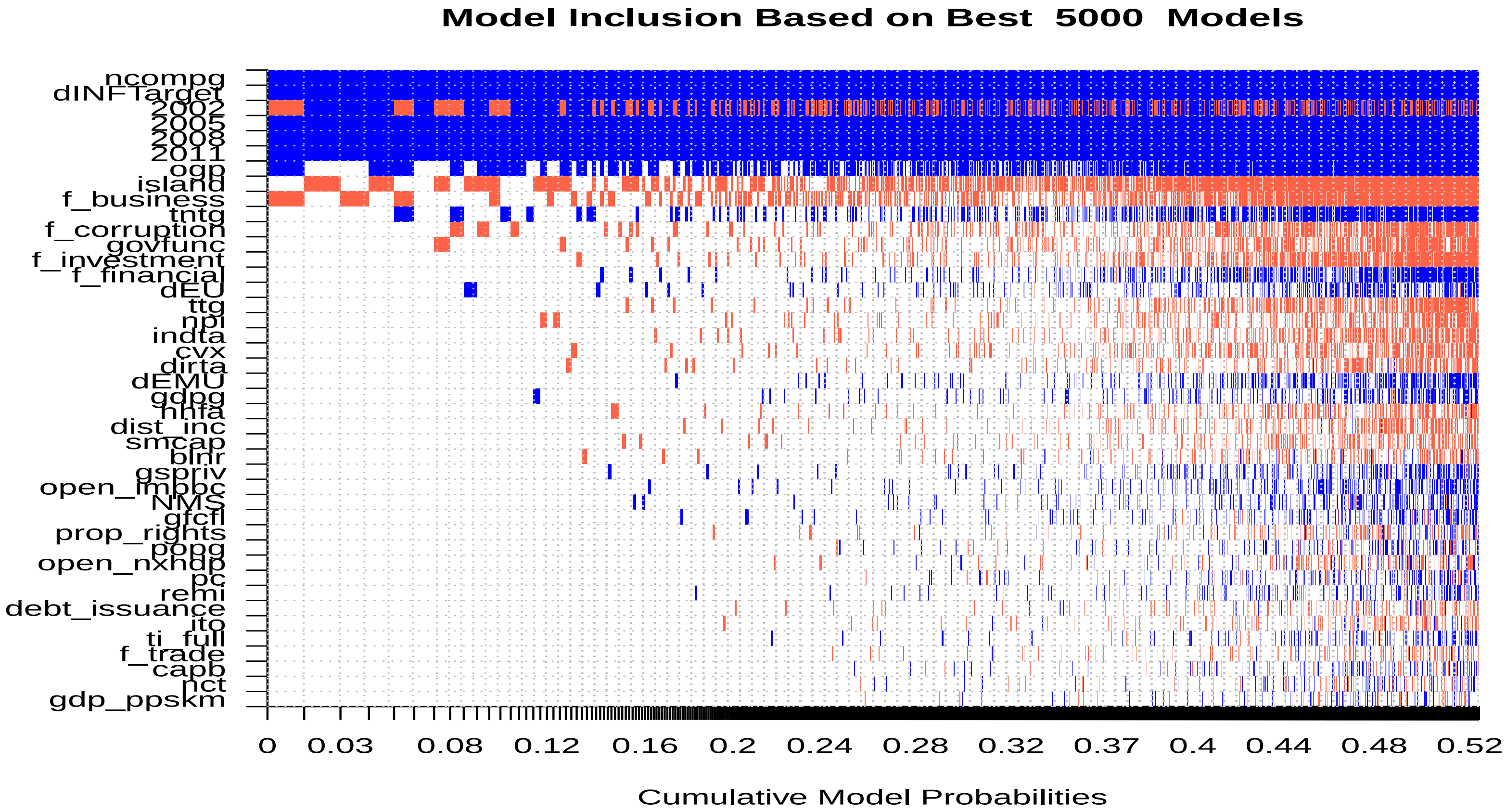
Note: hyper-g prior (BRIC, [Model II]). *Source:* own calculation using `R` package `bms`.

Figure 2: BMA – comparison of basic model specifications



Note: Models $I - III$ are shown in text; two other models represents robustness checks (Alt_I – g-prior BRIC, uniform and Alt_II – g-prior 'EBL', uniform); for explanations see main text. *Source:* own calculation using `R` package `bms`.

Figure 3: BMA – model inclusion



Note: columns in the figure denote individual models; all variables are listed according to their PIP (posterior inclusion probability) in descending order. Blue color (it would be a darker colour in grayscale) = the variable is included and the estimated sign is positive, red color (it would be a lighter colour in grayscale) = the variable is included and the estimated sign is negative, and 'no color' (white) – the variable is not included in the model. The horizontal axis measures the cumulative posterior model probabilities. Model with hyper-*g* prior (BRIC, [Model II]). *Source:* own calculation using `R` package `bms`.

Table 4: **BMA – complete results, EU-27, 1995–2011**

variable	PIP	Post mean	Post SD	CPS	t-test	variable	PIP	Post mean	Post SD	CPS	t-test	variable	PIP	Post mean	Post SD	CPS	t-test
ncomp	1.000	0.645	0.104	1.000	6.188	ncomp	1.000	0.624	0.110	1.000	5.676	ncomp	1.000	0.624	0.110	1.000	5.668
d2002	1.000	0.001	0.011	0.584	0.067	d2002	1.000	0.001	0.011	0.620	0.079	d2002	1.000	0.001	0.011	0.625	0.083
d2005	1.000	0.024	0.011	1.000	2.177	d2005	1.000	0.022	0.011	1.000	1.965	d2005	1.000	0.022	0.011	0.999	1.962
d2008	1.000	0.029	0.015	1.000	1.870	d2008	1.000	0.029	0.016	0.999	1.779	d2008	1.000	0.029	0.016	0.999	1.781
d2011	1.000	0.032	0.016	1.000	2.028	d2011	1.000	0.030	0.016	0.999	1.858	d2011	1.000	0.030	0.016	0.999	1.852
dINFTarg	1.000	0.058	0.011	1.000	5.159	dINFTarg	1.000	0.056	0.012	1.000	4.840	dINFTarg	1.000	0.056	0.012	1.000	4.832
ogp	0.684	0.004	0.003	1.000	1.272	ogp	0.633	0.004	0.003	1.000	1.134	ogp	0.630	0.004	0.003	1.000	1.126
island	0.553	-0.021	0.022	0.000	-0.967	island	0.558	-0.022	0.023	0.000	-0.950	island	0.562	-0.022	0.023	0.000	-0.956
f_business	0.376	0.000	0.001	0.000	-0.694	f_business	0.373	0.000	0.001	0.000	-0.675	f_business	0.375	0.000	0.001	0.000	-0.678
tnt	0.274	0.082	0.149	1.000	0.550	tnt	0.272	0.076	0.143	1.000	0.532	tnt	0.272	0.076	0.143	1.000	0.532
f_corruption	0.189	0.000	0.000	0.000	-0.424	f_investment	0.214	0.000	0.000	0.000	-0.446	f_investment	0.215	0.000	0.000	0.000	-0.448
f_investment	0.158	0.000	0.000	0.000	-0.378	f_corruption	0.195	0.000	0.000	0.002	-0.413	f_corruption	0.193	0.000	0.000	0.002	-0.409
govfunc	0.142	-0.010	0.028	0.010	-0.350	govfunc	0.170	-0.011	0.030	0.018	-0.371	f_financial	0.176	0.000	0.000	0.996	0.386
f_financial	0.127	0.000	0.000	0.996	0.327	f_financial	0.169	0.000	0.000	0.996	0.377	govfunc	0.169	-0.011	0.030	0.017	-0.370
ttg	0.103	-0.066	0.229	0.000	-0.287	tt	0.140	-0.086	0.258	0.000	-0.333	tt	0.137	-0.084	0.256	0.000	-0.329
npi	0.089	0.000	0.001	0.002	-0.260	cvx	0.118	-0.170	0.583	0.000	-0.292	cvx	0.120	-0.175	0.590	0.000	-0.296
indta	0.084	-0.003	0.013	0.005	-0.251	npi	0.111	0.000	0.001	0.006	-0.275	indta	0.112	-0.004	0.015	0.005	-0.282
cvx	0.083	-0.129	0.517	0	-0.250	indta	0.111	-0.004	0.015	0.007	-0.279	npi	0.112	0.000	0.001	0.007	-0.277
dEU	0.082	0.001	0.006	0.98	0.243	dEMU	0.101	0.001	0.006	0.988	0.255	dEMU	0.101	0.001	0.006	0.987	0.255
dEMU	0.074	0.001	0.005	0.996	0.227	dEU	0.098	0.001	0.006	0.956	0.241	dEU	0.099	0.002	0.006	0.956	0.243
gdpg	0.062	0.024	0.12	0.960	0.196	dist_inc	0.089	-0.001	0.004	0.020	-0.226	gdpg	0.087	0.029	0.134	0.939	0.214
dirta	0.061	-0.001	0.005	0.046	-0.189	gdpg	0.086	0.029	0.134	0.937	0.214	dist_inc	0.087	-0.001	0.004	0.019	-0.223
dist_inc	0.058	-0.001	0.003	0.016	-0.193	hhfa	0.081	-0.001	0.005	0.088	-0.190	dirta	0.082	-0.001	0.006	0.148	-0.159
hhfa	0.058	-0.001	0.004	0.051	-0.180	dirta	0.078	-0.001	0.006	0.146	-0.156	hhfa	0.081	-0.001	0.005	0.090	-0.189
gspriv	0.054	0.007	0.040	0.942	0.173	blnr	0.076	0.000	0.003	0.386	-0.054	blnr	0.078	0.000	0.003	0.390	-0.052
smcap	0.053	0.000	0.002	0.019	-0.176	smcap	0.076	0.000	0.002	0.041	-0.190	gspriv	0.076	0.008	0.046	0.895	0.178
blnr	0.052	0.000	0.002	0.234	-0.113	open_impbc	0.074	0.002	0.010	0.933	0.173	smcap	0.074	0	0.002	0.039	-0.188
open_impbc	0.051	0.001	0.009	0.981	0.170	gspriv	0.073	0.008	0.045	0.903	0.177	open_impbc	0.074	0.002	0.010	0.930	0.169
NMS	0.048	0.001	0.004	0.921	0.148	pc	0.072	0.001	0.004	0.862	0.161	pc	0.071	0.001	0.004	0.866	0.159
gfcfl	0.042	0.001	0.007	0.836	0.108	gfcfl	0.067	0.000	0.010	0.618	0.020	gfcfl	0.069	0.000	0.011	0.617	0.019
prop_rights	0.041	0.000	0.000	0.288	-0.062	NMS	0.066	0.001	0.004	0.855	0.138	NMS	0.067	0.001	0.004	0.856	0.139
pc	0.040	0.000	0.003	0.829	0.111	pop	0.065	0.034	0.294	0.736	0.117	pop	0.065	0.036	0.298	0.746	0.121
pop	0.039	0.022	0.226	0.734	0.099	prop_rights	0.064	0.000	0	0.396	-0.028	prop_rights	0.064	0.000	0	0.381	-0.033
open_nxhdp	0.037	-0.001	0.02	0.317	-0.071	capb	0.058	0.000	0.001	0.780	0.112	open_nxhdp	0.059	-0.002	0.025	0.351	-0.060
ito	0.036	0.000	0.001	0.134	-0.104	ito	0.058	0.000	0.001	0.196	-0.105	ti_full	0.058	0.000	0.002	0.855	0.116
remi	0.035	0.000	0.003	0.963	0.117	open_nxh	0.058	-0.002	0.025	0.327	-0.069	ito	0.058	0.000	0.001	0.194	-0.106
debt_issuance	0.034	0.000	0.001	0.239	-0.074	remi	0.057	0.000	0.003	0.929	0.127	capb	0.058	0.000	0.001	0.776	0.112
ti_full	0.034	0.000	0.001	0.886	0.101	ti_full	0.056	0.000	0.002	0.859	0.115	debt_issuance	0.057	0.000	0.001	0.362	-0.046
f_trade	0.033	0.000	0.000	0.084	-0.099	debt_issuance	0.054	0.000	0.001	0.371	-0.043	f_trade	0.056	0.000	0.000	0.102	-0.119
capb	0.031	0.000	0.000	0.715	0.071	f_trade	0.053	0.000	0.000	0.108	-0.113	remi	0.056	0.000	0.003	0.922	0.124
nct	0.029	0.000	0.001	0.485	-0.002	nct	0.050	0.000	0.001	0.509	0.005	nct	0.053	0.000	0.001	0.510	0.004
gdp_ppskm	0.028	0.000	0.001	0.595	0.026	gdp_ppskm	0.049	0.000	0.001	0.592	0.031	gdp_ppskm	0.050	0.000	0.001	0.587	0.030

Note: for explanations see main text. All numbers are rounded to three decimal places. CPS (Conditional Positive Sign) is the 'posterior probability of a positive coefficient expected value conditional on inclusion' (for details see Zeugner (2012)). *Source:* own calculation based on Eurostat (2013) and other sources given in the text.

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