METHODOLOGICAL ANNEX
TO THE ANALYSES OF THE CZECH REPUBLIC'S CURRENT ECONOMIC ALIGNMENT WITH THE EURO AREA

INTRODUCTION

This methodological annex accompanies the main text of the Analyses of the Czech Republic's current economic alignment with the euro area and presents their theoretical foundations (section A), the motivation for the individual analyses (section B) and the literature used (section C).

This annex is available as a separate document on the CNB website at http://www.cnb.cz/en/monetary_policy/strategic_documents/emu_accession.html. It will be updated as needed, i.e. not necessarily every year.

A   THEORETICAL FOUNDATIONS

The basic theoretical starting point for examining whether individual countries are good candidates for introducing a single currency is the theory of optimum currency areas.[1] In the context of the creation of the single European currency, knowledge of this theory is often used to assess the appropriateness of the adoption of the euro by the existing euro area countries and the rationality of the same step for the new EU Member States.[2] Factors that contribute to the benefits of the single currency (compared to a free nominal exchange rate) make up the set of optimum currency area properties.

Economists agree on the general fundamental costs and benefits of introducing a single currency, but the significance of the individual arguments may change over time or depending on the specific features of the economies concerned. The benefits include reduced international trade costs, in particular the elimination of exchange rate risk and the costs of hedging against it, as well as lower transaction costs and easier-to-compare prices. The costs include non-recurring ones stemming from the change of legal tender and long-term ones due to the risk of greater volatility in economic activity and consumption as a result of the loss of independent monetary policy and to a reduction in the effectiveness of domestic macroeconomic policy.

The key features determining the suitability of a country's participation in a currency area are similarity of transmission mechanisms and a high degree of economic integration. Similarity of transmission mechanisms ensures that the single monetary policy will not have different macroeconomic impacts in different parts of the monetary union. A high degree of economic integration increases the benefits arising from the single currency, as trade and investment barriers are eliminated. The latest empirical studies do indeed confirm that the introduction of the single currency has a positive effect on international trade.[3]

Business cycle alignment and similarity of shocks reduce the costs of giving up certain adjustment mechanisms on entering the monetary union. This is because aligned business and financial cycles mean that the single monetary policy is appropriate for all members of the monetary union. Mutual trade and structural similarity align business cycles, while differences in labour market regulation and differences in fiscal and structural policies reduce their alignment.[4] A further deepening of coordination of structural policies across countries is therefore important for greater alignment of business cycles in the euro area.[5]

The costs of joining the monetary union also depend on the economy's ability to make use of other adjustment mechanisms. These mechanisms include labour and product market flexibility and countercyclical fiscal policy. A flexible labour market and a mobile labour force can at least partly offset persisting asymmetric shocks in the monetary union. The loss of independent monetary policy can be offset to some extent by the use of fiscal policy. However, the countercyclical effect of fiscal

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[1] Mundell (1961), McKinnon (1963) and Kenen (1969) are regarded as the cornerstones of this theory. A newer literature survey can be found, for example, in De Grauwe (2013).

[2] In addition to economic arguments, the decision to adopt the euro is motivated by political and social demand, as analysed, for example, in Eichengreen (2008) and Spolaore (2013).

[3] The original literature was fairly optimistic as regards the effects of the single currency on trade. Rose (2000), for example, found effects amounting to hundreds of per cent. However, later studies – such as Baldwin (2006) – are far more sceptical, and Havránek (2010) even finds in a meta-analysis that the effect of euro adoption on trade between euro area countries is not statistically significant and with high probability is less than 5%. By contrast, the latest studies return to positive but somewhat lower estimates – see, for example, Glick and Rose (2016) and Rose (2016). Furthermore, Bergin and Lin (2012) present evidence that the effects of the single currency on trade may be visible before euro adoption and the effect of the single currency on trade is underestimated if this effect is not taken into account in empirical studies.

[4] Duran and Ferreira-Lopes (2015), Inklaar et al. (2008).

[5] Lukmanova and Tondl (2017).

policy is critically dependent on the shape of public finances, i.e. on whether fiscal policy has the necessary room for manoeuvre.[6]

Temporary effects of euro adoption may also be important for acceding countries. These effects include a fall in the risk premium, an easing of the credit conditions and changes in productivity in the tradable and non-tradable sectors.[7] Another potential cost for converging countries is a persisting inflation differential,[8] which may be reflected in a fall in real rates and thus have a temporary destabilising effect on the economy via macrofinancial linkages.[9]

The general principles are confirmed by analyses based on structural macroeconomic models.[10] The conclusion of the model analyses is that the costs increase as domestic demand shocks (fiscal shocks in particular) grow in importance and decrease as the degree of trade integration increases. For example, a simulation of the costs of euro adoption in Central European countries using a DSGE model concludes that the costs of the loss of independent monetary policy are high for the Czech Republic and Poland relative to Hungary because of the large significance of domestic demand shocks, such as shocks to government consumption.[11]

The attractiveness of entering the monetary union is also related to the effectiveness of its institutions.[12] Studies point out that the main problem in the euro area during the crisis was weak political integration.[13] Fiscal rules which could help create sufficient fiscal room before a crisis can only be effective if there is an institution to enforce them (however, the solution does not have to be a full fiscal union).[14] On the other hand, some studies argue that the euro area may be functioning and beneficial to all members even without a fiscal union, but only provided that rescue mechanisms are introduced within the banking union.[15] However, uncertainty about the future functioning of euro area institutions provides a rationale for new Member States to consider their entry thoroughly and to wait at least until the rules of operation of euro area institutions are clarified before joining the monetary union.[16]

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[6] Romer and Romer (2018), Babecká Kucharčuková and Brůha (2017).

[7] Ahrend et al. (2008) and Lin and Treichel (2012) point out that an excessive decrease in long-term interest rates (compared to that implied by the Taylor rule under independent monetary policy) after the adoption of the single currency in some economies gave rise to bubbles in asset markets, property markets in particular. Overvaluation of the real exchange rate, identified for Greece, Ireland and Portugal by El-Shagi et al. (2016), may also be a risk to macroeconomic stability.

[8] Brůha and Podpiera (2007).

[9] Examples for individual countries can be found in Martin (2010), Hampl and Skořepa (2011) and Lin and Treichel (2012).

[10] For example, Ferreira-Lopes (2010) explores the costs of euro adoption for Sweden and the UK, concluding that the costs of euro adoption would outweigh the benefits in these countries.

[11] Ferreira-Lopes (2014).

[12] For example, De Grauwe (2010a,b).

[13] Razin and Rosefielde (2012).

[14] Wyplosz (2015).

[15] Mongelli (2013). Similarly, a study by Neri and Ropele (2015) shows that the ECB's monetary policy helped reduce the impacts of the debt crisis even without fiscal coordination.

[16] Podpiera et al. (2015).

B MOTIVATION FOR THE INDIVIDUAL ANALYSES AND TECHNICAL DESCRIPTION OF THE METHODS USED

The specific analyses making up the core of the Alignment Analyses were performed on the basis of the theoretical considerations outlined in the previous section. As the basic theoretical starting point is the theory of optimum currency areas, the analyses focus on the symmetry and alignment of key economic indicators, the operation of adjustment mechanisms and the institutional set-up of the euro area.

For each of the analyses, the data sources used to calculate the indicators are presented, and where more sophisticated methods are used (going beyond a simple graphical comparison or simple sample-based statistics such as means, standard deviations and correlations) those methods are described in more detail.

Economic alignment of euro area countries

To assess the attractiveness of euro area entry, it is vital to evaluate whether economic developments are sufficiently aligned across the euro area countries. Any misalignment of the euro area itself reduces the attractiveness of entry, because such misalignment can be reflected in internal and external imbalances and can also increase the political risk of disintegration.

The economic alignment of the euro area countries was analysed using simple descriptive statistics – means, standard deviations and medians – of macroeconomic fundamentals (e.g. real GDP growth, the unemployment rate, the inflation rate and long-term interest rates). The individual descriptive statistics were calculated across countries, i.e. with no weight adjustment for the size of the given economy or the population of the given country. In addition to unweighted values, the charts show values for the euro area as a whole.

The data sources are Eurostat, the ECB and CNB calculations.

Real economic convergence

An unfinished process of real convergence before entering the monetary union constitutes a significant macroeconomic cost. This is because continuing convergence of output and productivity is connected with price level convergence, which is reflected in an inflation differential in the event of adoption of the single currency (whereas an economy with its own currency can converge through trend appreciation of the nominal exchange rate). The inflation differential resulting from the higher inflation would be reflected in lower real interest rates, leading to potential adverse effects on macrofinancial and overall macroeconomic stability. For these reasons, convergence of GDP, productivity, the price level, trend appreciation of the real exchange rate and, last but not least, relative wages, which reflect differences in productivity and the price level, should be monitored.

The comparison of GDP per capita at purchasing power parity (PPS – Purchasing Power Standard) and the average price level of GDP is based on Eurostat data. The wage level data are taken from the European Commission's AMECO database (indicator "Nominal compensation per employee: total economy") in both euro and PPS. The real exchange rate against the euro is based on the Harmonised Index of Consumer Prices. The average annual rate of real appreciation is calculated as the geometric mean of the exchange rate changes over the last ten years.

The outlook for future real appreciation for the next five years is based on two alternative estimates of panel data models which link the price level of final consumption of households with GDP at

purchasing power parity per capita for 36 European countries between 1995 and the latest available observation.[17]

Model I was estimated using a two-stage least-squares panel method with no fixed or random effects:

$P_{C,it} = 22.75 + 0.79\ GDP_{PPS,it} + 0.93\ AR(1)_{it}$,

where $P_{C,it}$ is the price level of final consumption of households in country i in year t, $GDP_{PPS,it}$ is its gross domestic product at purchasing power parity per capita (in both cases EA=100) and $AR(1)_{it}$ is the first-order autoregressive term.

Model II was estimated using the same method, but with cross-sectional fixed effects, which enable us to account for price level differences due to other structural country-specific characteristics not directly specified by the model. The estimate is as follows:

$P_{C,it} = 63.95 + FE_i + 0.28\ GDP_{PPS,it} + 0.72\ AR(1)_{it}$,

where FE_i is the fixed effect for country i and the other symbols are the same as in the previous equation.

The simulations of the future equilibrium pace of real exchange rate movements for individual countries take as their starting point the estimates of GDP and the price level for the current year. These are based on European Commission and Eurostat forecasts for real GDP growth, inflation and, as appropriate, the nominal exchange rates of their national currencies against the euro in that year. They also assume convergence of GDP towards the level of the EA at a rate of 2.5% a year. In the case of Model II, the simulations also account for the statistically significant positive relationship between the individual countries' fixed effects and their GDP per capita at purchasing power parity. It is therefore assumed for converging economies that their other, unspecified characteristics will converge towards the advanced euro area countries in parallel with convergence of GDP.[18]

Real interest rates are derived from three-month money market interest rates. The average annual level of nominal interest rates is deflated by the annual inflation rate for the country concerned, using the Harmonised Index of Consumer Prices. The estimate of real "equilibrium" rates going forward is based on the assumptions of full elimination of the money market risk premium thanks to euro adoption and an equilibrium three-month real rate in the euro area of 0.5%.[19] From this figure, the range of the estimates of future equilibrium real exchange rate appreciation for each of the countries (see above) is subtracted, corresponding to the future expected inflation differential vis-à-vis the euro area average.

Cyclical alignment of economic activity

In addition to long-term convergence of the level of economic activity, sufficient business cycle alignment is an important factor for the single monetary policy to be optimal for the acceding country. Cyclical alignment can be measured using the correlation of economic activity.

Mutual relationships between the rates of economic activity in individual countries and the euro area are assessed using the pairwise correlation coefficients applied to real GDP time series, industrial production indices (IPIs) and export indices, taking into account the different lags of the time series in the different countries relative to the euro area series. To identify the impact of the onset of the economic crisis on the size of the correlation coefficient, correlation coefficients are given both for the

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[17] See Čihák and Holub (2003, 2005).
[18] Convergence of GDP per capita at purchasing power parity of 1 pp will increase the estimated fixed effect of the country by 0.50 pp (i.e. it will reduce the negative fixed effect in the case of less advanced countries). The overall impact of convergence of GDP per capita of 1 pp is 0.78 (0.28 + 0.5) pp, i.e. it is similar as in Model I.
[19] Compared to the pre-2018 issues of the Alignment Analyses (as well as the assumptions of the CNB's forecasts), this assumption has been lowered by 1 pp owing to increasing empirical evidence of a marked decline in the euro area equilibrium real interest rate.

entire period of the last ten years and for the same period excluding 2008 Q4 and 2009 Q1 (October 2008 to March 2009 for IPIs).

Simple correlations are calculated over a moving time window to obtain the rolling correlation. The corresponding time window for a given quarter is defined as the last 20 observations (five years). The rolling correlation should help reveal trends in alignment.

When examining the alignment of cyclical behaviour between selected economies in order to assess the impact of economic policy, it is appropriate to monitor the correlation only within certain cycles. In the case of monetary policy, cycles of between one and a half and eight years long are usually considered. Cyclical correlation can be measured using frequency-specific correlation,[20] which is a function of the length of the cycle considered and, like simple static correlation, takes values in the range [-1,1]. High correlations at frequencies corresponding to business cycles indicate cyclical alignment, although the time series examined may differ in their high-frequency or trend components. The overall correlation is a weighted average of the partial correlations across the entire spectrum monitored.

The analysis uses seasonally adjusted quarterly real GDP time series at 2010 constant prices (expressed in national currencies), monthly time series of the Industrial Production Index adjusted for working days and seasonal effects, and quarterly time series of exports to the euro area expressed in the national currency. The time series enter the calculation as quarter-on-quarter and month-on-month differences of natural logarithms.

The source of the data on GDP, IPI and exports is Eurostat. Data on exports to the euro area are available only in euros in the IMF database, so they were converted into national currencies using average quarterly exchange rates according to Eurostat.

Structural similarity of the economies

The risk of asymmetric shocks to which monetary policy would not necessarily react to the necessary extent decreases with increasing similarity of the structure of economic activity between the acceding economy and the monetary union.

The structural similarity of the economies is measured using the Landesmann structural coefficient. The coefficient is calculated by comparing the shares of individual sectors, e.g. industry or construction, in total value added in the country under comparison vis-à-vis the reference country (i.e. the euro area). The difference between the shares is weighted by the share of the sector in the total. The weighted shares are then summed. The calculation of the coefficient can be expressed formally as follows:

$$\mathrm{SL} = \sum_{i=1}^{n} \sqrt{\left(\mathrm{sh}_A^i - \mathrm{sh}_B^i\right)^2 \cdot \left(\frac{\mathrm{sh}_A^i}{100}\right)}$$

,

where sh_A^i is the percentage share of the *i*-th sector in value added as a whole in the country under comparison and sh_B^i is the percentage share of the *i*-th sector in value added as a whole in the euro area.[21] The coefficient is normalised to SL/100 and therefore takes values in the range [0, 1]. The closer the coefficient is to zero, the more similar in structure are the economies.

The source of the value added data is Eurostat (gross value added at annual frequency).

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[20] Croux, Forni and Reichlin (2001).
[21] The structure of the coefficient is described in detail in Landesmann (1995) and also in Flek et al. (2001).

Integration of economies with the euro area

Strong trade and ownership integration with the euro area increases the potential benefits arising from the elimination of exchange rate risk and from transaction cost savings upon euro adoption. Strong intra-industry trade fosters cyclical convergence via the transmission of economic shocks and increases the symmetry of business cycles. Foreign investment can also increase economic alignment and, due to penetration of technology, also has a significant favourable effect on the productivity of domestic firms and therefore supports convergence.

The Grubel-Lloyd (GL) index was used to analyse intra-industry trade:

$$GL_t = 1 - \frac{\sum_i |X_t^i - M_t^i|}{\sum_i (X_t^i + M_t^i)}.$$

GL_t is the ratio of the absolute value of net intra-industry trade to foreign trade turnover. X_t^i and M_t^i denote the exports and imports of the country under review from/to the euro area of the *i*-th commodity at time *t*. The index takes values ranging from 0 to 1. A value of 0 means that all trade is inter-industry trade and that there is specialisation in different commodities. By contrast, a value of 1 indicates that all trade is intra-industry trade.[22]

The value of the GL index depends, among other things, on the level of detail of the branch breakdown. The breakdown according to the one- or two-digit SITC is a rather broader sector breakdown which may put together in one category branches whose output is not closely related,[23] resulting as expected in a higher value of this indicator for all countries. Although the qualitative message of the analysis is relatively independent of the degree of aggregation selected, the cross-country differences are largest when using the five-digit (most detailed) breakdown.

The Grubel-Lloyd index is calculated using data on total exports and imports to and from the euro area in the countries under review. To calculate the index, foreign trade is broken down on the basis of the five-digit SITC classification. The data source is the Eurostat COMEXT database.

The data source for foreign direct investment from euro area countries and direct investment in euro area countries is Eurostat (except in the case of Hungary, where the data source is the national central bank). Eurostat is also the source of the GDP data.

Financial cycle alignment

In pursuing its objectives, monetary policy affects the overall behaviour of the financial sector. Alignment of the acceding country's financial cycle with that of the monetary union is therefore important for the country's adoption of the single monetary policy. In the event of misalignment, the economic costs stemming from the loss of national monetary policy or from the limits imposed on national powers in macroprudential policy could be high.

To measure financial cycle alignment, a composite financial cycle indicator was constructed. It measures the position in the financial cycle in seven financial market segments characterising demand and supply factors and takes into account their degree of mutual synchronisation. The indicator contains time series of seven variables: the credit impulse to households and non-financial corporations,[24] the annual growth rate of property prices, the credit spread between the client interest rate on new loans to households and non-financial corporations and the interbank rate[25] and also includes consumer and business confidence indicators. The time series were first smoothed using a centred moving average with a window length of three quarters. The individual variables were then

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[22] Flek et al. (2001).
[23] This is particularly so in SITC 7 (Machinery and transport equipment).
[24] The credit impulse is the increase in the stock of loans relative to GDP. For more details, see, for example, Biggs, Mayer and Thomas (2009).
[25] The resulting value must then be multiplied by -1 so that the lowest (highest) value of the credit spread corresponds to the peak (trough) of the financial cycle.

transformed to the interval (0, 1) using an estimate of the empirical distribution function[26] so that high values correspond to an expansionary phase of the cycle and low values to its trough. This transformation was performed for the sake of mutual comparability of the input time series, which are measured in different units. The value of the indicators at time t is defined as

$$FCI_t = \bar{y}_t \times l_t$$

where $\bar{y}_t$ is a weighted average of the seven transformed time series $y_{i,t}$,

$$\bar{y}_t = \sum_{i=1}^{7} w_i y_{i,t}$$

and l_t is the highest eigenvalue of the covariance matrix C_t, which measures the degree of mutual (linear) dependence between the input variables relative to the overall dispersion (the trace of matrix C_t). The weights, w_i, set by expert judgement, take into account the importance of the variable in the description of changes in the financial cycle. Greatest weight is assigned to the credit impulse in the household sector and the non-financial corporations sector and to property price growth (0.22 in all cases). The weight of the credit spread for households and non-financial corporations is 0.12 for both series, and the confidence indicators for the two sectors have the lowest weight (0.05 each).

l_t measures the share of the data variability that can be explained by the first principal component and indicates the degree of synchronisation of the input variables. The higher is l_t, the higher is the proportion of the behaviour of the variables that can be explained by the effect of a single factor and the stronger is the signal regarding the shift of the economy further within the cycle. The covariance matrix C_t was estimated recursively using the EWMA method with smoothing factor $\lambda = 0.95$.[27]

$$C_t = \lambda C_{t-1} + (1 - \lambda)(\boldsymbol{y}_t - 0.5)'(\boldsymbol{y}_t - 0.5),$$

where 0.5 is the theoretical mean.[28] The results obtained using this method are identical to the estimate of the covariance matrix with weights that decrease exponentially into the past.

The correlation, or rather covariance, between the financial cycle indicator for the Czech Republic and the euro area was estimated in a similar way to the synchronisation of the individual variables. The only difference was that the theoretical mean of 0.5, which cannot be used for variables affected by the degree of synchronisation, was replaced by the actual sample average.

The data sources are the ECB, Eurostat, the BIS and national central banks.

Interest rate convergence

Alignment of short-term interest rates reflects the action of similar monetary conditions, i.e. the suitability of adopting the single monetary policy. Fundamentals-based convergence of long-term interest rates, which are primarily affected by how fiscal policy is conducted, is also suitable for acceding countries for smoother economic developments after accession to the euro area. If long-term rates are aligned, they will leave no room for an asymmetric shock associated with the one-off elimination of the risk premium upon euro adoption.

The data sources are Thomson Datastream (three-month interbank market rates) and Eurostat (ten-year government bonds).[29]

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[26] See, for example, Holló et al. (2012).
[27] Holló et al. (2012) work with $\lambda = 0.93$. This analysis uses a higher λ assigning a lower weight to the last observation because of the use of longer time series and the evaluation of longer-term synchronisation.
[28] See Holló et al. (2012).
[29] These series are compiled for the purposes of assessing the Maastricht convergence criterion on long-term interest rates and are based on the gross yield on government bonds on the secondary market with approximately ten years to maturity.

Exchange rate volatility and alignment

The major impulses affecting an open economy include non-fundamental exchange rate shocks. Under a floating exchange rate regime, low volatility of the exchange rate between two countries can be regarded as an indicator of their potential to share a single currency. A high correlation between the exchange rates of two currencies vis-à-vis a third, reference currency is a sign of a lower intensity of asymmetric shocks arising from non-fundamental exchange rate fluctuations, and therefore of a higher ability to share a common currency.

The historical exchange rate volatility is calculated as the standard deviation of the logarithmic daily exchange rate returns for a period of six months and is presented in annualised terms.

The implied volatility is derived from market prices of options using the given valuation model. This volatility is directly quoted in the trading system. The data source is Thomson Datastream.

Exchange rate alignment is measured using the time-varying correlation of the exchange rates of the national currencies and that of the euro vis-à-vis the US dollar as the reference currency.[30] The correlation coefficient at time *t* is based on a time-varying covariance matrix obtained using a GARCH model estimate[31] and is calculated according to the following formula:

$$corr_t = \frac{\mathrm{cov}(X/USD, EUR/USD)_t}{\sqrt{\mathrm{var}(X/USD)_t * \mathrm{var}(EUR/USD)_t}}$$, where *X* represents the national currencies.

This approach enables one to calculate a time-varying correlation coefficient, which provides more information than a constant correlation coefficient of the exchange rate of the national currency against the euro. A higher correlation means similar developments in exchange rate volatility (change), which can be interpreted as synchronisation of exchange rate shocks in the countries under review.

The analysis covers the last ten years. Daily data from Thomson Datastream were used.

Financial market alignment

In line with the definition of financial integration based on the law of one price, two methods can be used to measure financial integration: price-based measures and news-based measures. The more the individual segments of the euro-candidates' financial markets are integrated with the euro area, the more the prices of these assets will be affected by common (global) factors rather than by local (national) factors. It can also be expected that with growing integration the individual segments of the financial market will be a less likely source of asymmetric shocks.

Price-based measures

The concept of sigma-convergence focuses on the dispersion of the yields on identical asset types in different countries at a given moment in time. It thus identifies the degree of integration vis-à-vis the benchmark country achieved at that moment in the individual selected financial market segments. A sigma (σ) close to zero indicates low dispersion. To quantify sigma-convergence, a calculation is used of the (cross-section) standard deviation, according to the formula:

$$\sigma_t = \sqrt{\frac{\sum_{i=1}^{N}(Y_{i,t} - \bar{Y}_i)^2}{N-1}}$$

where Y is the asset yield, $\bar{Y}$ is the mean value of the yield over time *t* and *i* stands for the individual countries (i = 1, 2, …, N). For the purposes of this analysis, we use N = 2, i.e. we explore the

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[30] This calculation was inspired by Aguilar and Hördahl (1998).
[31] The bivariate BEKK GARCH specification is used; see Engle and Kroner (1995).

evolution of sigma-convergence over time between the euro area and one of the countries under review.[32] For graphical illustration, the results were normalised over the whole time period and filtered using the Hodrick-Prescott filter with the recommended weekly time series coefficient λ = 270,400.

News-based measures

This method (Baele et al., 2004) assumes that local shocks, which get more alike with increasing integration, can be diversified in an integrated region by investment in other comparable assets. In line with these assumptions, the price movements of a benchmark asset should reflect all relevant common (global) news. So, in a fully integrated market, the price changes of an asset in a single country should not be systematically higher or lower than the price changes of the benchmark asset. Quantification of the degree of shock integration can be estimated for the money, foreign exchange and government bond markets using the following regression:

$$\Delta Y_{i,t} = \alpha_{i,t} + \gamma_{i,t} \Delta Y_{b,t} + \varphi_{i,t}$$

where $\Delta Y_{i,t}$ represents the change in individual asset yields in country i at time t, b denotes the benchmark country (Germany for the government bond market, otherwise the euro area), $\alpha_{i,t}$ is a specific constant for each country, $\gamma_{i,t}$ denotes the strength of the transmission of the change in the benchmark asset yield to the relevant asset of country i and $\varphi_{i,t}$ is a random term. An increase in this type of integration requires α to converge to zero, γ to converge to one and the ratio of the variances of coefficients γ (for benchmark and national assets) to be close to one. The time-varying parameters γ were estimated using recursive estimation.

The magnitude of parameters γ expresses the degree of identical response of an asset of a selected country and a comparable benchmark asset to certain news.

The calculations for both measures of financial integration were carried out using weekly data (daily data averages) from Thomson Datastream, covering the period January 2002 to June 2018. Three-month interbank rates were used for the money market, national currencies quoted against the US dollar for the foreign exchange market, five-year government bonds for the bond market and national stock indices for the stock market. The relevant time series were adjusted for exchange rate effects.

Financial system

The similarity of the financial systems of the Czech Republic and the euro area indicates how similarly the transmission of monetary policy from monetary policy rates (or other monetary policy instruments) to real economic activity and especially to inflation will work in the Czech Republic. This is important for considering how appropriate the settings and impacts of the single monetary policy will be for the Czech economy.

Depth of financial intermediation (the ratio of financial sector assets to GDP at current prices) expresses the asset strength of intermediation by banks and non-bank financial institutions: insurance corporations, pension funds, credit unions, management companies and investment funds (unit trusts), financial leasing corporations and other financial corporations (forfaiting and factoring companies, investment firms, bureaux de change, etc.). Generally speaking, the more advanced the market, the larger the assets and the deeper the financial intermediation relative to GDP.

Indebtedness of the private sector (the ratio of the gross book value of loans to non-bank clients – corporations and households – to GDP at current prices) expresses the level of lending by banks.

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[32] For pairs of countries, the calculated values in each period are essentially equal to half the square of the yield differential.

Usually, the more advanced the market, the larger this ratio, but an excessively high value may reflect overleveraging of the private sector.

The data sources are Eurostat, the ECB, national central banks and IMF IFS.

Structure of financial assets and liabilities of corporations and households

A similar financial position and structure of financial assets and liabilities of sectors of individual economies is one of the key conditions for the single monetary policy to have a symmetric effect. The similarity of the structure of the financial assets and liabilities of Czech households and non-financial corporations with that of the euro area can be assessed using the Landesmann index.

The Landesmann structural coefficient (the structure of which is described in more detail above in the section *Structural similarity of economies*) is calculated by comparing the shares of individual financial instruments on the asset side of the household balance sheet in the total assets of this sector in the country under comparison relative to the reference country (i.e. the euro area). In the case of non-financial corporations, assets are replaced by liabilities. The side of the balance sheet that better characterises the sector's activity and is more important to it is therefore used for each sector. The coefficient takes values in the range [0, 1]. The closer the coefficient is to zero, the more similar in structure are the economies.

Quarterly financial accounts data published by national central banks and the ECB are used as the input data for the analysis of the alignment of the structure of the financial assets and liabilities of non-financial corporations and households. The quarterly financial accounts are compiled according to ESA 2010 methodology. In line with national accounting, a unified classification of institutional units and financial instruments is being promoted. As regards institutional units, the analysis provides a detailed examination of real sectors, i.e. non-financial corporations (S.11) and the merged sector of households (S.14) and non-profit institutions serving households (S.15). The analysis distinguishes six main types of financial instruments: currency and deposits, securities other than shares, loans, shares and other equity, and other accounts receivable/payable including insurance technical reserves and financial derivatives.

The analysis works with outstanding amounts of financial assets and liabilities as at the end of the period (quarter) under review. Consequently, the effect of transactions, revaluation and other changes in the volume of assets/liabilities on the change between the initial and final balance in each quarter is not explicitly taken into account.

Effect of monetary policy on client interest rates

A similar function of the interest rate channel of monetary policy, i.e. transmission of changes in financial market interest rates to client rates, is a prerequisite for successful functioning of an economy under a single monetary policy.

The interest rate sensitivity of loans to non-financial corporations and loans for house purchase is expressed by the breakdown of new loans by initial interest rate fixation period. Subsequently, the degrees of similarity between the breakdown of loans in the Czech Republic and in the other countries under review are compared with that for the euro area as a whole.

Average weighted interest rates on new business, which reflect the rates agreed for all new business during the month, and three-month money market interest rates were used in the graphical comparison of interest rate spreads between client and market rates.

The data sources are the ECB and the CNB.

Spontaneous euroisation

A high degree of euroisation, i.e. substitution of the domestic currency with a foreign one (the euro) to provide the functions of money as a medium of exchange and a store of value, disrupts the functioning of independent monetary policy but reduces the relative costs of adopting a common currency. Spontaneous euroisation is usually motivated by domestic factors such as low confidence in

the domestic currency or high trade integration with the euro area. Moreover, elevated demand among economic agents for foreign currency loans and deposits (financial euroisation) may pose a risk to financial stability in the event of a sharp depreciation of the domestic currency.

Spontaneous euroisation is analysed using data on the shares of foreign currency (euro-denominated) loans and deposits in the total loans and deposits of non-financial corporations and households with domestic banks (financial euroisation). Its degree is compared in the Czech Republic and selected Central European countries, i.e. Poland and Hungary, using ECB data. In addition, the symmetry/asymmetry of the evolution of the shares of foreign currency loans and deposits in individual economic sectors in the Czech Republic is assessed using CNB data. The Czech Republic's trade integration with the euro area was calculated as the ratio of exports to GDP. The analysis also covers the effect of the interest rate differential on loans in domestic and foreign currency on demand for foreign currency loans using ECB data. The interest rate differential is calculated from interest rates on new large loans to non-financial corporations (loans of over EUR 1 million).

In addition, the degree of the use of the euro in domestic supplier-customer transactions of domestic corporations and the level of hedging of domestic corporations' exports using standard futures are analysed using data from the survey of non-financial corporations conducted by the CNB and the Confederation of Industry of the Czech Republic.

The analysis of financial euroisation covers the last ten years and that of the domestic supplier-customer euro transactions of corporations covers the last seven years, i.e. the period for which the survey is available.

Inflation persistence

The ability of the economy to absorb shocks effectively and the functioning of monetary policy are also reflected in price flexibility and inflation persistence, i.e. the speed at which inflation returns to equilibrium after a shock. Significant differences in inflation persistence in the countries of a monetary union cause the single monetary policy to have asymmetric impacts and thereby increase the macroeconomic costs of the monetary union.

Inflation persistence is measured as the sum of autoregressive coefficients. The results of modelling inflation persistence are largely dependent on the assumption made regarding the mean to which inflation converges.[33] If the inflation time series contains structural changes or breaks which the model process does not allow for, the inflation persistence estimate is typically biased upwards. Because of the transformation process, accompanied by disinflation, price convergence, gradual price deregulation and changes in monetary policy regime, it is the time series of transition countries that are most affected by breaks in the mean values of inflation. The method used therefore models the autoregressive process with the mean value of inflation changing over time. The following model is used:

$$\pi_{t+1}^{T} = \pi_{t}^{T} + \eta_{1t}$$

$$\pi_{t+1}^{P} = (1-\delta)\pi_{t}^{P} + \delta\pi_{t+1}^{T}, 0 < \delta < 1,$$

$$\pi_{t} = \left(1 - \sum_{i=1}^{4}\varphi_{i}\right)\pi_{t}^{P} + \sum_{i=1}^{4}\varphi_{i}L^{i}\pi_{t} + \varepsilon_{1t}, \sum_{i=1}^{4}\varphi_{i} < 1,$$

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[33] Marques (2004) and Cecchetti and Debelle (2006).

where π_t^T is medium-term inflation (or the central bank's implicit inflation target), π_t^P is the inflation target perceived by the public, η_{1t} and ε_{1t} represent independent white noises, L^i is the lag operator and $\sum_{i=1} \varphi_i$ is the sum of autoregressive coefficients, which measures inflation persistence. Inflation π_t is the observed variable. The Kalman filter and Bayesian estimation are used to estimate the model parameters.[34]

Quarterly data on HICP inflation (annual HICP changes) for the last ten years are used for the calculation. The data source is Eurostat.

Fiscal policy

Following the loss of independent monetary policy, fiscal policy will play a key role in stabilising the economy in the event of asymmetric shocks. Effective use of the stabilising function of fiscal policy is conditional on the creation of room for the free operation of automatic fiscal stabilisers, which can dampen shocks without the need for ad hoc discretionary measures. If discretionary measures are necessary, fiscal policy should be countercyclical, i.e. discretionary measures – like automatic stabilisers – should stimulate aggregate demand during recessions and dampen it during expansions. The adoption of discretionary measures should not jeopardise the fulfilment of obligations arising for EU Member States from European fiscal rules.

Effective use of the stabilising function of fiscal policy is thus conditional on sound public finances, the presence of automatic stabilisers, sufficient public budget flexibility, which can be assessed using, for example, the size of non-mandatory expenditures, and last but not least long-term fiscal sustainability. The current situation of, and outlook for, Czech public finances, including an assessment of their sustainability, are therefore important measures of the economy's preparedness to join the monetary union.

The implementation of national fiscal policies in the EU is coordinated so as to ensure fiscal discipline of the Member States. In addition to the fulfilment of the fiscal convergence criteria, EU fiscal rules require the fulfilment of a medium-term objective (MTO) aimed at creating sufficient room for the stabilising function of fiscal policy to operate. The MTO is defined in the form of the structural balance expressed as a percentage of GDP; for the Czech Republic, it is set at -1%.

The structural balance is the general government balance adjusted for the effect of economic developments and one-off measures. The effect of economic developments is expressed by the cyclical component of the general government budget balance, which can be estimated using two basic methods. The two methods provide somewhat different results. When interpreted correctly, however, they are sufficient to identify the basic characteristics of fiscal policy and the main trends in public budgets.

 (i) The first, older, method is based on estimating the production function and determining the sensitivity of the general government budget balance to the output gap (the total budgetary elasticity). This approach is used by the European Commission and other international institutions (OECD, IMF).

(ii) The alternative approach to calculating the cyclical component was introduced by the ECB in 2001 (the ESCB method). This approach is based on the relationship of individual revenue and expenditure items of the general government budget sensitive to economic developments to their macroeconomic bases. The estimate of the cyclical component is derived by using the deviations of the macroeconomic bases from their trend (obtained using the HP filter) and linking the partial elasticities

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[34] The methodology draws on the article by Franta, Saxa and Šmídková (2007), where it is applied to data from a different source and period.

of tax/expenditure items to the macroeconomic bases. The output gap thus does not enter this calculation. Moreover, three of the five macroeconomic bases used are labour market variables, and economic shocks affect the labour market with a time lag and hence do not reflect changes in GDP immediately.

The European Commission assesses fiscal sustainability at EU level, regularly publishing an Ageing Report and a Fiscal Sustainability Report. The former presents a detailed estimate of the future path of age-related expenditures in EU countries, while the latter assesses the public finance sustainability of EU countries in the short, medium and long term.

For internal analytical purposes, the CNB has developed its own model of Czech public finance sustainability.[35] The model aims to show the main trends in government debt in relation to the demographic forecast, population ageing costs and other selected parameters. Using model scenarios, we can then assess possible legislative and economic changes relating to the pension system, health care, taxes and so on, and simulate various debt paths depending on expected financial market developments.

All the fiscal figures commented on in the document are based on the ESA 2010 methodology, which is the key methodology with regard to considerations of euro area accession. The exception is the table covering mandatory and quasi-mandatory expenditures in the Czech Republic, which uses figures from the state budget, which is monitored on a cash (non-accrual) basis.

The data sources are the CZSO, the CNB, the Ministry of Finance of the Czech Republic, Eurostat and the European Commission.

The labour market and the product market

Labour market and product market flexibility is another mechanism through which the economy can cope with asymmetric shocks in a monetary union. There are numerous measures of labour market flexibility, including long-term unemployment, the unemployment trap and labour mobility (both regional and international), via which the economies of the member states are able to absorb asymmetric shocks, especially longer-term ones, thanks to change in the labour supply.

Labour market flexibility, product market flexibility and the quality of institutions can be measured using various composite indicators; the Global Competition Index was chosen for this document. Higher values of this index should be associated with a greater ability of economies to overcome adverse shocks.

Long-term unemployment is analysed by comparing the long-term unemployment rate (the share of those unemployed for twelve months or more under ILO methodology in the labour force). The data source is Eurostat.

Regional differences in unemployment are measured by the coefficient of variation. The coefficient of variation in the regional unemployment rate is the ratio of the standard deviation weighted by district size to the average unemployment rate. The size of the coefficient of variation depends on the degree of disaggregation. Data for similar region sizes (e.g. NUTS II or NUTS III) and the evolution of the coefficient of variation over time can be used for comparison. The data source is Eurostat.

The CZSO publishes the volume of internal migration (movement between municipalities). Data on registered internal migration in other countries are published in statistical yearbooks. In the Czech Republic, migration of foreign nationals with long-term residence (over 1 year) is included in the statistics.

International mobility is assessed using foreign migration and the proportion of foreign nationals in the population. The source of the data on registered international mobility for individual countries (immigration and emigration) and the proportion of foreign nationals in the population is Eurostat.

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[35] Ambriško et al. (2017).

The sources of the other data are the MLSA, the CZSO and the OECD.

Methodology of the Global Competitiveness Index 4.0

The Global Competitiveness Index (GCI), published by the World Economic Forum (WEF), defines competitiveness as the set of institutions, policies and factors that determine a country's level of productivity and hence also its economic growth. The index methodology was updated in 2018, when the Global Competitiveness Index 4.0 (GCI 4.0) was created. The main motivation for developing the GCI was to provide a more appropriate description of productivity and associated economic and social relations in the era of the ongoing Fourth Industrial Revolution.

The GCI 4.0 covers a sample of 140 countries and explains more than 80% of the differences in income levels and 70% of the differences in long-term economic growth between countries and economies. A positive and relatively close correlation between economic level as measured by GNI per capita and the GCI 4.0 has also been demonstrated. The link between quality of institutions and GNI per capita can be described with a similarly close relationship. Another interesting finding is that there is a positive correlation between the openness and the competitiveness of an economy, regardless of how advanced the country is. These relationships also apply to the substantially smaller sample of eight countries selected for comparison in this document.

The marked change in the GCI is mainly due to the fact that the number of indicators monitored has been reduced from 114 to 98. Only 34 indicators have been retained from the previous issue, while the other 64 indicators are completely new. The indicators monitored and assessed in the GCI 4.0 are divided into four sub-indices and further broken down into 12 pillars. These 12 pillars are assessed separately; the clustering into sub-indices serves only for better orientation and is of no major importance, unlike in the previous version of the index. The computation of the GCI 4.0 is based on successive aggregations of scores from the most disaggregated indicator level all the way up to the overall index for the country. The arithmetic mean is generally used for the most disaggregated categories and weighting is applied to the higher aggregation levels. All the indicators are assessed using the same weights for each country.[36]

In line with economic theory, the GCI 4.0 identifies all the major factors associated with productivity and economic growth in the era of the Fourth Industrial Revolution. Maintaining and developing competitiveness hinges primarily on having well-functioning public and private institutions (Pillar 1), a well-developed infrastructure (Pillar 2), the ability to use information and communication technology appropriately (Pillar 3) and a stable macroeconomic environment (Pillar 4). No less important is human capital, i.e. health and skills (Pillars 5 and 6). The quality of the market environment is also significant. This area focuses on a country's ability to provide an even playing field for firms on the product market (Pillar 7), the flexibility of the labour market (Pillar 8), the availability of financial capital (Pillar 9) and the overall market size (Pillar 10). The final category – called "Innovation ecosystem" – indicates the private sector's capacity to generate and adopt new technologies (Pillar 11) and the quantity and quality of research and development (Pillar 12).

The pillars are assigned to the sub-indices as shown in the following table:

Sub-index	Pillar
Enabling environment	Institutions
	Infrastructure
	ICT adoption
	Macroeconomic stability

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[36] A detailed description of the calculation of the Global Competitiveness Index 4.0 can be found at: http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf

Sub-index	Pillar
Human capital	Health
	Skills
Markets	Product market
	Labour market
	Financial system
	Market size
Innovation ecosystem	Business dynamism
	Innovation capability

The banking sector and its shock-absorbing capacity

The condition of the financial sector plays an important role in the economy's ability to absorb economic shocks. In particular, stability of the banking sector, which accounts for the bulk of the total assets of Czech financial institutions (except the CNB), is of key importance in the Czech Republic.

Return on equity (RoE, %) refers to net profit per unit of invested capital. It can be regarded as a measure of profitability of the banking business, assessing its economic efficiency.

Non-performing loans (NPLs)/total loans (%) – NPLs ("loans in default" in Czech accounting terminology) in gross book value as a percentage of total loans in gross book value express how large or how concentrated is the credit risk faced by the country's banking sector. NPLs are loans that are classed as substandard, doubtful or loss loans.

The capital ratio (%) – the ratio of a bank's capital to the coverage of unexpected losses from the risks it undertakes – assesses the outlook for a bank's financial situation and indicates its ability to cover potential future losses with capital. The capital ratio is an aggregate indicator reflecting all activities of a bank (both balance sheet and off-balance sheet) as well as the potential losses (reducing profit) which a bank may incur from the risks it undertakes and the impairment of assets.

The ratio of deposits to loans provided (deposits/loans to residents) expresses the extent to which loans provided are financed by deposits of private sector residents. Values of this indicator above 100% indicate that banks have a sufficient volume of deposits relative to the volume of loans provided and their long-term financing is thus less dependent on other sources.

The data sources are the CNB, the ECB, national central banks and IMF FSI.

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