LIMITS OF FORECASTING IN THE FACE OF ECONOMIC SHOCKS: A CASE STUDY OF THE CZECH REPUBLIC (2006–2024)

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Abstract

This paper aims to analyze the accuracy of macroeconomic forecasts issued by the Ministry of Finance of the Czech Republic in the period of three major global shocks: the 2008–2009 financial and debt crisis, the COVID-19 pandemic, and the Ukrainian war. The analysis is based on Theil's coefficient, which quantifies the deviation between forecasted and actual values of GDP and inflation. The results show that in all three unexpected events, forecast accuracy significantly deteriorated following the onset of shocks, regardless of whether early warning signs were observable. The study highlights the limitations of quantitative models in predicting the effects of shocks and emphasizes the need for systematic integration of qualitative analysis and scenario-based approaches into the forecasting process. The paper recommends developing an early warning framework based on expert risk assessment as a complement to standard model-based forecasting.

Key words: Forecast; economic growth; demand shocks, supply shocks

JEL Code: E37, E66, C53

Introduction

Since 1995, the Ministry of Finance of the Czech Republic has been preparing and publishing its Macroeconomic Forecast every quarter. The forecast is based on the results of the macroeconomic model of the Czech economy HUBERT, which is a simple dynamic stochastic general equilibrium (or DSGE) model. Similarly, the Czech National Bank uses the DSGE model g3+.

DSGE models generally work with a time series of macroeconomic variables in combination with calibrated parameters and modeled stochastic shocks. For example, the HUBERT model uses, among others, quarterly time series of real and nominal GDP, consumer price index, or GDP deflator. The model parameters are calibrated based on the professional literature; for the calibration method (Štork, Z., Závacká, J., & Vávra, M. 2025). The HUBERT model also allows the simulation of fiscal and monetary shocks or technological and external shocks. The shocks are simulated using first-order autoregressive processes. This simulation describes how the variable develops over time based on its past.

From a brief description of the HUBERT model, it follows that the prediction is based mainly on information about past economic development. This is not a specific feature of the HUBERT model, but a general feature of DSGE models. The authors of the prediction are of course aware of this. In the next phase, the model results are therefore evaluated by experts, and the final result is compared with the forecasts of other domestic and foreign institutions. In this context, the Ministry of Finance organizes a colloquium of experts twice a year. For example, in May 2025, the colloquium assessed 19 forecasts of the development of the Czech economy for the years 2025 to 2028 (Ministry of Finance of the Czech Republic, 2025).

From this brief description, it follows that predictions are essentially based on past data. The success of forecasts is based on the assumption of smooth, stable economic development. Appropriately calibrated models can also derive the reaction of the economy to unexpected internal (demand or supply) and external (e.g., political and technological) shocks.

However, models cannot predict the shocks themselves. This is a matter of expert estimates. Shocks are by their nature unexpected events, but they do not come "out of the blue", they are usually preceded by some symptoms. The question is whether experts can identify symptoms of the "unexpected" event in advance and adequately project them into the model.

In the last twenty years, three significant, global shocks with a direct impact on the Czech economy can be found.

The global financial crisis and eurozone debt crisis. In September 2008, the collapse of Lehman Brothers investment bank (related to the US mortgage market crisis) triggered the global financial crisis. Following global developments, the Czech Republic experienced a recession in 2009 and the following years, 2011 and 2012. The second part of the recession was related to the eurozone debt crisis and domestic fiscal restrictions.

COVID-19 pandemic. The virus causing COVID-19 was first identified in China in December 2019. In response to the global pandemic, the first widespread measures (closed schools, shops, restrictions on mobility) were adopted in the Czech Republic in March 2020. The measures resulted in a recession in 2020 when GDP fell by 5.5% year-on-year.

War in Ukraine and energy crisis. In late February 2022, Russia launched a military offensive against Ukraine. The invasion resulted in a reduction in natural gas supplies from Russia and an interruption in trade flows with Russia and Belarus due to sanctions, which in particular caused a significant increase in energy prices. The result was a “standard” supply shock, with the average annual inflation rate reaching 15% in 2022 and 10% in 2023. Inflation was accompanied by an output stagnation in 2023; real GDP decreased by 0.1% year-on-year.

1 Hypothesis

Each of these shocks may or may not have had certain symptoms that indicated its arrival. In retrospect, the signs of the mortgage crisis were obvious. However, some investors were able to identify this danger in advance, invest appropriately, and realize significant profits. A "classic" example is the hedge fund Scion Capital managed by Michael Burry. The fund achieved a profit of approximately USD 725 million in 2008 (+489% after fees). A direct analysis of Burry's strategy is presented by Pedersen, LH (2009) or Lo, AW (2012), and Burry's approach is also touched upon in studies dedicated to the prediction of the 2008 crisis, e.g., Fostel, A., & Geanakoplos, J. (2012) or Bengtsson, E. (2013). The primary materials are Scion investment letters Capital from 2001 to 2008, see Burry, M.J. (2001–2008).

Our analysis failed to identify any studies published before December 2019 that addressed the potential COVID-19 pandemic economic effects. It is therefore reasonable to assume that the COVID-19 pandemic could not have been included in the considerations of the macroeconomic forecasts for 2009.

The Crimean crisis and the hybrid war in Donbas lasted in varying degrees of intensity from 2014 to early 2022. In February 2014, Russian troops without designation occupied key locations in Crimea, and in March 2014, Russia officially annexed Crimea. Subsequently, the war in Donbas began between the Ukrainian army and pro-Russian separatists. From this perspective, it was possible and appropriate to consider the economic consequences of a scenario that would lead to a deepening of the conflict, restrictions on energy supplies from Russia, and disruption of trade with this country.

From the above, it follows that in two cases it was possible to observe symptoms (i.e., in the case of the global financial crisis and the eurozone debt crisis, as well as in the case of the energy crisis associated with the war in Ukraine). In the third case (the COVID-19 pandemic), the symptoms were not observable. Based on these facts, the tested hypothesis can be formulated: *the lowest accuracy of predictions can be expected in the case of the COVID-19 pandemic, compared to the two other shocks.*

2 Methodology

There are several tools and methods used to measure how close forecasts or predictions are to actual outcomes, for example, mean absolute error, root mean square error, mean absolute percentage error, or R-squared (coefficient of determination). Theil's Inequality (or Accuracy)

Coefficient (TH) exists in several versions. Let P is the forecasted value, y is the real value of the variable and i is time. Then, we can express Theil's Coefficient as:

$$TH1 = \frac{\sqrt{\frac{1}{n}}\sum_1^n (Pi-yi)^2}{\sqrt{\frac{1}{n}}\sum Pi^2 + \sqrt{\frac{1}{n}}\sum yi^2} \quad (1)$$

In this version of Theil's Accuracy Coefficient TH1, a value close to 0 indicates a highly accurate forecast, while a value near 1 indicates poor prediction.

$$TH2 = \frac{\sqrt{\frac{1}{n}}\sum_1^n (Pi-yi)^2}{\sqrt{\frac{1}{n}}\sum (y_i - y_{i-1})2} \quad (2)$$

TH2 variant compares the forecast accuracy against a naïve method that is based on static adaptive expectations. If TH2 < 1, the forecast is better than a naïve prediction. If TH2 > 1, the naïve method performs better.

The Theil's Accuracy Coefficient can also take the form:

$$TH3^2 = \frac{\sum (yi-Pi)^2}{\sum yi^2} \quad (3)$$

$$TH3 = \sqrt[2]{TH3^2} \quad (4)$$

In this case of Theil's coefficient, we calculate the percentage magnitude of the estimate error, i.e., the smaller its value the better the extrapolation of the observed variable is. If the coefficient is close to zero, it indicates a highly accurate forecast, while higher values suggest greater errors. This formulation is similar to the mean squared error but expressed as a ratio, helping to evaluate relative forecasting performance.

In the following parts of the contribution, the third version of Theil's coefficient will be applied. We apply the same time perspective to all three unexpected events described in the section Introduction. We monitor the accuracy of the prediction three years before the shock occurred. We then extend the period of study to four years by adding data from the year of the turning point to the original three-year period. We monitor the accuracy of the forecasts four years later. We are talking about forecasts that were published one or two years before the actual state of the indicator was achieved. For example, if the real value of the inflation rate is from year (i), we regard forecasted inflation rates from years (i – 1) and (i – 2).

3 Results

In this section, we will present the results of an analysis that was intended to show whether experts were able to identify and include at least one of the aforementioned three shocks in

time. The paper presents an assessment based on a combination of Theil's coefficients and graphical analysis.

Economists overwhelmingly consider **the global financial and debt recession of 2008–2009** to be the result of a negative demand shock, although the recession contained some elements of a supply shock (Blanchard, O. 2009) or (Ahearne, A. G., & Fernald, J. G. 2010).

In standard macroeconomic theory, the global financial crisis caused a sharp contraction in demand, resulting in falling output and inflation. The statement is also valid for the Czech Republic. In 2009, real GDP fell by 4.7%, while the rate of inflation decreased from 6.3% in 2008 to 1%.

An analysis of the accuracy of the predictions of the Ministry of Finance of the Czech Republic for the years 2006 to 2011 is contained in the article (Soukup, J. 2012). Here we will only summarize its basic conclusions.

Analysis shows that the annual growth of real output estimated by the Ministry of Finance for the years 2006 to 2008 was relatively accurate. The problem is connected with the same variable estimate for 2009. The forecast failed to determine the breakpoint in the economic cycle and failed to identify in advance the beginning of the recession. It is fully valid for a two-year forecasting time horizon, and even for the annual time horizon.

The forecasts of the annual rate of inflation were more accurate than the real GDP growth forecasts. However, it is true that the prognosis accuracy decreased in connection with the 2009 recession.

From a quantitative perspective, these conclusions are illustrated in Table 1. Here, the Theil coefficients for GDP and rate of inflation predictions with one- and two-year horizons are presented. The Theil coefficient for the relatively stable period of 2006 to 2008 reached the value TH = 46% for the two-year forecast and 38% for the annual forecast. Let us add the year 2009 and consider the accuracy of the forecasts for the years 2006 to 2009. The Theil coefficient value now increases, to TH = 101% for the two-year forecast and TH = 96% for the annual forecast.

Tab. 1: Theil's Coefficients

Period	Theil's Coefficient			
	GDP Forecast		Inflation Rate Forecast	
	2 years before	1 year before	2 years before	1 year before
2006 - 2008	**0.46**	**0.38**	**0.45**	**0.4**
2006 - 2009	1.01	0.96	0.48	0.47
2017 - 2019	**0.45**	**0.49**	**0.30**	**0.34**
2017 - 2020	1.18	0.95	0.34	0.33
2017 – 2019, 2022	0.42	0.49	0.84	0.74

Source: Soukup, J. 2012 for years 2006 - 2011; own computation for years 2017 - 2024

Let us move on to the second and completely unexpected event, **the COVID-19 pandemic**. Economists consider the pandemic shock as a combination of supply and demand shocks, with different types of shocks dominating at different stages of the pandemic (Brinca, P., Duarte, J.B., & Fariae Castro, M. 2020), (Gopinath, G. 2020, March 9), or (Guerrieri, V., Lorenzoni, G., Straub, L., & Werning, I. 2022). In the early phase (spring 2020) it was a supply shock (lockdowns, production outages), which was accompanied by a sharp demand shock, mainly in services. In the next phase (2021–2022), demand recovered faster than supply, mainly thanks to government support, but supply problems persisted.

From a theoretical point of view, negative supply shocks increase inflation and reduce output, while negative demand shocks deepen the decline in output, but on the contrary act against the growth of inflation (and thus at least partially compensate for supply-side inflationary pressures). Therefore, with this combination of demand and supply shocks, it is reasonable to expect a larger fluctuation in output than in inflation. This is confirmed for the Czech Republic by the data from the tables in the annexes. In 2020, there was a 5.3% decline in GDP, but the change in the rate of inflation was not significant.

Figure 1 illustrates the Czech real GDP annual growth from 2017 to 2024 (solid line). The dashed line indicates a prediction with an annual forecasting time horizon: e.g., the 2020 prediction was published in August 2019. The dotted line indicates a prediction with a two-year forecasting time horizon: e.g., the 2020 prediction was published in August 2018.

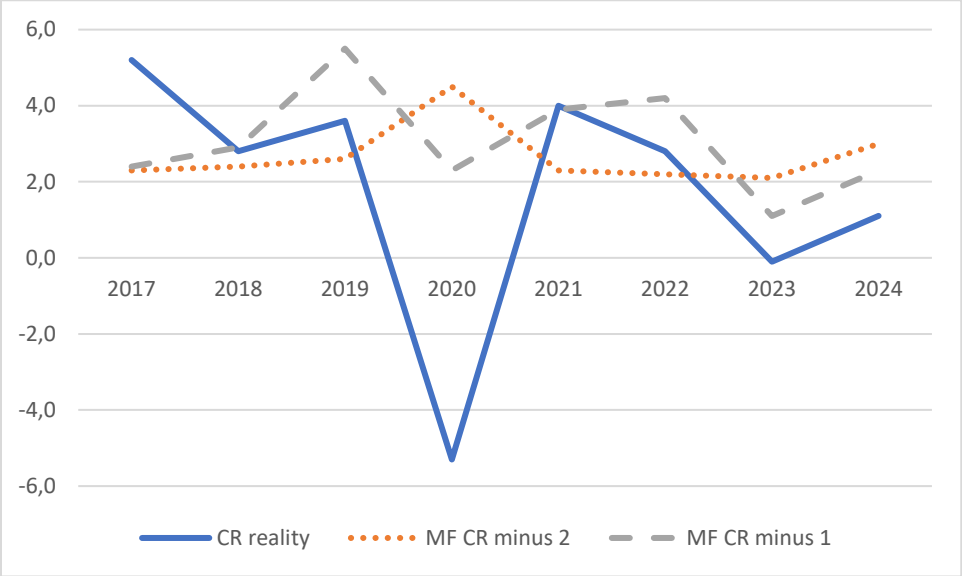
The figure shows that analysts were able to fairly reliably estimate real GDP growth in forecasts for years when there were no significant changes in this variable, i.e., for the years 2017 to 2019. However, excessive optimism is reflected in the forecast of real GDP growth for the Covid year 2020, which was published both in August 2019 and August 2018. Here, analysts failed to predict the turning point, they forecasted economic growth for 2020, but the Czech economy entered a recession.

We can reach the same conclusions if we evaluate the accuracy of these forecasts using the Theil index, the values of which are in Table 1. The Theil coefficient for the years 2017 to 2019 reached the value TH = 45% for the two-year forecast and 49% for the annual forecast.

Let's add 2020 and consider the accuracy of forecasts for the years 2017 to 2020. The value of the Theil coefficient now increases significantly, to TH = 118% for a two-year forecast and TH = 95% for a one-year forecast. It is true that this indicator significantly "penalizes" a rare and significantly worse result in the forecast, and on the contrary brings a significant "bonus" for well-estimated sudden breaks in the development of predicted values. However, the predictive power of the forecasts has significantly deteriorated. Analysts were unable to

predict a recession not only two years but not even one year before its onset. The calculation is thus in line with the graphical analysis.

Fig. 1: Growth rate of GDP: prediction and reality 2017 - 2024



Source: own computation

We will now move on to the analysis of the forecasts of the average annual rate of inflation in the Czech Republic for the years 2017 to 2020. In the previous part of this article, we stated that analysts have achieved a solid estimate of the real GDP growth for the years 20172019. This also corresponds to a relatively good estimate of the rate of inflation, as shown in Fig. 2. For the year 2020, the forecasted annual rate of inflation deviated from reality. However, the forecast for the entire monitored period 20172020 is optimistic and consistently underestimates the level of the inflation rate compared to reality.

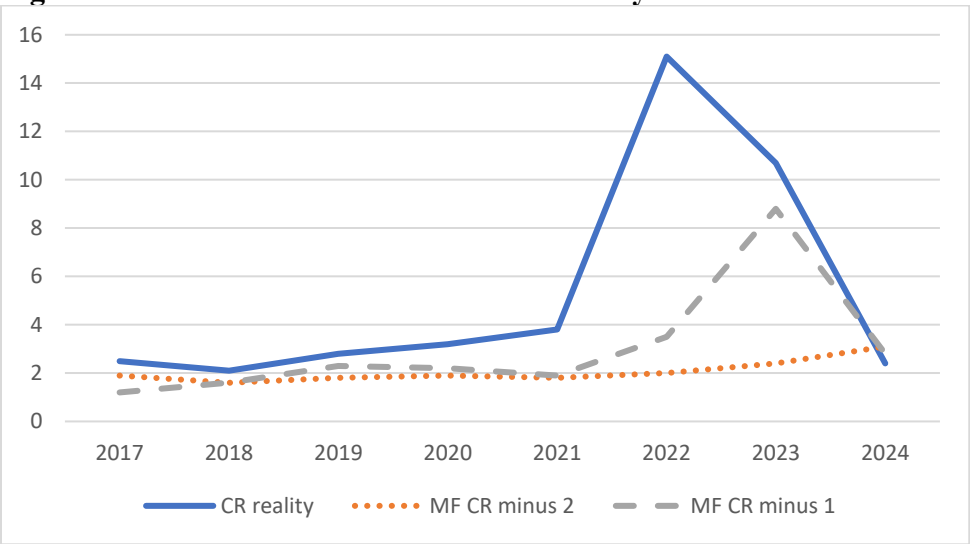
Similar conclusions can be reached if we use the Theil coefficient. The two-year forecast for 20172019 shows a value of TH = 30%, and the annual forecast is associated with a value of TH = 34%. The two-year forecast for 20172020 shows a value of TH = 34% and the annual forecast is TH = 33%. Inflation estimates were more accurate than real GDP growth estimates.

The theoretical connection between the real GDP growth and the rate of inflation was valid. Experts failed to predict the turning point in GDP growth. On the other hand, estimates of the rate of inflation remained fairly accurate. However, let us not forget that negative demand and supply shocks, acting together, deepen the decline in GDP, but in the case of an impact on the price level, they act in the opposite direction, their effects compensate each other and thus reduce the fluctuation in the rate of inflation. And a more stable indicator is easier to predict.

The third unexpected event is **the Russian invasion of Ukraine in 2022.** From the point of view of economists, this is a global negative supply shock associated with rising energy

prices and disruption of trade routes (Boone, L. 2022) or (Di Bella, G., Lewis, M., & Vashakmadze, E. 2022). By standard theory, a supply shock can be expected to cause stagnation or a decline in GDP and an increase in the inflation rate.

Fig. 2: Rate of Inflation: Prediction and Reality 2017 - 2024



Source: own computation

Figure 2 shows that the negative supply shock was reflected in a significant increase in the price level in 2022 and 2023. The prediction with a two-year time horizon did not count on this unexpected event at all. The prediction with a one-year time horizon did not expect an increase in the price level for 2022, but it already took this shock into account for 2023.

The supply shock in 2022 slowed economic growth in the Czech Republic and caused a 0.1% decline in GDP in 2023; the Czech economy stagnated. Predictions were more optimistic for both years, but not so significantly. GDP forecasts were thus more accurate than price ones.

Again, the Theil coefficients confirm the predictions' accuracy. There is only one year between the 2020 pandemic and the start of the Russian invasion of Ukraine in 2022. Therefore, we cannot use the same methodology, i.e., calculate the Theil coefficient for the three years preceding the unexpected event, and then add the year with the shock and calculate the index for four years.

We start from the value of the Theil index for the years 2017 - 2019. In the next step of the calculation, we will add data for 2022 to these three years. The two-year GDP growth forecast for 2017 to 2019 and 2022 shows a value of TH = 42%, the annual GDP growth forecast is associated with a value of TH = 49%. The inflation prediction with a two-year time horizon for four years shows a value of TH = 84%, and the annual inflation forecast is associated with a value of TH = 74%. Estimates of real GDP growth were more accurate than estimates of the rate of inflation. The calculation of the Theil coefficients thus confirms the conclusions of the

graphical analysis, experts failed to identify the supply shock in time and reflect it in the forecast.

Conclusion

As already mentioned in the contribution, models can work with past data and based on them propose the expected development of the economy, assuming more or less smooth economic development. Similarly, models can evaluate the effects of various shocks, but they cannot identify these unexpected events.

It is a fact that forecasts are not and cannot be based solely on statistical data and methods. Experts apply a qualitative analysis of the economy, which is also the content of the aforementioned colloquiums investigating forecasts for the Czech economy. However, the colloquiums are held after the forecasts have been processed, and the positions of various institutions on the expected development of the economy are compared and harmonized.

The paper did not confirm the hypothesis that the COVID-19 pandemic would have the lowest prediction accuracy compared to the other two shocks. The prediction inaccuracy was more or less the same in all three cases. None of the three shocks examined were identified and considered in the preparation of the predictions.

Qualitative analysis has probably been underestimated. Economic shocks cannot be eliminated – that would contradict the nature of these events. Protection against shocks does not mean predicting them, but rather creating model and institutional frameworks that increase the resilience of models to their occurrence. It is therefore worth considering the development of a system that would use standard qualitative methods to search for potential threats (shocks) and, on their basis, ensure the creation of alternative scenarios for economic development. This would therefore be a preliminary stage in the creation of predictions themselves.

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Annexes

Tab. 2: Real growth of the gross domestic product 2006 - 2011 (%)

year	2006	2007	2008	2009	2010	2011
CR reality	7.0	5.7	3.1	-4.7	2.7	1.8
MF CR minus 2	3.3	4.0	4.8	5.1	5.2	2.4
MF CR minus 1	4.0	5.0	5.0	4.8	0.3	2.3

Notes: MF CR minus 2 = forecast precedes reality 2 years, i.e., the forecast for 2010 was published on July 2008.
MF CR minus 1 = forecast precedes reality 1 year, i.e., the forecast for 2010 was published in July 2009.
Sources: Macroeconomic prediction, July of the corresponding year

Tab. 3: Inflation rate2006 - 2011 (%)

year	2006	2007	2008	2009	2010	2011
CR reality	2.5	2.8	6.3	1.0	1.5	1.9
MF CR minus 2	2.5	2.6	3.0	2.3	2.5	2.1
MF CR minus 1	2.2	2.8	3.4	2.9	1.1	3.5

Notes: see tab. 1
Sources: Macroeconomic prediction, July of the corresponding year

Tab. 4: Real growth of the gross domestic product 20017 - 2024 (%)

year	2017	2018	2019	2020	2021	2022	2023	2024
CR reality	5.2	2.8	3.6	-5.3	4.0	2.8	-0.1	1.1
MF CR minus 2	2.3	2.4	2.6	4.5	2.3	2.2	2.1	3.0
MF CR minus 1	2.4	2.9	5.5	2.3	3.9	4.2	1.1	2.3

Notes: see tab. 1
Sources: Macroeconomic prediction, July of the corresponding year

Tab. 5: Inflation rate2017 - 2024 (%)

Year	2017	2018	2019	2020	2021	2022	2023	2024
CR reality	2.5	2.1	2.8	3.2	3.8	15.1	10.7	2.4
MF CR minus 2	1.9	1.6	1.8	1.9	1.8	2.0	2.4	3.1
MF CR minus 1	1.2	1.6	2.3	2.2	1.9	3.5	8.8	2,8

Notes: see tab. 1
Sources: Macroeconomic prediction, July of the corresponding year

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