When are we in recession?

Estimating recession probabilities for Slovakia

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In this article we estimate a model of recession probabilities for Slovakia. In the first part we summarise the techniques most widely used to identify business cycle turning points. We then look at the empirical issue arising from GDP data revisions. Next we estimate a Markov-switching model of recession probabilities for Slovakia. This model identified two recessions, at the beginning of 1999 and 2009. A subsequent sensitivity analysis showed, however, that these results should be treated with caution due to considerable uncertainty related to GDP data revisions. This model should therefore be seen mainly as a supplementary analytical tool for monitoring the business cycle in Slovakia.

1. Overview of business cycle dating methods

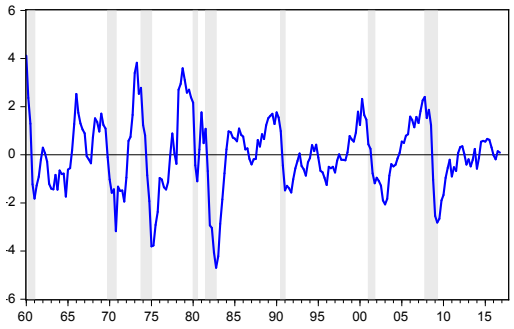
Recessions in advanced economies are most commonly defined as a fall in quarterly real GDP in at least two consecutive quarters. Although this definition is sufficiently accurate in most cases, it is not always reliable. It would not, for example, apply to the Slovak economy in the wake of the global economic crisis of 2008-2009. Although Slovak GDP slumped by a record 9.1% in 2009:Q1, it has not contracted in successive quarters since 1999. Such a simple definition of recession also fails to capture the volatility of economic output during certain recessions, when temporary revivals of growth do not necessarily imply the end of the downturn (Hamilton, 2011).

Given the deficiencies in simple definitions of recessions, some foreign institutions have established expert committees for the purpose of identifying recessions. In this task, the committees give more importance to expert judgement than to precise definitions. Furthermore, by extending the set of indicators considered, for example, employment, sales and/or disposable income, they attempt to address the issue of GDP data revisions or the changing nature of recessions. A typical and the most well-known committee of this type is the Business Cycle Dating Committee (BCDC) of the National Bureau of Economic Research (NBER) in the United States. Another is the Euro Area Business Cycle Dating Committee of the Centre for Economic Policy Research (CEPR) in London. The most common drawbacks of such committees is that they tend to publish their results with a substantial delay and their decisions are not always transparent.

Another conventional way of monitoring business cycles is by estimating the output gap. There are a many available techniques in this field, including technical filters (Hodrick-Prescott, bandpass, etc.), potential output estimates based on the production function, and multivariate structural filters for estimating the unobserved output gap. These techniques link recessions with periods when GDP is lower than its trend, potential or equilibrium level. In other words, a negative GDP growth rate does not automatically imply a recession. At the same time, the output gap technique produces a rather symmetrical length of periods of excessive and subdued GDP growth. The expert committees, however, identify recessions in only a small proportion of the intervals that show a negative output gap. This can also be seen in Chart 1, where we compare the HP-filtered output gap in the United States with the NBER-determined recession dates. On the other hand, if a recession were defined as a period when the output gap is very pronounced – for example, more than two percentage points – Chart 1 would correctly capture a majority of recessions. The correct threshold for a 'pronounced' output gap would, however, be determined on an ad hoc basis.

In order to more accurately distinguish slightly subdued phases in the US economy from evident crisis periods, a large number of empirical articles have attempted to simulate the NBER recession dates using econometric models. A detailed overview of the literature on such techniques may be

Chart 1 Business cycle in the United States – HP-filtered output gap vs NBER recession dates



Sources: OECD Real-Time Data and Revisions Database, NBER and author's own calculations.
Note: Blue line – HP-filtered output gap in per cent of GDP; grey bands – NBER-determined recession dates.

found in Hamilton (2011), which was also our source for the following description.

In one type of recession-identifying model, coincident and leading indicators are compiled. These are typically monthly indicators that are assumed to correlate closely with real activity developments. For example, Stock and Watson (1989) estimated a common factor in their sample of monthly variables using a dynamic factor model. In an attempt to imitate the NBER-determined recession dates, they then interpreted a certain development pattern of the common factor as corresponding to recessions. The exercise was repeated for sets of coincident and leading indicators with the aim of both identifying recessions in real time and also forecasting the occurrence of recessions.

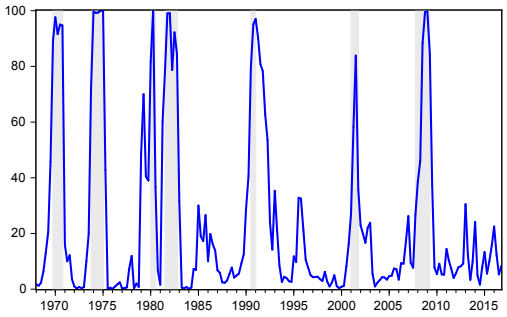
Although Stock and Watson's model produced promising results for the United States up to the end of the 1980s, it failed to predict the 1990-91 and 2001 recessions. Hamilton (2011) attributed this failure to leading indicators, such as interest rates and the spread between the yield on commercial paper and Treasury bills. In other words, the relationship between those indicators and recessions broke down over time. Similar failures occurred with models that used yield curve data. Such models erroneously predicted the outbreak of a crisis in 2006.[1] According to Hamilton's (2011) conclusions, the objective of forecasting crises was shown to be overly ambitious, while models based on leading indicators are relatively successful in identifying recessions shortly after they have started.

In view of the changing information content of real activity indicators, Hamilton (2011) puts forward his own approach, namely a Markov-switching model based solely on the GDP series. The identification of a recession in parallel with the release of new national accounts data appears to be relatively prompt, especially when compared with how long it takes the NBER to determine recession dates[2]. The case for applying the mentioned Markov-switching model to the United States is further supported by the considerable agreement between its results and the NBER recession dates (see Chart 2).

2. GDP DATA REVISIONS AND OUTLIERS

Among the drawbacks of the Markov-switching model is estimation difficulty and the resulting uncertainty of its results. Estimates may be imprecise if the sample is short, and especially at the end of the observed interval. In addition, the accuracy of end-sample estimates will be undermined by GDP data revisions. Although, in the case of advanced economies GDP data are less volatile and the revisions are relatively modest compared with those in emerging market economies, such as Slovakia. This conclusion is inferred from the average absolute changes in quarterly GDP growth values resulting from revisions. According to our calculations, in the United States the average of such changes for the period 1995-2013 was 0.13 percentage point, while in Slovakia it was 0.47 percentage point.[3] The

Chart 2 US recessions – Hamilton's Markov-switching model vs NBER recession dates

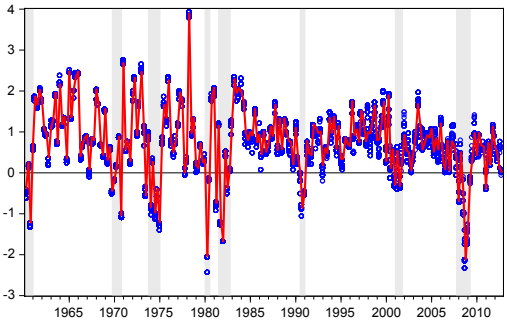


Sources: James Hamilton and FRED Economic Data (Federal Reserve Bank of St. Louis).
Note: Blue line – probability of recession; grey bands – NBER-determined recession dates.

history of GDP data revisions in the United States and Slovakia are shown in Charts 3 and 4.

A closer look at US GDP revisions shows a broadly even level of data uncertainty across the business cycle. In other words, the NBER-determined recession dates and periods leading up to these recessions are not accompanied by larger than usual data revisions. The same, however, cannot be said about the Slovak data. For example, in several quarters prior to the start of 1999 we observe elevated data uncertainty (see black-dotted ovals in Chart 4). Furthermore, the most recently available data show that the Slovak economy probably entered a recession in the first half of 1999. It appears, however, that the beginning of the recession, i.e. the first quarter in which GDP fell, may have been shifted backwards depending on which version of the historical data is followed. A similar type of error may have occurred at the end of 2000 (green-dotted oval in Chart 4). The earlier versions of the GDP data for the given period showed an economic downturn that might indicate a recession, which vanished in later vintages of the GDP series.

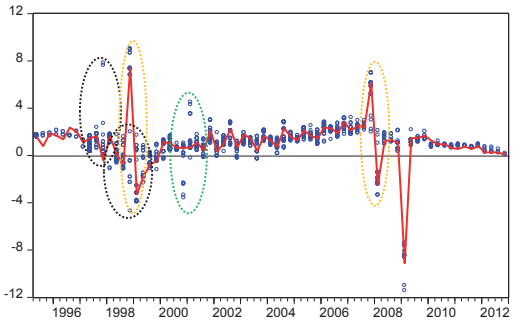
Chart 3 GDP data revisions in the United States (quarter-on-quarter percentage changes; seasonally adjusted)



Sources: OECD Real-Time Data and Revisions Database (data releases from 1999:M7 to 2017:M3) and NBER.
Note: Blue circles – GDP revision history; red line – GDP according to March 2017 data; grey bands – NBER-determined recession dates.

1 *See, for example, Chauvet and Potter (2005), or Estrella and Trubin (2006), authors whose results are released on a regular basis by the Federal Reserve Bank of New York.*
2 *For example, the NBER determined that the United States had been in recession from August 1990 to March 1991. The NBER's determination was not announced until April 1991, i.e. in the month after the recession had ended. At the same time, data showing a slowdown in GDP growth were already available in November 1990, five months before the NBER's announcement.*
3 *We may use the relative average absolute values of the revisions as an alternative measure, dividing the original indicator of revision sizes by the average growth rate for the given period. The relative indicator stands at 0.22 for the United States and 0.48 for Slovakia, which still confirms the elevated uncertainty surrounding the Slovak GDP estimates.*

Chart 4 Slovak GDP data revisions (quarter-on-quarter percentage changes; seasonally adjusted)



Sources: Statistical Office of the Slovak Republic (SO SR) and NBS (historical time series of first data releases for the periods from 2006:Q1 to 2013:Q2).
Note: Blue circles – GDP revision history; red line – GDP according to March 2017 data.

In addition to being revised, the Slovak GDP data also includes outliers, e.g. at the end of 1998 and 2007 (orange-dotted ovals in Chart 4). In the first case, the growth acceleration followed by a steep contraction in the next period resulted from excessive government investment in the period prior to the general election. Subsequently that year, the new government was compelled to reduce expenditure for the purposes of debt consolidation, thereby tipping the economy into recession. In the second case, according to the Statistical Office of the Slovak Republic (SO SR), the well above average GDP growth rate at the end of 2007 stemmed from the fact that cigarette sellers stocked up heavily on cigarettes ahead of an increase in consumption taxes on cigarettes from 1 January 2008. Whether the GDP contractions at the beginning of 1998 and 2008 are identified as recessions depends on which definition is used, and therefore a pure model-based approach that takes no account of expert analysis could produce erroneous results.

It is somewhat more straightforward to date the impact of the global financial crisis on the Slovak economy in the first quarter of 2009. Data revision for this period did not alter the timing of the impact of the crisis, while the different versions of historical data differed only in the extent of the GDP contraction. In sum, a real-time model-based estimation of recession probabilities in Slovakia will entail a considerable degree of uncertainty owing to significant GDP growth revisions and outliers.

3. Estimation of a Markov-switching model of recession probabilities

We based our exercise on the model of Chauvet and Hamilton (2006), who estimated recession probabilities for the United States. Under the model's assumptions, the quarterly GDP growth rate, y_t, is derived from two alternative normal distributions depending on whether the economy is in recession ($S_t = 1$) or in expansion ($S_t = 2$):

$$y_t|S_t = 1 \sim N(\mu_1, \sigma_1^2)$$
$$y_t|S_t = 2 \sim N(\mu_2, \sigma_2^2).$$

The respective density functions are denoted as $\phi_i(y_t\,;\,\mu_i, \sigma_i)$ for i = 1,2. For the United States, the literature typically assumes the same standard deviation in growth in both phases of the cycle ($\sigma_1 = \sigma_2$). For Slovakia, we relaxed this assumption in view of the fact that GDP growth has been more volatile around recessions than in periods of expansion (see Chart 4).

The recession probability at time t, which is conditional on the development of y_t for τ=1,...,t, can be expressed as

$$P(S_t = 1\,|y_t, y_{t-1}, \dots, y_1) = \frac{\xi_t \phi(y_t; \mu_1, \sigma_1)}{\xi_t \phi(y_t; \mu_1, \sigma_1) + (1-\xi_t)\phi(y_t; \mu_1, \sigma_1)},$$

where the term ξ_t is a recursive chain denoting the conditional probability of recession ($S_t = 1$), defined as follows:

$$\xi_t = p_{11} P(S_{t-1} = 1|y_{t-1}, y_{t-2}, \dots, y_1) + (1 - p_{22}) P(S_{t-1} = 2|y_{t-1}, y_{t-2}, \dots, y_1),$$

where $p_{11} = P(S_t = 1|S_{t-1} = 1)$ denotes the probability of the recession in *t-1* continuing in period *t* and $p_{22} = P(S_t = 2|S_{t-1} = 2)$ denotes the probability of a continuing expansion across the periods *t* and *t-1*.

As for the estimated probability of a recession in period *t*, we will differentiate the filtered and smoothed estimate[4] according to whether *t* is the end point of the sample (*t*=*T*). If t<T, the smoothed estimate is refined by additional observations between *t* and *T*. The filtered estimate may therefore be less precise than its smoothed version.

Using the above relationships we can express the conditional probability function for y_t as

$$f(y_t|y_{t-1}, y_{t-2}, \dots, y_1) = \sum_{j=1}^{2} f(y_t|S_t = j)\, P(S_t = j\,|y_t, y_{t-1}, \dots, y_1) = \xi_t \phi(y_t;\, \mu_1, \sigma_1) + (1 - \xi_t)\phi(y_t;\, \mu_1, \sigma_1)$$

The parameters of the model $\boldsymbol{\theta} = (\mu_1, \mu_2, \sigma_1, \sigma_2, p_{11}, p_{22})$ are then estimated by maximising the likelihood function for $t=1,\dots,T$:

$$\sum_{t=1}^{T} \log f(y_t|y_{t-1}, y_{t-2}, \dots, y_1; \boldsymbol{\theta})$$

4. Results for Slovakia

We estimated a Markov-switching model for the seasonally adjusted quarter-on-quarter GDP growth rate over the period 1995:Q2–2016:Q4. We used two specifications of the model. In one

4 *The smoothed estimate of recession probability can be written as: $P(S_t = 1|y_T, Y_{T-1}, \dots, Y_t, \dots, y_1)$.*

Estimation results for Slovakia

Parameter	Designation	Baseline model	Treatment of outliers
μ_1	Average growth in recession	0.05	-3.11
μ_2	Average growth in expansion	1.13	1.12
σ_1	Standard deviation of growth in recession	4.21	3.88
σ_2	Standard deviation of growth in expansion	0.66	0.70
p_{11}	Probability of recession continuing from t-1 to t	0.71	0.31
p_{22}	Probability of expansion continuing from t-1 to t	0.96	0.97
	Average length of recessions (quarters)	3.4	1.5
	Average length of expansions (quarters)	34.5	23.1
	Number of quarters in recession*	6	2

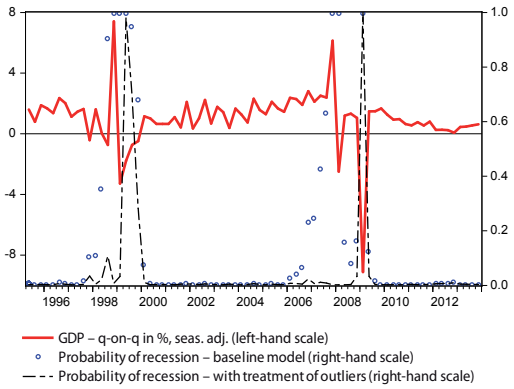
Source: Author's own calculations.
**We assumed a recession when the probability exceeded 98%: $P(S_t=1 \mid Y_T) > 0.98$.*

of them we included additional dummy variables to treat the elevated volatility (outliers) at the turn of 1998-1999 and 2007-2008. According to our findings, these outliers have a significant impact on the estimates, mainly in regard to the average length and probability of recession. The parameters of the model, θ, under the two specifications are shown in Table 1. Chart 5 compares histograms of GDP growth in expansions and recessions under the baseline model, and Chart 6 shows the recession probability estimate on a quarterly basis.

The results shown in Table 1 and Chart 5 confirm that average GDP growth is significantly lower in a recession than in an expansion and that the standard deviation (volatility) is higher in a recession. Crisis periods are far shorter (1 to 3 quarters) than expansions (5 to 9 years). Without the treatment of outliers in the GDP data, the model would indicate somewhat more frequent and longer lasting recessions, as is clear from the difference between the estimated recession probabilities under the baseline model and extended model (Chart 6). It is arguable, however, whether the volatile periods at the turn of 1998-1999 and 2007-2008 should be included in the recession phase of the cycle, since the economic circumstances behind the GDP developments are not clear. When it comes to interpreting the historical developments, we are therefore inclined to follow the results of the extended model.

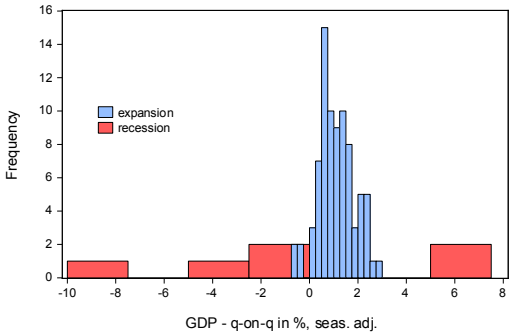
Next we examined the sensitivity of the results to GDP data revisions. We compared the estimated recession probabilities on March 2017 data with estimates based on historical data vintages. We observed the revision history over the period 2006:Q1 – 2013:Q2, with the time series end points corresponding to the first national accounts releases for the given quarter. As Chart 7 shows, the relatively pronounced changes resulting from the data refinements cause the model to erroneously signal a recession on several occasions between 2000 and 2008 (green-dotted area in Chart 7). Most of these cases, which are now seen not to be recessions at all, occur in the middle of the time series. Some estimates after 2006:Q1 are, however, end points of the estimation interval. This sensitivity analysis shows that identifying reces-

Chart 6 Recession probabilities



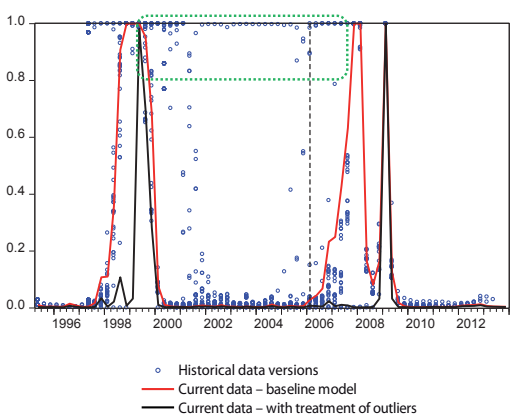
Source: Author's own calculations.

Chart 5 Histogram of GDP growth in expansions and recessions – baseline model



Source: Author's own calculations.
Note: The baseline model identifies a recession in six quarters, including 1998:Q4 and 2007:Q4 with positive growth outliers of around 6%.

Chart 7 The impact of GDP data revisions on the estimation of recession probabilities



Source: Author's own calculations.

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sions in Slovakia by means of a Markov-switching model may be subject to imprecision due to considerable data uncertainty. Therefore such results must be treated with caution. The model may, however, be useful as a supplementary analytical tool in business cycle monitoring.

5. Conclusion

In this article we have described the most widely-known techniques for identifying business cycle turning points. The simple definition of a recession as a fall in quarterly real GDP in at least two consecutive quarters fails to capture all recessions. For example, the impact of the global financial crisis on the Slovak economy was mostly concentrated in the first quarter of 2009. Although expert committees tasked with identifying recessions (e.g. the NBER in the United States) provide a more precise account, their announcements tend to be tardy and not always transparent. By contrast, econometric models provide more transparent and quicker results. Output gap estimates imply a broadly symmetrical periods of excessive and subdued GDP growth. In contrast, recession probability models differentiate more precisely between crisis periods and periods of below-average GDP growth. One of the most well-known recession probability models for the United States is Hamilton's Markov-switching model, which produces results very similar to the NBER-determined recession dates.

Applying this type of model to Slovak data, we identified two recessions in the Slovak economy, at the beginning of 1999 and 2009. A sensitivity analysis of the results showed that national accounts revisions cause considerable uncertainty in recession probability estimates. This is mainly apparent when the model erroneously provides positive signals of a crisis. It may therefore be concluded that this technique is useful mostly as a supplementary analytical tool for business cycle monitoring.

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Ponuka podujatí Inštitútu bankového vzdelávania NBS, n. o., na október 2017

INŠTITÚT BANKOVÉHO VZDELÁVANIA NBS, n.o.

Názov vzdelávacieho podujatia	Dátum konania
Osobitné finančné vzdelávanie – základný stupeň, stredný stupeň, vyšší stupeň – sektor Poistenie a zaistenie	2. – 3. 10. 2017
Brain Leaders: Intenzívny neurotréning na rozvoj koncentrácie pozornosti a pamäti, Modul A	3. 10. 2017
Platobný styk I	3. 10. 2017
Hrdinský Time Management	4. 10. 2017
Právo Európskej únie	4. 10. 2017
Solvency II v praxi	4. 10. 2017
Základy bankovníctva a poisťovníctva pre zamestnancov s neekonomickým vzdelaním III	4. 10. 2017
Zvládnite stres so zdatným mozgom	5. 10. 2017
LEKTOR: Akreditovaný vzdelávací program MŠVVaŠ SR I.	5. - 6. 10. 2017
Základné deriváty finančného trhu – oceňovanie a účtovanie	9. – 12. 10. 2017
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Obozretná regulácia bánk v EÚ a Bazilej III	10. 10. 2017
LEKTOR: Akreditovaný vzdelávací program MŠVVaŠ SR II.	10. 10. 2017
Spotrebiteľské rozhodcovské konanie	11. 10. 2017
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Silný rečník: Ako pútavo prezentovať?	19. 10. 2017
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SEPA – SEPA SCT a SEPA DD a príslušná legislatíva	24. 10. 2017
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Základy bankovníctva a poisťovníctva pre zamestnancov s neekonomickým vzdelaním VI	25. 10. 2017
Osobitné finančné vzdelávanie – základný stupeň, stredný stupeň, vyšší stupeň – sektor starobné dôchodkové sporenie	25. – 26. 10. 2017
Ochrana bankového tajomstva	26. 10. 2017
Ochrana spotrebiteľa vo finančných službách	26. 10. 2017
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