

One of the main characteristics of economic developments in Iceland and abroad is the recurrent alternation of economic contractions and expansions, commonly referred to as business cycles. These cycles can vary in duration and strength but are generally considered to last from one to eight years. There are various methods for identifying and dating business cycles, and in the US and the eurozone, expert committees are tasked with this. In the US, this is done by the National Bureau of Economic Research (NBER), and in the eurozone it is done by the Centre for Economic Policy Research (CEPR). Both use a variety of statistical methods to date business cycles based on underlying developments in a large number of economic variables. In other countries, where no official business cycle dates are published, simpler statistical methods are used and their reliability generally assessed based on how closely they approximate official business cycle estimates for the US and the eurozone.

One popular approach is the Markov switching model of Hamilton (1989), which has been shown to match closely the timing of economic contractions and expansions in the US (see, for example, Hamilton, 1989) and the eurozone (see, for example, Artis *et al.*, 2004), as well as being suitable for analysis and interpretation of the main characteristics of business cycles. Basically, the Markov switching model assumes that business cycles can be described as stochastic processes where the economy switches between two growth phases, or regimes. In one phase, GDP growth is weak or even negative, thus corresponding to a recession. In the other phase, GDP growth is stronger, corresponding to an expansion. In the Markov switching model, the probability distribution of regime switches is estimated jointly with the average growth rate of each phase. This model has previously been used by Elíasson (1998) and Pétursson (2000) to date business cycles in Iceland.

#### A simple Markov switching model of business cycles

If  $g_t$  represents GDP growth, the Hamilton Markov switching model can be described in its simplest form as follows:

$$(1) \quad g_t = \mu(s_t) + v_t$$

where  $\mu(s_t)$  is average GDP growth and  $v_t$  is a normally distributed random variable with a mean of 0 and a standard deviation of  $\sigma_v$ . Therefore, according to the Markov model, GDP growth fluctuates around its average,  $\mu(s_t)$ , which is determined by a latent random variable,  $s_t$ , which can take two values that reflect, on the one hand, the recessionary phase ( $s_t=0$ ),  $\mu_0$ , and on the other hand, the expansionary phase ( $s_t=1$ ),  $\mu_1$ :

$$(2) \quad \mu(s_t) = (1 - s_t)\mu_0 + s_t\mu_1$$

The probability of switching between a recession and an expansion is described with a two-state Markov chain:

$$(3) \quad \Pr(s_t = 0 | s_{t-1} = 0) = p; \quad \Pr(s_t = 1 | s_{t-1} = 1) = q$$

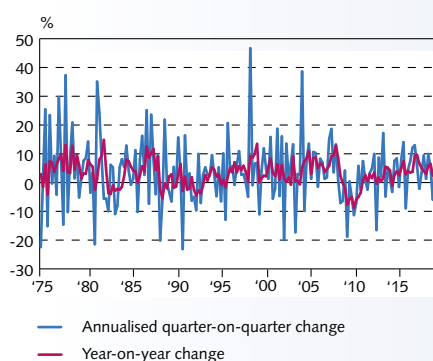
If the economy is currently in a recession, there is a probability of  $p$  that it will remain there into the next period, but a probability of  $(1 - p)$  that it will switch to the expansionary phase. Similarly, there is a probability of  $q$  that the economy will continue to expand in the next period if it is currently in the expansionary phase, whereas there is a probability of  $(1 - q)$  that it will switch to the recessionary phase.

To estimate the Markov model of business cycles in Iceland, quarterly GDP data from Q1/1975 through Q4/2018 are used. Because Statistics Iceland's quarterly national accounts extend only

#### Box 1

### Economic recessions in Iceland since 1975

Chart 1  
Output growth in Iceland<sup>1</sup>  
Q1/1975 - Q4/2018



1. Quarter-on-quarter change based on seasonally adjusted data. Data from 1997 onwards are from Statistics Iceland; data from before 1997 are Central Bank estimates.

Sources: Statistics Iceland, Central Bank of Iceland.

back to 1997, quarterly data prepared by the Central Bank for its macroeconomic model database are used for the period 1975-1996 (the methodology is described in Danielsson *et al.*, 2015, Chapter 14). As Chart 1 shows, quarterly GDP growth figures fluctuate widely, and there is often significant irregularity between quarters. Annual GDP growth is smoother and more regular; therefore, the Markov model is estimated with annual GDP growth; i.e., the logarithmic change in GDP from the same quarter in the prior year.

In order to describe short-term developments in GDP growth during the period more clearly, the model is estimated with two lags in GDP growth, which is consistent with the results of the Schwarz information criterion.<sup>1</sup> The estimated model is therefore given as:

$$(4) \quad g_t = \alpha(s_t) + \beta g_{t-1} + \gamma g_{t-2} + v_t$$

where average GDP growth in the two regimes is given as  $\mu(s_t) = \alpha(s_t)/(1 - \beta - \gamma)$ . Table 1 shows the estimation of the Markov switching model. In expansionary phases, GDP growth averages 4.8%, whereas during recessionary phases it averages -3.5%. The empirical results also indicate that the two business cycle phases are highly persistent: the probability of remaining in an expansion from one quarter to the next is about 95%, while the probability of remaining in a recession is slightly less, or 80%. It is therefore highly likely that the economy will continue in the same phase from one quarter to the next, and switching between states is relatively rare. This can also be seen in the estimation of the expected duration of the regimes. According to the empirical results, the expected duration of a recession is five quarters, or 1.25 years, whereas expansions are quite a bit longer, at about five years. Finally, the table shows the estimation of the unconditional probability of being in a recession or expansion during this period spanning nearly half a century. According to the estimation, the domestic economy has been in a recession for about a fifth of the period from 1975 onwards, and in an expansion for about 80% of the same period (average GDP growth over the entire period is therefore 3.1%; that is,  $0.2 \times (-3.5\%) + 0.8 \times 4.8\%$ ). As can be expected, the economy is more often expanding than contracting, and expansions are generally much longer than recessions. Furthermore, the estimation of the expected duration of the two regimes corresponds to an average complete business cycle length of just over six years. As is mentioned above, this is consistent

Table 1 Estimation of two-state Markov switching model<sup>1</sup>

	<i>Parameter estimation</i>
Average GDP growth during recessions, $\mu_0$	-0.035
Average GDP growth during expansions, $\mu_1$	0.048
Probability that ongoing recession will continue, $p$	0.800
Probability that ongoing expansion will continue, $q$	0.950
Expected duration of recessions, $d_0 = 1/(1-p)$	5.00
Expected duration of expansions, $d_1 = 1/(1-q)$	20.05
Probability of being in a recession, $\Pr(s_t = 0) = (1-q)/(2-p-q)$	0.200
Probability of being in an expansion, $\Pr(s_t = 1) = 1 - \Pr(s_t = 0)$	0.800

1. The table shows the results of estimating a two-state Markov switching model with quarterly data for the period from Q1/1975 through Q4/2018 (176 observations). Data from 1997 onwards are from Statistics Iceland; data from before 1997 are Central Bank estimates. The duration of recessions and expansions is given in quarters.

Source: Central Bank of Iceland.

1. The Hamilton Markov switching model can be expanded in various ways; for instance, by increasing the number of states or allowing the variability of the random variable  $v_t$  to differ between states. Various versions and expansions of the model are discussed in Pétursson (2000).

with the typical cycle duration. The Markov switching model successfully describes the main characteristics of conventional business cycles.

### Estimated dating of recessions

The Markov model also provides an estimation of the probability that the economy is in a recession; i.e., periods where the probability that  $s_t=0$  is greater than 50% (Chart 2). The empirical results identify four such episodes: the first in the early 1980s, the second towards the end of the 1980s, the third early in the 1990s, and the fourth in the wake of the 2008 financial crisis. Table 2 provides more detailed information about these four episodes.

Table 2 Recessions in Iceland since 1975<sup>1</sup>

Beginning	End	Change GDP (%)	Average GDP growth (%)	Duration (quarters)	Duration (years)
Q2/1982	Q4/1983	-4.9	-1.7	7	1.75
Q2/1988	Q4/1988	-2.2	-2.8	3	0.75
Q4/1990	Q4/1992	-7.2	-1.9	9	2.25
Q2/2008	Q3/2010	-12.1	-4.1	10	2.50

1. The table shows the beginning and end of recessions estimated using the two-state Markov switching model in Table 1. The change in GDP shows the change from the peak at the beginning of the recession until its end; average GDP growth shows the annual average change in GDP during the recession.

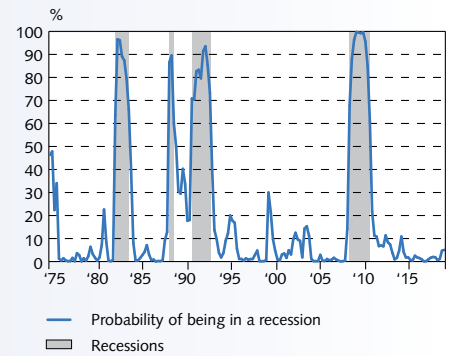
Source: Central Bank of Iceland.

The first recession, from mid-1982 through end-1983, lasted just under two years. Its beginning can be traced to the severe fish catch failure that caused a steep decline in exports and economic activity. GDP contracted by nearly 5% from the beginning to the end of the recession, and annual GDP growth averaged -1.7% over the period. Later in the 1980s, a decline in fish catches concurrent with a deterioration in terms of trade led to a recession lasting from mid-1988 through the end of that year. This recession was therefore relatively short and mild, but GDP contracted by just over 2%. The third recession came soon thereafter, beginning in late 1990 and lasting until end-1992. It was considerably more severe than its predecessor: it lasted more than two years, and GDP contracted by over 7%. In addition to the still-palpable impact of the downturn in fish catches and the erosion in terms of trade came the contractionary effect of significant monetary tightening towards the end of the decade, after nominal interest rates were liberalised and domestic economic policy increasingly focused on price stability. The last recession, which followed the financial crisis in autumn 2008, was by far the most severe experienced by Iceland over this half-century period.<sup>2</sup> GDP growth contracted by 12% in just over two years, and average GDP growth measured -4% over the period. This can be seen even more clearly in Chart 3, which shows seasonally adjusted GDP over the period.<sup>3</sup>

2. It was also the most severe in modern Icelandic history, as is discussed in Einarsson *et al.* (2015).

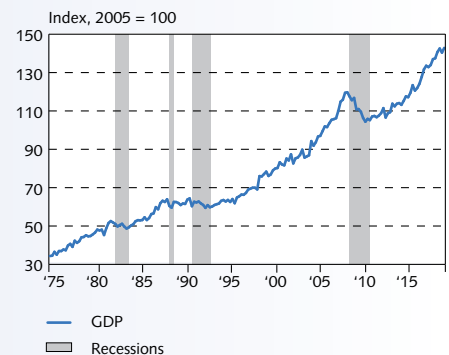
3. The dating of these four recessions accords well with the results of other research on the domestic business cycle – for example, Magnússon and Einarsson (1985), Eliásson (1998), and Pétursson (2000) – the last two of which are also based on an estimation of the Markov switching model. The main differences lie in the dating of the two recessions in the late 1980s and early 1990s, which Eliásson (1998) and Pétursson (2000) identify as a single recession lasting eight years. The dating also accords well with the findings of Einarsson *et al.* (2013), who used the Harding and Pagan (2002) turning point algorithm.

Chart 2  
Economic recessions in Iceland<sup>1</sup>  
Q1/1975 - Q4/2018



1. Smoothed probability of being in a recession according to a two-state Markov model for economic growth. Estimated using quarterly data for the period 1975-2018. Data from 1997 onwards are from Statistics Iceland; data from before 1997 are Central Bank estimates. Sources: Statistics Iceland, Central Bank of Iceland.

Chart 3  
GDP in Iceland and economic recessions<sup>1</sup>  
Q1/1975 - Q4/2018



1. Seasonally adjusted gross domestic product (GDP). Data from 1997 onwards are from Statistics Iceland; data from before 1997 are Central Bank estimates. Sources: Statistics Iceland, Central Bank of Iceland.

### International comparison of recessions

Table 3 compares the dates of recessions in Iceland with those in the US and the eurozone, based on official dating by NBER and CEPR. As the table shows, they line up quite well. A recession occurred internationally in the mid-1970s, following the first OPEC crisis. No recession was measured in Iceland according to the Markov model, but as can be seen in Chart 2, the model comes very close to identifying H1/1975 as a recession. There was a recession in the US and the eurozone in the early 1980s, owing mainly to policy action taken by central banks around the world in a bid to rein in inflation. The recession in the early 1990s stemmed from the same causes, albeit amplified by the adverse impact of the 1990 oil crisis. A brief recession occurred in the US in the early 2000s, due to an abrupt correction in tech company share prices. A worldwide recession occurred in the wake of the global financial crisis, but in 2011-2013 the euro area also experienced a recession relating to sovereign debt problems facing a number of eurozone countries.

Table 3 International comparison of recession dates from 1975<sup>1</sup>

<i>United States</i>	<i>Eurozone</i>	<i>Iceland</i>
Q1/1974-Q1/1975 (5)	Q4/1974-Q1/1975 (2)	
Q2/1980-Q3/1980 (2)		
Q4/1981-Q4/1982 (5)	Q2/1980-Q3/1982 (10)	Q2/1982-Q4/1983 (7)
		Q2/1988-Q4/1988 (3)
Q4/1990-Q1/1991 (2)	Q2/1992-Q3/1993 (6)	Q4/1990-Q4/1992 (9)
Q2/2001-Q4/2001 (3)		
Q1/2008-Q2/2009 (6)	Q2/2008-Q2/2009 (5)	Q2/2008-Q3/2010 (10)
	Q4/2011-Q1/2013 (6)	
Average duration 1.0 year	Average duration 1.5 year	Average duration 1.8 year
Average contraction -2.1%	Average contraction -2.2%	Average contraction -6.6%

1. The table shows the dates of recessions in Iceland, taken from Table 2, and a comparison with recessions in the US (dated by NBER) and the eurozone (dated by CEPR). The duration of each recession, in quarters, is shown in parentheses.

Sources: CEPR, European Central Bank AWM database, NBER, Thomson Reuters, Central Bank of Iceland.

As can be seen in Table 3, all four recessions in Iceland have foreign counterparts occurring at or near the same time, and the domestic business cycle is in the same phase as that in the US and the eurozone 80% of the time. Recessions have generally been longer in duration in Iceland than in the other two economies, but they are fewer in number. Table 3 also shows that recessions in Iceland have generally been deeper. In part, this reflects the severity of the 2008 financial crisis, but it also reflects the fact that Iceland's economy has long been more volatile than larger advanced economies.

### Summary

Estimating the domestic business cycle using the Hamilton Markov switching model identifies four recessions in Iceland since 1975. The first occurred in the early 1980s, following a severe catch failure. Two recessions occurred around 1990: the first took place following a deterioration in terms of trade and a contraction in the marine sector after several years of overfishing, and the second was compounded by the contractionary impact of rising real interest rates after the liberalisation of nominal rates in the late 1980s. The last and most severe recession followed on from the global financial crisis, which struck in autumn 2008. Although domestic factors weigh heavily in the recessions in Iceland, the similar timing of the beginning of recessions in Iceland, the US, and the eurozone suggests that international factors are also important.

### Sources

- Artis, M., H.-M. Krolzig, and J. Toro (2004). The European business cycle. *Oxford Economic Papers*, 56, 1-44.
- Danielsson, Ásgeir, Bjarni G. Einarsson, Magnús F. Gudmundsson, Svava J. Haraldsdóttir, Thórarinn G. Pétursson, Signý Sigmundsdóttir, Jósef Sigurdsson, and Rósa B. Sveinsdóttir (2015). QMM: A quarterly macroeconomic model of the Icelandic economy – Version 3.0. Central Bank of Iceland *Working Papers* no. 71.
- Einarsson, Bjarni G., Guðjón Emilsson, Svava J. Haraldsdóttir, Thórarinn G. Pétursson, and Rósa B. Sveinsdóttir (2013). On our own? The Icelandic business cycle in an international context. Central Bank of Iceland *Working Papers* no. 63.
- Einarsson, Bjarni G., Kristófer Gunnlaugsson, Thorvardur Tjörvi Ólafsson, and Thórarinn G. Pétursson (2015). The long history of financial boom-bust cycles in Iceland – Part I: Financial crises. Central Bank of Iceland *Working Papers* no. 68.
- Elíasson, Lúdvík (1998). Mæling á íslenski hagsveiflu á ársfjórðungsgrunni. [In Icelandic] [En: Measuring the Icelandic business cycle on a quarterly basis]. Central Bank of Iceland, unpublished manuscript.
- Hamilton, J. D. (1989). A new approach to the economic analysis of non-stationary time series and the business cycle. *Econometrica*, 57, 357-384.
- Harding, D., and A. Pagan (2002). Dissecting the cycle: A methodological investigation. *Journal of Monetary Economics*, 49, 365-381.
- Magnússon, Guðmundur and Tór Einarsson (1985). Hagsveiflur, gengismál og jöfnunarsjóðir [in Icelandic] [En: Business cycles, exchange rate matters, and equalisation funds]. In *Klemensarbók* (ed. Sigurdur Snævarr). Reykjavík: Félag viðskipta- og hagfræðinga.
- Pétursson, Thórarinn G. (2000). Business cycle forecasting and regime switching. Central Bank of Iceland *Working Papers* no. 7.