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By

Bjarni G. Einarsson, Gudjón Emilsson,
Svava J. Haraldsdóttir, Thórarinn G. Pétursson,
and Rósa B. Sveinsdóttir

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On our own? The Icelandic business cycle in an international context*

Bjarni G. Einarsson† Gudjón Emilsson† Svava J. Haraldsdóttir†
Thórarinn G. Pétursson† Rósa B. Sveinsdóttir†

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Abstract

This paper analyses the properties of the Icelandic business cycle and whether it is synchronised with the business cycles of other developed countries. We start by identifying business cycle turning points and the average amplitude and duration of expansionary and contractionary periods in Iceland. We then extract the cyclical component of a large set of economic variables to document key stylised facts of the Icelandic business cycle. The resulting regularities of the domestic business cycle are also compared to business cycle regularities of other developed countries. Finally, we attempt to identify underlying structural shocks through long-run identification restrictions on a vector autoregressive (VAR) representation of the data, and look at the interconnection of these underlying shocks in Iceland and other developed countries. Our results suggest that although the characteristics of the domestic business cycle are in some aspects similar to business cycles in other developed countries, there are some important differences. Furthermore, our results indicate that the domestic business cycle is to a large extent asymmetric to the business cycle of other developed countries. These findings should be of importance for policymakers, and serve as a useful benchmark for modelling the Icelandic economy. The results should also serve as an important input for the analysis of the appropriate monetary and exchange rate regime for Iceland.

Keywords: Iceland, business cycles, stylised facts, international comparison of business cycles, international business cycle spillovers.
JEL Classification: E30, E32, F44.

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† Economics and Monetary Policy, Central Bank of Iceland, Kalkofnsvegur 1, 150 Reykjavik, Iceland. Emails: bge@cb.is, ge@cb.is, sjh@cb.is, thgp@cb.is and rbs@cb.is, respectively.

1 Introduction

Business cycles are defined as recurrent and broad-based movements in aggregate economic activity where expansionary periods are followed by contractions (cf. Burns & Mitchell, 1946). The empirical relationships between output and other economic variables are commonly referred to as "stylised facts" of business cycles (cf. Kydland & Prescott, 1990). These cycles may vary in size and duration over time, but they are usually defined to have periodicities of one and half year to eight years, while fluctuations over higher frequencies are referred to as irregular fluctuations and lower frequency fluctuations are thought of as movements in trend components (cf. Stock & Watson, 1999).

In analysing and documenting the Icelandic business cycle, we start by looking at turning points in the raw data using a modification of the Harding & Pagan (2002) algorithm for identifying business cycle turning points. Following the seminal paper by Stock & Watson (1999), we also analyse the Icelandic business cycle by prefiltering the data using the Baxter-King band-pass filter to extract the cyclical component from the raw data. We then move on to documenting stylised facts of the business cycle by reporting bivariate correlations between the cyclical component of output and a large set of economic variables at different leads and lags.[1]

The resulting regularities of the domestic business cycle and a comparison of business cycles of other developed countries are of importance in themselves and for policymakers. The results also serve as a useful benchmark for modelling the Icelandic economy, as any useful model of the economy should be able to replicate the key properties of the domestic business cycle and its links to the global business cycle.

How interlinked the domestic business cycle is with the business cycles of other countries is also of importance when analysing the appropriate monetary and exchange rate regime for Iceland. As stated by the Optimal Currency Area (OCA) literature (see Mundell, 1961, and McKinnon, 1963), a high degree of business cycle synchronisation should be an important criterion for participation in a monetary union. Accordingly, it is less costly to give up a country's monetary and exchange rate independence if its business cycle is highly synchronised to the business cycle of other monetary union members. With asymmetric business cycles, the adjustment to shocks can be more prolonged and costly and the loss of monetary sovereignty could therefore be costly for Iceland.[2]

This is currently of particular interest, given the fact that Iceland applied for European Union membership in July 2009 with the aim of entering the euro area and replacing the Icelandic króna with the euro soon after. Analysing whether the Icelandic and euro area business cycles are synchronised is therefore of central importance for the current

[1] A companion paper compares the production and export structure of the Icelandic economy with those of other developed countries (see Einarsson et al., 2013).

[2] Against this, one must weigh evidence suggesting that the OCA criteria are in fact endogenous, such that countries may fulfill the criteria after monetary union membership, even if they fail to fulfill the criteria prior to membership, through increased trade and financial integration (see Rose, 2000, and Frankel & Rose, 1998). Furthermore, a number of studies suggest that flexible exchange rates can act as a source of shocks just as well as a shock absorber (see Breedon et al., 2012).

debate. Thus, we start by looking at the cross-correlation structure of output in Iceland and a number of other developed countries over different leads and lags and different time periods. This approach, however, has the drawback that it does not distinguish between the underlying shocks causing business cycle movements and how these shocks are propagated through the economy. Business cycles can therefore be synchronised across countries either due to the fact that the countries are subject to the same underlying shocks or because factor mobility and other adjustment mechanisms are sufficient to prevent different structural shocks to lead to asymmetric business cycles. We therefore extend the analysis by identifying the underlying structural shocks through long-run identification restrictions on a vector autoregressive (VAR) representation of the data, and look at the interconnection of these underlying shocks in Iceland and other developed countries.

The remainder of the paper is structured as follows: section 2 provides an overview of the history of output fluctuations in Iceland and analyses the contributions of key expenditure components to average growth and fluctuations over different periods. In section 3 the main characteristics of business cycle fluctuations in Iceland are analysed and compared to the characteristics of business cycles in a number of other developed countries. The stylised facts of the Icelandic business cycle and how they compare to studies for other countries are the subject of section 4. In the second half of the paper we analyse how strongly the domestic business cycle is interlinked with business cycles of other developed countries; first by looking at the cross-correlation structure of domestic and foreign output over different leads and lags and different time periods (section 5) and then by looking at the synchronisation of underlying shocks identified from a structural VAR analysis (section 6). Section 7 concludes.

2 Economic fluctuations in Iceland

2.1 Output growth and fluctuations

Annual GDP growth in Iceland averaged 3.8% in the period 1946-2010 with a standard deviation of 4.5%. As table 1 shows, average growth has ranged from almost 5% in the period 1946-1979 to just above 2% in the 1980s to early 1990s. Average growth picked up in the latter half of the 1990s but has measured at 2.3% in the first decade of this century. The table also shows that the standard deviation of output growth gradually declined from 5% in the period 1946-1979 to 2% in the late 1990s, but has increased strongly again in the first decade of this century which reflects the large fluctuations in the run up to and following the financial crisis in 2008.

In this period about 7-8 large up- and downswings can be identified (figure 1a). The early part of the period saw large downswings (in the late 1940s and late 1960s) related to deteriorating terms of trade and collapsing fish catch, followed by rebounds in growth in the early 1950s and early 1970s. Two further contractions followed in the early 1980s and early 1990s; again following falling fish catches. Indeed as argued by Gudmundsson et al.

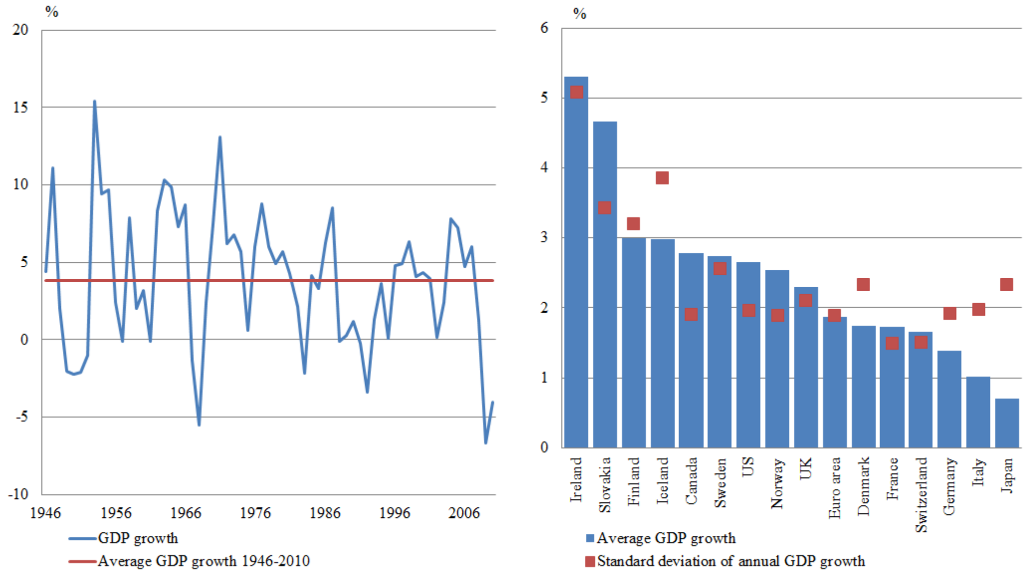

Figure 1: (a) GDP growth in Iceland 1945-2010. (b) GDP growth in various developed countries 1994-2010. *Source*: Statistics Iceland.

	Period				
%	1946-2010	1946-1979	1980-1993	1994-2000	2001-2010
Average GDP growth	3.8	4.9	2.2	4.0	2.3
St. dev. of GDP growth	4.5	5.0	3.3	1.9	4.7

Table 1: Average GDP growth and its standard deviation over different periods. *Source*: Statistics Iceland.

(2000) and Daníelsson (2004, 2008), the main driving forces behind these large fluctuations in economic activity in Iceland have been large swings in terms of trade, profit margins in the fishing industry, changes in industrial structure, and rapid deepening of financial markets (see also Snævarr, 1993). The exception is the latest contraction in 2008, which follows a systemic banking and currency crisis (see Ólafsson & Pétursson, 2011, for a more detailed discussion of the latest crisis).

Figure 1b compares average growth in Iceland over the period 1994-2000 with other countries, with average growth measuring 3% in Iceland but 2.4% in the comparison countries. Fluctuations in output are however much higher in Iceland than in most of the other countries, with the standard deviation of output growth measuring at almost 4% in Iceland compared to 2.5% on average for the other countries. The exception is Ireland, where the standard deviation of output growth is roughly 5%. The high volatility of economic activity in Iceland and Ireland remains even if the latest crisis is excluded: the standard deviation of output growth remains almost twice as high in Iceland and Ireland (about 2.3%) than in the other countries (1.4%). Section 3 onwards compares the properties of the Icelandic business cycle to business cycles of other developed countries in more detail.

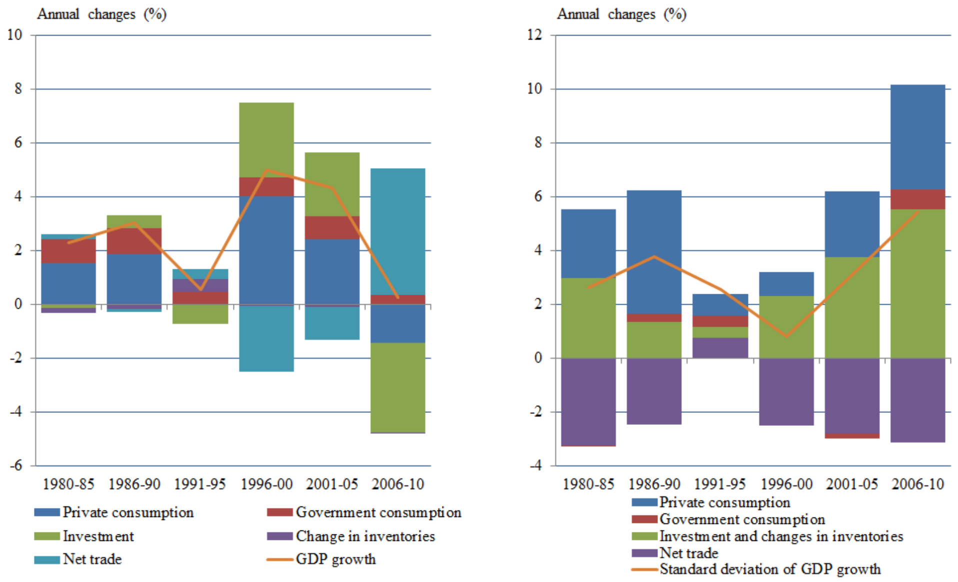

Figure 2: (a) GDP growth and contribution of expenditure components. (b) GDP fluctuations and contribution of expenditure components. *Sources*: Central Bank of Iceland, Statistics Iceland.

2.2 Contributions to output growth and fluctuations

Figure 2 shows the contributions of expenditure components to output growth and output fluctuations in different periods. Private consumption contributed most to growth in periods of upswings, i.e. in the 1980s and the latter half of the 1990s, while the contribution of investment was of similar magnitude in the strong growth period of the early half of the first decade of this century. Figure 2a also shows that the poor growth performance of the early 1990s can mainly be traced to weak investment activity. This also applies to the late 2000s, where investment results in a very large negative contribution to output growth. Movements in domestic demand are usually offset by net trade, thus mitigating fluctuations in output. Finally, the contribution of government consumption measured positive in all sub-periods, albeit less so in contractionary periods. Government consumption has therefore usually been procyclical, thus increasing economic fluctuations.

Figure 2b repeats the same exercise for the standard deviation of output growth. This is done by decomposing the variability of output growth as:

$$\sigma_{\Delta y} = \frac{C}{Y} \times \sigma_{\Delta c} \times \rho_{\Delta c,\Delta y} + \frac{G}{Y} \times \sigma_{\Delta g} \times \rho_{\Delta g,\Delta y} + \frac{I}{Y} \times \sigma_{\Delta i} \times \rho_{\Delta i,\Delta y} +$$

$$\frac{X}{Y} \times \sigma_{\Delta x} \times \rho_{\Delta x,\Delta y} - \frac{M}{Y} \times \sigma_{\Delta m} \times \rho_{\Delta m,\Delta y}$$

where Δy denotes the year-on-year changes in log level of GDP and $\sigma_{\Delta y}$ is the standard deviation of GDP growth as measured by Δy. C denotes private consumption and $\rho_{\Delta c,\Delta y}$ is the contemporaneous correlation between output and consumption. The same applies for public consumption (G), investment and changes in inventories (I), exports (X) and imports (M). Each sub-component is weighted with its average expenditure share over the same time period.

From Figure 2b it can be seen that volatility in investment is almost always the largest contributor to fluctuations in output growth although its share in GDP is only around 20%.[3] The exceptions are the late 1980s, when volatility in private consumption weighs the heaviest and the early 1990s when the contribution of private consumption and net trade are similar. As discussed earlier, in other periods, net trade is the main contributor to reducing economic volatility, while domestic demand contributes to increasing output volatility.

3 Defining business cycles

In the most simplistic way, business cycles can be thought of as the regular up- and downswings in economic activity - most commonly measured using developments of real GDP. A business cycle consists of four components: a contraction, a trough, an expansion and a peak. These components do, however, not necessarily appear in an orderly or predictable way and may differ in size and duration over time. Identifying these cycles can therefore be difficult. Furthermore, most economic time series also display trends or certain growth patterns which can mask the cyclical properties of the data, making the identification even more challenging.

In order to identify expansionary and contractionary periods one has to identify the turning points of the business cycle.[4] Some countries have set up committees of experts that have been assigned to identify and date turning points. The two best known examples of such committees are the Business Cycle Dating Committee of the National Bureau of Economic Research (NBER) in the US and the Centre for Economic Policy Research (CEPR) committee in the euro area. The NBER committee in the US has been operating since 1929. According to their definition a recession is a period between a peak and a trough where a significant decline in economic activity spreads across the economy and can last from a few months to more than a year. Similarly, an expansion is a period between a trough and a peak, where economic activity rises substantially. The committee applies its best judgement each time and there is no fixed rule used to determine turning points. Various measures of broad economic activity are examined, such as real GDP and gross domestic income. Monthly indicators are also examined to choose the months of peaks and troughs. There is no fixed rule about what weights the committee assigns to the

[3]The share of investment in GDP peaked in 2007 when it reached 35% but went down to 14% in 2010. Over 1980-2010, the share measures at 22%. Over the same period, the share of private consumption is 58%, while the share of public consumption is 22% and the export and import shares are 36% and 37%, respectively. These expenditure shares for private consumption, investment and imports are almost identical to the average OECD levels, whereas the public consumption share is somewhat higher and the export share somewhat lower.

[4]A number of simple rules have been used throughout the literature to identify turning points. One well known rule, attributed to Arthur Okun, defines a recession as at least two quarters of negative quarter-on-quarter growth in real GDP.

various indicators or about what other measures are considered. The CEPR committee operates in a similar way.

To make business cycle identification operational, it is useful to decompose the economic time series into three components: a trend component, a business cycle component and an irregular component. For aggregate output, the trend component reflects the (possibly time-varying) potential growth rate of the economy. The business cycle component reflects the fluctuations of output around its potential level, while the irregular component represents a residual that can reflect measurement errors. Armed with this definition, one can use different time series filters to remove the trend and irregular components from the data to identify the business cycle component of the series. The most simplistic approach would be to linearly detrend the logarithm of the data. This approach tends to exaggerate the business cycle in the data and retain fluctuations of a short duration that are arguably not related to business cycles. Furthermore, this procedure is statistically valid only if the data is trend stationary, a questionable assumption for most economic data: Nelson & Plosser (1982) show that most economic data is in fact difference stationary. If that is the case, a more appropriate approach would be to take the first difference of the data to identify business cycles. As Stock & Watson (1999) show, however, this tends to exacerbate the difficulties presented by short-run noise, which obscures the cyclical fluctuations in the data.

The problem with these simplistic approaches has spurred the creation of more advanced approaches that better isolate the cyclical component of economic time series. The two most popular examples are the Hodrick & Prescott (1997) filter and the Baxter & King (1999) band-pass filter (see the discussion in Appendix A). These more advanced filters require, however, a more precise definition of the cyclical component of the data. The common definition (see, for example Stock & Watson, 1999) is to define the periodicities of a business cycle to be between 6 quarters and 8 years. Fluctuations of a higher frequency than 6 quarters are therefore consigned to the irregular component of the data, while fluctuations of a lower frequency than 8 years are assumed to be associated with the trend component of the data. As Stock & Watson (1999) show, the Hodrick-Prescott filter - while improving upon the first-differencing filter - still passes much of the high frequency noise outside the business cycle frequency band compared to the Baxter-King filter.[5]

Business cycles identified through prefiltering the data using filters such as the Baxter-King band-pass filter are commonly referred to as "growth cycles" that basically attempt to measure the deviations of economic activity from its long-run trend growth rate. An alternative approach is the "classical business cycle" approach which attempts to identify business cycles by directly looking at turning points in the raw data itself (see a discussion of these two approaches in Stock & Watson, 1999). The outcomes from these two approaches can differ slightly and both have advantages and disadvantages. For example, classical

[5] Another benefit of the Baxter-King filter compared to the Hodrick-Prescott filter is that specifying the smoothing parameter of the Hodrick-Prescott filter can be difficult, especially when using data of other frequencies than quarterly. See Canova (2007) for a further discussion on different measures of separating the business cycle component from trend output growth and the issues that may arise in that context.

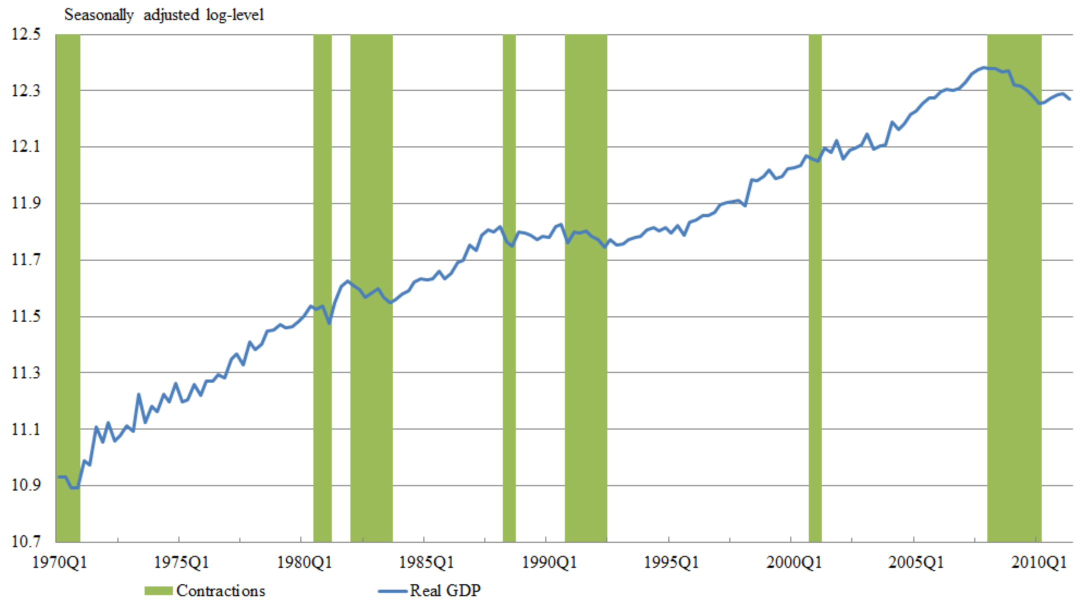

Figure 3: Periods of contractions and expansions in Iceland 1970Q1-2011Q2 based on the classical business cycle approach. *Sources*: Central Bank of Iceland, Statistics Iceland.

cycles tend to underestimate the number of business cycles in the data, while growth cycles tend to overestimate the number of business cycles.[6] Classical cycles also tend to have recessions that are considerably shorter than expansions because of the underlying trend growth in the data, while growth cycles tend to have expansions and contractions of approximately the same duration. Business cycle chronology by growth cycles is also less sensitive to the underlying trend growth in the data. Classical cycles therefore tend to identify very few business cycles in economies which have exhibited high growth rates over extensive periods. In addition, they suffer from a lack of statistical foundations. On the other hand, growth cycles are inconsistent with some modern macroeconomic theories in that they assume that the determinants of the cyclical and trend components are largely distinct. In what follows, we use both approaches to describe the Icelandic business cycle and compare it to business cycles of other developed countries.

3.1 Characteristics of classical business cycles in Iceland

Figure 3 depicts the logarithm of quarterly real GDP in Iceland for the period 1970-2011.[7] The data show a clear long-run trend (GDP has increased by 280% over the period), while also exhibiting regular fluctuations at higher frequencies than business cycles (see above). Without further transformation of the time series it is therefore difficult to separate the

[6] For example, when compared to the business cycle chronology of the NBER Business Cycle Dating Committee.

[7] Official quarterly GDP data for Iceland is only available from 1997. For the period 1970-1997, we use quarterly GDP data constructed by the Central Bank of Iceland, see chapter 14 in Daníelsson et al. (2009) for a description of how the data is constructed (the data is available at http://www.cb.is/publications-and-speeches/research/macromodel-qmm/).

Expansions	Duration	Amplitude	Contractions	Duration	Amplitude
Period			Period		
71Q1-80Q2	38	65	80Q3-81Q1	3	-6
81Q2-81Q4	3	15	82Q1-83Q3	7	-8
83Q4-88Q1	18	27	88Q2-88Q3	2	-7
88Q4-90Q3	8	8	90Q4-92Q2	7	-8
92Q3-00Q3	33	32	00Q4-01Q1	2	-2
01Q2-07Q4	27	33	08Q1-10Q1	9	-13
10Q2-	5(+)	1(+)			

Table 2: Turning points of classical business cycles in Iceland using the MBBQ algorithm, 1971Q1-2011Q2. Real GDP seasonally adjusted. Duration is measured in quarters. Amplitude measures an expansion (contraction) as the change in output from trough (peak) to the next peak (trough) in percentages. (+) indicates that the latest expansionary period is still ongoing.

cyclical fluctuations, which are of main interest, from the long-run component and from the short-run noise which stems from temporary factors such as changes in weather or measurement errors.

We start by attempting to identify business cycles using the classical approach. First, we need to identify the turning points of the cycle. In the classical business cycle analysis, a turning point is reached when output is at its local extremum. An expansionary phase is defined as the period between the local minimum and maximum whereas the contraction phase is defined as the period between the local maximum and minimum. To date the turning points we use James Engel's modification of the Harding & Pagan (2002) BBQ algorithm (MBBQ algorithm).[8] The algorithm identifies a local maximum (minimum) as a peak (trough) relative to the two quarters on either side. A screening process is, furthermore, imposed on the initial turning points. The main restrictions are:

- A phase, the period between turning points, must last at least 2 quarters.
- A complete cycle (i.e. peak-to-peak and trough-to-trough) should last at least 5 quarters. This ensures that the periods of expansions and contractions are of a certain length.
- A peak and a trough must alternate. If two peaks (troughs) occur in a row the higher (lower) one is chosen.
- In addition the algorithm makes sure that no turning point can be determined within 2 quarters length of the end points of the series.

Over the period 1970 to 2011, the algorithm identified 13 turning points in Iceland's real GDP. Table 2 lists the turning points and the duration and amplitude of each expansion

[8]The Harding-Pagan BBQ algorithm is originally based on the Bry & Boschan (1971) algorithm. Details on the BBQ algorithm can be found on James Engel's website: http://www.ncer.edu.au/data/.

Characteristic	Expansion	Contraction	Cycle
Average duration	21.2	5.0	26.2
Median duration	22.5	5.0	27.5
Max duration	38.0	9.0	41.0
Min duration	3.0	2.0	10.0
Proportion (%)	80.9	19.1	-
Average amplitude (%)	30.0	-7.3	-
Quarterly amplitude (%)	1.4	-1.5	-

Table 3: Characteristics of the classical cycle in Iceland 1971Q1-2010Q1. Duration measured in quarters. Proportion measures the proportion of time spent in either phase. Quarterly amplitude or steepness is measured as the ratio of the average amplitude to the average duration of the period.

and contraction. The turning points are similar to those highlighted in section 2.1 and to those identified in Pétursson (2000) who uses a Markov-switching model to identify the Icelandic business cycle. In both cases the results show a downswing in 1982-1983. However, no downswing is found in 1975 which is the case in Pétursson (2000). Here, we also find that the period 1988-1992 is divided into two downswings while it is one large downswing in Pétursson (2000).[9]

Table 3 displays the main features of the average classical cycle for Iceland. The average duration of business cycles in Iceland is around 26 quarters or 6½ years, with expansions lasting substantially longer than contractions. The average duration of expansions is 21 quarters while contractions last on average only 5 quarters. The amplitude measure shows that the average decline in real GDP during contractions (-7.3%) is considerably smaller than the average increase during expansions (30%). Quarterly amplitude shows the steepness or speed with which real GDP changes in contractions and in expansions. In Iceland the average quarterly amplitude of real GDP is 1.4% in expansions, which is slightly less than the quarterly decline of real GDP in contractions (-1.5%). Over the period 1970-2011, Iceland has spent nearly 20% of the time in contraction according to the MBBQ algorithm. According to table 2, the recession that started in 2008 lasted just over 2 years with an amplitude of -13% which makes it the deepest recession in the sample period. Figure 3 shows the contractionary periods identified by the classical approach in table 2.

Comparing the characteristics of the Icelandic business cycles to other OECD countries identified with the classical approach reveals that the number of contractions and expansions in Iceland are similar to the average over all the countries from 1991 to 2010 (see table 4).[10] The average duration of contractions is also similar to the overall average, while the average duration of expansions is only half as long as in other sample countries. Italy, Germany and Denmark depict the highest frequency of cycles over the data period,

[9]It should be borne in mind that different methods are used and the data in table 2 uses quarterly data while Pétursson used annual data.

[10]See, for example, Canova (1998) and Male (2010), and the references therein.

	Contraction periods (peak to trough)				
	Number of contractions	Duration	Time in contraction (%)	Amplitude (%)	Quarterly amplitude (%)
Canada	1	6.0	9.5	-3.4	-0.6
Denmark	5	3.3	23.0	-3.0	-0.9
Euro area	2	4.5	12.2	-3.6	-0.8
Finland	2	4.0	17.6	-10.7	-2.7
France	2	4.5	12.2	-2.6	-0.6
Germany	5	3.3	21.9	-2.6	-0.8
Ireland	1	13.0 (+)	16.0	-15.3	-1.2
Iceland	**4**	**5.3**	**29.5**	**-6.6**	**-1.2**
Italy	6	3.8	31.1	-1.9	-0.5
Japan	3	5.0	19.0	-5.3	-1.1
Norway	4	3.3	17.7	-1.8	-0.6
Slovakia	1	2.0	3.1	-1.4	-0.7
Switzerland	4	3.8	20.3	-1.5	-0.4
Sweden	2	5.0	19.2	-7.9	-1.6
UK	2	6.0	12.0	-6.6	-1.1
USA	1	6.0	9.5	-4.2	-0.7
Average	2.8	4.9	17.1	-4.9	-1.0

	Expansion periods (trough to peak)				
	Number of expansions	Duration	Time in expansion (%)	Amplitude (%)	Quarterly amplitude (%)
Canada	1	67.0	90.5	49.7	0.7
Denmark	4	14.3	77.0	10.0	0.7
Euro area	2	60.0	87.8	33.5	0.6
Finland	1	61.0	82.4	56.4	0.9
France	2	60.0	87.8	32.3	0.5
Germany	4	14.3	78.1	7.8	0.5
Ireland	1	68.0	84.0	106.9	1.6
Iceland	**3**	**18.3**	**70.5**	**23.4**	**1.3**
Italy	6	9.2	68.9	5.0	0.5
Japan	4	13.0	81.0	7.9	0.6
Norway	3	21.7	82.3	17.8	0.8
Slovakia	2	41.0	96.9	53.3	1.3
Switzerland	4	18.0	79.7	9.9	0.6
Sweden	1	59.0	80.8	47.9	0.8
UK	1	66.0	88.0	45.6	0.7
USA	1	67.0	90.5	51.9	0.8
Average	2.5	41.1	82.9	35.0	0.8

Table 4: Characteristics of classical business cycles in Iceland and selected countries 1991Q1-2010Q4. Data for countries other than Iceland are from the OECD *Economic Outlook*. The present contraction that started in 2008Q1 in Ireland has not yet ended according to the result from MBBQ. Data for Slovakia is only available from 1993Q1. (+) indicates an ongoing contractionary period.

followed by Iceland, Norway and Switzerland. Iceland has spent the second longest time in contractions. Finland has the steepest contractions, on average -2.7% per quarter, Sweden follows (-1.6%) and after that Iceland and Ireland with the third steepest contractions (-1.2%).

However, when expansions are considered, Ireland has the highest quarterly amplitude (1.6% per quarter). Iceland and Slovakia have the second most (1.3%) and Finland the third (0.9%). In an international comparison, the average classical Icelandic business cycle as dated by the MBBQ algorithm can therefore be characterised by steep contractions and expansions, similar to cycles in Finland, Ireland and Slovakia, consistent with the high volatility of output in Iceland reported in table 1.

All the countries in the sample ended a long expansion phase in the period 2007Q4 to 2008Q3. This expansion lasted 5-7 years in Japan, Norway and Switzerland, but 15-18 years in the US, UK, the euro area, Sweden, Denmark, and Canada. In the case of Iceland, the expansion at the beginning of this century lasted for nearly 7 years. The contraction period that followed lasted around 1 year, ending in 2009Q2, for all but two countries: Iceland where it ended a year later (in 2010Q1) and Ireland which is still in recession according to data extending to 2011.

3.2 Characteristics of growth cycles in Iceland

Here we attempt to identify growth cycles using the Baxter-King band-pass filter to extract the cyclical component of real GDP from the data. As previously discussed, we assume that the periodicity of a business cycle ranges from 6 quarters to 8 years.[11] We use an 8 quarter centred moving average for the band-pass filter which means that no values are produced for the first and last eight observations. The cyclical component of the time series therefore begins in 1972Q2 and ends in 2010Q4. Baxter & King (1999) recommend using a 12 quarter moving average, but due to relatively few observations, we decided to use only eight quarters.[12] This leads us to identify more frequent cycles than a filter based on a 12 quarter moving average (see Appendix A), but to offset this we impose more stringent conditions on what can constitute an expansion or a contraction. We base those on the MBBQ algorithm discussed in the previous section. We also add an additional rule to what can constitute as a turning point which is necessary in order to avoid too frequent and short cycles. The conditions are:

- Cyclical turning points are either peak or trough points which must be a local extremum. A peak (trough) has to be higher (lower) than the preceding two data points as well as the following two data points (except for end points).

[11] According to the previous analysis using the classical definition of business cycles, the average duration of a business cycle in Iceland is 26 quarters (6.5 years), where the shortest cycle was 10 quarters (2.5 years) and the longest 41 quarters (10 years and a quarter). However, classical cycles tend to overestimate the length of expansion periods due to the underlying trend in the data.

[12] The ideal filter requires infinite numbers of past and future values of the data. It can therefore be better approximated using longer lags but at the cost of losing observations at the start and end of the sample. See Appendix A for further details.

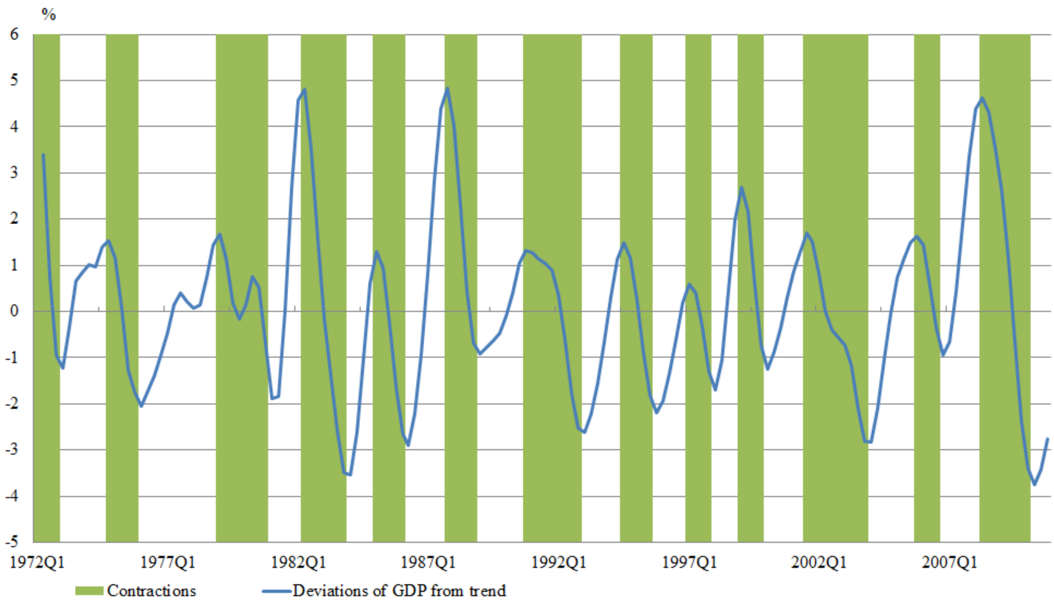

Figure 4: Cyclical component of Icelandic GDP based on the Baxter-King band-pass filter and the additional restrictions described in the main text. *Sources*: Central Bank of Iceland, Statistics Iceland.

- Furthermore, peaks and troughs must alternate. If double peaks (troughs) occur, the higher (lower) one is chosen.

- Finally, it is required that an expansionary or a contractionary phase to reach certain amplitude in order for a growth point to be considered as a peak (trough). More specifically it must have at least 0.3 percentage points growth above (below) trend growth.

These restrictions ensure that the 8 quarter moving average returns the same number of cycles as if using the 12 quarter moving average.

The resulting cyclical component of real GDP is plotted in figure 4. Upswings occur when GDP is above its long-term trend and conversely for downswings. An expansionary phase is defined as the period between a trough and a peak and a contractionary phase is defined as the period between peak and trough.

Table 5 shows the timing of peaks and troughs in the Icelandic business cycle using the growth cycle approach. In total, 12 peaks are identified, with the deviations from trend GDP ranging from 0.6% in the late 1996 to almost 5% in early 1982, late 1987 and early 2008. There are 13 troughs identified, the deepest occurring in late 1983 and early 2010, when output is estimated to have been more than 3.5% below its trend level. The duration of expansionary and contractionary phases is broadly similar throughout the sample period. The longest expansion lasts for 12 quarters, from late 1975 to late 1978 and the shortest for 4 quarters whereas the duration of contractionary phases ranges from 4-10 quarters. The amplitude of expansionary and contractionary phases has decreased

Contractions (peak to trough)				Expansions (trough to peak)			
Peak	Duration	Highest point (%)	Amplitude (%)	Trough	Duration	Lowest point (%)	Amplitude (%)
				1972Q4	7	-1.22	2.75
1974Q3	5	1.54	-3.60	1975Q4	12	-2.06	3.73
1978Q4	8	1.68	-3.56	1980Q4	5	-1.89	6.69
1982Q1	7	4.80	-8.35	1983Q4	4	-3.55	4.83
1984Q4	5	1.29	-4.18	1986Q1	6	-2.90	7.74
1987Q3	5	4.84	-5.75	1988Q4	7	-0.91	2.24
1990Q3	9	1.33	-3.93	1992Q4	6	-2.61	4.08
1994Q2	5	1.47	-3.47	1995Q3	5	-2.00	2.59
1996Q4	4	0.59	-2.43	1997Q4	4	-1.84	4.53
1998Q4	4	2.69	-3.65	1999Q4	6	-0.96	2.67
2001Q2	10	1.71	-4.55	2003Q4	7	-2.84	4.47
2005Q3	4	1.63	-2.57	2006Q3	6	-0.94	5.56
2008Q1	8	4.62	-8.37	2010Q1	-	-3.75	-

Table 5: Growth cycles in Iceland using Baxter-King band-pass filtered real GDP 1972Q1-2010Q4. Duration measured in quarters. Amplitude of expansion (contraction) is from the lowest (highest) point to the highest (lowest) growth point.

overall although it has picked up again recently. In the time period 1972-1989 the average amplitude of a expansionary (contractionary) phase was 4.7% (5.0%) while it was 4.0% (4.1%) after 1990.

On average the amplitude of expansionary and contractionary phases have been just above 4% (see table 6). The expansionary and contractionary phases have on average lasted for just above 6 quarters. The average duration of the phases is therefore about the same, although the median duration of expansionary phases is longer than of contractions. The shortest contractionary and expansionary phases have lasted for a year, while the longest contraction has lasted for 2.5 years and the longest expansion for 3 years. A complete cycle usually spans 3 years. Finally, the time in a contractionary and expansionary phase is roughly split equal over the sample period.

Characteristic	Contraction	Expansion	Cycle
Average duration (quarters)	6.2	6.3	11.8
Median duration	5.0	6.0	11.0
Max duration	10.0	12.0	17.0
Min duration	4.0	4.0	70
Proportion (%)	49.7	50.3	-
Average amplitude (%)	-4.3	4.4	-
Quarterly amplitude (%)	-0.7	0.7	-

Table 6: Characteristics of growth cycles in Iceland 1972Q4-2010Q1.

	Contraction periods (peak to trough)				
	Number of contractions	Duration	Time in contraction (%)	Amplitude (%)	Quarterly amplitude (%)
USA	3	7.0	34.4	-2.9	-0.4
UK	3	8.0	35.8	-2.7	-0.3
Denmark	4	7.0	43.8	-3.1	-0.4
Euro area	3	14.0	65.6	-2.8	-0.2
Finland	3	7.3	33.3	-4.8	-0.6
France	3	8.0	38.1	-2.5	-0.3
Ireland	4	6.3	41.0	-3.8	-0.6
Iceland	**6**	**5.7**	**50.7**	**-4.2**	**-0.7**
Italy	4	8.8	55.6	-2.8	-0.3
Japan	3	6.0	27.3	-4.8	-0.8
Canada	4	5.8	35.4	-2.6	-0.5
Norway	4	7.8	44.9	-2.3	-0.3
Slovakia	2	5.5	19.0	-6.9	-1.3
Switzerland	4	8.0	52.5	-2.6	-0.3
Sweden	3	8.3	39.1	-4.3	-0.5
Germany	4	8.5	51.5	-2.9	-0.3
Average	4	7.6	41.7	-3.5	-0.5

	Expansion periods (trough to peak)				
	Number of expansions	Duration	Time in expansion (%)	Amplitude (%)	Quarterly amplitude (%)
USA	3	14.0	65.6	2.2	0.2
UK	3	14.3	64.2	2.1	0.1
Denmark	4	9.0	56.3	2.8	0.3
Euro area	3	7.3	34.4	2.4	0.3
Finland	3	14.7	66.7	3.8	0.3
France	3	13.0	61.9	2.4	0.2
Ireland	4	9.0	59.0	3.5	0.4
Iceland	**6**	**5.8**	**49.3**	**3.9**	**0.7**
Italy	4	7.0	44.4	2.5	0.4
Japan	4	12.0	72.7	3.3	0.3
Canada	4	10.5	64.6	2.3	0.2
Norway	4	9.5	55.1	2.3	0.2
Slovakia	2	23.5	81.0	5.4	0.2
Switzerland	3	9.7	47.5	2.6	0.3
Sweden	3	13.0	60.9	3.6	0.3
Germany	4	8.0	48.5	2.4	0.3
Average	4	11.3	58.3	3.0	0.3

Table 7: Characteristics of growth cycles in selected countries 1993Q1-2010Q4. Growth cycles found with Baxter-King band-pass filter (historical data from 1991Q1 to 2011Q1 and forecasted values from OECD *Economic Outlook* for 2011Q2 to 2012Q4 are used, first and last two years are lost in the filtering process). Data for Slovakia are only available since 1993Q1. Quarterly amplitude or steepness is measured as the ratio of the average amplitude to the average duration of the period.

Table 7 compares the main characteristics of Icelandic growth cycles with that of 15 other countries for the period 1991Q1 until 2010Q4. The Icelandic cycles are quite distinctive from the sample countries. Expansions and contractions seem more short-lived and more frequent than on average in the other countries. At the same time, the amplitude of contractions and expansions is greater than on average. It is also interesting that while the Icelandic economy has spent roughly equal time in contraction and expansion over the sample period, the ratio of time spent in an expansionary phase is much higher on average for the other countries.

4 Stylised facts of the Icelandic business cycle

This section analyses key regularities of the Icelandic business cycle, as captured by the correlation structure of the cyclical component of various economic variables. These statistical properties of business cycles are often referred to as "stylised facts" (see, for example, Kydland & Prescott, 1990, Cooley, 1995, and Stock & Watson, 1999).[13] We analyse nearly 100 economic time series. Due to the fact that a number of important data series are not available before the 1990s and in an attempt to avoid the high inflation period of the 1980s, we use quarterly data over the period 1992-2011. This is obviously a relatively short sample to analyse business cycles and all results therefore need to be interpreted accordingly.[14] The cyclical component of the data is obtained using the Baxter-King band-pass filter discussed in the previous section, with an 8 quarter moving average. Thus, the cross-correlation analysis spans the period 1994-2009. Prior to extracting the cyclical component of the data, we also filter out seasonal fluctuations from the log-transformed data (except for the interest rate, the unemployment rate, inflation, output gap, and series which are reported as a percentage of GDP) using the X12 seasonal filter.

The data are split into six categories: national accounts components and balance of payments, labour market, prices and inflation, financial markets and wealth, exchange rate and international output, and various high-frequency economic indicators. In each section a table is reported with the standard deviation of the cyclical component of the series and the cross-correlation of the cyclical component of each series and the cyclical component of GDP at various leads and lags, i.e. $corr(x_t, y_{t+k})$ for different k, where y_{t+k} is the seasonally adjusted cyclical component of log output and x_t is the seasonally adjusted cyclical component of the given variable. A large positive (negative) correlation at $k = 0$ indicates contemporaneous procyclical (countercyclical) behaviour of the data. The lead-lag correlation structure also gives information on whether a series leads or lags the aggregate business cycle (as measured by the cyclical component of GDP). Hence, a large positive (negative) correlation at $k > 0$ indicates that the series leads the cycle, whereas

[13] See, for example, Canova, 1998 and Male, 2010 for an overview of some stylised business cycle facts.

[14] Some of the data are available for an even shorter time period. The data was obtained from the Central Bank of Iceland database (http://www.cb.is/publications-and-speeches/research/macromodelqmm/), Capacent Gallup, the Directorate of Labour, Macrobond, Reuters/EcoWin, Nasdaq OMX Nordic Exchange Iceland, and Statistics Iceland.

the series would lag the cycle for $k < 0$. Correlations close to zero at all leads and lags would indicate that the series is largely acyclical.

4.1 National account sub-components and balance of payments

In table 8 we start by looking at various national account sub-components and balance of payment items. Bold numbers indicate the largest cross-correlation coefficient for each series. Starting with the cyclical properties of GDP itself, we find evidence of strong persistence in the domestic business cycle as observed by the high autocorrelation of the cyclical component of GDP.

Domestic demand is found to be strongly procyclical, as are all its sub-components. Private consumption, the largest component of domestic demand, is strongly procyclical and leads the cycle by 1-2 quarters. We also find that consumption is more volatile than output, with a standard deviation of 3.8% compared to a 1.6% standard deviation of GDP. This seems at odds with the consumption smoothing property of the life-cycle hypothesis; a common finding in other developed countries, although there are a few exceptions such as Japan and UK (see, for example, Baxter, 1995). We return to this issue in section 4.7.

Consistent with international evidence (see e.g. Stock & Watson, 1999), total investment is found to be the most volatile component of domestic demand with a standard deviation of 10.1% and is strongly procyclical. As is the case with consumption, we find that total investment and its sub-components lead the cycle by 1-2 quarters. Business investment is found to be very volatile (a standard deviation of 13.6%) and leads the cycle by 2 quarters. Investment in the aluminium and power sector, which accounts for 30% of business investment on average, is even more volatile, reflecting its lumpy nature. This investment item is also found to have weaker links to the domestic business cycle, reflecting the fact that the aluminium smelters are under foreign ownership and the investment plans have stronger links to global economic developments than domestic economic developments. Of the three sub-components of investment, residential housing investment and public investment are the least volatile with standard deviation of around 9%. Both investment components are strongly correlated to the cycle and lead it by 1-2 quarters.

Consistent with international evidence, we find that public consumption is less volatile than GDP. It, however, appears to be procyclical with a 2 quarter lag. Thus, government consumption seems to pick up roughly half a year after output starts growing, suggesting a lack of active countercyclical fiscal policy in Iceland. In most other industrial countries government consumption is either found to be countercyclical or almost acyclical, cf. Crucini (2006) and Male (2010).

Reflecting the small, open economy nature of the Icelandic economy, we find that imports and exports of goods and services are strongly procyclical, with imports leading the cycle by 2 quarters, while exports are contemporaneous to the cycle. While the volatility of exports at cyclical frequencies is similar to what is found in other developed countries,

		Cross correlation with output lagged and led by k quarters								
	Std.dev. (%)	-6	-4	-2	-1	0	1	2	4	6
Gross domestic production	1.6	-0.2	0.0	0.6	0.9	1.0	0.9	0.6	0.0	-0.2
Private consumption	3.8	-0.2	-0.3	0.1	0.4	0.6	**0.7**	0.7	0.3	0.2
Public consumption	1.0	0.3	0.6	**0.7**	0.6	0.4	0.2	0.0	-0.3	-0.3
Investment	10.1	-0.2	-0.2	0.1	0.3	0.6	0.7	**0.7**	0.5	0.4
Business investment	13.6	-0.2	-0.3	0.0	0.2	0.5	0.6	**0.6**	0.5	0.4
Aluminium and power investment	23.1	-0.2	-0.2	0.1	0.3	0.4	**0.4**	0.4	0.2	0.3
Residential investment	9.0	-0.1	-0.1	0.3	0.5	0.7	**0.7**	0.6	0.3	0.0
Public investment	8.7	0.0	-0.1	0.1	0.3	0.5	0.7	**0.7**	0.4	0.0
Net stockbuilding (% of GDP)	0.2	**0.6**	0.3	-0.2	-0.3	-0.3	-0.2	0.0	0.3	0.1
Domestic demand	3.7	-0.1	-0.2	0.2	0.4	0.6	**0.7**	0.7	0.4	0.3
Imports of goods and services	7.3	-0.2	-0.3	0.0	0.2	0.4	0.6	**0.7**	0.4	0.3
Exports of goods and services	3.3	-0.5	-0.2	0.4	0.6	**0.7**	0.5	0.2	-0.4	-0.6
Trade account balance (% of GDP)	2.7	0.0	0.1	0.1	0.0	-0.2	-0.3	-0.4	-0.5	**-0.6**
Current account balance (% of GDP)	3.8	-0.1	-0.3	-0.3	-0.2	-0.1	-0.1	-0.1	-0.2	**-0.5**
Income account balance (% of GDP)	3.3	0.0	**-0.4**	-0.4	-0.2	0.0	0.1	0.3	0.2	0.0
Potential output	0.7	0.3	0.5	0.7	**0.7**	0.7	0.6	0.5	0.4	0.3
Output gap (% of potential output)	1.2	-0.4	-0.3	0.4	0.7	**0.9**	0.8	0.5	-0.1	-0.3

Table 8: Volatility and cross correlation of national account and balance of payments variables with output lagged and led by k quarters 1994Q1-2009Q2.

imports are found to be much more volatile in Iceland than in other developed countries. This does not come as a surprise as imports and consumption of durable goods tends to fluctuate with fluctuations in the exchange rate (see below). Exports are less sensitive to exchange rate movements as the biggest export industries, i.e. marine and aluminium production (accounting for 60% of total exports), run close to full capacity under quantity constraints, i.e. quotas for the fisheries industry and long lead time on investment in the aluminium sector (see further in Einarsson et al., 2013).

The trade balance is less volatile than domestic demand and is found to be countercyclical and leading the cycle by 6 quarters. Thus, net trade tends to reduce economic fluctuations in Iceland as previously discussed. This countercyclical property of net trade is a common finding in developed countries (see Stock & Watson, 1999, and Crucini, 2006). Although the income balance is found to lag the cycle, the overall current account balance shows a similar cyclical behaviour to the trade balance.

Finally, table 8 reports the cyclical behaviour of the Central Bank's estimate of potential output and the resulting output gap published by the Bank (for details, see Daníelsson et al., 2009). As expected, potential output is found to be much smoother than actual output, but also to be procyclical and broadly contemporaneous to the cycle. The results for the output gap are very similar to those of the cyclical component of GDP itself, suggesting that the cyclical properties of those two largely coincide (although the Bank's output gap estimate is found to be somewhat smoother than the cyclical component of output used here).

4.2 Labour market

In table 9 we move on to the domestic labour market. As is commonly found, the cyclical component of unemployment is strongly countercyclical, while total hours are strongly procyclical. Unemployment is found to lead the cycle by 1 quarter while total hours are contemporaneous to the cycle. However, unlike total hours, average hours seem broadly acyclical. Vacancies are also found to be acyclical, while issued work permits are procyclical and lag the cycle by 1 quarter.[15] The labour participation rate is found to be weakly procyclical or even acyclical, while labour productivity seems to be procyclical and leading the cycle by 4 quarters.[16] Nominal wages are however found to be strongly procyclical and leading the cycle by 2 quarters. Real wages, both the producer and consumer real wage rate, are also procyclical and lead the cycle by 2 quarters.

Our findings on the aggregate labour market are broadly in line with findings from other countries, except that average hours and vacancies are usually found to be strongly procyclical (see, for example, Stock & Watson, 1999, for the US, Husebo & Wilhelmsen, 2005, for Norway and McCaw, 2007, for New Zealand), while no such relationship is detected here. The procyclical nature of real wages is, however, much more evident in the

[15] Data on vacancies and work permits is only available since 1996.

[16] The so-called Dunlop-Tashis puzzle, i.e. a weak contemporaneous correlation between total hours and labour productivity whereas theory predicts a high correlation, is also evident in the Icelandic data.

		Cross correlation with output lagged and led by k quarters								
	Std.dev. (%)	-6	-4	-2	-1	0	1	2	4	6
Total hours	1.6	-0.1	0.1	0.5	0.6	**0.7**	0.6	0.5	0.2	0.0
Average hours	1.0	-0.1	-0.1	0.1	0.2	0.3	0.3	0.3	0.1	0.0
Unemployment rate	0.8	0.2	0.0	-0.4	-0.6	-0.7	**-0.7**	-0.6	-0.3	-0.1
Vacancies (total)	34.2	-0.2	-0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Vacancies (capital area)	47.0	-0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Issued work permits	23.0	-0.4	0.0	0.3	**0.4**	0.4	0.2	0.0	-0.3	0.0
Trend labour productivity	0.4	0.1	-0.1	-0.1	0.0	0.1	0.3	0.4	**0.5**	0.4
Participation rate	0.5	-0.4	-0.1	0.3	0.3	0.4	0.3	0.2	-0.1	-0.2
Nominal wages	1.6	0.4	0.2	0.1	0.2	0.4	0.6	**0.7**	0.4	-0.1
Nominal wage inflation	2.4	0.2	-0.2	-0.4	-0.2	0.0	0.3	**0.5**	0.5	0.0
Real wages (defl. with GDP deflator)	2.0	0.1	-0.2	0.0	0.3	0.6	0.7	**0.8**	0.5	0.1
Real wage inflation (defl. with GDP deflator)	2.8	-0.1	-0.6	-0.5	-0.2	0.1	0.3	**0.5**	0.3	0.0
Real wages (defl. with CPI)	2.3	0.2	-0.2	0.0	0.2	0.5	0.7	**0.8**	0.5	0.1
Real wage inflation (defl. with CPI)	3.2	0.0	-0.5	-0.5	-0.3	0.0	0.3	**0.5**	0.4	0.0

Table 9: Volatility and cross correlation of labour market variables with output lagged and led by k quarters 1994Q1-2009Q2.

Icelandic data than for example in the US data (Stock & Watson, 1999) and is more in line with standard New Keynesian models of the business cycle. Husebo & Wilhelmsen (2005) and McCaw (2007) also find procyclical real wages for Norway and New Zealand, respectively, but they seem contemporaneous to the cycle in Norway and lagging the cycle by up to 6 quarters in New Zealand. Volatility of employment data at the cyclical frequency is in most cases found to be in line with the variability of cyclical output, as found in other countries. Unlike other countries, however, we find that average hours are less volatile than output. We also find nominal and real wages to be much more volatile than productivity, whereas most other studies find that wages are less volatile than productivity.

Normally, employment moves across sectors as the state of the economy changes. Examining sectorial employment may therefore give an idea of how activity in different sectors moves over the business cycle. In table 10 we therefore report the correlation structure of disaggregate employment levels with the cyclical component of GDP. Employment in the service sector (such as retail and finance) is procyclical and leads the cycle, while employment in the construction sector and in agriculture lags the cycle. Somewhat surprisingly, we also find that employment in public administration seems to be procyclical and lagging the cycle. This could reflect the general tendency of the government to expand during upswings and contract during downswings, as apparent from the procyclical nature of government consumption noted earlier. On the other hand, we find some evidence of countercyclical employment levels in education with a lead of up to 6 quarters. A possible explanation could be that workers move out of education into better paid jobs in the private sector as the economy picks up, while workers move again into educational services in a downswing, seeking better job security. Similar evidence, although to a lesser extent, is found in fish processing. Finally, while sectorial employment levels are quite volatile at business cycle frequencies, these movements are in most cases relatively weakly related, and in many sectors unrelated, to the aggregate business cycle.

4.3 Prices and inflation

Table 11 reports the cross-correlation structure of output and different price series. A common finding among developed countries is that price levels are countercyclical and lead the cycle (see, for example, Chadha & Prasad, 1994, Stock & Watson, 1999, Agresti & Mojon, 2001, and Male, 2010). This is also the case in the Icelandic data: aggregate price series, such as the consumer price level and the GDP price deflator, are found to be countercyclical and lead the cycle by 1-2 quarters (overall and domestic consumer prices and the consumption deflator) and up to 8 quarters (the GDP deflator). This leading countercyclical behaviour can also be found in most of the other domestic price series reported in table 11. Two noticeable exceptions are the price deflators for public consumption and housing investment, which are found to be procyclical and lagging the cycle by 4-6 quarters.

Again consistent with international findings, the rate of change in prices, i.e. inflation rates, are however found to be procyclical and lagging the cycle by 4 quarters, suggesting

Sectoral employment	Std.dev. (%)	Cross correlation with output lagged and led by k quarters								
		-6	-4	-2	-1	0	1	2	4	6
Agriculture	6.1	**0.6**	0.1	-0.3	-0.3	-0.2	-0.1	0.2	0.4	0.4
Fishing	5.7	-0.2	0.0	0.2	0.1	0.0	-0.1	-0.2	-0.2	-0.1
Fish processing	6.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	**-0.4**
Other industry	1.7	-0.1	0.1	0.2	0.3	0.2	0.2	0.1	0.1	0.1
Utilities	8.7	0.0	-0.1	0.0	0.1	0.2	0.3	0.3	0.1	-0.2
Construction	6.6	0.1	0.5	**0.7**	0.7	0.6	0.5	0.3	0.0	-0.2
Retail trade and repair service	3.6	0.3	0.2	0.2	0.3	0.4	0.4	**0.5**	0.4	0.1
Hotel and restaurant	5.8	0.0	0.2	0.1	-0.1	-0.2	-0.3	-0.3	-0.1	0.2
Transport	3.8	-0.1	0.0	0.2	0.2	0.1	0.1	0.0	0.0	0.1
Financial and insurance	5.9	0.4	0.1	0.0	0.1	0.3	0.4	**0.5**	0.4	0.0
Real estate services	3.1	0.1	-0.1	-0.1	0.0	0.1	0.2	0.3	0.2	0.0
Public administration	6.9	**0.5**	0.4	0.1	-0.1	-0.1	-0.2	-0.1	0.0	0.2
Educational	6.7	0.0	0.2	0.4	0.3	0.3	0.1	-0.1	-0.5	**-0.6**
Health and social services	3.1	-0.2	0.2	0.3	0.2	0.0	-0.2	-0.3	-0.2	0.1
Cultural and other social services	12.4	0.2	-0.3	-0.4	-0.3	-0.1	0.1	0.4	**0.6**	0.3

Table 10: Volatility and cross correlation of sectoral employment variables with output lagged and led by k quarters 1994Q1-2009Q2.

that inflation starts rising roughly one year after a business cycle upswing and continues to rise for a few quarters after the economy starts to slow down.[17] Although the volatility of the price level and inflation have fallen markedly since the high inflation period in the 1980s, it remains high compared to other developed countries (see Pétursson, 2010) and has risen following the surge in inflation in the wake of the recent boom-bust cycle (see table 12). Furthermore, unlike what can be found in most other developed countries, the consumer price level and consumer price inflation tend to be more volatile than GDP output volatility, although the difference has declined over time.

Table 11 also reports the cyclical properties of key external prices and the terms of trade. As with the domestic price level, export and import prices in domestic currency are found to be countercyclical and leading the cycle by 2 quarters (import prices) and 8 quarters (export prices). Relative export and import prices, i.e. the terms of trade, are however found to be procyclical and lead the cycle by 3-4 quarters. The two most important export prices are the prices of aluminium and marine goods (which account for 80% of merchandise exports in 1997-2010). The table also reports the cyclical properties of the prices in foreign currency. Both are found to be procyclical and leading the cycle by 1-2 quarters. Key import prices in foreign currency, such as oil and non-oil commodity prices are, however, found to be acyclical. The cyclical properties of terms of trade seem therefore mostly driven by the cyclical properties of export prices, with the effects of marine prices appearing stronger than those of aluminium prices (the correlation of the cyclical components of marine prices and the terms of trade is 0.8 but 0.5 for the cyclical components of aluminium prices and the terms of trade). This procyclical property of terms of trade in Iceland is commonly found in other small developed countries (e.g. Mendoza, 1995, Agénor et al., 2000, Rand & Tarp, 2002, and Male, 2010), which could reflect the importance of terms of trade shocks for the domestic business cycle (see, also Gudmundsson et al., 2000).

Finally, table 11 reports the cross-correlation structure of the cyclical component of nominal and real house prices. Both are found to be strongly procyclical, with nominal house prices lagging the cycle by a quarter and real house prices contemporaneous to the cycle. This is in line with international studies (e.g. Agresti & Mojon, 2001 and McCaw, 2007) and is consistent with positive demand shocks leading to stronger activity and higher house prices through increased demand, but also with a positive feedback through higher house prices increasing household net worth and domestic demand.

4.4 Financial markets and wealth

In table 13 we report the cross-correlation structure of output and various financial variables. Broad money (M3) is found to be procyclical and lagging the cycle by 2 quarters. In line with standard theory and international evidence (e.g. Stock & Watson, 1999), we find

[17]See, for example, Ball & Mankiw (1994) for a discussion on the implications of these findings for economic modelling and the importance in distinguishing between the level and rate of change correlations of prices with output.

		Cross correlation with output lagged and led by k quarters										
	Std.dev. (%)	-8	-6	-4	-2	-1	0	1	2	4	6	8
Consumer price index (CPI)	1.3	-0.2	0.3	0.5	0.2	-0.1	-0.3	-0.5	**-0.5**	-0.4	-0.3	-0.3
CPI inflation	2.2	-0.2	0.3	**0.6**	0.4	0.2	0.0	-0.1	-0.2	-0.1	-0.1	-0.2
Domestic component of CPI	2.8	-0.2	0.4	0.5	0.1	-0.2	-0.5	**-0.6**	-0.6	-0.3	0.0	-0.2
Domestic CPI inflation	5.3	-0.3	0.3	**0.7**	0.4	0.1	-0.2	-0.3	-0.4	-0.1	0.1	-0.1
Imported component of CPI	2.9	-0.2	0.3	0.4	0.0	-0.3	-0.6	**-0.7**	-0.7	-0.4	-0.3	-0.4
Imported CPI inflation	5.0	-0.2	0.4	**0.7**	0.4	0.1	-0.1	-0.3	-0.3	-0.1	-0.1	-0.4
GDP price deflator	1.6	-0.1	0.3	0.4	0.1	-0.1	-0.3	-0.3	-0.3	-0.2	-0.2	**-0.4**
GDP price inflation	2.9	-0.2	0.2	**0.4**	0.2	0.1	0.0	-0.1	0.0	0.1	-0.1	-0.3
Private consumption price deflator	1.8	0.0	0.3	0.4	0.1	-0.1	-0.3	-0.5	**-0.5**	-0.4	-0.3	-0.4
Public consumption price deflator	1.5	0.1	**0.5**	0.5	0.2	0.0	-0.2	-0.2	-0.2	-0.2	-0.3	-0.2
Total investment price deflator	3.0	-0.1	0.2	0.4	0.1	-0.1	-0.3	-0.4	**-0.5**	-0.3	-0.2	-0.4
Government investment price deflator	2.3	-0.1	0.2	0.4	0.2	0.0	-0.2	-0.4	**-0.4**	-0.3	-0.2	-0.4
Housing investment price deflator	2.0	-0.2	0.2	**0.4**	0.1	-0.1	-0.2	-0.3	-0.4	-0.2	-0.2	-0.2
Imports of goods and services price deflator	6.5	-0.1	0.1	0.4	0.2	0.0	-0.2	-0.3	**-0.4**	-0.3	-0.2	-0.4
Exports of goods and services price deflator	5.6	-0.1	0.2	0.4	0.2	0.0	-0.2	-0.3	-0.3	-0.2	-0.1	**-0.4**
Terms of trade	2.5	0.0	0.0	-0.2	-0.2	-0.1	0.1	0.2	0.4	**0.4**	0.1	-0.1
Aluminium prices (in foreign currency)	10.8	0.2	-0.1	-0.3	-0.1	0.1	0.3	0.6	**0.7**	0.6	0.5	0.0
Price of marine products (in foreign currency)	3.7	0.1	-0.1	-0.1	0.2	0.4	0.5	**0.6**	0.5	0.2	-0.1	-0.2
Oil prices (in foreign currency)	18.3	0.0	-0.2	-0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.2
Commodity prices (in foreign currency)	6.6	0.1	-0.1	-0.2	-0.2	-0.1	0.1	0.3	0.4	**0.5**	0.4	0.0
Nominal house prices	3.5	-0.2	-0.1	0.2	0.6	**0.7**	0.7	0.6	0.4	0.1	0.0	0.3
Real house prices (deflated with CPI)	4.0	-0.1	-0.2	0.0	0.4	0.6	**0.7**	0.6	0.5	0.2	0.1	0.3

Table 11: Volatility and cross correlation of price variables with output lagged and led by k quarters 1994Q1-2009Q2. Correlation measures for domestic consumer price index, imported consumer price index, domestic inflation and imported inflation are for the period 1997Q1-2009Q2.

Period	St. dev. of CPI (%)	St. dev. of CPI relative to GDP	St. dev. of CPI inflation (%)	St. dev. of CPI inflation relative to GDP
1980-2008	3.6	1.9	8.4	4.5
1994-2008	1.3	0.8	2.2	1.3
1997-2008	1.5	0.9	2.4	1.4
2001-2008	1.7	0.9	2.8	1.5

Table 12: Standard deviation of the cyclical components of prices and output.

that nominal and real interest rates are also procyclical and roughly contemporaneous to the cycle. The cross-correlation structure furthermore suggests that higher interest rates are associated with a cyclical downturn 8 quarters ahead which is consistent with previous studies of the Icelandic business cycle and the transmission mechanism of monetary policy (see, Pétursson, 2001, and Daníelsson et al., 2006, 2009).[18] The spread between long and short nominal rates, i.e. the slope of the yield curve, is also found to be procyclical and slightly lagging the cycle, although there is a small negative correlation at longer leads, providing tentative evidence for the idea that an inverted yield curve is a good predictor of cyclical downturns.

Household wealth and disposable income are both found to be procyclical and leading the cycle by 1 quarter. The same pattern appears for corporate debt, while household debt lags the cycle by 2 quarters.[19] Finally, we find that stock prices tend to be procyclical and leading the cycle by 2 quarters. This is different from the other key domestic asset prices, house prices, which tend to lag the cycle as reported above (also found in Stock & Watson, 1999).

4.5 Exchange rate and international developments

In table 14 we look at the cross-correlation structure of exchange rate movements and various international variables vis-á-vis domestic output. Both the real and the nominal exchange rate are found to be procyclical and leading it by 2 quarters.[20] Thus, an exchange rate appreciation is usually followed by a cyclical upswing. This seems to be mainly through private consumption, which has a strong positive contemporaneous correlation with exchange rate movements (see the discussion in section 4.7).[21]

[18] The countercyclical leading property of longer real interest rates becomes even clearer when looking at the cyclical component of investment.

[19] The procyclical behaviour of corporate debt appears similar across different sectors of the economy.

[20] An increase in nominal exchange rate value indicates a depreciation of the króna, while a rising real exchange rate value indicates a real appreciation.

[21] As shown by Pétursson (2010), this procyclicality between exchange rate movements and private consumption is unusually strong in Iceland compared to other developed countries. This strong comovement feeds into a strong correlation between exchange rate movements and imports, while the comovement of exports and the exchange rate is much smaller. Presumably, this reflects the large import component of private consumption, while the supply of exporting goods is to an important degree price inelastic, as discussed in section 4.1.

		Cross correlation with output lagged and led by k quarters										
	Std.dev. (%)	-8	-6	-4	-2	-1	0	1	2	4	6	8
Broad money (M3)	4.4	0.0	0.2	0.4	**0.6**	0.6	0.5	0.3	0.1	-0.4	-0.5	-0.3
3 month nominal interest rate	1.2	0.0	0.2	0.4	0.6	0.7	**0.7**	0.7	0.6	0.4	0.1	-0.3
1 year nominal interest rate	1.1	0.2	0.1	0.1	0.4	0.6	0.8	**0.9**	0.8	0.5	-0.1	-0.5
5 year nominal interest rate	0.7	0.3	0.3	0.3	0.3	0.3	0.4	**0.4**	0.4	0.3	0.1	-0.2
Long-term real interest rate (indexed yields)	0.6	0.4	**0.4**	0.1	0.0	0.0	0.2	0.3	0.4	0.2	-0.1	-0.2
Spread between 5 year and 3 month nominal rates	0.9	-0.2	0.1	0.4	0.5	**0.6**	0.5	0.5	0.4	0.3	0.1	0.0
Household disposable income	3.3	0.2	0.1	0.2	0.4	0.5	0.7	**0.7**	0.6	0.4	0.1	0.0
Household wealth	5.8	0.0	-0.2	-0.1	0.2	0.4	0.5	**0.6**	0.6	0.4	0.3	0.4
Household debt	3.3	0.1	0.4	0.7	**0.7**	0.6	0.4	0.2	0.0	-0.3	-0.2	0.0
Corporate sector debt	17.4	0.3	0.2	-0.1	0.0	0.2	0.5	**0.6**	0.6	0.0	-0.4	-0.2
Stock prices	28.7	0.1	-0.2	-0.3	0.0	0.2	0.4	0.6	**0.7**	0.5	0.4	0.3

Table 13: Volatility and cross correlation of financial variables with output lagged and led by k quarters 1994Q1-2009Q2.

		Cross correlation with output lagged and led by k quarters										
	Std.dev. (%)	-8	-6	-4	-2	-1	0	1	2	4	6	8
ISK/USD exchange rate	9.3	-0.1	0.2	0.4	0.2	0.0	-0.3	-0.4	**-0.5**	-0.3	-0.2	-0.3
ISK/EUR exchange rate	9.2	-0.1	0.4	0.5	0.1	-0.1	-0.4	-0.6	**-0.6**	-0.3	-0.1	-0.5
Nominal effective exchange rate (trade weighted)	7.1	-0.1	0.2	0.3	0.2	-0.1	-0.3	-0.5	**-0.5**	-0.3	-0.2	-0.4
Real effective exchange rate (relative prices)	5.9	0.1	-0.1	-0.3	-0.2	0.0	0.3	0.4	**0.5**	0.3	0.1	0.3
International output (trade weighted)	0.8	0.0	-0.2	-0.1	0.1	0.3	0.5	0.6	**0.6**	0.4	0.2	-0.2
International short-term interest rate (trade weighted)	0.6	0.3	0.3	0.2	0.2	0.3	0.4	0.5	**0.5**	0.4	0.1	-0.2
International trade (imports of trading partners)	2.3	0.0	-0.1	0.0	0.1	0.3	0.4	**0.5**	**0.5**	0.4	0.2	0.0
International stock prices (MSCI Standard Index)	9.4	0.1	-0.2	-0.4	-0.1	0.1	0.4	0.6	**0.7**	0.6	0.1	-0.2

Table 14: Volatility and cross correlation of exchange rate and international variables with output lagged and led by k quarters 1994Q1-2009Q2.

	Std.dev.	Cross correlation with output lagged and led by k quarters								
	(%)	-6	-4	-2	-1	0	1	2	4	6
Sale of cement	13.2	-0.2	-0.1	0.2	0.4	0.6	0.7	**0.7**	0.6	0.3
Car registration	28.5	-0.3	-0.4	-0.1	0.1	0.4	0.5	**0.5**	0.3	0.2
Consumer confidence index	28.2	-0.5	-0.6	-0.3	-0.1	0.3	0.5	**0.7**	0.4	-0.2
Turnover of paycards	2.3	-0.3	-0.2	0.2	0.4	0.6	**0.7**	0.6	0.3	0.1
Fast moving consumer goods	3.1	-0.2	-0.2	0.2	0.5	0.8	**0.9**	0.8	0.0	-0.5

Table 15: Volatility and cross correlation of leading indicator variables with output lagged and led by k quarters 1994Q1-2009Q2. For the consumer confidence index and turnover of cards the correlation measures are for the period 2001Q1-2009Q2. For fast moving consumer goods the correlation measures are for the period 2002Q1-2009Q2.

The international business cycle is found to lead the domestic business cycle by 2 quarters. Thus, an international cyclical upturn is usually associated with a domestic cyclical upturn half a year later.[22] A similar procyclical pattern is found for international short-term interest rates, trade and stock prices.

4.6 Various high-frequency economic indicators

Finally, we report in table 15 the cyclical properties of various high-frequency indicators of the domestic business cycle. As expected, we find that they all lead the cycle and therefore seem to have some predictive power for the cyclical component of output. We find that the sale of cement, new cars registry and the consumer confidence index are procyclical and lead the cycle by 2 quarters, while turnover of payment cards and fast moving consumer goods lead the cycle by 1 quarter.[23]

4.7 Why is consumption so volatile in Iceland?

A striking feature of the Icelandic business cycle is the high variability of private consumption. This can be seen from figure 5, which compares the standard deviation of output and consumption across a number of OECD countries over the period 1994-2010. The standard deviation of private consumption growth stands out in Iceland: measuring 7% while only 1.3% on average among the other OECD countries. As figure 6 shows, this volatility in private consumption in Iceland is also well beyond what can be explained by the volatility of external conditions (exports and terms of trade).

[22] We analyse the links between the domestic and international business cycle more closely in sections 5 and 6.

[23] Data on payment card turnover and the consumer confidence index are only available from 2001 and fast moving consumer goods from 2002.

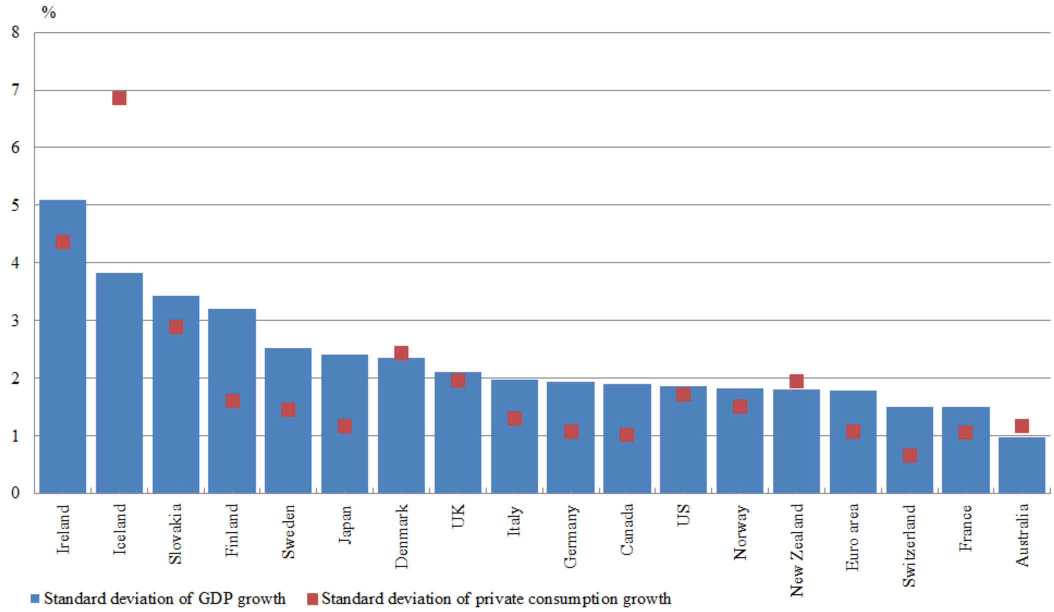

Figure 5: Standard deviation of GDP and consumption in various OECD countries 1994-2010. *Sources*: OECD, Statistics Iceland.

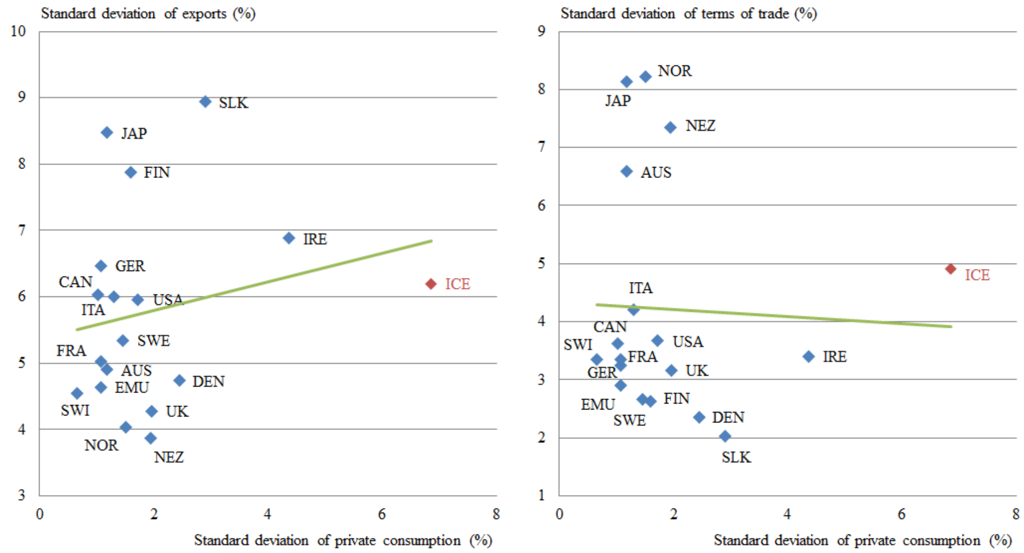

Figure 6: (a) Volatility of private consumption and exports. (b) Volatility of private consumption and terms of trade. *Sources*: Macrobond, Statistics Iceland.

	Std.dev.	Cross correlation with output lagged and led by k quarters								
	(%)	-6	-4	-2	-1	0	1	2	4	6
Private consumption	3.8	-0.2	-0.3	0.1	0.4	0.6	**0.7**	0.7	0.3	0.2
Durables	18.4	-0.3	-0.4	-0.1	0.2	0.4	0.5	**0.5**	0.3	0.2
Purchases of vehicles	34.3	-0.3	-0.5	-0.2	0.1	0.3	0.5	**0.5**	0.4	0.2
Semi-durables	4.4	-0.1	0.0	0.4	0.6	**0.6**	0.6	0.5	0.2	0.1
Non-durables	1.5	-0.2	-0.2	0.4	0.7	**0.8**	0.8	0.6	0.1	-0.1
Services	1.2	-0.1	0.1	0.4	0.5	0.6	**0.6**	0.5	0.3	0.2

Table 16: Volatility and cross correlation of sub-components of consumption with output lagged and led by k quarters 1994Q1-2009Q2.

To understand where this volatility of private consumption is coming from, it can be useful to start by looking at different sub-components of private consumption expenditure. Table 16 shows the standard deviation of the cyclical component of private consumption and its four main sub-components (durables, non-durables, semi-durables, and services) over different time periods. The table also includes expenditure on motor vehicles separately.

Consumption of durable goods has on average accounted for 9.5% of total consumption expenditure in the time period 1994-2010 and constitutes by far the most volatile component in total consumption with standard deviation of 18.4%, with expenditure on motor vehicles particularly volatile. Consumption of semi-durables (e.g. clothes, books, CDs and sport equipment) weighs just under 12% of total consumption expenditure and is also very volatile and fluctuates by more than output. As expected, expenditure on non-durables (e.g. food, drink, medicine and other necessities), which weighs roughly 30% of total consumption expenditure, and services (e.g. housing, education, leisure activity and health care), which weigh just under 42% of total expenditure, are much more stable than durable consumption (with a standard deviation of 1.2-1.5%).[24]

The table also reports the correlation structure of the cyclical component of sub-components with the business cycle. All sub-components are found to be procyclical, with durable consumption and consumption expenditure on services leading the cycle by 1 or 2 quarters, while semi- and non-durable consumption is contemporaneous to the cycle. Non-durable consumption is found to have the strongest ties to the cycle, while durable consumption is least sensitive to the cycle.

As table 17 shows, the correlation of different sub-components of consumption with the business cycle have remained stable over the period 1994Q1-2009Q2. The table, however, shows a clear increase in consumption volatility in the second half of the period, i.e. after the adoption of floating exchange rate regime. The increased volatility in durable consumption is particularly striking.

[24]Note that only a small part of health care services and education in Iceland is measured as private consumption since the major part of these components are treated as public consumption.

	94Q1-09Q2		94Q1-00Q4		01Q1-09Q2	
	Corr.	Std.dev. (%)	Corr.	Std.dev. (%)	Corr.	Std.dev. (%)
Private consumption	0.6	3.8	0.5	1.8	0.6	4.8
Consumption excl. durables	0.7	2.5	0.5	1.4	0.8	3.1
Durables	0.4	18.4	0.4	6.6	0.5	24.2
Purchases of vehicles	0.3	34.3	0.3	9.4	0.4	45.7
Durables excl. vehicles	0.6	13.2	0.6	5.6	0.6	16.2
Non-durables	0.8	1.5	0.8	1.1	0.8	1.7
Semi-durables	0.6	4.4	0.3	2.1	0.7	5.6
Services	0.6	1.2	0.3	0.9	0.7	1.5
GDP	1.0	1.6	1.0	1.3	1.0	1.9
Exchange rate	-0.3	7.1	0.1	3.0	-0.4	9.2
Disposable income	0.7	3.3	0.0	1.9	0.8	4.2

Table 17: Volatility and cross correlation of sub-components of consumption and various economic variables with output over different periods.

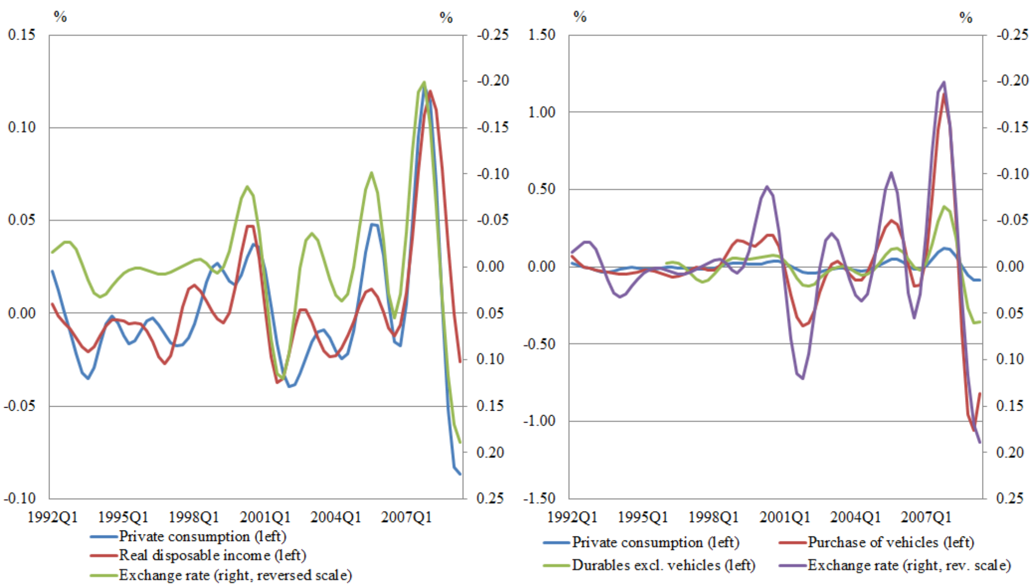

Figure 7: (a) Cyclical component of consumption, income and exchange rate. (b) Cyclical component of sub-components of consumption and exchange rate. *Sources*: Central Bank of Iceland, Statistics Iceland.

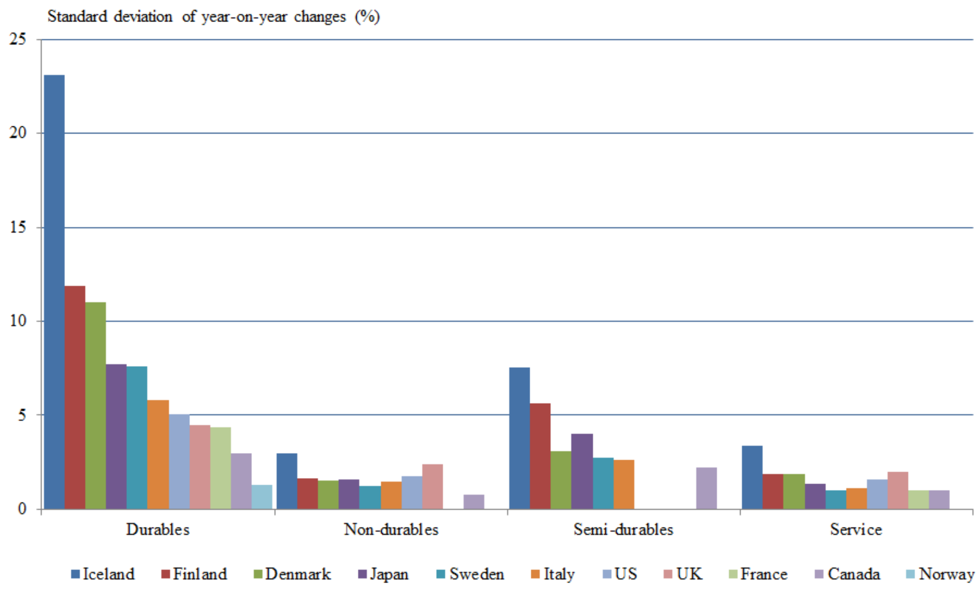

Figure 8: Standard deviation of sub-components of private consumption 1991-2010. *Sources*: Macrobond, Statistics Iceland.

As the table shows, this increase in consumption volatility coincides with an increase in income volatility and a large increase in exchange rate fluctuations. Figure 7 shows the development of the cyclical component of consumption, the exchange rate and real disposable income. The close comovement of consumption and its sub-components with exchange rate fluctuations (with a correlation of 0.9) and the coinciding increase in exchange rate fluctuations in the floating regime period and increased fluctuations in consumption comes through clearly. This especially holds for durable consumption, in particular expenditure on motor vehicles. With a small domestic manufacturing sector (see Einarsson et al., 2013) and a large share of durable goods imported, this may not come as a surprise. Thus, as the currency appreciates the relative price of imported consumption goods declines and large exchange rate fluctuations may therefore lead to pronounced fluctuations in consumption; both directly through changes in relative prices and indirectly through the effects of changes in domestic inflation on real income and wealth.

Finally, figure 8 compares the volatility of consumption expenditure sub-components in Iceland with some other developed countries. As expected, durable consumption is found to be the most volatile sub-component. As before, consumption fluctuations are found to be highest in Iceland and this holds across all sub-components. The comparison of fluctuations in durable consumption is particularly striking with the standard deviation in Iceland measuring at 23%, while Finland comes second with a standard deviation of 12%.[25] These results are robust to excluding data after the financial crisis, although the difference

[25] Data on purchases of automobiles was only found for three other countries: Denmark, France and the US. The standard deviation of automobile expenditure in Iceland is 32.3%, while 23.8% in Denmark. Automobile expenditure is much more stable in France (5.8%) and the US (6.2%).

between durable consumption in Iceland and the country with the second highest volatility (Finland) is less striking.

The results above point to exchange rate fluctuations as the "smoking gun" in terms of explaining highly volatile private consumption in Iceland. There are, however, other potential explanations such as the small resource based nature of the economy which tends to coincide with greater economic volatility (e.g. Breedon et al., 2012); the relatively underdeveloped domestic financial system making consumption smoothing relatively costly; a low saving rate and high debt levels, inter alia as a result of a tax system that encourages home-ownership and debt accumulation; and the fact that a large part of household savings are either tied up in long-term pension schemes or in housing, both of which are highly illiquid (Daníelsson, 2012). Finally, it is likely that the volatility of private consumption, and indeed economic activity in general - including the exchange rate itself, also stems from the relatively poor performance of domestic stabilisation policy. This includes fiscal policy, which as the results reported above suggest tends to be procyclical (see also Gudmundsson & Zoega, 1998), and monetary policy, which has not succeeded in delivering nominal stability (see, for example, Pétursson, 2010, and Central Bank of Iceland, 2012).

5 Are Icelandic and international business cycles symmetric?

At the core of the optimum currency area (OCA) literature is the idea that for a country to be a suitable member of a currency union, its business cycle needs to be symmetric with the currency union's business cycle. As argued by Mundell (1961), an independent monetary policy and a floating exchange rate can ease the adjustment of the economy following an idiosyncratic shock to the domestic economy. Assuming that labour mobility between countries within the currency union is relatively limited and that domestic wages and prices are slow to adjust, an idiosyncratic negative demand shock for domestic goods will for example lead to a decline in domestic activity and increases in unemployment. In this case a floating exchange rate will depreciate, thus helping relative factor prices adjust and absorbing some of the effect of this asymmetric shock by improving the competitive position of the export sector. An independent monetary policy can help even further by reducing domestic interest rates, further depreciating the currency and lowering domestic costs of funding. Inside a monetary union, these countercyclical properties of an independent monetary policy and a floating exchange rate are lost, and a greater share of the adjustment to the shock need to take place through declining domestic economic activity, which is presumably slower and costlier. In the case of symmetric shocks (a shock that is common to all members of the currency union), no exchange rate adjustment is needed however and a common monetary policy will suffice.

Thus, according to the OCA theory an analysis of the links between the domestic business cycle with that of other countries is an important input into the question whether Iceland should join a larger currency union, such as the euro area. However, as noted by Breedon et al. (2012), it is not obvious how effective a countercyclical policy tool a flexible

	GDP growth				Inflation			
	1992-2010	1992-1999	2000-2007	2000-2010	1992-2010	1992-1999	2000-2007	2000-2010
Euro area	0.51	0.20	0.17	0.62	-	-	0.18	-0.13
Canada	0.50	0.43	0.16	0.55	-0.01	0.32	-0.34	-0.38
Denmark	0.42	0.06	0.31	0.59	0.23	0.09	0.24	0.24
Finland	0.66	0.64	0.34	0.66	0.31	0.37	0.47	0.29
France	0.51	0.26	0.17	0.62	0.00	0.42	-0.36	-0.21
Germany	0.31	-0.09	0.11	0.42	-0.03	0.56	0.38	0.04
Ireland	0.49	0.33	-0.22	0.60	-0.17	0.13	0.37	-0.32
Italy	0.41	-0.06	0.10	0.57	-0.24	0.26	-0.13	-0.06
Japan	0.30	-0.18	0.19	0.44	-0.13	0.25	-0.21	0.19
Norway	0.35	-0.01	0.27	0.66	0.28	0.08	0.09	0.26
Slovakia	0.54	0.18	0.35	0.64	-0.25	0.57	-0.07	-0.23
Sweden	0.49	0.44	0.24	0.51	0.12	0.41	0.34	0.13
Switzerland	0.50	0.39	0.42	0.56	0.04	0.63	0.10	0.07
United Kingdom	0.62	0.58	-0.08	0.66	0.33	0.55	0.21	0.55
United States	0.45	0.50	0.15	0.52	-0.18	0.26	-0.01	-0.25
Average	0.47	0.24	0.18	0.57	0.02	0.35	0.08	0.02

Table 18: Contemporaneous correlation coefficients of GDP growth and inflation in Iceland and a number of other OECD countries. Price level data for the euro area as a whole are only available from 1996 and thus can not be included in the first half of the sample period. *Source*: OECD.

		Correlation with the Icelandic business cycle lagged led by k quarters								
	Volatility	-8	-4	-2	-1	0	1	2	4	8
Iceland	1.9	-0.3	-0.4	0.6	0.9	1	0.9	0.6	-0.4	-0.3
		Business cycles in other countries								
Euro area	1.0	-0.2	0.0	0.2	0.4	0.5	0.6	0.6	0.5	-0.4
Canada	0.9	-0.4	0.0	0.3	0.4	0.4	0.4	0.4	0.3	-0.1
Denmark	1.2	-0.4	0.0	0.3	0.4	0.5	0.6	0.5	0.4	-0.1
Finland	1.8	-0.3	-0.1	0.3	0.5	0.6	0.7	0.7	0.4	-0.5
France	0.8	-0.2	0.0	0.2	0.4	0.5	0.6	0.6	0.4	-0.3
Germany	1.2	-0.2	-0.1	0.1	0.3	0.4	0.6	0.6	0.5	-0.5
Ireland	1.6	-0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.6	-0.2
Italy	1.1	-0.1	-0.1	0.1	0.2	0.4	0.5	0.6	0.5	-0.4
Japan	1.4	0.1	-0.4	-0.2	0.0	0.3	0.5	0.6	0.6	-0.2
Norway	0.8	-0.4	0.0	0.2	0.4	0.5	0.6	0.7	0.5	-0.4
Slovakia	1.7	-0.1	-0.2	0.3	0.6	0.7	0.7	0.6	0.1	-0.4
Sweden	1.6	-0.2	-0.1	0.1	0.3	0.4	0.5	0.6	0.5	-0.2
Switzerland	0.9	-0.2	0.0	0.2	0.4	0.6	0.7	0.7	0.4	-0.6
United Kingdom	1.0	-0.3	-0.2	0.2	0.4	0.6	0.7	0.7	0.4	-0.4
United States	0.9	-0.3	-0.3	0.1	0.3	0.5	0.6	0.7	0.5	-0.1
Average	1.2	-0.2	-0.1	0.2	0.4	0.5	0.6	0.6	0.4	-0.3

Table 19: Volatility and correlation coefficient of the Icelandic business cycle lagged and led by k quarters with other countries for the period 1993-2010. Baxter-King band-pass filtered seasonally adjusted real GDP (historical data from 1991Q1 to 2011Q1 and forecasted values from OECD *Economic Outlook* for 2011Q2 to 2012Q4 are used, first and last two years are lost in the filtering process). Volatility is measured as the standard deviation of the business cycle for each country normalised such that the volatility of the euro area business cycle is 1.

exchange rate and an independent monetary policy are for such a small economy as Iceland. In fact, their results suggest that for small economies like Iceland, an independent currency has been an important source of shocks rather than an effective shock absorber. Furthermore, the results in Frankel & Rose (1998) suggest that currency union membership can lead to more synchronised business cycles, thus indicating that this OCA criteria is in fact endogenous to the exchange rate regime. Therefore the question whether it is necessary to find strong ties between the domestic and international business cycles in historical data for the choice of exchange rate regime remains open and outside the scope of this paper.

5.1 Correlation of GDP growth and inflation

We start this section of the paper by looking at simple correlation coefficients of output growth and inflation rates for Iceland and a number of other OECD countries. As table 18 shows, the correlation of GDP growth in Iceland and the other countries measures 0.47 on average over the whole sample period (0.51 for the euro area). However, looking at different subsamples clearly indicates that this relatively high correlation mainly reflects the

Period	1993-2010		1993-1999		2000-2007		2000-2010	
	Vol.	Corr.	Vol.	Corr.	Vol.	Corr.	Vol.	Corr.
Iceland	1.9	1.0	1.4	1.0	1.6	1.0	2.1	1.0
	Business cycles in other countries							
Euro area	1.0	0.5	0.6	-0.3	0.7	0.6	1.1	0.7
Canada	0.9	0.4	0.8	0.0	0.7	0.5	1.0	0.6
Denmark	1.2	0.5	1.0	0.1	0.8	0.6	1.4	0.6
Finland	1.8	0.6	0.9	0.1	1.2	0.7	2.2	0.7
France	0.8	0.5	0.6	-0.2	0.6	0.7	0.9	0.7
Germany	1.2	0.4	0.6	-0.3	0.9	0.4	1.4	0.5
Ireland	1.6	0.4	1.0	-0.5	1.5	0.5	1.8	0.6
Italy	1.1	0.4	0.8	-0.5	0.8	0.6	1.2	0.6
Japan	1.4	0.3	0.9	-0.3	1.0	0.6	1.7	0.4
Norway	0.8	0.5	0.8	-0.2	0.6	0.6	0.7	0.8
Slovakia	1.7	0.7	1.1	0.8	1.3	0.6	2.0	0.7
Sweden	1.6	0.4	1.1	-0.1	1.0	0.5	1.8	0.5
Switzerland	0.9	0.6	0.6	0.0	0.8	0.6	1.0	0.7
United Kingdom	1.0	0.6	0.4	0.1	0.7	0.5	1.2	0.7
United States	0.9	0.5	0.4	0.4	0.7	0.5	1.1	0.5
Average	1.2	0.5	0.8	-0.1	0.9	0.6	1.4	0.6

Table 20: Volatility and contemporaneous correlation coefficients of the Icelandic and foreign business cycles over different periods. Baxter-King band-pass filtered seasonally adjusted real GDP (historical data from 1991Q1 to 2011Q1 and forecasted values from OECD *Economic Outlook* for 2011Q2 to 2012Q4 are used, first and last two years are lost in the filtering process). Volatility is measured as the standard deviation of the business cycle for each country (in %).

global crisis since 2008 which has caused a substantial decline in output in most developed economies. Looking at the period up to the crisis, gives much lower correlation coefficients.

Table 18 also reports correlation coefficients for inflation. As can be seen, the correlation of inflation with the largest currency areas, the euro area and the US, is negative when the whole time period is considered (1992-2010 for the US and 2000-2010 for the euro area). Inflation development in Iceland in this time period seems to be more similar to the development in the other Nordic countries and in the UK. If only the first half of the period is considered (1992-1999), in which Iceland experienced first disinflation and then a period of low and stable inflation, inflation development in Iceland seems to have been similar to all the other countries considered except for Norway, Denmark and Ireland. When only the latter half of the period is considered (2000-2010) the same story emerges as in the whole sample with inflation development in Iceland being most similar to the development in the other Nordic countries and in the UK. Excluding the inflation spike after the currency crisis in 2008 does not change the results except for the correlation with inflation developments in Germany and Ireland rises somewhat. On average, inflation development in Iceland is weakly linked to inflation developments in the other countries considered, except for the first half of the sample.

5.2 Correlation of the cyclical component of output with the cyclical component of output in other countries

Instead of looking at correlation coefficients of output itself, in table 19 we report correlation coefficients of the cyclical component of output in Iceland and several other OECD countries (using the Baxter-King filter) over leads and lags of up to 2 years. First, we see, as reported in the previous section, that the Icelandic business cycle is more volatile than in most other developed countries. We also find that a contemporaneous correlation ranging from zero for Japan to 0.6 for Finland, Slovakia, Switzerland and the UK. The contemporaneous correlation coefficient is found to be 0.5 on average and for the euro area as well. Overall, the international business cycle seems to lead the domestic business cycle by 1-2 quarters, consistent with the findings in the previous section.

As can be seen in table 20, the links between the domestic and foreign business cycles are found to be somewhat sensitive to the time period analysed. The links have become stronger in the last decade and, unlike the results from table 18 these findings do not seem to be sensitive to whether the recent crisis period is included or not. Finally, the table shows that business cycle volatility has on average been increasing in recent years and even more so in Iceland than in the other countries.

6 Identifying the structural shocks to output in Iceland and their correlations with corresponding shocks abroad

The above analysis of the comovement of domestic output with output in other developed economies does not make any distinction between the main sources of the business cycle, i.e. what kind of underlying structural shocks drive the business cycle (i.e. external shocks on both the supply and demand side of the economy). Such an analysis is useful because it distinguishes between the sources of business cycles and how these shocks are propagated through the economy. Output in two countries can move together either because the two countries are subject to the same underlying structural shock or because the flexibility of the economies (e.g. factor mobility) is sufficient to prevent different structural shocks to lead to asymmetric business cycles. Alternatively, the countries could be hit by a common structural shock but different structure of the economies or different policy responses reduces the comovement of output between the two countries. It is therefore important to try to separate the effects of the adjustment mechanism from the effects of the underlying shocks.

This section therefore seeks to identify the main sources of business cycles in Iceland and how they correlate with corresponding shocks in other developed countries. A structural VAR model is used to identify supply and demand shocks, using the identification approach originally suggested by Blanchard & Quah (1989) and applied in an identical setting by Bayoumi & Eichengreen (1993).

Country	Supply shocks	Demand shocks
Iceland	89	11
Euro area	37	63
Canada	70	30
Denmark	45	55
Finland	47	53
France	70	30
Germany	99	1
Ireland	93	7
Italy	77	23
Japan	62	38
Norway	93	7
Slovakia	88	12
Sweden	95	5
Switzerland	93	7
United Kingdom	80	20
United States	90	10
Average (excl. Iceland)	76	24

Table 21: Variance decomposition of 10 quarter forecast of GDP growth (% of total variation). The underlying supply and demand shocks are estimated using a two-dimensional VAR model of output and prices with restrictions imposed on the long-run dynamics of output (cf. Blanchard & Quah, 1989, and Bayoumi & Eichengreen, 1993).

6.1 Is the Icelandic business cycle driven by supply or demand shocks?

Supply shocks are those who originate on the supply side of the economy, e.g. shocks to technology, productivity, terms of trade, or to natural resource utilisation. As discussed in Gudmundsson et al. (2000), terms of trade shocks and resource shocks seem an important source of supply shocks in Iceland, given its small size and reliance on natural resources in export activity. These supply shocks can be expected to permanently affect the potential output level of the economy and thus have a permanent effect on domestic output and the price level. Furthermore, it should be expected that the supply shocks move output and the price level in the opposite direction, i.e. a positive supply shock should increase output while lowering the price level.

Demand shocks, on the other hand, are shocks that are considered to have a permanent effect on the domestic price level but only a temporary effect on domestic output.[26] These could include policy shocks, both to monetary and fiscal policy (i.e. nominal and real demand shocks). Furthermore, it should be expected that the demand shocks move output and the price level in the same direction, i.e. a positive demand shock should both increase output and raise the price level.

[26] There are, however, theoretical models which suggest that demand shocks can have a permanent effect on domestic output (for a discussion, see Farrant & Peersman, 2006). It might therefore be more appropriate to refer to these shocks as temporary and permanent rather than supply and demand shocks. However, here we will follow the tradition in the literature and refer to them as supply and demand shocks.

This allows us to use the long-run restrictions approach suggested by Blanchard & Quah (1989) and Bayoumi & Eichengreen (1993) on an estimated VAR model, which allows for unrestricted short-run dynamics, while imposing the identifying restriction that demand shocks are not allowed to have long-run effects on output, while supply shocks can have long-run output effects. The estimated VAR model can then be used to decompose historical variation in output into supply and demand driven components.

Table 21 shows the variance decomposition of output for Iceland and various other countries for the period 1999-2010. As the table reveals, the most important source of the domestic business cycle during the period are supply shocks.[27] This is also the case for most of the other countries, although the share of demand shocks is found to be greater for Denmark, Finland and the euro area. This is similar to what is found in other studies, with most finding that 50-90% of business cycle variations can be traced to supply shocks (see e.g. Artis & Ehrman, 2006, Bjornland, 2004, Clarida & Gali, 1994, or Funke, 2000).[28]

6.2 Are domestic and foreign supply and demand shocks correlated?

Having established that the largest share of the variability of output in Iceland can be traced to supply shocks, we now move on to analysing whether the underlying supply and demand shocks are correlated with corresponding shocks in other developed countries.

As table 22 shows, the contemporaneous correlation of domestic and international supply and demand shocks is quite limited, with the average correlation of supply shocks essentially zero, while the correlation of demand shocks is about 0.1. The correlations with the euro area supply and demand shocks are also essentially zero. Higher correlations are found for Sweden and Norway, while a negative correlation is found for supply shocks in the large developed countries. In all cases, the correlation coefficients remain low, however. In general it would thus appear that the Icelandic business cycle is very weakly related to the business cycles of other developed countries. This especially applies to supply shocks. This is important in relation to the question of whether Iceland should join a monetary union with any of these countries, as one would expect that a significant part of demand shocks will disappear when a country joins a monetary union as the importance of country-specific policy driven shocks will be reduced (idiosyncratic monetary policy shocks will disappear, while the scope for country-specific fiscal policy is markedly reduced). Thus, it can be argued that a low correlation between union members' demand shocks is less of a problem than a low correlation between supply shocks, which are more

[27] It is however an open question as to how well this simple identification scheme manages to capture the main drivers of the domestic boom period of 2003 to 2007 when one demand shock upon another hit the economy and the availability of credit increased considerably and financial institution's balance sheets grew rapidly (see e.g. Sighvatsson, 2007). The identification scheme is based on a simple representation of financial markets and financial institutions which can reduce it's ability to reflect macroeconomic developments when the effects of financial institutions and markets on economic development are greater than usual.

[28] In all the countries, we find that the identified supply shocks move output and prices in the opposite direction while demand shocks move output and prices in the same direction. The only exception is Ireland (a problem Bayoumi & Eichengreen, 1993, also run into).

	Supply shocks	Demand shocks
Euro area	0.03	-0.01
Canada	-0.03	-0.04
Denmark	0.00	0.02
Finland	-0.07	0.11
France	0.01	0.01
Germany	-0.12	0.12
Ireland	-0.06	-0.07
Italy	0.01	0.21
Japan	-0.08	0.11
Norway	0.17	0.21
Slovakia	0.14	0.07
Sweden	0.25	0.37
Switzerland	0.04	0.22
United Kingdom	-0.09	0.11
United States	-0.19	0.18
Average	0.00	0.11

Table 22: Contemporaneous correlation coefficients of supply and demand shocks in Iceland with corresponding shocks in a number of OECD countries. The underlying supply and demand shocks are estimated using a two-dimensional VAR model of output and prices with restrictions imposed on the long-run dynamics of output (cf. Blanchard & Quah, 1989, and Bayoumi & Eichengreen, 1993).

likely to remain after joining a monetary union, although the results in Frankel & Rose (1998) suggest that the importance of idiosyncratic supply shocks may also decline after currency union membership.

As previously discussed, this weak link between domestic and foreign supply shocks probably reflects the fact that the main source of most domestic supply shocks can be traced to shocks connected to the country's natural resources,[29] both related to relative prices and quantities, but these factors weigh far less in the production structure of other developed countries, especially the larger ones (see Einarsson et al., 2013). The low correlation of domestic and foreign demand shocks probably mainly reflects the fact that Iceland has operated an independent monetary policy and has suffered several demand shocks that have mostly been specific to Iceland.

Table 23 compares the correlation coefficients of supply and demand shocks in Iceland and other developed countries with corresponding shocks in the euro area. The correlation coefficients are on average highest for countries that have adopted the euro, with the correlation being higher among core members than member countries on the periphery (see also figure 9).

[29] Although the results in Daníelsson (2008) suggest that the importance of these shocks has declined since the 1990s.

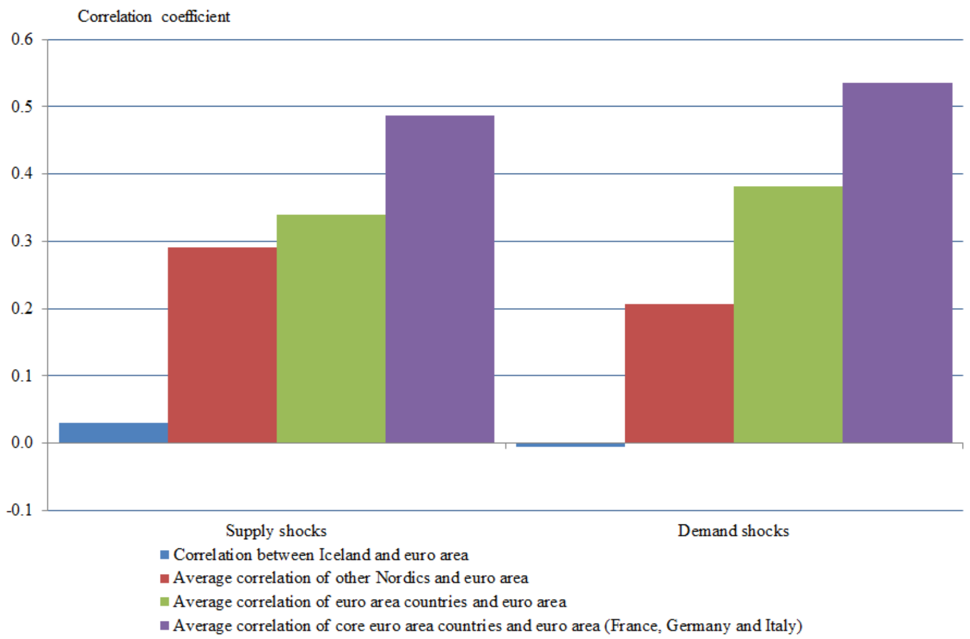

Figure 9: Contemporaneous correlation coefficients of supply and demand shocks. *Sources*: Macrobond, Central Bank of Iceland.

	Supply shocks	Demand shocks
Iceland	0.03	-0.01
Canada	0.03	0.18
Denmark	0.37	0.33
Finland	0.31	0.36
France	0.42	0.54
Germany	0.48	0.07
Ireland	0.34	0.29
Italy	0.56	0.40
Japan	0.30	0.37
Norway	0.29	-0.04
Slovakia	-0.07	0.03
Sweden	0.19	0.18
Switzerland	0.38	0.32
United Kingdom	0.12	0.27
United States	0.20	0.15
Average (excl. Iceland)	0.28	0.25

Table 23: Contemporaneous correlation coefficients of supply and demand shocks with corresponding shocks in the euro area. The underlying supply and demand shocks are estimated using a two-dimensional VAR model of output and prices with restrictions imposed on the long-run dynamics of output (cf. Blanchard & Quah, 1989, and Bayoumi & Eichengreen, 1993).

Of the euro area countries represented in table 23, Slovakia has the shortest experience of using the euro and diverges considerably from other member countries since the correlations of supply and demand shocks to shocks in the euro area are close to zero. Of the countries outside the euro area the correlation of demand shocks in Norway to demand shocks in the euro area is very limited, which probably reflects the fact that Norway operates an independent monetary policy, while the correlation of supply shocks is much higher.

As an alternative to using aggregate euro area data, it is possible to use individual euro area country data to extract common euro area supply and demand shocks and to analyse to what degree these common shocks can explain supply and demand shocks in individual countries. We do this by using the underlying supply and demand shocks for the euro area countries from the structural VAR analysis in the previous section and proxy the common euro area supply and demand shocks using the first component from a principal component analysis. We find that the common supply shock component explains about a third of the variability of supply shocks among all the euro area countries while the common demand shock explains just about half of the variability of demand shocks among the euro area countries.

Having obtained a measure of the common euro area shocks, we then proceed by regressing individual country shocks on these common euro area shocks and report in table 24 R^2 as a measure of the degree to which the common shocks explain individual country shocks. Again, we find that the links with the euro area business cycle are strongest among euro area member countries (except for Slovakia), with common euro area supply shocks explaining roughly 40% of the variability of supply shocks in France, Finland and Germany and up to 70% in Italy, with similar findings for demand shocks. By comparison, the share of variability in Icelandic supply and demand shocks explained by these common euro area shocks is numerically very small and statistically insignificant (see also figure 10).

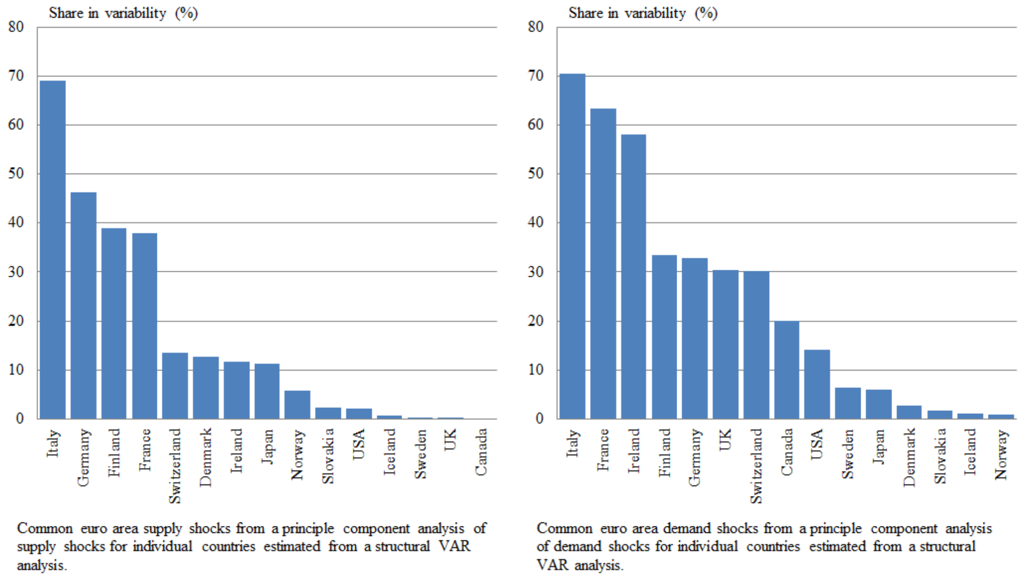

Figure 10: (a) Share of common euro area supply shocks explaining individual country supply shocks. (b) Share of common euro area demand shocks explaining individual country demand shocks. *Sources*: Macrobond, Central Bank of Iceland.

	Supply shock		Demand shock	
	Share of variability (%)	p-value	Share of variability (%)	p-value
Iceland	0.6	0.60	1.2	0.44
Canada	0.0	0.99	20.0	0.00
Denmark	12.6	0.01	2.7	0.25
Finland	38.9	0.00	33.4	0.00
France	37.9	0.00	63.4	0.00
Germany	46.3	0.00	32.9	0.00
Ireland	11.6	0.02	58.0	0.00
Italy	69.1	0.00	70.4	0.00
Japan	11.3	0.02	5.9	0.08
Norway	5.8	0.09	1.0	0.48
Slovakia	2.3	0.29	1.7	0.36
Sweden	0.3	0.71	6.3	0.08
Switzerland	13.6	0.01	30.2	0.00
United Kingdom	0.2	0.76	30.3	0.00
United States	2.1	0.32	14.1	0.01
Average (excl. Iceland)	18.1		26.5	

Table 24: The underlying supply and demand shocks are estimated using a two-dimensional VAR model of output and prices with restrictions imposed on the long-run dynamics of output (cf. Blanchard & Quah, 1989, and Bayoumi & Eichengreen, 1993). Common euro area shocks are estimated using the first principle component from a principle component analysis on shocks in individual member countries. The table shows R^2 from regressions of individual countries' shocks on the estimated common shocks and p-values for the null hypothesis of R^2 being statistically insignificant.

7 Conclusions

This paper analyses the properties of the Icelandic business cycle and whether it is synchronised with the business cycles of other developed countries. We find that although the characteristics of the domestic business cycle are in some aspects similar to business cycles in other developed countries, there are important differences. For example, we find that the periodicity and amplitude of the domestic cycles is greater than commonly found in other countries. We also find that the volatility of the Icelandic economy has picked up again in the last ten years after declining in the 1990s. Furthermore, we find that strong output volatility is reflected in volatile domestic demand and, in fact, we find that one of the distinctive features of the Icelandic business cycle is the tendency of consumption to fluctuate far greater than output and well beyond what can be explained by external conditions. Among other stylised facts of the domestic business cycle of note, we find that domestic demand components and imports are procyclical and slightly lead the cycle. Exports are also procyclical but contemporaneous to the cycle. We also find that total hours are procyclical and contemporaneous to the cycle while unemployment is countercyclical and slightly leads the cycle, while average hours are broadly acyclical. Furthermore, we find productivity and real wages to be procyclical and leading the cycle. Unlike other countries, however, we find wages to be more volatile than productivity. Similar patterns are also found in disaggregate labour market data. Additionally, we find inflation to be procyclical and lagging the cycle, while export prices and terms of trade are procyclical and lead the cycle. In line with standard models of the transmission mechanism of monetary policy, we also find nominal and real interest rates to be contemporaneously procyclical while countercyclical at longer leads. Asset prices and household wealth are also found to be procyclical and lead the cycle, except for house prices which are either contemporaneous or slightly lag the cycle. Finally, we find the nominal and real exchange rate to be procyclical and leading the cycle.

Our results indicate that the domestic business cycle is to a large extent asymmetric to the business cycle of other developed countries. We find that the contemporaneous correlation between domestic and foreign output is relatively low when excluding the latest global crisis period or when only looking at the cyclical component of output. The strongest links are found with the business cycles of the small peripheral euro area countries and other small European countries outside the euro area, while links with business cycles in the large developed countries and the euro area as a whole seem weaker. This is further corroborated when looking at the correlations of underlying structural shocks identified by imposing long-run restrictions on a VAR representation of the data. As for most other developed countries, we find that supply shocks explain most of output variation in Iceland. At the same time, we find that these structural shocks are very weakly linked with corresponding shocks in other developed countries. The shocks that drive the Icelandic business cycle seem to have the most in common with shocks in Sweden and Norway. The links with the US and the euro area are much weaker, however.

These findings may have important implications for the debate on the pros and cons of a possible membership of Iceland in the euro area or, indeed, in another larger monetary union through unilateral adoption of another currency such as the US dollar. Although the declining importance of country-specific policy shocks should reduce the importance of idiosyncratic demand shocks upon entry into a monetary union, the theory of optimal currency areas indicates that the low correlation of domestic supply shocks with supply shocks in other countries may lead to an amplification of business cycle fluctuations upon membership. Some qualifications are, however, in order as the results of the findings of a number of papers suggest that membership in a monetary union can also lead to gradual increase in business cycle synchronisation through increased trade and financial integration and that a flexible exchange rate can also be a source of shocks just as well as being a shock absorber. The small size of the Icelandic economy, its small and shallow foreign exchange market, and the very high volatility of private consumption that seems strongly correlated with exchange rate fluctuations, reported in this paper, could suggest that this qualification is important for Iceland and that membership in a larger monetary union might not lead to greater business cycle volatility despite the weak links of the domestic and foreign business cycles found in historical data.

Appendix A Identifying turning points using the Baxter-King band-pass filter

Baxter & King (1999) designed a band-pass filter that isolates the cyclical component of any economic time series by removing the trend and irregular components from the original data. Baxter and King defined a business cycle to range between 6 to 32 quarters as suggested by the NBER chronology of US business cycles. The Baxter-King filter is designed to pass through periodic fluctuations between 6 and 32 quarters while components at higher and lower frequencies are removed. The higher frequency (corresponds to periodicity less than 6 quarters) is assumed to represent irregular components and measurement errors while the lower frequency (more than 32 quarters) is associated with trend growth.

The Baxter-King filter is based on a centred moving average of the data and therefore implies that observations at the start and end of the sample are lost. The filter therefore involves a tradeoff: an ideal filter can be better approximated with longer moving averages, i.e. adding more leads and lags, but at the cost of losing a larger share of the data. In their paper, Baxter and King recommend using moving averages based on 12 quarters of past and future data.

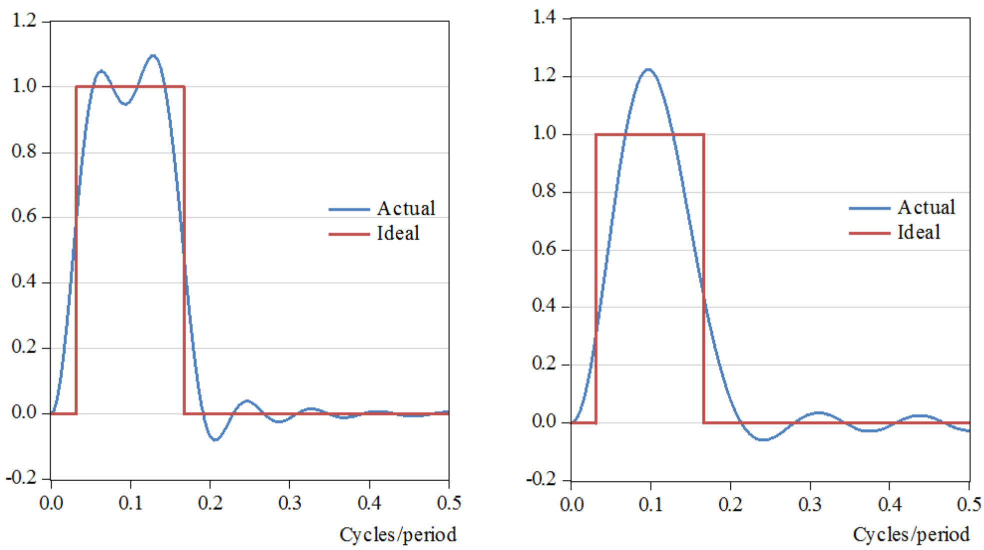

Figure 11: (a) Frequency response function for Baxter-King band-pass filter of Icelandic GDP using a 12 quarter moving average. (b) Frequency response function for Baxter-King band-pass filter of Icelandic GDP using an 8 quarter moving average. *Sources*: Statistics Iceland, Central Bank of Iceland.

Figures 11a and 11b compare the result of applying the Baxter-King filter to seasonally adjusted real GDP in Iceland. The former shows results where 12 leads and lags are used to compute the moving averages. Consequently 12 quarters are dropped at the beginning and end of the sample, which is a significant share of the total data sample in short data spans as used in this paper. The figure therefore compares the outcome with using only 8

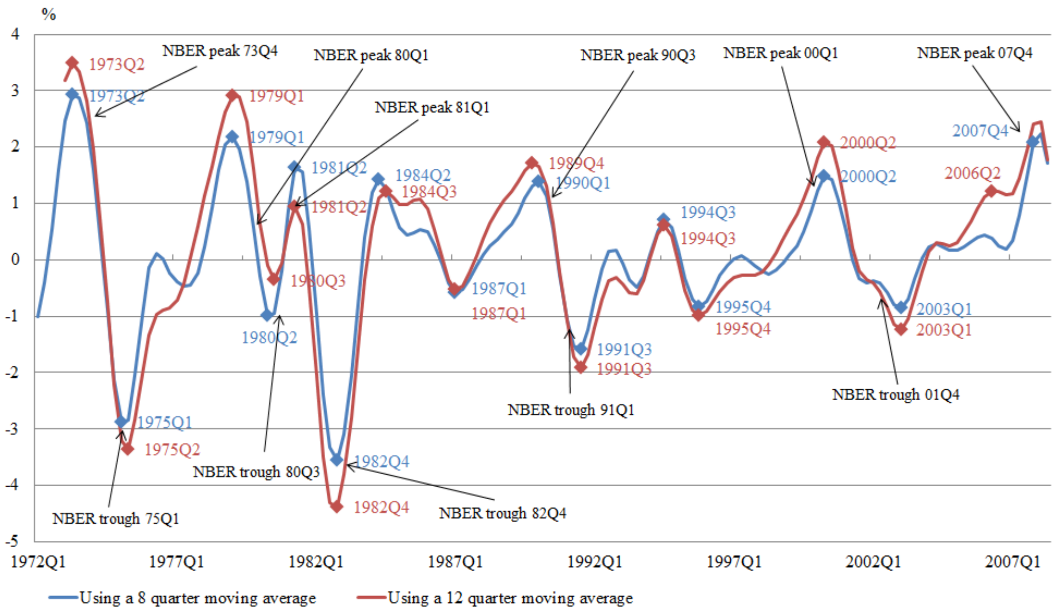

Figure 12: The US business cycle using the Baxter-King band-pass filter and NBER business cycle dates. *Sources*: Macrobond, NBER.

leads and lags. As evident from the figures, the 12 quarter moving average approximates the ideal filter somewhat better than the 8 quarter moving average: the 8 quarter moving average eliminates more of the low frequency and the high frequency noise but slightly increases the effect of the middle frequency, thus implying more frequent cycles.

The performance of the Baxter and King band-pass filter can be evaluated further by using US data and comparing the peaks and troughs implied by that filtering technique to the official business cycle turning points identified by the NBER Business Cycle Dating Committee (see figure 12). In the data period 1972Q1-2007Q4 the NBER Business Cycle Dating Committee identifies 6 peaks and 5 troughs whereas the Baxter and King filter based on a 12 quarter centred moving average results in 8 peaks and 7 troughs. The timing of the turning points with the filtering approach is also broadly similar to the NBER identification.

The figure also reports the peaks and troughs identified using an 8 quarter moving average. In this case more, frequent business cycles are identified when compared to the official NBER chronology, thus suggesting that a 12 quarter moving average is more appropriate. However, in this paper we choose to apply an 8 quarter moving average due to the relatively short data sample available. To compensate for the implied loss of efficiency, we however impose more stringent conditions on what can constitute as an expansionary (contractionary) periods by restricting expansions (contractions) to periods when growth is at least 0.3 percentage points above (below) trend growth. By imposing this condition the 8 quarter filter gives exactly as many turning points as the 12 quarter filter for both the US and the Icelandic business cycles.

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