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International business cycles: How do they relate to Switzerland?

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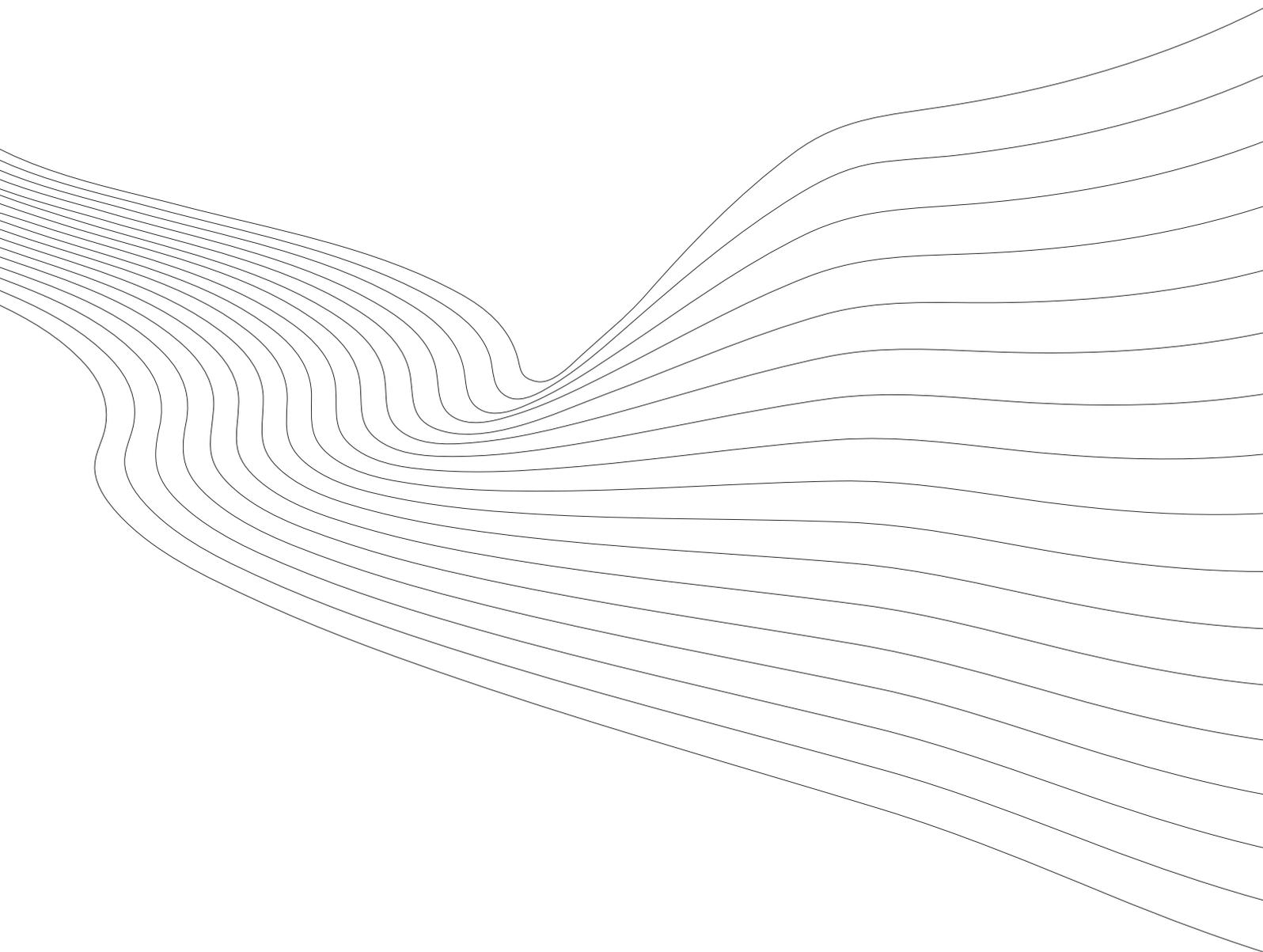
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KOF Working Papers

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Abstract

This paper first discusses concepts, definitions and theoretical explanations for international business cycles. This is followed by an overview of previous empirical studies. We then argue that for *ex post* analyses the output gap is a univariate quantification of the business cycle that is comparable across space and time and readily available (or rather computable from GFP series), which recommends its use for our purposes. Based on an unbalanced panel of quarterly output gap series in a panel of 40 countries from 1960q1 to 2011q3, we then test a number of hypotheses regarding the imbeddedness of the Swiss economy into international business cycles and possible changes thereof over the recent years. The results identify layers of international business cycles, where the integration of Switzerland is pronounced. Moreover it markedly deepened after 1994. A case for Switzerland being ‘special’ can hence not be made in terms of its recent business cycle pattern.

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1. Introduction

From an economic as well as a political perspective, Switzerland has a special role within Europe or even in the global world. Being situated in the middle of Europe and surrounded by EU member states, Switzerland is neither (and reluctant to become) a member of the EU nor the European monetary union. This special situation gives rise to several aspects that may influence the national business cycle in a (possibly) different way than other comparable countries.

In particular, we direct our attention to possible international interconnectedness of business cycles across countries worldwide. This paper will first discuss concepts, definitions and theoretical explanations for international business cycles. This is followed by an overview of previous empirical studies. We then argue that for *ex post* analyses – notwithstanding its well-known end point problem – the output gap is a univariate quantification of the business cycle that is comparable across space and time and readily available (or rather computable from GFP series), which recommends its use for our purposes. Finally, based on an unbalanced panel of quarterly output gap series in a panel of 40 countries from 1960q1 to 2011q3, we test a number of hypotheses regarding the imbeddedness of the Swiss economy into international business cycles and possible changes thereof over the recent years.

The results identify layers of international business cycles, where the integration of Switzerland is pronounced. Moreover it markedly deepened after 1994. A case for Switzerland being ‘special’ can hence not be made in terms of its recent business cycle pattern.

International business cycles: concepts and definitions

The concepts of international business cycles or a world business cycle¹ have long captured the imagination of economists. In either case, the cycle is affecting more than a single country. In a fully integrated world economy, we might find a dominant world business cycle with no pronounced regional variation, whereas in a less than fully integrated world, some of the trans-national cyclical co-movement will be confined to geographical regions or economic blocks.

¹ For a discussion of the world business cycle, see *Gregory et al.* (1997 and 1999).

The economic history of the last decades records an increase in economic openness. Typically, however, we do not see countries unambiguously opening their economies towards the rest of the world.² Rather, we see some removal of international barriers to economic activity going hand-in-hand with the consolidation of supra-national economic blocks that tear down borders within but at the same time erect new barriers vis-à-vis the rest of the world. Hence, the typical pattern of economic globalisation is currently the formation of blocks, resulting in a polycentric and possibly hierarchical structure. Accordingly, a reasonable assumption is that, presently, different layers of business cycles proceed at the same time. Formally, this structure can be represented as a polycentric hierarchy of cycles, where the cyclical position of country i at time t $P_{i,t}$ is determined by country-specific ('idiosyncratic') factors $I_{i,t}$, supra-national developments $S_{j,t}$, business conditions within structurally defined groups of countries $G_{k,t}$, and a world business cycle W_t , so that

$$P_{i,t} = f(I_{i,t}, S_{j,t}, G_{k,t}, W_t).$$

Note that this notation immediately suggests factor or principal component analyses as a method to address this concept empirically. In particular, the observed variable – $P_{i,t}$ – could be explained by a number of non-measurable latent variables that reflect the hierarchy of cycles. And indeed, a number of recent studies on international business cycles have referred to factor models. Before we turn to this research, we shall briefly summarise some fundamental theoretical considerations on international business cycles.

2. Theoretical considerations on international business cycles

The earliest theory of cyclical patterns in economic activity attributes them to nature: climate and weather, relating to predominantly agricultural economies. With the share of agriculture in output declining, the cyclicity of economic conditions in the secondary and tertiary sector is traditionally referred to an investment cycle, where at some stage over-investment leads to more or less severe corrections until a new boom sets in. The underlying assumption is that a considerable number of market participants are reacting to the same signals. These may be the employment outlook, profits, order books, raw material and intermediate goods prices, inventories, exchange rates, demand for exports or news about international crises and war or peace.

² For a stylised economic history from a trade and openness perspective, see *Bergsten* (2001).

Apart from this view, an influential school of theoretical, academic economists highlights the ‘real business cycle’ theory.³ Based on the assumption of rational and informed agents, this theory sees the origin of cycles in exogenous shocks (technical innovation or political intervention).

Moreover, though they do not represent the mainstream, some economists continue to refer to Schumpeter's theory of the business cycle (*Schumpeter* 1939). This theory ascribes the business cycle to clusters of innovations which lead to a general phase of prosperity. New products and procedures deliver monopoly rents to the pioneers; on the other hand they make some of the inherited capital stock obsolete in economic terms. This ‘creative destruction’ triggers vigorous price adjustments and consequently entrepreneurs and bankers face difficulty in assessing the profitability of further innovation and investment. Moreover, at that stage, a considerable part of investment is getting speculative rather than innovative. Once the initial cluster of innovations has diffused through the economy, profits converge towards zero. The boom is over and the economy returns to a stationary state. This may even manifest itself as a depression. Typically, however, the price adjustment that happened through the recession forms the basis for new innovative activity which again culminates in a cluster of innovations. Evidence for this business cycle theory so far is sparse. Yet, it cannot be ruled out that the ‘Second Industrial Revolution’ (within the IT sector) has brought about a convergence of technological trajectories, which would result in a clustering of innovations and hence constitute the basis for a next Schumpeter cycle.

These theories comprise a number of arguments that can likewise serve as theoretical explanations for a *supra-nationality* of business cycles. Generally, a systematic commonality of economic activity across different territorial units has to be attributed to cyclical forces operating across regions.⁴ These could affect either prices or quantities or both, and relate to goods and services, factors of production, financial securities or to psychological factors such as consumer confidence or the ‘animal spirits’ of entrepreneurs. Hence, as far as economic agents react to signals from abroad, we would expect to find trans-nationality in business cycles. Real business cycle theory directly implies that the business cycle will be supra-national if this is true for the driving forces, i.e. the technology and policy shocks that are

³ See *Lucke* (2002).

⁴ See, amongst others, *Clark and Van Wincoop* (2001) and *Artis* (2003).

hitting the international economy.⁵ From a Schumpeterian perspective, a common technological trajectory would constitute the basis for supra-nationality of the business cycle.⁶

Economic theory hence states a number of plausible arguments for the emergence of international business cycles and identifies potentially triggering factors as well as likely channels for international transmission and diffusion. Some of the factors that drive the business cycle operate predominantly domestically, while others have more international significance. In this context, we would expect that countries are not necessarily affected to the same degree by the factors that drive international cycles. Geographic, cultural and technological proximity would imply more similar reactions to impulses from the international economy. Moreover, 'cyclical proximity' is affected by economic and political integration (or disintegration) and thus not time invariant.

The economic integration of Europe is an important illustration of these considerations, as it has shaped or at least deepened a distinctive European business cycle.⁷ The cyclical integration is nevertheless far from complete. In particular, private consumption is still heavily affected by country specific idiosyncrasies.⁸ Furthermore, according to some findings, it appears that the overall deepening of cyclical integration in the EC/EU has flattened out in the new millennium, and the recent financial crises triggered by high indebtedness of some euro zone economies puts a bold question mark behind the assertion that the European economic integration is continuously deepening.⁹ Intra-European frontiers hence continue – to some extent – to be boundaries for the business cycle.¹⁰

Switzerland is neither a member of the EU nor of the EMU (and not likely to become one in the foreseeable future); nevertheless, based on a number of bilateral treaties, its goods and factor markets are highly integrated into the EU, which is by far its major trading partner. Accordingly, in economic terms, Switzerland can be practically considered to be as integrated into the EU as the UK, Sweden, or Denmark – the only EU members that have so far voluntarily maintained their national currencies and hence monetary policy as a nationally

⁵ *Norrbin and Schlagenhauf* (1996) find "limited support" for real business cycles in form of industry specific cycles with international business cycles. *Imbs* (1999) shows that OECD countries with similar industrial specialisations are characterised by distinctive co-movement of economic activity.

⁶ This might especially affect groups of countries with a similar human capital endowment, allowing for a quick diffusion of clusters of innovations; see *Comin and Hobijn* (2004).

⁷ See *Fatás* (1997).

⁸ See *Ambler et al.* (2004).

⁹ See *Artis* (2003).

¹⁰ See *Clark and van Wincoop* (2001).

controlled tool to steer the economy through the business cycle and the bumpy evolution of the international economy.

At this stage, we can conclude that business cycles are nowadays a more or less international phenomenon. From a global perspective, the cyclicity of economic activity can analytically be decomposed into local, regional,¹¹ industry specific, national and supra-national cycles and –possibly – a global cycle. The empirical studies on international business cycles that we are going to survey in the following section will provide additional evidence for this view.

3. Previous research on international business cycles

So far, most attempts to identify international business cycles have – at least implicitly – referred to the classical NBER concept of *Burns and Mitchell* (1946), which defines the business cycle as a co-movement of a number of economic parameters and aggregates. For example, *Vahid and Engle* (1993) and *Cubadda* (1999) showed that business cycles can be modelled econometrically by ‘common feature’ and ‘co-dependence’ analyses (both based on cointegration) as a joint movement of the cyclical components of income and consumption. Some widely cited studies specify international business cycles as dynamic factor models, where a multi-dimensional variable space of economic time series across a sample of countries is reduced to a limited number of dimensions.¹² The results of this approach are promising. It has been demonstrated that factor models are sufficiently general to identify characteristic cyclical movement patterns of a large number of variables in the first factor. Studies that consider larger numbers of countries normally find a polycentric or hierarchical structure. Moreover, the empirical literature suggests that there may be a global factor that is mainly driven by shocks, along with cyclical movements of more confined nature.¹³

Amongst analyses referring to dynamic factor models, the work of *Kose et al.* (2003) has to be highlighted. These authors subjected yearly time series of output, consumption and investment from 1960 to 1990 across 60 countries, taken from the Penn World Tables,¹⁴ to a dynamic factor analysis and identified a world factor as well as factors for North America,

¹¹ The regional level *within* a country will not be subjected to an analysis in this section. For advances in this direction, see *Belke and Heine* (2004) as well as *Tondl and Traistaru-Siedschlag* (2006).

¹² See e.g. *Norrbin and Schlagenhauf* (1996), *Gregory et al.* (1997), *Forni et al.* (2001), *Kose et al.* (2003) and *Marcellino et al.* (2003). Dynamic factor models are, of course, also suitable for the identification of NBER type business cycles within *one* country or *one* region, see e.g. *Stock and Watson* (1999), *Bandholz and Funke* (2003) and *Mariano and Murasawa* (2003).

¹³ See *Malek Mansour* (2003).

¹⁴ For a description of this data set, see *Summers and Heston* (1988).

Europe, Oceania, Latin America, Africa, Asia (rich) as well as Asia (poor). This study is remarkable as it refers to a comparably broad country sample,¹⁵ so that – unlike in other studies – the multi-layer structure of business cycles that becomes visible in this analysis draws a more convincing picture of the world business cycle than studies that rely on smaller country samples. *Kose et alii's* central result is that there indeed is a world cycle that accounts for a considerable share of output fluctuation. Moreover, co-movement is more pronounced within the group of developed countries, indicating that the international transmission of the world business cycle to the poorer parts of the world is less effective, which is an intuitively persuasive structural finding, given that these countries are less integrated into the world economy. On the other hand, apart from a North American factor (covering the NAFTA countries) supra-national factors emerge far less important than in previous studies. Furthermore, compared to output, consumption and investment are governed more by country specific factors. Finally, the analysis confirms a hierarchy with the world factor accounting for the bulk of the lowest frequencies, whereas the subsequent factors tend to explain the higher frequencies of the underlying series.

Notwithstanding these encouraging findings, a severe disadvantage of dynamic factor analysis in practical terms is its requirement regarding the completeness and consistency of the data, and the econometric effort is remarkable. The empirical literature on international business cycles thus still refers to less complex methods, and the resulting findings are sometimes no less revealing. *Christodoulakis et al.* (1995) for example, screened HP-filtered quarterly series from EC countries for cross correlations and found close co-movements of output growth, from which they concluded that these countries constitute a distinctive international business cycle. *Ambler et al.* (2004) ran pairwise cross correlations of different macroeconomic indicators for a number of developed countries and found plenty of positive, albeit usually only weak to moderate correlations. Interestingly, the private consumption cycles again show hardly any sign of international integration. Based on a time varying weighting matrix which is derived from the ‘stylised facts’ of national and international business cycles, *Lumsdaine and Prasad* (2003) identified a European and a world business cycle factor.

A few studies refer to standard (cross sectional) rather than dynamic factor or principal component analyses. Though they do not model the time dimension, a significant advantage

¹⁵ The extension of the usual sample size of around 20 countries to 60 comes at a price: *Kose et al.* (2003) analyse yearly instead of the usual quarterly series, and the quality of the data quoted in the Penn World Tables is occasionally rather doubtful (see Section 4.1 of this section).

in practical terms is that they require only one variable (a time series reflecting the cycle) per country. The points on the time axis are then treated as observations. Accordingly, countries that exhibit a similar cycle tend to 'load' (correlate) on the same factors or principal components. An early application of this method is a study by *Fuhrmann* (1980). However, it comprises only three countries. More recently, *Sayek and Selover* (2002) conducted a principal component analysis of GDP growth rates of five European countries as well as the US and obtained two principal components with eigenvalues greater than one. They interpreted this as a reflection of one general factor as well as two supra-national cycles with opposite phases, one of them comprising Germany and France and the other the UK and the US. *Bezmen and Selover* (2005) conducted a comparable analysis for a number of Latin American countries, the EU, Japan and the US. Their results point to a comparably low degree of cyclical integration within Latin America. Yet another approach that builds on principal component analysis is suggested by *Holmes* (2002). This study assessed business cycle convergence towards Germany by examining stationarity of a first principal component of deviations of a number of EU countries' cycles from the German cycle, which is an elegant way to specify a centre-periphery model empirically. *Holmes* found strong convergence towards the German cycle during the 1990s for Belgium, France and the Netherlands.

Yet another statistical method that has proven useful for the identification of international business cycles is cluster analysis. For a sample of OECD countries, *Artis and Zhang* (2001) by means of hierarchical cluster analysis identified a group of Central European countries (Germany, France, Netherlands, Belgium and Austria), a predominantly Nordic periphery group (Denmark, Ireland, UK, Switzerland, Sweden, Norway and Finland), a southern periphery group (Italy, Spain, Portugal and Greece), a North American group (the US and Canada) as well as Japan as an cyclically isolated economy. A study by *Artis* (2003), covering an enlarged sample of OECD countries, constructed a dissimilarity measure based on cross correlations of GDP growth rates and subjected it to a hierarchical cluster analysis. As in *Artis and Zhang* (2001), the country groups that form clusters are similar, albeit not identical to the countries that constitute the major supra-national economic regions or blocks. *Boreiko* (2003) referred to 'fuzzy cluster analysis' – an algorithm allowing for more ambiguity than hierarchical clustering – to evaluate convergence of Eastern European transition economies with the EMU member countries. He found that Estonia and Slovenia are 'leaders' in convergence, which is in part attributed to 'business cycles correlation', in other words, to their accession to an international business cycle that is dominated by EMU member countries. Last but not least, a study by one of the authors of this investigation (*Graff*, 2006)

submitted a panel of yearly data on output gaps and capacity utilisation across developed 26 countries from 1960–2003 to a series of cross correlation, principal components and cluster analyses. He found evidence for a largely regionally defined hierarchy of cycles. The most important finding in our context is the detection of a strong co-movement of most countries in the sample, which is interpreted as the ‘world’ business cycle, along with an Scandinavian-Anglo-Saxon business cycle as well as a closely integrated group of non-Scandinavian and non-English speaking European countries plus Japan and Israel. Although Switzerland clusters closely together with Germany and Austria, its association with the French, Italian and Japanese cycle appears even stronger. However, as *Graff* (2006) analysed yearly data, which are likely to conceal the better part of the dynamics in international business cycles, and as the data end in 2003, i.e. just before full integration of EU goods and factor markets, an extension of this approach with quarterly data to the very present may shed new light on Switzerland’s position in the complex of international business cycles. We shall turn to this below.

To sum up the general observations of this section, we can conclude that the empirical evidence generally confirms the theoretical expectation of a hierarchical and to some degree polycentric structure of international business cycles. Yet, in detail, there is little congruence as far as the identification of countries that constitute particular international cycles is concerned. Most likely, apart from the large variety of methods applied, this has to be attributed to the diversity as well as to the typically small size of the country samples that these studies refer to.

4. An empirical analysis based on quarterly output gap data

As we have seen, international business cycles have been analysed with a range of strikingly diverse methods. Presently, dynamic factor analysis tends to dominate the field. Cross correlation analysis is also regularly applied. Principal component analysis and cluster analysis are used occasionally, but as they do not belong to the standard tools of econometrics, they are usually not the preferred methods.

The advantages and disadvantages of the different methods are rooted in their appropriateness to reflect the theoretical concept of international business cycles. Yet, in practical terms, requirements concerning the data regularly impair their applicability.

Dynamic factor as well as common feature- and co-dependence analyses are theoretically well defined implementations of the NBER concept (business cycles as a synchronism of a

large number of economic series). Yet, unless the analysis is restricted to few countries with a sound statistical basis, data availability erects high barriers for their implementation.

In contrast to this, a univariate characterisation of the cyclical movement allows to extend the empirical analyses to a significantly larger number of countries, which is clearly desirable when the aim is to identify a truly global structure. An international correlation matrix can for example help to identify international cyclical integration. Cross correlations allow for the consideration of phase shifts. The disadvantage of these methods is that the analysis is pairwise, so that it is not possible to determine a world business cycle or layers of cycles, possibly representing a hierarchy of cycles. For this purpose, data reduction algorithms like principal component analysis or factor analysis are appropriate methods. A first principal component (or factor) that correlates positively with a large number of country cycles can be interpreted as a world business cycle, whereas subsequent factors or principal components would suggest cycles comprising (geographically or structurally related) sub-groups of countries. To reveal a layer structure, cluster analysis, grouping country cycles and successively combining them into bundles ('clusters') according to their degree of similarity, would be the preferred method. Accordingly, these methods are particularly suitable for our purpose. Yet, they require that the cyclical position of a country is adequately captured in a single time series.

4.1 An indicator for cyclical development

Business cycles characteristically manifest themselves in over- or underutilisation of productive resources of an economy. Consequently, applied business cycle analysis regularly refers to variables reflecting the utilisation of the factors of production – labour and capital –, usually approximated by the unemployment rate and the rate of capital utilisation. Apart from this, variables like the output gap aim at quantifying aggregate economic capacity utilisation.

Labour and capital utilisation both consider just one factor of production and in doing so may give a distorted picture of the cyclical movement of an economy as a whole, unless labour and capital utilisation are co-moving. This, however, is usually not the case. Labour utilisation is typically *following* the business cycle, and furthermore, is it less cyclically responsive compared to capital utilisation. In addition to this, though unemployment statistics at a first glance seem to be a well-documented and readily available indicator of the business cycle, the data are almost hopeless for international and inter-temporal comparisons. Capital utilisation is more convincing, since it typically proceeds simultaneously with the business cycle. Unfortunately, capital utilisation is not well documented statistical information.

From a theoretical perspective, the output gap, which is defined as the relative deviation of the observed output (GDP) Y at time t from potential output Y^* , i.e. $(Y_t - Y^*_t)/Y^*_t$, is probably the most convincing concept to determine the cyclical position of an economy. And indeed, it is widely used amongst theorists as well as practitioners. Unfortunately, for practical purposes, the concept depends on the determination of Y^* , which – like the business cycle – is an inherently unobservable variable. Ideally, a macroeconomic production function should quantify the potential output path Y^*_t . Since this is a formidable task, it is common to refer to univariate statistical procedures – filters – that are designed to isolate the trend of the Y_t series from the cycle (and the noise) and then to interpret this trend as Y^*_t . Various low pass filters are doing the job fairly well, and this statistical approach impresses through its simplicity as well as comparability across time and space. We shall hence adopt this methodology.

Our data for Y_t are quarterly seasonally adjusted GDP volume indices from the OECD online National Accounts data base.¹⁶ The coverage at the time of writing is up to 2011q3 for most countries. Some series go as far back as 1948, but for most countries, the series start in 1960. For a considerable number of countries, however, the series start as late as in the 1990s, and for Russia in 2003. We are hence dealing with a highly unbalanced panel. The coverage is summarised in Table 1.

To estimate trend GDP, we use the common Hodrick-Prescott-filter, which is easy to implement and restricts discretion to one exogenous parameter,¹⁷ the intensity of smoothing. This assures reproducibility of our calculations. A disadvantage of this filter is the ‘end point problem’, which is due to the fact that symmetric filters become increasingly asymmetric towards the margins of a time series, which may cause substantial revisions as new data points are added. With the Hodrick-Prescott filter, this problem is especially severe for the last four to six data points. One strategy to mitigate this problem is to re-establish symmetry at the margin by forecasting a few data points. The resulting symmetry, however, is of purely technical nature, as the ‘true’ future values are of course unknown, so that any improvement of the end point characteristics of the filter is a function of the forecasting accuracy. Since economic forecasts are notoriously unreliable close to turning points, where early and reliable

¹⁶ See <http://stats.oecd.org/Index.aspx>; accessed on 30 November 2011 for this version of the paper. The quarterly GDP series referred to is labelled ‘B1_GE: Gross domestic product - expenditure approach – VOBARSA: Millions of national currency, volume estimates, OECD reference year, annual levels, seasonally adjusted’.

¹⁷ See *Hodrick and Prescott* (1997). Apart from the protagonists themselves, *Christodoulakis et al.* (1995), *Razzak* (2001) as well as *Artis* (2003), amongst many others, refer to the Hodrick Prescott-filter. We set the smoothing parameter to $\lambda = 1600$, as recommended for quarterly data, apply it to $\ln Y$ and refer to the de-logged filtered series as Y^* .

information about the cyclical profile would be mandatory to supply the symmetrical with a few future data points, we shall not resort to this illusionary remedy.

On the other hand, as we here are not first of all interested in a reflection of current economic activity, but rather in a heuristic, explorative review of the past, we can mitigate the end point problem by ‘sacrificing’ a few data points and analysing the more symmetric filter output only. After filtering, we hence restrict all further analyses to data from 1970q1 to 2010q4. Accordingly, at the left margin, where the data for some of the countries in our panel go back as far as 1960q1, the filter can draw on up to 40 out of sample data points, and at the right margin, where at the time of writing, all some time series extend at least to 2011q1 (for Greece), 17 up to 2011q2, and another 22 up to 2011q3. To adopt the filter output at the right margin to the last detectable trend we fill the missing observations for 2011q2 and 2011q3 with linear extrapolations from the last two observations. The data points 2011q1 to 2011q2 – no matter whether observed or interpolated – are then exclusively used for the filter and not analysed further. Thus, we are ‘sacrificing’ some data points in order to stabilise the HP filtered output gap estimates. Given that for the purpose of this paper we are interested in long term regularities rather than in the latest developments, this ‘sacrifice’ seems warranted.

4.2 Identification of international business cycles

To identify international business cycles, we refer to the output gap (OG) time series for all 40 countries of our sample. First, they are subjected to 39 pairwise cross correlation analyses with the Swiss series, so that we can identify similarity and potential phase shifts of the Swiss cycle vis-à-vis all other countries on an individual basis. This also allows us to assess whether business cycle integration has strengthened during the observed time period. A principal component decomposition of the data follows, with which we test whether there is empirical evidence for coexistence of a world business cycle along with supra-national business cycles. Finally, we conduct a cluster analysis which can illustrate a hierarchical structure of business cycles. The latter two steps of analyses will devote special attention to Switzerland.

Cross correlations

Here we examine pairwise correlations between the Swiss output gap OG_{CHE} and those of the other 39 countries of the sample OG_j , allowing for phase shifts of up to 7 quarters. Moreover, we *a priori* disregard correlations based on $n < 16$, which ensures coverage of at least 4 years, i.e. a shorter cycle. Finally, negative correlations are treated as ‘no correlation’, as we find it hard to conceive any transmission from some country to Switzerland, where the Swiss

economy is depressed (promoted) by a positive (negative) evolution elsewhere. (We shall nevertheless report the negative correlations, so that the reader may think of potential causality not obvious to the author.)

The results for the whole period are summarised in Table 2, referring to those 25 countries apart from Switzerland with observations for all quarters from 1970q1 to 2010q4. We show the absolute maxima of cross correlations amounting to at least 0.40. Integration with the European neighbours is high, most notably with Belgium, France, Portugal, Italy, Austria, Luxemburg and Germany. Most correlations are simultaneous, and when there is a phase shift, Switzerland's business cycle is always following rather than leading. No significant integration (i.e. the maxima of cross correlations with Switzerland lower than 0.40 in absolute terms) is detected with Norway, South Korea and Sweden. Negative correlations are found with New Zealand and Turkey. Distance from Switzerland appears to be the dominant feature for lack of business synchronisation, with the exception of Turkey, a developing country for most of the sample period, and Norway, an oil exporter whose economy is governed by its own laws. Sweden's maximum correlation with Switzerland is 0.37 at lead/lag zero, so that the $|0.40|$ threshold is missed only marginally.

Is this a stable pattern? Relevant to Switzerland, structural breaks are likely to have occurred around the collapse of the Bretton-Woods system in 1973/74, upon completion of the EU goods and factor markets integration in 1994, when the EMU came into being in 1999 or with the adoption of free movement of people between most countries of the EU and Switzerland in 2008. Given the limited degrees of freedom in our panel, we choose to have a closer look and compare the 1974–1993 and 1994–2010 sub-periods. Thus, we focus on the effect of the European goods and factor markets integration on the Swiss business cycle. Tables 3 and 4 summarise the results.

Comparing 1974–1993 (Table 3) with the total sample period does not reveal pronounced differences. Switzerland is now classified as 'leading' vis-à-vis Ireland, but the correlation is moderate; Negative cross correlations are now not detected with Turkey, the UK, Denmark and South Korea, implying that the UK and Denmark were not cyclically integrated with Continental Europe before 1993, and neither with Switzerland. Otherwise the picture remains very much the same.

For the 1994–2010 period, however, the pattern looks decisively different (Table 4). The overall degree of integration of the Swiss cycle with the rest of the world has markedly increased, in terms of numbers as well as strength of the correlations; the latter especially with

the main neighbouring countries and trading partners. Switzerland is still moving in line with the other countries; if not, it is still mostly lagging, leading only vis-à-vis Slovakia and Iceland. Notably, the British, Danish and Norwegian cycles are now positively correlated with the Swiss cycle; a fact that most likely is not mainly due to stronger bilateral links with Switzerland, but rather to both countries' stronger links with the rest of Europe. Negative correlations persist with New Zealand and Turkey. The cyclical integration with (what is now) the EMU (EA17) and the EU (EU27) is instantaneous and pronounced, with cross correlations close to 90%.

Pairwise correlation can reveal international integration of countries (pairwise or overall). Yet, it cannot clarify the structure between multiple business cycles. For this, other methods are more appropriate. We shall turn to these now.

Principal component analysis

We now submit the *OG* time series to a factor analysis. This will serve to get an idea of the number of underlying dimensions that can be interpreted as international cycles, as well as of the degree to which the countries can be associated with these dimensions.

As above, we split the sample period into a 1974–1993 and a 1994–2010 sub-period, which leaves us with 26 countries that have no missing observations (see Table 1), as required by this method. The *OG* series are by construction stationary, which implies that we can work with the conventional instruments of factor decomposition used in cross-sectional analyses.¹⁸

We refer to the standard method – principal component analysis – which among factor-analytic methods is the one that requires least assumptions about the covariance structure of the data. Principal component analysis is a method to reduce a data to a low number of dimensions.¹⁹ In particular, a principal component is a synthetic variable that results from a linear combination of observed variables. The starting point is a matrix of k variables that can be expected to be related to each other (correlated), and n observations. (Here k corresponds to the 26 business cycles reflected by OG_t and n to the quarterly observations.) Each variable X_1, \dots, X_k can exactly be expressed as a linear combination of k principal components H_1, \dots, H_k . For the i -th variable, observed at the j -th case, we get:

$$X_{ij} = a_{i1} H_{1j} + a_{i2} H_{2j} + \dots + a_{ik} H_{kj}, (i = 1, \dots, k; j = 1, \dots, n) .$$

¹⁸ Augmented Dickey-Fuller tests for the 26 series show that stationarity is not only implied by construction, but also statistically given. The series as well as the test statistics are available from the author upon request.

¹⁹ See e.g. *Johnston* (1984) and *Jolliffe* (1986).

The algorithm now determines what share of the overall variance of the k observed variables can be reproduced with $r < k$ principal components,

$$X_{ij} = a_{i1} H_{1j} + a_{i2} H_{2j} + \dots + a_{ir} H_{rj} + R_{ij}, \quad (i = 1, \dots, k; j = 1, \dots, n),$$

where R_{ij} stands for the unexplained rest when reducing the linear combination to r principal components observed at the j -th case of variable X_j . The components are subsequently determined by ordinary least squares in a way that the rest R_{ij} is minimised. The loadings a_{i1}, \dots, a_{ir} correspond to regression coefficients which would result from the multiple regression of variable X_i on the principal components. How many principal components are required to reproduce the data? The literature suggests variance shares of 70 to 90 per cent. Yet, as any threshold is arbitrary, looking at explained variance leaves room for discretion. In contrast to this, the eigenvalue-rule provides an exact number of components to be extracted: As the number of potential components is equal to the number of variables k and since the sum of the explanatory contributions of all potential principal components amounts to 100 per cent, an explanatory contribution below $(100/k)$ per cent (corresponding to an eigenvalue lower than unity) implies that this component contributes less to the explanation of the overall variance than an ‘average’ variable. The eigenvalues as well as the variance shares of the principal components with eigenvalues exceeding unity resulting from a principal components decomposition of OG_t for 1974–1993 are given in Table 5, which shows that according to the eigenvalue-rule, six principal components should be extracted, explaining close to 80% of the overall OG variance. The rotated factor loading matrix is reproduced in Table 6. (Absolute loadings below 0.5 are suppressed to ease interpretation.) A straightforward interpretation of this principal components decomposition is as follows: The cycle that is common to the largest subset of countries in the sample will emerge as the first principal component, representing the dominant cycle in the country group. Now, such a component indeed emerges from our data, as can be seen in Table 6, where the factor-loading matrix is sorted in descending order with respect to the strength of the loadings on the first principal component. The countries are thus ranked according to their congruence with our dominant business cycle.

The largest number of countries that are pronouncedly cyclically co-moving is ten. It comprises only European economies, mostly from Central Europe, including Switzerland. Australia, Canada, the UK and South Africa load on the second factor; which hence comprises British Commonwealth economies only. Factors 3 to 6 are less obvious to interpret. Yet, a number of country clusters within these components stand out, in particular Sweden

and Finland (component 5) as well as Norway and Denmark (component 6). Overall, having in mind the conclusions from the gravity model of trade, proximity matters both in terms of distance and culture, the same appears to hold for the integration of business cycles.

Again, let us compare the finding for the 1974–1993 with 1994–2010 (Tables 7 and 8). Clearly, the business cycle integration within the sample has markedly deepened. There are only five instead of four factors to be extracted, and the first factor is now pronouncedly more dominant, alone reproducing over 60% of the sample variance. Also, all economies load high on the first factor, apart from Turkey, Japan, Norway, South Africa, New Zealand, Greece and Australia. The other extracted factors appear to be driven by idiosyncratic country cycles (or co-movement with economies not in the sample). No obvious pattern can be associated with the second factor. The third factor points to some cyclical association between New Zealand and South Korea, and Greece as well as Australia (factors 4 and 5). As before, Switzerland shows high loadings exclusively on the first factor; but this is now an even more dominant factor. Also, only one country (France) is loading higher on this factor than Switzerland. This implies that of all 26 countries in the sample, in the later period, only one appears more in line with the common cycle than Switzerland.

Hierarchical cluster analysis

Cluster analyses are methods that decompose a data set into different groups (clusters). The algorithm relies either on *distinguishing between different clusters* or on the *similarity within a cluster*. For our purposes, we proceed as follows.

First, we transpose our matrix of variables and observations so that we obtain a data matrix with years as variables and countries as observations. Then we subject this matrix to a hierarchical cluster analysis with the squared Euclidian distance

$$\sqrt{\sum (OG_i - OG_j)^2} \quad (i \neq j)$$

as measure of similarity. We determine the cluster structure by means of the Ward-algorithm. Starting at the lowest level of dissimilarity, variable median values are successively calculated for all possible clusters, and the quadratic Euclidian distance between all observations (countries) is determined. The clustering then proceeds according to the minimum increase in the squared Euclidian distance. This clustering method considers all variables equally when determining the within group variance. Thus, homogeneity *within* a group is the focus (in contrast to algorithms aiming at clear-cut separation *between* clusters). This corresponds to a

focus on commonality of the business cycle within a country group, rather than on delimiting one cycle from the other.

Figures 1 to 3 show the resulting dendogrammes for the earlier and later sample periods (1974–1993 and 1974–2010), respectively as well as for the last eight years (2003–2010), where the latter ensures full coverage of the 40 countries in the sample. Examining the cluster structure from the left to right corresponds to bottom to top of the hierarchy. The countries with the most similar business cycles in the 1974–1993 period according to *OG*, are a group of four (Belgium, Italy, France and Spain), a group of three (Austria, Germany and the Netherlands) and a group of two (Australia and Canada). At the next level, groups of two are formed by the US and the UK, Denmark and Norway, and Ireland and Japan, where the last group appears like a statistical artefact. Switzerland appears only at stage three of the clustering, together with Luxembourg, which is possibly due to the fact that those countries both specialised in Private Banking for wealthy non-residents with an inclination to tax evasion or fraud. Moving to the right, lower level clusters combine into increasingly less similar ones, and the last two countries associated to a cluster are Greece and New Zealand, which is both intuitive as well as by and large in line with the results from the factor analyses.

Comparing this finding with the later period (figure 2), where the sample size increases from 26 to 29, shows that Switzerland is now cyclically pronouncedly more integrated: It enters at stage one, along with the Netherlands, Spain, Austria and Portugal. The clustering algorithm reveals some obvious locally or culturally induced co-movements (e.g. Australia and New Zealand or South Korea and Indonesia) as well as some supposedly statistical artefacts (e.g. Luxemburg and Mexico or Turkey and Argentina).

Finally, in the 2003–2010 period, for which we have data from all 40 countries in the sample, cyclical integration again has markedly increased. Moreover, the newly added countries mostly cluster in intuitively plausible way, e.g. Slovenia, Russia and Slovenia as well as India with Brazil and thereafter with Japan, the US and Korea. Former ‘outlier’ New Zealand now cluster at the first level together with close by (in relative terms) Australia and Indonesia. The economies that remain least integrated with the other 40 in the sample are Estonia, Turkey and Iceland, which does not seem implausible either. Interestingly, Switzerland, although pronouncedly integrated into a cyclical cluster of eight economies (apart from Switzerland Spain, South Africa, the Netherlands, Israel, Portugal, Poland and Norway), now seem cyclically more distant from its closest neighbours like Austria and Germany. However, we would not want to put too much stress on the findings from the 2003-

2010 period. While it demonstrates that the method continues to produce reasonable clusters when we add a number of transition economies and newly industrialising countries, the last period is so short that it covers hardly more than one cycle, and it is dominated by the recent world recession, so that we are careful not to infer too much from it.

5. Summary and conclusions

This paper first discussed concepts, definitions and theoretical explanations for international business cycles. This was followed by an overview of previous empirical studies. We then argued that for *ex post* analyses the output gap is a univariate quantification of the business cycle that is comparable across space and time and readily available (or rather computable from GFP series), which recommends its use for our purposes. Based on an unbalanced panel of quarterly output gap series in a panel of 40 countries from 1960q1 to 2011q3, we then test a number of hypotheses regarding business cycle integration in general, and in particular the imbeddedness of the Swiss economy into international business cycles and possible changes thereof over the recent years.

The results reveal layers of international business cycles, which can be interpreted along the lines of the gravity model of trade; business cycle integration is most likely amongst neighbours as well with culturally proximity and shared history. Moreover, comparing the early post-Bretton-Woods period up to 1993 with the later 1994–2004 years by and large shows a tendency for cycles pertaining to smaller groups of economies to dissolve into a more integrated cyclical co-movement.

The integration of Switzerland is pronounced. It also markedly deepened after 1994. A case for Switzerland being ‘special’ can hence not be made in terms of its recent business cycle pattern.

Notice that the findings conclusions in this paper are, unfortunately, based on a limited sample of countries, mostly OECD members, transition economies and a few newly industrialised countries, so that even if they comprise the lion’s share of world GDP, this is not a truly global analysis. The white spots are, due to limited data availability, most of Africa, Latin America and Asia. Extending this research to incorporate the poorer parts of the world is high on our agenda.

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Table 1: The panel – data availability

| Country | Start data | End data | Effective obs. (1970q1–2010q4) |
|---------|------------|-------------------|--------------------------------|
| AUS | 1960q1 | 2011q2 | 164 |
| AUT | 1960q1 | 2011q3 | 164 |
| BEL | 1960q1 | 2011q3 | 164 |
| CAN | 1960q1 | 2011q2 | 164 |
| CHE | 1960q1 | 2011q2 | 164 |
| DEU | 1960q1 | 2011q3 | 164 |
| DNK | 1960q1 | 2011q2 | 164 |
| ESP | 1960q1 | 2011q3 | 164 |
| FIN | 1960q1 | 2011q2 | 164 |
| FRA | 1960q1 | 2011q3 | 164 |
| GBR | 1960q1 | 2011q3 | 164 |
| GRC | 1960q1 | 2011q1 | 164 |
| IRL | 1960q1 | 2011q2 | 164 |
| ITA | 1960q1 | 2011q2 | 164 |
| JPN | 1960q1 | 2011q3 | 164 |
| KOR | 1970q1 | 2011q3 | 164 |
| LUX | 1960q1 | 2011q2 | 164 |
| MEX | 1960q1 | 2011q3 | 164 |
| NLD | 1960q1 | 2011q3 | 164 |
| NOR | 1960q1 | 2011q3 | 164 |
| NZL | 1960q1 | 2011q2 | 164 |
| PRT | 1960q1 | 2011q3 | 164 |
| SWE | 1960q1 | 2011q2 | 164 |
| TUR | 1960q1 | 2011q2 | 164 |
| USA | 1960q1 | 2011q3 | 164 |
| ZAF | 1960q1 | 2011q2 | 164 |
| IDN | 1990q1 | 2011q3 | 84 |
| ARG | 1993q1 | 2011q2 | 72 |
| SVK | 1993q1 | 2011q3 | 72 |
| CZE | 1995q1 | 2011q3 | 64 |
| HUN | 1995q1 | 2011q3 | 64 |
| ISR | 1995q1 | 2011q3 | 64 |
| POL | 1995q1 | 2011q2 | 64 |
| BRA | 1996q1 | 2011q2 | 60 |
| CHL | 1996q1 | 2011q3 | 60 |
| SVN | 1996q1 | 2011q2 | 60 |
| IND | 1996q2 | 2011q2 | 59 |
| ISL | 1997q1 | 2011q2 | 56 |
| EST | 2000q1 | 2011q3 | 44 |
| RUS | 2003q1 | 2011q2 | 32 |
| | | <i>EMU and EU</i> | |
| EA17 | 1995q1 | 2011q3 | 64 |
| EU27 | 1995q1 | 2011q2 | 64 |

Table 2: $OG_{CHE,j}$, cross correlations, $|r| \geq 0.4$, lead/lag ≤ 7 quarters, 1970-2010, $n = 164$

| <i>Lead (-) before CHE</i> | <i>Country</i> | <i>r</i> |
|------------------------------------|----------------|----------|
| 0 | BEL | 0.75 |
| 0 | FRA | 0.72 |
| -1 | PRT | 0.70 |
| 0 | ITA | 0.70 |
| 0 | AUT | 0.69 |
| 0 | LUX | 0.66 |
| 0 | DEU | 0.65 |
| -2 | GBR | 0.61 |
| 0 | FIN | 0.61 |
| 0 | NLD | 0.59 |
| -2 | JPN | 0.57 |
| -1 | CAN | 0.54 |
| 0 | ESP | 0.54 |
| -3 | USA | 0.52 |
| -3 | GRC | 0.50 |
| 0 | MEX | 0.47 |
| -2 | DNK | 0.46 |
| 0 | IRL | 0.45 |
| -1 | AUS | 0.44 |
| 1 | ZAF | 0.41 |
| <i>Negative cross correlations</i> | | |
| -7 | NZL | -0.41 |
| 4 | TUR | -0.40 |

Table 3: $OG_{CHE,j}$, cross correlations, $|r| \geq 0.4$, lead/lag ≤ 7 quarters, 1974-1993, $n = 80$

| <i>Lead (-) before CHE</i> | <i>Country</i> | <i>r</i> |
|------------------------------------|----------------|----------|
| 0 | ITA | 0.77 |
| 0 | BEL | 0.73 |
| 0 | LUX | 0.67 |
| 0 | PRT | 0.66 |
| 0 | FRA | 0.65 |
| 0 | AUT | 0.60 |
| 0 | DEU | 0.55 |
| 4 | MEX | 0.55 |
| -1 | NLD | 0.54 |
| -1 | CAN | 0.53 |
| 0 | FIN | 0.52 |
| 2 | IRL | 0.50 |
| -6 | USA | 0.48 |
| 0 | ESP | 0.47 |
| -2 | JPN | 0.45 |
| -1 | AUS | 0.43 |
| 0 | ZAF | 0.43 |
| <i>Negative cross correlations</i> | | |
| 2 | TUR | -0.53 |
| 7 | GBR | -0.52 |
| 5 | DNK | -0.49 |
| 3 | KOR | -0.40 |

Table 4: $OG_{CHE,j}$, cross correlations, $|r| \geq 0.4$, lead/lag ≤ 7 quarters, 1994-2010

| <i>Lead (-) before CHE</i> | <i>Country</i> | <i>r</i> | <i>n</i> |
|----------------------------|------------------------------------|----------|----------|
| 0 | NLD | 0.91 | 68 |
| 0 | AUT | 0.89 | 68 |
| 0 | FRA | 0.89 | 68 |
| 0 | ESP | 0.88 | 68 |
| 0 | DEU | 0.86 | 68 |
| 0 | BEL | 0.85 | 68 |
| 0 | FIN | 0.82 | 68 |
| 0 | ITA | 0.81 | 68 |
| -1 | GBR | 0.79 | 68 |
| 0 | LUX | 0.78 | 68 |
| 0 | PRT | 0.77 | 68 |
| -1 | IRL | 0.76 | 68 |
| -1 | USA | 0.74 | 68 |
| -1 | DNK | 0.74 | 68 |
| 0 | CAN | 0.74 | 68 |
| -1 | SWE | 0.73 | 68 |
| -1 | MEX | 0.72 | 68 |
| -1 | NOR | 0.62 | 68 |
| -1 | JPN | 0.59 | 68 |
| -2 | ARG | 0.57 | 68 |
| 0 | ZAF | 0.56 | 68 |
| 1 | SVK | 0.49 | 68 |
| -1 | AUS | 0.42 | 68 |
| 0 | ISR | 0.74 | 64 |
| -1 | POL | 0.67 | 64 |
| 0 | HUN | 0.65 | 64 |
| 0 | CZE | 0.61 | 64 |
| 0 | SVN | 0.78 | 60 |
| 0 | CHL | 0.60 | 60 |
| 0 | BRA | 0.57 | 60 |
| -2 | IND | 0.73 | 59 |
| 1 | ISL | 0.66 | 56 |
| 0 | EST | 0.75 | 44 |
| 0 | RUS | 0.91 | 32 |
| | <i>EMU and EU</i> | | |
| 0 | EA17 | 0.89 | 64 |
| 0 | EU27 | 0.88 | 64 |
| | <i>Negative cross correlations</i> | | |
| 3 | NZL | -0.43 | 68 |
| 6 | TUR | -0.60 | 68 |

Table 5: Principal component extraction, *OG*, 1974–1993

| Component | Initial Eigenvalues | | |
|-----------|---------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % |
| 1 | 8.767 | 33.72 | 33.72 |
| 2 | 3.557 | 13.68 | 47.40 |
| 3 | 2.761 | 10.62 | 58.02 |
| 4 | 2.103 | 8.09 | 66.11 |
| 5 | 1.959 | 7.53 | 73.65 |
| 6 | 1.023 | 3.93 | 77.58 |
| 7 | 0.884 | 3.40 | 80.98 |
| 8 | 0.807 | 3.10 | 84.08 |
| 9 | 0.656 | 2.52 | 86.61 |
| 10 | 0.601 | 2.31 | 88.92 |
| 11 | 0.446 | 1.72 | 90.63 |
| 12 | 0.399 | 1.54 | 92.17 |
| 13 | 0.326 | 1.26 | 93.43 |
| 14 | 0.264 | 1.02 | 94.44 |
| 15 | 0.211 | 0.81 | 95.25 |
| 16 | 0.200 | 0.77 | 96.02 |
| 17 | 0.181 | 0.70 | 96.72 |
| 18 | 0.168 | 0.65 | 97.37 |
| 19 | 0.153 | 0.59 | 97.98 |
| 20 | 0.126 | 0.49 | 98.44 |
| 21 | 0.098 | 0.38 | 98.82 |
| 22 | 0.089 | 0.34 | 99.16 |
| 23 | 0.076 | 0.29 | 99.50 |
| 24 | 0.060 | 0.23 | 99.68 |
| 25 | 0.049 | 0.19 | 99.87 |
| 26 | 0.034 | 0.13 | 100.00 |

Table 6: Rotated factor loadings matrix, OG, 1974–1993

| | Component | | | | | |
|-----|-----------|------|-------|-------|-------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| AUT | 0.83 | | | | | |
| PRT | 0.82 | | | | | |
| FRA | 0.81 | | | | | |
| BEL | 0.80 | | | | | |
| ITA | 0.79 | | | | | |
| LUX | 0.79 | | | | | |
| CHE | 0.77 | | | | | |
| ESP | 0.73 | | | | | |
| DEU | 0.67 | | | | | |
| NLD | 0.55 | | | | | 0.51 |
| AUS | | 0.90 | | | | |
| CAN | | 0.84 | | | | |
| GBR | | 0.58 | | | | |
| ZAF | | 0.56 | | | | |
| KOR | | | 0.84 | | | |
| MEX | | | -0.82 | | | |
| USA | | | 0.74 | | | |
| JPN | | | | 0.75 | | |
| NZL | | | | -0.72 | | |
| IRL | | | | 0.63 | | |
| GRC | | | | 0.61 | | |
| SWE | | | | | 0.86 | |
| FIN | | | | | 0.76 | |
| TUR | | | | | -0.60 | |
| NOR | | | | | | 0.87 |
| DNK | | | | | | 0.68 |

Table 7: Principal component extraction, OG, 1994–2010

| Component | Initial Eigenvalues | | |
|-----------|---------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % |
| 1 | 16.18 | 62.24 | 62.24 |
| 2 | 2.48 | 9.52 | 71.76 |
| 3 | 1.28 | 4.91 | 76.67 |
| 4 | 1.24 | 4.77 | 81.43 |
| 5 | 1.08 | 4.17 | 85.60 |
| 6 | 0.62 | 2.38 | 87.98 |
| 7 | 0.54 | 2.09 | 90.07 |
| 8 | 0.44 | 1.71 | 91.78 |
| 9 | 0.33 | 1.26 | 93.04 |
| 10 | 0.30 | 1.15 | 94.19 |
| 11 | 0.24 | 0.93 | 95.12 |
| 12 | 0.22 | 0.84 | 95.96 |
| 13 | 0.19 | 0.73 | 96.69 |
| 14 | 0.15 | 0.59 | 97.28 |
| 15 | 0.12 | 0.47 | 97.75 |
| 16 | 0.12 | 0.46 | 98.21 |
| 17 | 0.09 | 0.34 | 98.55 |
| 18 | 0.07 | 0.27 | 98.82 |
| 19 | 0.07 | 0.26 | 99.08 |
| 20 | 0.06 | 0.23 | 99.31 |
| 21 | 0.05 | 0.16 | 99.49 |
| 22 | 0.04 | 0.15 | 99.63 |
| 23 | 0.03 | 0.12 | 99.75 |
| 24 | 0.03 | 0.12 | 99.87 |
| 25 | 0.02 | 0.09 | 99.95 |
| 26 | 0.01 | 0.05 | 100.00 |

Table 8: Rotated factor loadings matrix, OG, 1994–2010

| | Component | | | | |
|-----|-----------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 |
| FRA | 0.92 | | | | |
| CHE | 0.89 | | | | |
| NLD | 0.88 | | | | |
| AUT | 0.87 | | | | |
| DEU | 0.85 | | | | |
| ESP | 0.85 | | | | |
| LUX | 0.84 | | | | |
| CAN | 0.84 | | | | |
| BEL | 0.84 | | | | |
| PRT | 0.78 | | | | |
| ITA | 0.77 | | | | |
| FIN | 0.75 | 0.51 | | | |
| SWE | 0.74 | | | | |
| GBR | 0.73 | | | | |
| DNK | 0.71 | | | | |
| MEX | 0.68 | | | | |
| USA | 0.66 | | | | |
| IRL | 0.64 | 0.56 | | | |
| TUR | | 0.91 | | | |
| JPN | | 0.67 | | | |
| NOR | | 0.60 | | | |
| ZAF | | 0.54 | | | |
| NZL | | | 0.90 | | |
| KOR | | | 0.84 | | |
| GRC | | | | 0.87 | |
| AUS | | | | | 0.83 |

Figure 1: Dendrogramme, hierarchical cluster analysis, *OG*, 1974–1993

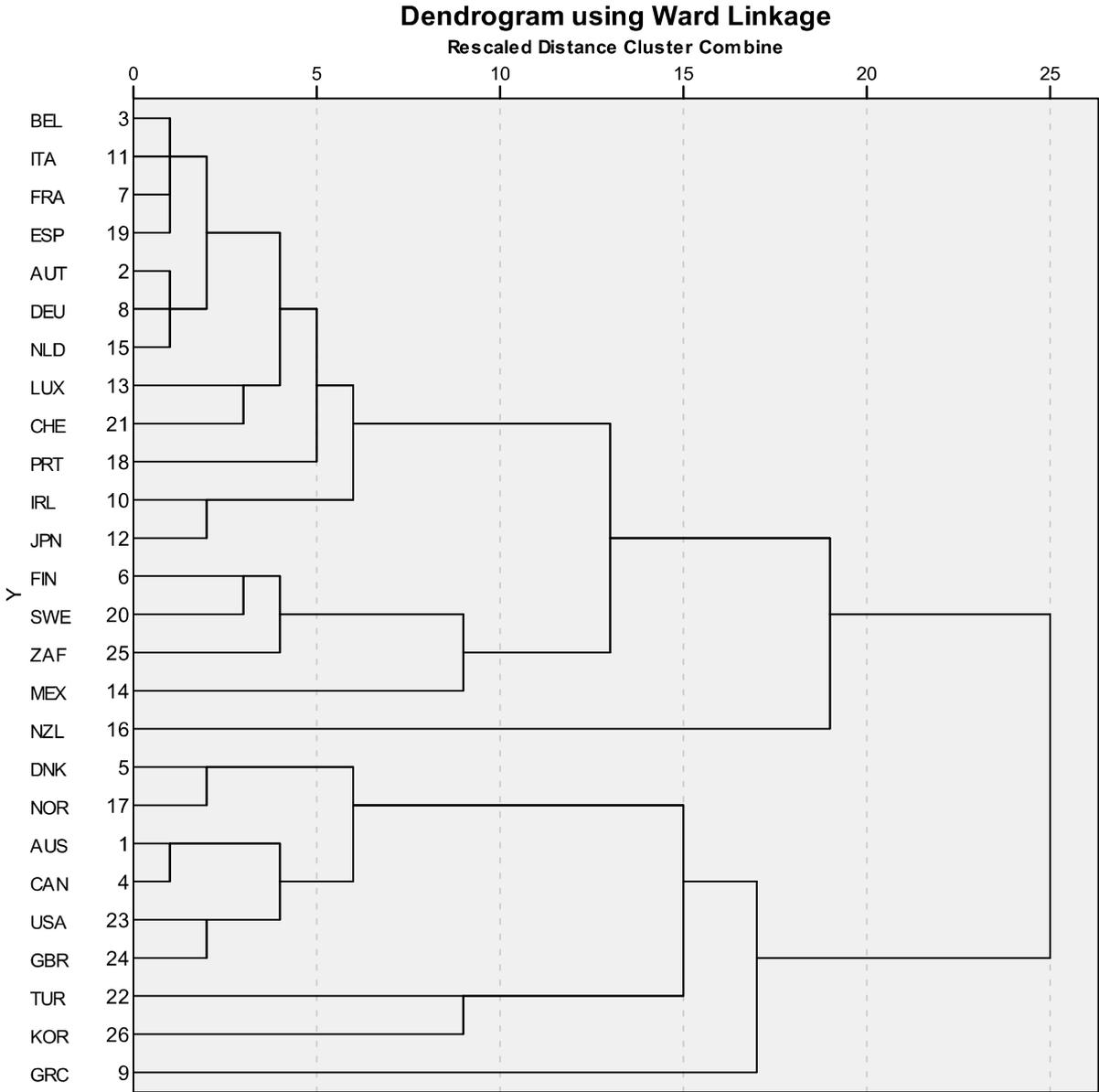


Figure 2: Dendrogramme, hierarchical cluster analysis, OG, 1994–2010

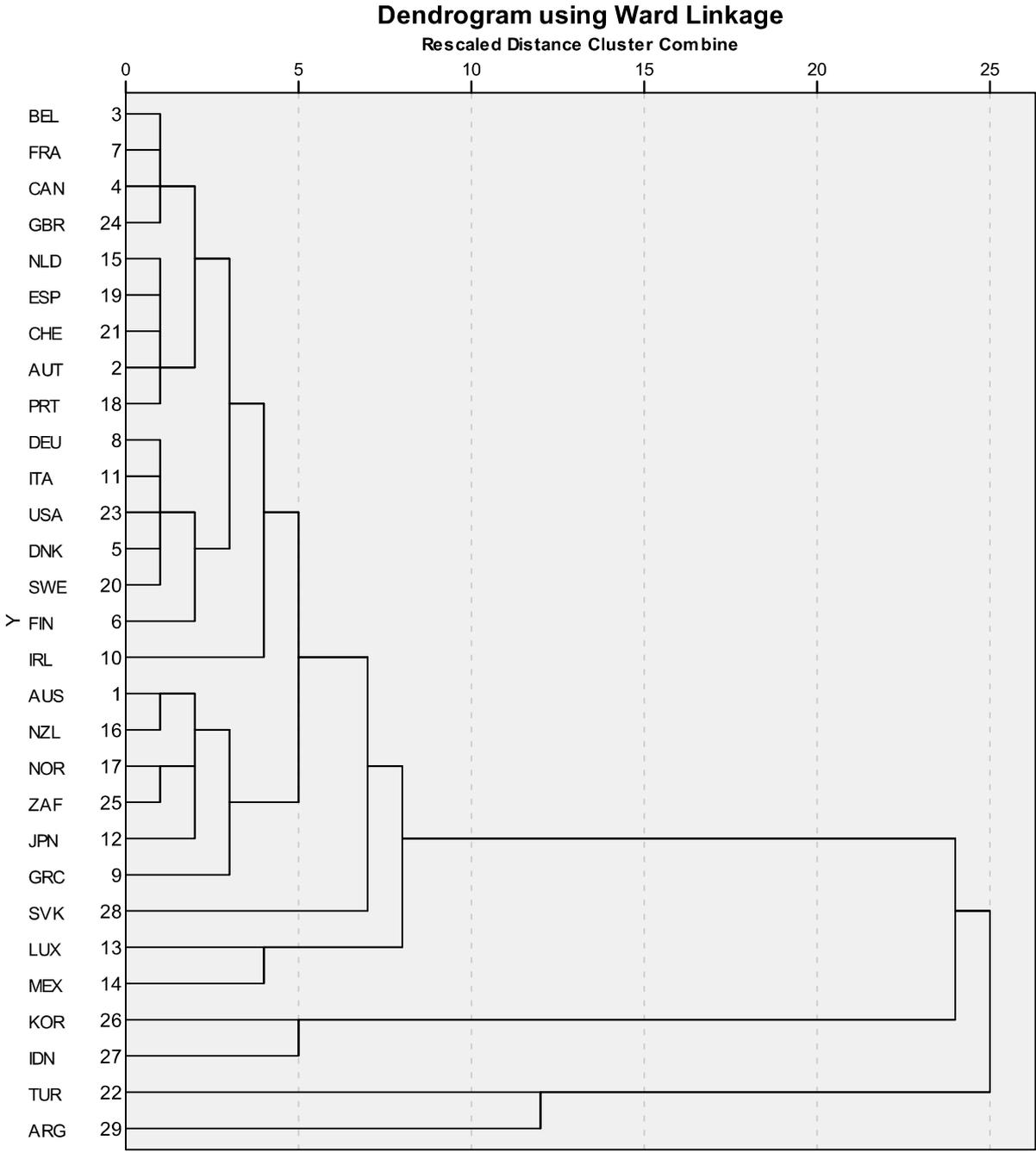


Figure 3: Dendrogramme, hierarchical cluster analysis, OG, 2003–2010

