Measuring Actual Economic Integration

Glenn Rayp[1] and Samuel Standaert[2,3]
Department of Economics
Ghent University

Introduction

Despite the academic and policy interest and in contrast with other aspects of institutional economics (like governance), a systematic and standard index of regional integration is still lacking. An index that gives a quantitative measure of the level of regional integration is deemed useful, because it would allow to determine the trends in the world economy more precisely (e.g. the link between globalization and regionalization), to monitor integration policy initiatives more accurately and to assess the effectiveness of current or past policy initiatives (e.g. aiming at indicating good practices). Yet, in their review, De Lombaerde, Dorrucci, Genna, and Mongelli (2008, p.2) note that "*only a few attempts have been undertaken to design composite indices of regional integration and no proposal has been systematically and continuously used as a policy tool*."

The most plausible explanations for this dearth are data availability and methodological issues. Regional integration is a complex and multidimensional process and therefore difficult to capture by a single or a few indicators. Consequently, a larger set of data is used, usually of very different quality in which scoring by the analyst is not uncommon. Interpretation and analysis of the data demands a summary indicator that integrates the information of all the available data, which immediately brings up the problem of how to

1email: Glenn.Rayp@UGent.be
2email: Samuel.Standaert@UGent.be
3We are indebted to Gaspare Genna, Philippe De Lombaerde and the participants of UNU-CRIS's Expert Workshop on Indicator-Based Monitoring of Regional Economic Integration for their comments and suggestions.

summarize (i.e. aggregate) the individual indicators and which weighting scheme to use. For example, Feng and Genna (2003) follow Hufbauer and Scott (1994) in their construction of Integration Achievement Scores by taking the simple arithmetic average of the categories that measure distinct components of (institutional) regional integration. The index of institutional regional integration in Dorrucci, Firpo, Fratzscher, and Mongelli (2004) is also computed as an unweighted average of assigned achievement scores in each of the Balassa stages in regional integration, which is then related to a set of indicators of actual economic integration indicators in order to study causal effects. In UNECA (2001, 2002, 2004) the composite index is constructed as a weighted mean: first at the country level taking expert opinions as the basis of the weighting scheme; Second at the regional level, using country GDPs as weights. Dennis and Yusof (2003) take as composite integration indicator the simple arithmetic average of a small subset of their key indicators. Finally, the UN-ESCWA (2006) report uses a principle component analysis to compute the level of actual integration of Arab countries.

In this contribution, we propose a new approach to constructing a regional integration indicator, that is a Bayesian state-space approach, which can remedy to the obstacles mentioned and therefore allow a systematic and continuous use.

De Lombaerde, Dorrucci, Genna, and Mongelli (2011) formulate a three-step method in constructing a composite index. The first step concerns the principles on which the individual indicators of the index should be based: relevance, accuracy and credibility, data availability, timeliness and comparability. Often, these principles are (partially) neglected out of necessity: the lack of indicators that take account of the multidimensionality of regional integration compels the use of incomplete or inaccurate data. Of course, this is common to whichever method is used to construct an aggregate indicator. However, the state-space approach can take the uncertainty of the data into account, as well as correct for missing values in a statistically transparent way, in contrast to other methods that have been used.

The second step of De Lombaerde et al. (2011) refers to the classification of the variables according to particular aspects of regional integration, e.g. the distinction between indicators of the actual integration process and the institutional characteristics. The state-space approach allows for such a functional distinction between the indicators and can

deal with this in two ways: either as separate composite indices, which can be further used for analytical purposes, or as components of a more general index, in which case their respective weights are informative about the impact on the integration process just like their correlation gives an indication of their complementarity.

The third and final step of De Lombaerde et al. (2011) consists of the construction of the composite regional integration index, in particular the issues of the determination of the weighting scheme for the indicators (e.g. statistical or not) and the method of aggregation (e.g. arithmetic mean or more involved). There, the Bayesian state-space approach offers the advantage of making fewer assumptions in determining the indicators' weights and of being more transparent in the aggregation.

In the next section, we describe the principles of the Bayesian state-space methodology. We keep this description brief and refer the interested reader to more formal and thorough treatments of the subject. To show the potential of the approach, we discuss in the third section the construction of an indicator of actual economic integration at the bilateral country level for the member countries of the OECD. For these countries a large set of indicators of good data quality are available such that due account can be taken of the multidimensionality of regional integration. Based on this first application, we consider in the fourth section the extensions that the method allows. Conclusions are drawn in the last section.

1 Methodology

This section only aims to give a limited overview of the state-space methodology. For more information on state-space models and how to estimate them, see Kim and Nelson (1999) or Durbin and Koopman (2012). More detailed information on this particular model can also be found in Standaert (2013) where it is used to combine indicators of corruption.

1.1 The state-space model

The main idea in the state-space model is to estimate the unknown overall level of regional integration *RI* (the state variable), using the information in the different

indicators of regional integration, y[4]. In order to understand how this happens, it is necessary to go back to the two equations that define its workings: the measurement (eqn. 1) and state equation (eqn. 3).

$$y_{i,t} = C + Z * RI_{i,t} + \varepsilon_{i,t} \tag{1}$$

$$\varepsilon_{i,t} \sim N(0,H) \tag{2}$$

$$RI_{i,t} = T_i * RI_{i,t-1} + \nu_{i,t} \tag{3}$$

$$\nu_{i,t} \sim N(0,1) \tag{4}$$

for all country-couples $i \in [1,n]$ and years $t \in [1,N]$.

The measurement equation states that the k indicators of regional integration $y_{i,t}$ (for example the level of bilateral trade) depend on the overall level of integration $RI_{i,t}$. The error term $\varepsilon_{i,t}$ captures differences in the quality of the indicators whether due to measurement errors or because of the influence of factors other than the level of integration. The better an indicator $y^{(j)}$ measures the level of integration, the smaller the variance of the corresponding error term $H_{(j,j)}$.

The $(1 \times k)$ vectors C and Z rescale the indicator variables to put them on equal footing. The exact rescaling parameters are indicator-specific, but are kept constant over time and country-couples. Similarly, each indicator can differ in terms of its reliability, but the reliability of an indicator does not change over i or t if the indicator is not missing (cf. infra).

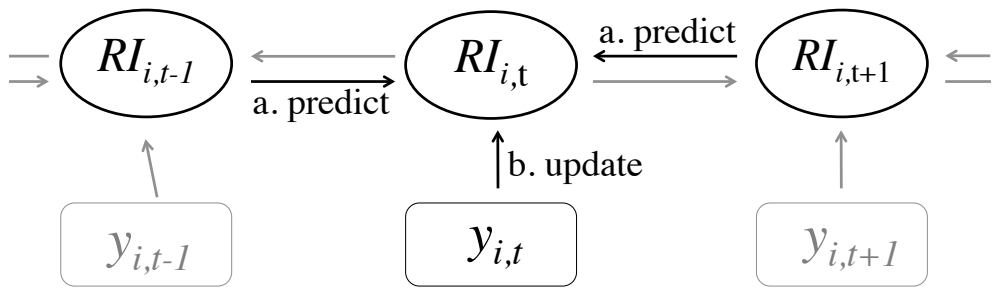
The state equation (eqn. 3) allows the current level of integration to depend on its past values. The level of dependence, T_i, can vary for each country-couple i, but is restricted to lie within the [-1,1] interval. This rules out ever-increasing values for the RI index and ensures that the model converges to a steady solution. However, it does not preclude non-stationarity in the level of regional integration.

Figure 1 illustrates the advantage of adding the time-dependency in the state equation. To the extent that the level of integration depends on its previous values, both past and future information are used to predict what the level of integration is today (step *a*). This

[4] For the sake of readability, the notation is sometimes simplified. $y^{(j)}$ is a single indicator of integration for all country-couples and all years. $y_{i,t}$ is the vector of all indicators in a given year and for a given country-couple, while this vector for all years and all country-couples is simply y.

prediction is governed by the state equation (eqn. 3). This forecasted value is then compared to the indicators of integration today $y_{i,t}$ and using the parameter values in the measurement equation (eqn. 1) the estimated level of integration is adjusted (step *b*). The stronger the time-dependence, the more important step *a* becomes. The more reliable an indicator is, the bigger the influence of step *b* is.

Figure 1: Estimation using time dependency



Because the $RI_{i,t-1}$ and $RI_{i,t+1}$ also depend on their past values and future values, the entire time-series is used when estimating the current level of integration. The advantages are manifold. First of all, it significantly increases the number of years for which the indicator can be reliably computed. Moreover, the increase in information helps the algorithm to better distinguish between random measurement errors and the actual changes in the level of integration. This results in smoother estimates made with smaller confidence bounds.

The strength of the state-space model is the ease with which it handles missing observations. Simply put, missing observations are replaced by information which has absolutely no value: $y = 0$ and $var(\varepsilon) = \infty$. This allows the model to run uninterruptedly without fundamentally changing the value of missing data. Moreover, because the entire time-series is used when estimating the value of RI, it negates the need to impute or otherwise manipulate missing data (Kim and Nelson, 1999; Durbin and Koopman, 2012).

An additional advantage of this model is that it encapsulates a number of other techniques. For example, if we assume that RI does not depend on its previous values ($T = 0$) and all indicators have the same reliability ($H_{(j,j)} = c_H$), it can be shown that this model will return a principle component analysis. If in addition it is assumed that all

indicators are scaled the same way ($Z_{(j,1)} = c_Z$ *and* $C_{(j,1)} = c_C$), then it returns a simple average.

In other words, the usefulness of the state-space approach follows directly from the validity of the assumptions on the parameter values. If the level of integration is not expected to depend on its previous values ($T = 0$) a principle component analysis suffices. However, if these assumptions are incorrect, using simple techniques will discard information and could lead to incorrect conclusions. It also means that it is possible to test the validity of the state-space model ex-post using the estimated parameter values.

1.2 Bayesian estimation

In order to estimate the state-space model, it is necessary to solve for the level of RI as well as the parameters of the state and measurement equation: H, Z, C and T. As the number of countries and years increases, this estimation becomes more and more cumbersome. However, using a Bayesian Gibbs sampler, it can be split up into different sections that can be dealt with one at a time.

If the values for RI were known, the state and measurement equations would be simple linear regressions and we could easily compute and draw from their distributions. Similarly, if the parameters were known, we could draw from the distribution of RI using a simulation smoother (Durbin and Koopman, 2012). It can be shown that by iteratively drawing from both conditional distributions while conditioning on the last drawn value, these draws will converge to the unconditional distribution. After discarding the first non-converged values (the burn-in), the remaining drawn values can be used to reconstitute the original unconditional distribution of RI as well as those of the parameters. For more information on Bayesian econometrics and Gibbs sampling see Lancaster (2004) and Koop, Poirier, and Tobias (2007).

Because this model is estimated in a Bayesian framework, it is necessary to be explicit about the prior distribution of the parameters. However, seeing that there is no ex-ante information on them we use flat priors. This means that these parameters are not restricted in any way. The only variables that are limited are T_i, whose values have to lie

inside the [-1,1] interval, and the diagonal elements of the variance H, whose values have to be strictly positive.

$$p(C) \sim 1 \tag{5}$$

$$p(Z) \sim 1 \tag{6}$$

$$p(\log(H_{(j,j)}) \sim 1, \quad \forall j \in [1,n] \tag{7}$$

$$p(T_i) = .5 * 1_{T \in [-1,1]}, \quad \forall i \in [1,k] \tag{8}$$

2 An application to the OECD

2.1 Defining integration

This section illustrates the state-space approach by measuring the level of regional integration between the members of the OECD. Specifically, it examines the level of Actual Economic Integration (AEI) defined by Mongelli, Dorrucci, and Agur (2005, p.6) as "*the degree of interpenetration of economic activity among two or more countries belonging to the same geographic area as measured at a given point in time*."

This definition is relatively narrow and puts strict limits on the variables to be included. It excludes institutional or cultural integration. Even within the perspective of economic integration, it focuses on actual interpenetration of activities. Strictly speaking, this implies that co-movement of prices and GDP and other factors from the optimal-currency-area theory should not be included. In addition, it focuses on actual integration as opposed to measuring the potential benefits of integration.

As a result, the *AEI* indicator computed here is relatively neutral. It does not rely on any specific (economic) theory on integration, nor does it treat integration as necessarily good or bad. It simply measures the extent to which the economic flows of two countries are intertwined. Needless to say, this definition is but one of the many possible choices and the state-space methodology can be easily expanded to include different aspects of regional integration.

The unit of analysis in this study is country couples, and their integration is measured in a directional sense. In other words, the values of the index $AEI_{B,A}$ express to what extent

the bilateral economic flows between countries A and B are important for country A[5]. Allowing the values of $AEI_{B,A}$ to differ from $AEI_{A,B}$ makes sense in a network where country size varies significantly. For example, that the German-Estonian trade is important for Estonia does not necessarily imply that the same holds for Germany.

It is important to note that even using this definition of regional integration, many other units of analysis are possible. For instance it would also be possible to study the level of integration of a country within a region. The choice of unit should be primarily driven by the intended use of the indicator. For example, as defined here, the results enable us to build a directed and weighted network of integrated countries, but other uses require different definitions and basic units.

2.2 Data

Actual economic integration is measured on four levels, organized according to the "four freedoms" of the European Single Market: flows of goods, flows of services, FDI and other financial flows and migration. For each a distinction is made between incoming and outgoing flows.

In order to compare the importance of the flows over countries, they are normalized both using GDP (population in the case of migration) and as a percentage of total flows. This means that for each different category four different variables are used: incoming flows to GDP, outgoing flows to total outgoing flows, etc. The idea is that there are two dimensions in which the bilateral flows can matter for a country: either it covers a significant fraction of total flows and/or it represents a large proportion of GDP. By rescaling the indicators in this way, the size of the country is abstracted from the index: only the relative size of the flows matters.

Because some product categories play a more crucial role than others, the disaggregated data is used whenever appropriate. For example, the international trade in fuels is of crucial importance for the economy and for that reason it is separated from the total trade flows. Conversely, making a distinction between the international migration of men and

[5] In network theory the link (or edge) going from country (node) A to country B is denoted $X_{B,A}$ (Newman, 2010).

women would not serve much practical purpose and is left out. Table 1 lists the different categories of economic flows.

Table 1: Categories of integration variables

Trade in goods	**Trade in services**
- Agriculture, hunting, forestry and fishing	- Travel
- Mining and quarrying	- Communication
- Total Manufacturing	- Construction
- Electricity, water and gas	- Insurance
- Total trade (DOTS)	- Financial
Financial flows	- Computer and Informational
- FDI	- Royalties and license fees
- Equity (CPIS)	- Transportation
- Long-term debt securities (CPIS)	- Other business services
- Short-term debt securities(CPIS)	- Other commercial services
Migration	
- Total migration	

Almost all bilateral flow data comes from the OECD statistical compendium and the OECD iLibrary. The only exceptions are the non-FDI financial flows, which come from the IMF's Coordinated Portfolio Investment Survey (CPIS). In addition, total trade is taken from IMF's Direction of Trade Statistics (DOTS). The reason is that the disaggregated trade data of the OECD is only available from the 1980s onwards, while the DOTS data starts in 1950. Using both total trade and all of its sub-categories would lead to problems of perfect multicollinearity, which is why OECD's "other trade" is dropped from the dataset. Finally, the data on GDP and population is taken from the Penn World Tables (Heston, Summers, and Aten, 2012).

The dataset was constructed for all 34 current members of the OECD from 1970[6] to 2010. The data for Belgium and Luxembourg is consolidated into the Belgium-Luxembourg Economic Union because the earliest data is often not available for both countries

[6] Estonia (1991), Slovakia (1993), Slovenia (1993) and the Czech Republic (1991) are added later to the sample.

separately. This gives us a total 33 times 32 or 1,056 country-couples whose level of integration is studied over a period of 41 years.

2.3 Results

The Gibbs sampler ran for 100,000 iterations, of which the first 50,000 were discarded as burn-in. Setting the variance of the annual change in integration to one (eqn. 3) gives us values for AEI which lie between -13 and 133. However, the exact scaling of the AEI index is arbitrary and can be adjusted as long as the relative differences remain unchanged.

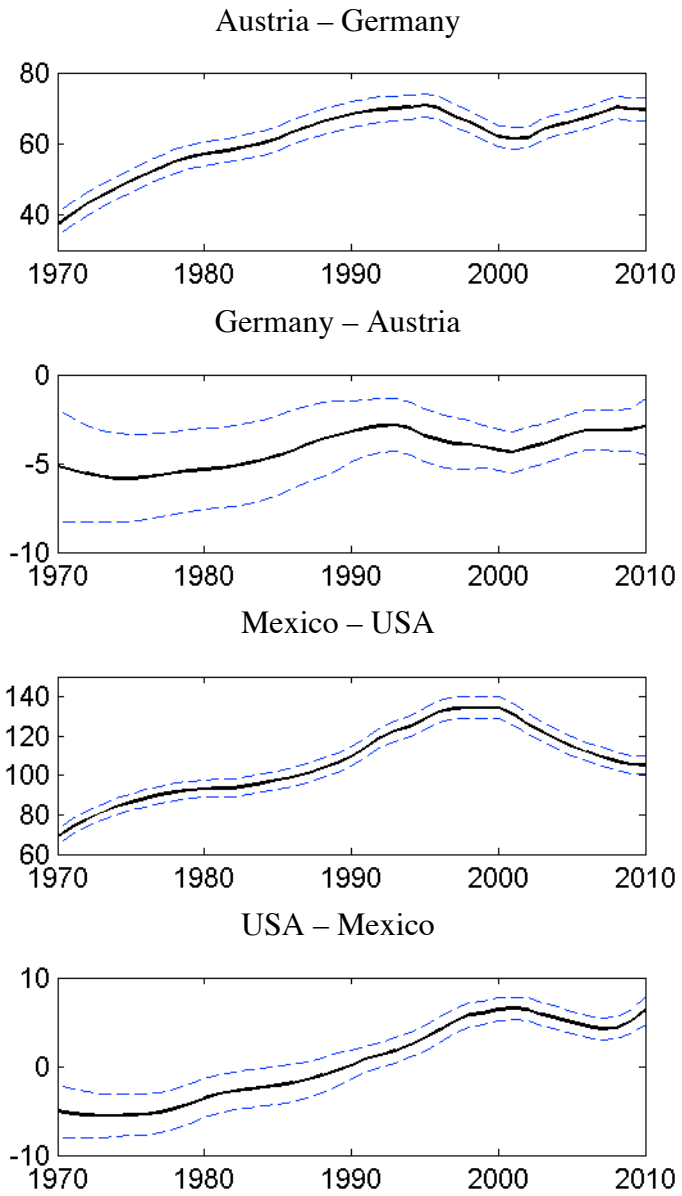
Figure 2 plots the level of integration and the 90% confidence bounds for four country-couples. It illustrates many of the points made in the previous sections. For example, while the bilateral flows between Mexico and the United States of America are crucial for Mexico (they lie entirely within the top 95th percentile of all AEI values), they are far less important for the USA. The same holds for the flows between Austria and Germany, but to a lesser extent.

Secondly, we see that as the number of missing observations decreases, the uncertainty bounds grow tighter. This is especially clear in the second panel. The number of indicators for Austria-Germany increases from 4 (1970-1984) to 80 (2003-2008) falling back to 40 in 2009, and this is reflected in the size of the confidence bounds.

Returning to the individual indicators of integration, figure 4 graphs their correlation with the AEI index. It shows the indicators from all four different types of flows are highly correlated with the index, but that migration (represented by diamonds) weighs the least. A possible explanation is the opposite influence that different types of integration have on other flows. For example, economic migration is expected to subside when high trade between countries creates opportunities in the home country. On the other hand, the existence of many migrants from a particular country increases the information on potential beneficial trade, implying a positive correlation. To the extent that this is indeed the case, this might be resolved by including indicators that are able to distinguish between different motivations for migration: economic versus political migration, high-skilled versus low-skilled, etc.

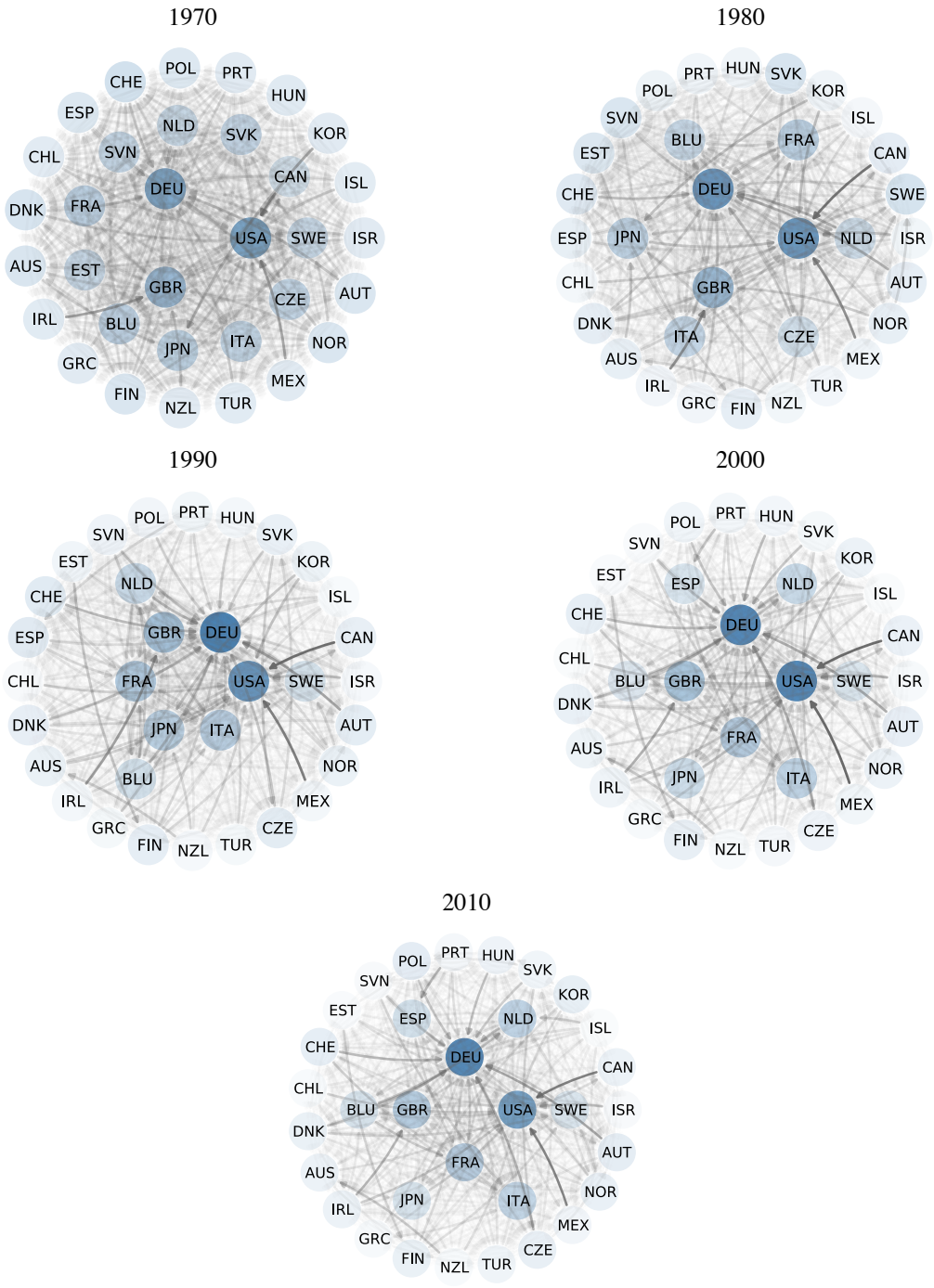
Figure 2: Plot of AEI indicator with 90% confidence interval

Sender country – Partner country



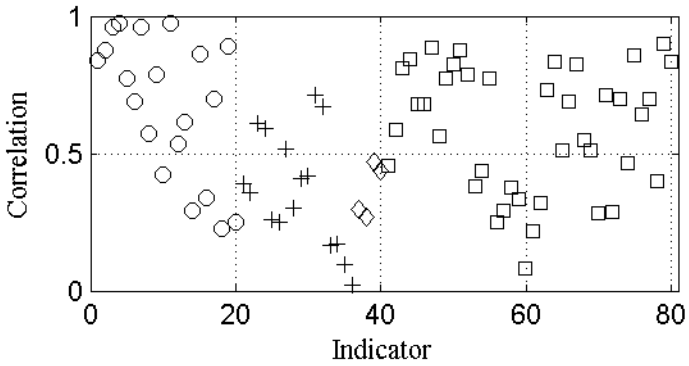
Plot of AEI estimates (full lines) and its 90% confidence interval (dotted lines).

Figure 3: Plot of the network formed by the AEI indicator



Countries are represented by their ISO code, with the Belgium-Luxemburg Economic Union abbreviated to BLU. The color of countries reflects the weighted indegree while level of the AEI index is reflected in the opacity of the arrow: the darker the colors, the higher these values are. Finally, the position on the concentric circle of the countries is determined by the importance of a country for its trading partners multiplied by the GDP of those trading partners (weighted indegree with AEI*GDP sender as weights).

Figure 4: Correlation of AEI with individual indicators



Plot of the correlation of the AEI index with the individual indicators from which it was computed. ○ denote trade in goods; + financial flows; ◇ migration; and □ trade in services.

Weighted directed network

As mentioned, we can use the values for AEI to construct a weighted directed network (Newman, 2010). Using the python software package NetworkX, we can show the shape of this network in every decade (figure 3). The values of the index are reflected in the darkness of the arrow between the countries. The position and color of the countries are determined by its weighted indegree[7]: the more important a country is for its partner countries, the darker its color and the more central its position. The colors reflect only the values of the AEI index, which could lead to the situation where a country that is strongly connected to a few small countries takes up a central position on the network. To capture this, the position of the country also depends on the size of the partner countries: the higher the level of integration with countries with high GDP, the closer to the center a country is positioned. Unsurprisingly, it shows that the most central players in the OECD are the USA, Germany and the United Kingdom, with France, Italy and Japan a close second.

When comparing the network's structure over time, it becomes clear that trade among the OECD countries is being condensed to a few central players. In 1970, most countries had a lot of incoming and outgoing arrows and the level of AEI was relatively similar between many country-pairs. In contrast the pattern in 2010 reveals a stark divergence between core and periphery countries. The former have many incoming arrows

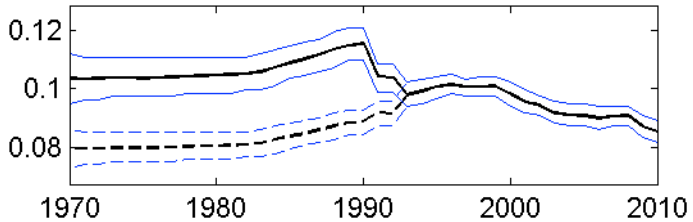
[7] The weighted indegree of a country is the sum of the AEI index of all incoming arrows.

representing high levels of integration, while the latter have one predominant link to one of the core countries and fewer incoming arrows. The standard deviation of AEI values reflects this: it rises from 7.32 in 1970 to 10.47 in 2010, falling back slightly to 9.93 in 2010. Similarly, the indegree (reflected in the color of the countries) decreases for the periphery and increases for the core. It should be mentioned that these changes only apply to the relative level of integration of countries. In other words, these results do not necessarily imply that trade between peripheral countries has increased, only that the increase with core countries has been larger.

A second pattern in the evolution of the network is the rise and subsequent fall of the USA. While it remains one of the core countries, its importance in the network starts to decline in the year 2000. A possible explanation is the rise China and other Asian countries as major trading partners outside the OECD, especially because this pattern is also apparent for Japan. Conversely, during the same period Italy and Spain take up a more central position in the network.

An often-used metric to study the overall connectivity of a network is the network density. It is defined as the number of links (edges) between countries divided by the total number of possible links: $n/(n-1)$ with n the number of countries. However, since AEI is a continuous variable, a threshold has to be defined which separates the connected countries from the unconnected ones. Figure 5 plots the network density with the threshold set at 10% lowest value (14.6). Because the Gibbs sampler returns the entire probability distribution of the AEI index, it is possible to construct the 95% confidence interval for the network density. It shows that the overall connectedness significantly decreased over time (at 1% significance level). One possible explanation is that this result is driven by the addition of a number of lesser-connected countries in the early nineties, i.e. Estonia, the Czech Republic, Slovakia and Slovenia. To control for this, the density was recomputed keeping the number of countries constant (the dotted line). While this takes out the initial drop in the 90s, it does not do away with the decline in density in the 00s. This is probably due to the concentration of trade, which raises the AEI index for links between core and periphery, but lowers it between periphery countries. Seeing that there are more periphery countries, the overall connectivity declines.

Figure 5: Network density



The uninterrupted line represents the network density including 95% confidence interval. The dotted line corrects for the inclusion of new countries by keeping the total number of nodes constant over time.

The EU and NAFTA

This section briefly looks at the effect of the expansion of the European Union (EU) and formation of the North American Free Trade Agreement (NAFTA) on the AEI index. Do these trade agreements increase the level of actual economic integration for the participating countries?

Table 2: Effect of EU and NAFTA on Actual Economic Integration

AEI	(1)	(2)
EU	6.538***	2.903***
	(0.232)	(0.328)
NAFTA	47.174***	51.295***
	(1.514)	(2.204)
years EU	-	0.120***
		(0.009)
years NAFTA	-	-0.506***
		(0.194)
sender EU	-0.644***	-0.667***
	(0.124)	(0.123)
target EU	1.898***	1.875***
	(0.130)	(0.129)
sender NAFTA	-0.858***	-0.860***
	(0.189)	(0.190)
target NAFTA	6.242***	6.239***
	(0.243)	(0.243)
controls for time	yes	yes
Observations	43296	43296
country-couples	1056	1056
years	41	41

Linear regression of the AEI index on dummy variables EU and NAFTA (one when both are member, zero otherwise) and control variables. Standard errors (between brackets) are corrected for the uncertainty of the AEI index. *, **, *** denote significance at 10, 5, 1% significance level.

Table 2 shows the results of a difference-in-difference study of the level of integration. The level of actual integration is regressed on two dummy variables EU and NAFTA, which are one if both sender and target country are members of the same agreement in a certain year. Additional controls are added to ensure that the effect is not driven by the characteristics of the countries that joined the integration agreements, or the time period in which they joined. As was the case with the network density, the standard errors are adjusted for the uncertainty of the AEI estimate[8].

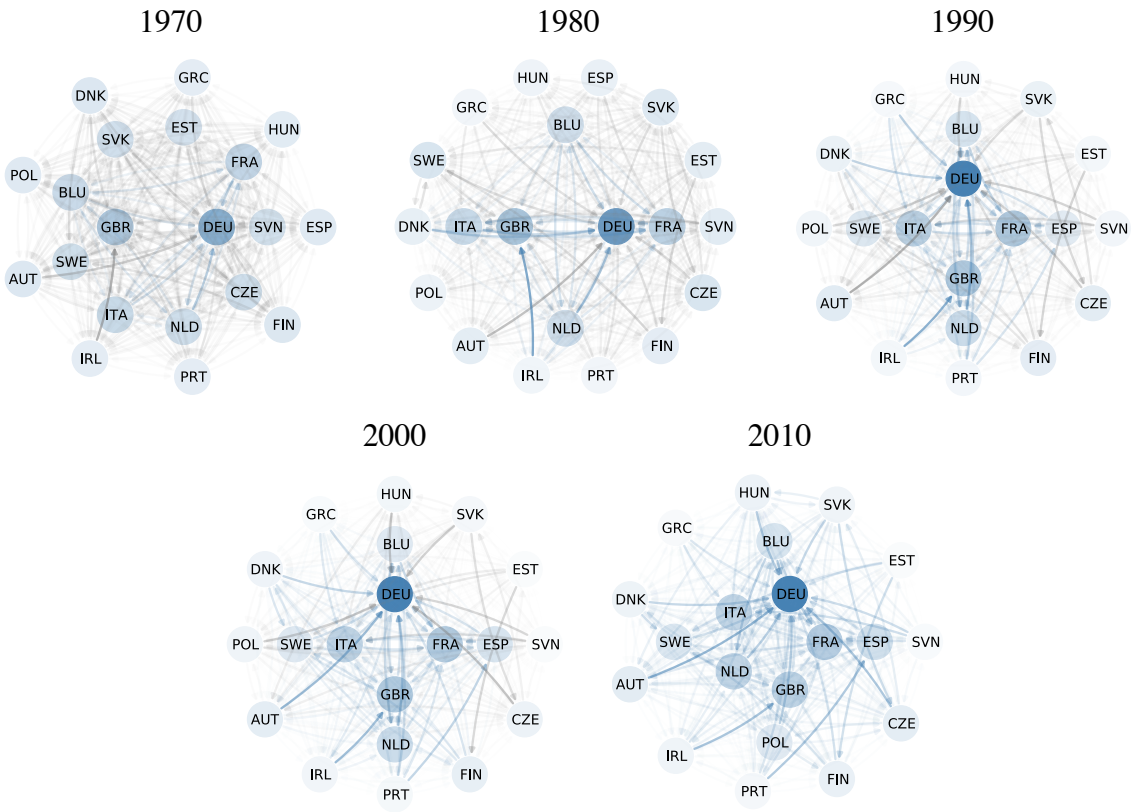
It shows that entering into the EU on average caused a 6.5-point increase in the AEI index, while joining NAFTA causes the index to grow with 46 points. The second column compares the immediate impact of joining a RIA versus the effect over by including the minimum number of years both countries are a member of the agreement. It reveals that the increase happens gradually in the EU, while in NAFTA the level of integration increases quickly and then slowly degenerates of time. While significant this effect is nevertheless small: the maximum decrease is -8. It is once again most likely driven by the emergence of Asia on the global market. Lastly, the control variables indicate that regardless of whether they are a member themselves, the OECD countries are significantly more likely to be highly integrated with members of the EU and NAFTA. This confirms the central position the latter take up in the OECD.

A similar pattern emerges when plotting the network structure of the EU (figure 6). The edges between member countries become brighter over time. However, at the same time, we also see the concentration of trade towards the core countries. The combined effect of both trends causes the network density to increase until the mid 90s, after which it decreases to its original level (figure 7).

---

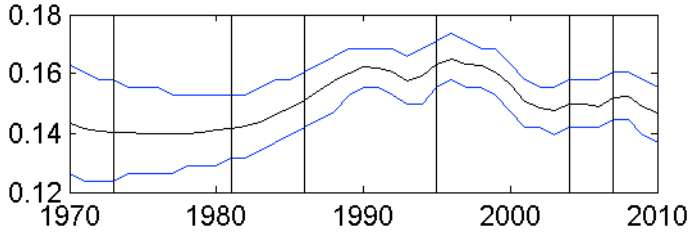
[8] In table 2, the following regression is estimated: $AEI = \beta X + \mu$ with $\mu \sim N(0,\sigma^2)$. This is done by drawing a value for β using randomly drawn values of the AEI index from the Gibbs sampler: $\beta^{(j)}|X,AEI^{(j)} \sim N[b; (X'X)^{-1}e'e/(n-k)]$ with $b=(X'X)^{-1}X'AEI^{(j)}$ and $e = AEI^{(j)} - Xb$. The adjusted standard deviation is then computed using the drawn values of $\beta^{(j)}$.

Figure 6: Network structure EU-25



Network structure of the EU-25 member countries, excluding Cyprus, Latvia, Lithuania and Malta. The color of the links (edges) reflects the height of the AEI index, the position and color of the countries the weighted indegree. If both countries are a member of the EU, the link between them changes color.

Figure 7: Network density of the EU-25



Network density of the EU-25 member countries, excluding Cyprus, Latvia, Lithuania and Malta.

Comparison with other techniques

In this section, the AEI index is compared to the two other techniques used in the literature: the simple average and a principle component analysis (pca). Firstly, both are applied when all data is available, but this only provides us with 68 observations. The

computations are then adjusted to cope with this missing observations problem. The mean is calculated when at least one data point is available and the weights are adjusted every time. The weights of the pca are computed once using the pairwise correlation matrix, and the index is composed when at least one observation is available. Keep in mind that the parameters of the state-space model are kept constant over time themselves.

As was already mentioned, both techniques can be seen as simplified versions of the AEI index where the values of the parameters are restricted in some way. This means that we can test the statistical validity of the state-space approach using the parameter values we find. Figure 8 plots out these including their 95% confidence interval. However, for clarity's sake only the first thirty drawn; Z, C and H actually have $k = 80$ elements, while T has $n(n - 1) = 1056$. From these graphs, it immediately becomes clear that the assumptions that $T = 0$ or that Z, C and H are constant over all indicators are invalid. T lies very close to one for almost all parameters, and Z, C and H significantly differ even after all indicators have been standardized to mean zero and a standard deviation of one.

However, the overall correlation (table 3) indicates the mean results of the three techniques do not differ that much from each other. The only exception is the adjusted pca analysis, which scores relatively low. This can be explained by the fact that the weights are kept constant for all country-couples and time-periods, ignoring the availability of the indicators.

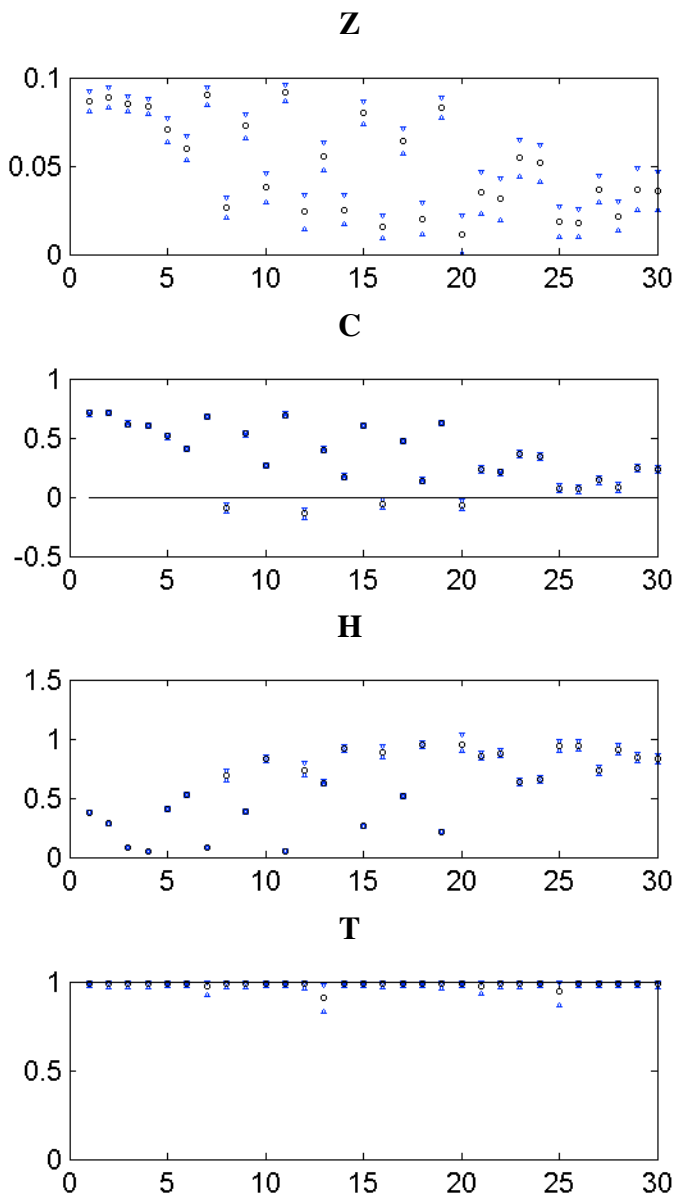
The last two columns of table 3 decompose the overall correlation into the correlation between the means for each country (between), and that of the demeaned series (within). It shows that the strong overall correlation is the result of the high correlation of the mean values. The within-variation on the other hand differs significantly over the three methods. This implies that while the methodology might not matter in a cross-country study, this radically changes when the level of integration is compared over time. This could lead to substantial differences in fixed effects studies, that use only the within variation, or for example in the analysis of the effect of institutional integration on actual economic integration (cf. Dorrucci et al., 2004).

Table 3: Correlation with mean and principle component analysis

	Obs.	Overall	Between[(a)]	Within[(b)]
mean	68	0.9902	0.9575	0.2527
pca	68	0.9885	0.9491	0.2537
mean (adj.)	37134	0.9315	0.9725	0.4094
pca (adj.)	37134	0.4811	0.7229	0.09

[(a)]The between correlation is defined as the correlation between the means of each country-pair; [(b)]The within correlation is the correlation between the demeaned values for all country-pairs.

Figure 8: Parameters state-space model



Plot of the first 30 parameter values of Z, C, H and T (circles) and their 95% confidence interval (triangles).

Lastly, the adjusted mean and the state-space model differ significantly in the confidence with which they make their predictions. Assuming normality or using the central limit theorem, the variance of the mean is equal to σ^2/k with σ^2 the population variance of $y_{i,t}$. This implies that as the number of available data increases from 4 to 80, the standard deviation falls to less than one fourth of its original level. While the AEI index's reliability also decreases as availability increases, the difference is far less pronounced. The reason is that the AEI index uses all available data from the entire time-series and gives less weight to indicators that are less reliable. This results in confidence bounds that are on average are only half as large. Resizing the AEI index and the mean to lie between zero and one, the average standard deviation of AEI is only 0.008 versus 0.016 for the adjusted mean. Moreover, in less than 1% of the sample is the standard deviation of the mean lower.

3 Extensions

As was mentioned, the model estimated in this paper can be extended in multiple ways. An obvious extension is to include a larger number of countries. As more non-OECD countries are added, the quality and availability of data becomes increasingly problematic. However, as was demonstrated the model is particularly well suited to handle these problems. The main concern would be computational power. Expanding the current dataset with one country would add 34 additional country-couples times 41 time periods or 1394 observations. Running the model with 193 countries for the same time period would result in more than one and a half million observations.

A second extension concerns the type of integration studied and the unit of analysis. The state-space model can be used to study potential economic integration, or political integration. With respect to the latter, a powerful advantage of the state-space model is that it can combine different types of data. For example, the model defined in section 2 only combines continuous variables, but through the use of latent variables it can easily be extended to combine dichotomous information or a combination of both:

$$y^*_{i,t} = C + Z * RI_{i,t} + \varepsilon_{i,t} \tag{9}$$

$$y^*_{i,t} = \begin{cases} 1 & if\ y^*_{i,t} \geq 0, \\ 0 & otherwise. \end{cases} \tag{10}$$

The value of the (observed) dichotomous indicator y depends on the value of the (unobserved) continuous latent variable $y^\star$ which in turn is driven by the to-be-estimated level of regional integration RI.

The ability to combine both different types of data means that qualitative data on integration can be added without having to impose a subjective scaling. This means that different aspects of integration can be viewed in a parallel, rather than a sequential way. For example, currency unions can be viewed separately from customs unions. In this way, the index would prevent a one-track, EU-dominated view of integration. Secondly, it also does away with the linear scaling between the different forms of integration as the information contained in the continuous indicators provide a natural scaling. For example, if closing a free trade agreement goes hand in hand with a significant increase in bilateral flows, the scaling parameters C and Z (eqn. 9) will be significantly higher than when it leaves those flows unperturbed.

4 Conclusion

Despite a "spaghetti bowl" full of agreements of different types, not so much is known about regional integration. Frequently, this is linked to the absence of a representative and adequate measure thereof.

Regional integration is a complex and multidimensional process, which is the main reason why a systematic standard index of integration is lacking to this day. Even the most basic of definitions of regional integration encompasses many different aspects, increasing the difficulty of finding appropriate data exponentially. The solutions to these problems often undermine the objectivity of the resulting index: different definitions, data and methodologies lead to different results and rankings.

The state-space model can bring some much needed objectivity and standardization to the problem of measuring regional integration. By using the time structure present in the regional integration indicators, it circumvents the problem of missing observations. Moreover, the model is designed filter out the measurement noise from the integration

signal and deals with data of inferior and dissimilar quality. The Bayesian estimation of the model returns the entire probability distribution of the regional integration indicator, making it possible to say whether the change in the index over time is significant or whether the level of integration significantly differs between countries. Moreover, this uncertainty can be taken into account whenever the index is used in statistical research or in computations like the network density.

To illustrate the advantages of the state-space model, we computed the level of actual economic integration for all current members of the OECD, based on indicators of international flows of goods, of services, FDI and other financial flows and migration. Whereas the state-space method leads to a similar overall ranking of countries relative to the other approaches used in the literature (either the mean or a principle component analysis), the time pattern of individual countries differs substantially. Looking at the overall evolution of the index, we observe an increase in of the integration level between the OECD countries in the first 20 years, which then declines steadily in the last 20 years. In addition, we notice the weakening of the central position of the US and Japan in the integration network, as well as the shift of Spain, Poland, Hungary and Slovakia from a peripheral to an intermediate position after their adhesion to the European Union. Overall, European integration agreements as well as NAFTA seem to have had a positive effect of actual economic integration.

Based on this first application of the state-space approach, two extensions immediately come forward. First, the estimation of the index for an arbitrary country-couple at the world level, where one will face much more frequent missing or low quality data. Second, the inclusion of institutional characteristics or the estimation of an institutional economic integration index. A next challenge is the use of the indicator for analytical purposes in view of its estimated character, non-stationarity and endogeneity, which calls for appropriate techniques such as a Bayesian VAR approach. This we intend to consider in future research.

References

P. De Lombaerde, E. Dorrucci, G. Genna, and F. P. Mongelli. Quantative monitoring and comparison of regional integration processes: Steps towards good practice. United Nations University - Comparative Regional Integration Studies, 2008.

P. De Lombaerde, E. Dorrucci, G. Genna, and F. P. Mongelli. Composite indexes and systems of indicators of regional integration. In P. De Lombaerde, R. G. Flôres, P. L. Iapadre, and M. Schulz, editors, The Regional Integration Manual. Routledge/Warwick studies in globalization, 2011.

D. J. Dennis and Z. A. Yusof. Developing indicators of ASEAN integration - a preliminary survey for a roadmap. REPSF Project 02/001, August 2003.

E. Dorrucci, S. Firpo, M. Fratzscher, and F. P. Mongelli. The link between institutional and economic integration: Insights for Latin America form the European experience. Open Economies Review, 15:239–260, 2004.

J. Durbin and S. Koopman. Time Series Analysis by State Space Methods. Oxford University Press, 2nd edition, 2012.

Y. Feng and G. Genna. Regional integration and domestic institutional homogeneity: A comparative analysis of regional integration in the Americas, Pacific Asia and Western Europe. Review of International Political Economy, 10(2):278–309, May 2003.

A. Heston, R. Summers, and B. Aten. Penn world table version 7.1. Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, July 2012.

G. C. Hufbauer and J. J. Scott. Western Hemisphere Economic Integration. Institute for International Economics, Washington, DC, July 1994.

C.J. Kim and C. R. Nelson. State-Space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications. MIT Press, 1999.

G. Koop, D. J. Poirier, and J. L. Tobias. Bayesian Econometric Methods. Cambridge University Press, 2007.

T. Lancaster. Introduction to Modern Bayesian Econometrics. John Wiley & Sons, 2004.

F. P. Mongelli, E. Dorrucci, and I. Agur. What does European institutional integration tell us about trade integration. European Central Bank Occasional Paper Series, (40), December 2005.

M. Newman. Networks: an introduction. Oxford University Press, 2010.

S. Standaert. Divining the level of corruption: a Bayesian state-space approach. Ghent University Working paper 2013/835, 2013.

UN-ESCWA. Annual review of developments in globalization and regional integration in the Arab countries. Technical report, United Nations, New York, 2006.

UNECA. Annual report on integration in Africa. methodology for calculating indices of economic integration effort in Africa. Technical report, UN Economic Commission for Africa, Addis Ababa, 2001.

UNECA. Annual report on integration in Africa. Technical report, UN Economic Commission for Africa, Addis Ababa, 2002.

UNECA. Assessing regional integration in Africa. Technical report, UN Economic Commission for Africa, Addis Ababa, 2004.