Exploring hubness in Regional Trade Agreements

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!!!!Very preliminary version. Please do not quote!!!!

Abstract

In the plethora of Regional Trade Agreements (RTAs) some countries take in a more central position than others in the sense that some countries are much more engaged with other countries through RTAs. Furthermore, the position of some countries is that of a hub: they have (many) trade agreements with other countries (bilateral and plurilateral), but the countries they are engaged with ('spokes') do not have trade agreements with each other. Using the current number of RTAs in goods and services as notified to the WTO until now, we develop a measure to assess the 'hubness' of a country in its trade agreements with the rest of the world. The paper then explores the extent to which being a hub is a prerogative of advanced countries, as is often (implicitly) assumed in the literature on RTAs. This is important because of the literature's focus on the asymmetric welfare consequences for the hub (positive) and spokes (negative) of being part of a hub-and-spoke relationship.

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1. Introduction

The number of Regional Trade Agreements (RTAs) has been growing steadily over the past few decades, amounting to 2000+ RTAs at the beginning of 2016. Involving a total number of 188 countries, this implies an average number of RTAs of more than 10 RTAs per country, even though countries vary considerably in their involvement with RTAs. The countries in the top-10 of RTA involvement have more than 35 RTAs each, while the majority of countries are involved in 1-3 RTAs at most. In fact, the distribution of RTA involvement is highly skewed: 30% of all countries account for no less than 82% of all RTAs in the world. (All numbers are based on the WTO's database and seeing the EU as one entity).

As such, some countries seem to take in a more central position than others in the plethora of RTAs around the world. A clear example would be the EU, which is currently engaged in RTAs with a total number of 79 countries through 37 different RTAs. Countries like the EU are typically referred to as 'hubs' in the global RTA network. A hub is thereby defined as a country that has (many) regional trade agreements with other countries (bilateral and plurilateral), while its partner countries (the spokes) do not have trade agreements with each other (or at least not to the same extent).

The issue of hubness in RTAs has not been formally analyzed in the literature thus far. This paper is the first to provide a systematic analysis of hubness in RTAs. It develops a measure for the hubness in trade agreements of a country vis-à-vis each of its partner countries and uses the current number (that is, 5 February 2016) of RTAs in goods and services as notified to the WTO to determine the average hubness of a country regarding all of its trade agreements. Using the unweighted average of bilateral hubness indicators as a benchmark, the paper assesses the robustness of a country's hubness by using more intricate average measures as well, for instance ones that use weighing schemes to account for differences in importance of RTAs and their partners for countries.

The ultimate goal of the paper is to determine to what extent being a hub is a prerogative of advanced countries, as is often (implicitly) assumed in the literature on RTAs. Preliminary findings based on the benchmark average indicate that more than half of the top-10 hubs in the world are developing countries. This gives a different perspective on the well-received finding in the literature that the welfare consequences of hub-and-spoke arrangements are typically positive for hubs (read: advanced economies) and negative for spokes (read: developing countries).

The set-up of the paper is as follows. Section 2 offers descriptive statistics of the current state of RTAs in the world, based on information retrieved from the WTO database on RTAs in force at the beginning of February 2016. In section 3 we derive a measure of hubness in RTAs, using it to determine the hubness of countries around the world. Section 4 concludes and presents an agenda for further research.

2. Overview of RTAs in the World

We take the 'List of all RTAs in force' as available on www.wto.org as starting point for generating a database that can be used to assess a country's hubness in Regional Trade Agreements. All data were

retrieved on 05-02-2016[2] and we confine ourselves to RTAs that have been notified to the WTO as Customs Union (CU) or Free Trade Area (FTA) as defined in Paragraph 8(a) and 8(b) of Article XXIV of GATT 1994, respectively. We exclude RTAs that are solely denoted as Economic Integration Agreements as defined in Article 5 of GATS (though none were) as well a Partial Scope Agreements (PSAs). From now on we therefore use RTAs to mean notified CUs and FTAs in goods.

Looking at the data, we see that a total of 188 countries are involved with one or more RTAs. Of these countries 158 countries are members of the WTO, 18 countries have observer status and 12 countries are neither a member, nor an observer to the WTO. This count excludes the 19 Overseas Countries and Territories (OCT) of European countries. The total number of countries and OCT included in the database is therefore 207.

Of all 162 WTO members (per 30 November 2015, including the EU as a separate member, so next to each of the individual member states of the EU), 3 countries are not involved in an RTA: Cuba, Mauritania, and Mongolia. Of all 22 states that have an observer status, 4 countries are not involved in an RTA: Afghanistan, Holy See (Vatican), Iran, and Sao Tome and Principe.

Including OCT, the average number of agreements (plurilateral and bilateral) is 13.47. The average number of plurilateral agreements is 2.66 and the average number of bilateral agreements is 10.81.

The country that is overall most involved in RTAs is Iceland, with a total of 60 RTAs. Norway is the country that ranks second, with 59 RTAs. Other countries with a high number of RTAs are: Chile (52), Republic of Korea (51), Turkey (48), Ukraine (47), and Mexico (40). Without exception, these RTAs consist mainly, or (nearly) exclusively, of bilateral RTAs. On the other hand, of all 207 countries and OCT that are involved in RTAs, 58 countries are involved in one RTA, 35 in 2 RTAs and 10 in 3 RTAs. Half of all countries and OCT are therefore engaged in at most 3 RTAs. For the vast majority of these countries it holds that these agreements are (mainly) plurilateral RTAs. Exceptions are Macao China (1 bilateral RTA), Bhutan, and Uruguay (1 plurilateral and 1 bilateral RTA each), Sri Lanka (1 plurilateral RTA and 2 bilateral RTAs). The EU countries are each involved in 38 RTAs, of which 9 plurilateral and 29 bilateral. The US are involved in 14 RTAs, of which 2 plurilateral and 12 bilateral.

The countries that are most involved with plurilateral agreements are the EU countries: 9 plurilateral RTAs. This of course includes the EU Treaty itself, but also agreements with country groupings like the OCT countries, the EEA countries (Iceland, Liechtenstein, Norway), CARIFORUM (14 countries in the Caribean area, including Suriname), and four East- and South African States. None of the agreements is with another RTA, however. A number of Central-American countries comes next in terms of number of plurilateral RTAs. El Salvador and Honduras are each involved in 7 plurilateral RTAs, Guatamala and Costa Rica each have 6 plurilaterals, and Nicaragua has 5 plurilateral RTAs. A number of countries of the former Sovjet Union are also heavily involved in plurilateral RTAs: Russian Federation, Kazakhstan and Belarus each have 5 plurilateral RTAs. Some 14 other countries are engaged in 3-4 plurilateral RTAs,

[2] Since then six more agreements have been notified, which have not been included thus far.

including Asian and African countries. A major share of all countries and OCT, however, are only involved in one plurilateral RTA: 40.1%. The share of countries and OCT not involved in a plurilateral RTA is 5.3%.

There is only one agreement to which all parties are RTAs. This concerns the EFTA-SACU trade agreement, a bilateral agreement consisting of an RTA between the FTA of Iceland, Liechtenstein, Norway and Switzerland (EFTA) and the CU between Botswana, Lesotho, Namibia, South-Africa, and Swaziland (SACU).

On top of the list of countries with most bilateral RTAs are Iceland (57), Norway (56), Chile (51), and the Republic of Korea ("South Korea": 51). Also Turkey and Ukraine are heavily involved in bilateral RTAs: 48 and 45 bilateral RTAs, respectively. The other countries in the 'bilataral RTA Top-10' are Mexico, Israel, Jordan, and Georgia, with 38, 36, 36 and 35 bilateral RTAs, respectively. However, 45.9 of all countries and OCT are not involved in bilateral RTAs at all. A further 16.4% is involved in up to five bilateral RTAs.

The percentage distribution of the total number of RTAs is given in Table 1[3]:

Table 1: Percentage distribution of countries' involvement in RTAs.

	Percentage of countries and OCT with:		
	RTAs (both types)	Plurilateral RTAs	Bilateral RTAs
0 RTAs	0.5%	5.3%	45.9%
1-3 RTAs	49.8%	76.8%	10.1%
4-10 RTAs	15.0%	17.9%	11.1%
11-20 RTAs	4.8%	-	2.9%
21-30 RTAs	4.3%	-	18.8%
31-40 RTAs	22.7%	-	8.2%
> 40 RTAs	2.9%	-	2.9%

Source: author's calculations based on wto.org.

Both the distributions of plurilateral and bilateral RTAs are skewed. Regarding plurilateral RTAs, some 30% of all countries account for about 67% of all plurilateral RTAs, and 50% of all countries account for 82% of all plurilateral RTAs. Regarding bilateral RTAs it holds that 30% of all countries account for close to 90% of all bilateral RTAs and 50% of all countries for nearly all bilateral RTAs. Since there is a strong correlation between the number of bilateral RTAs and all RTAs,[4] the skewness of the distribution of all RTAs is close to that of bilateral RTAs: 30% of all countries account for about 82% of all RTAs and 50% of all countries account for 94% of all RTAs.

The number of RTAs also differs per continent. Using the UNSTATS classification of countries into geographical areas[5], we construct Table 2 below. Europe tops all other countries in terms of total and

[3] Including OCT. The non-zero percentage of countries with zero RTAs overall is explained by the suspension of Paraguay's membership of MERCOSUR since 2012.

[4] The correlation between the different types of RTAs is as follows: CORR(all, bilateral) = 0.988; CORR(all, plurilateral) = 0.554; CORR(plurilateral; bilateral) = 0.418.

[5] See http://unstats.un.org/unsd/methods/m49/m49regin.htm. Whenever a country or OCT did not appear in the UN list, we have assigned the regional entity that is closest to the geographical location of the country or OCT. This

average number of RTAs, also for the subdivision in bilateral and plurilateral RTAs. From the table we also infer that Africa and the Americas have by and large similar average mean and median values for all three RTA categories. Asia has on average more RTAs than either of these regions, which is mainly on account of a substantially higher average number of bilateral RTAs than Africa and the Americas.

Within regions there are also differences. Within the Americas, for instance, none of the Caribbean countries are involved in bilateral RTAs. Central and Latin America has on average more RTAs than Northern-America, which is mainly due to the relatively high number of RTAs many of the Central-American region countries are involved in.[6]

Within Asia, Central and Southern Asia clearly falls short with respect to the total and bilateral averages in Eastern and South-Eastern Asia and Western Asia. Western Asia is most involved in bilateral and plurilateral RTAs. The high maximum number of plurilateral RTAs for Western Asia is due to the inclusion of Cyprus, a European Union member. Taking Cyprus out would bring the average for plurilateral RTAs for Western-Asia down to 1,29, well below the averages of the other Asian regions (It also lowers the other averages, but this not affect the ranking: the bilateral average for Western-Asia goes down to 15,71, its overall average to 17,00).

Table 2 shows that countries and regions clearly differ with respect to the magnitude of plurilateral and bilateral RTAs they are involved in. However, does this also mean that countries differ a lot regarding how many countries they have freed trade with? Clearly, a bilateral contract governs free trade with one country only, while a plurilateral contract governs free trade with at least two countries.

For all 196 countries and OCT that are involved in a plurilateral RTA, the average number of countries per plurilateral RTA is 14.6 and the median value is 10.6. On average, therefore, one plurilateral RTA is equivalent to more than 14 bilateral RTAs. As expected, countries also differ widely in this respect. The standard deviation is 11.93 and the maximum number of countries per plurilateral RTA is 46 and the minimum 2.

There are also clear differences between the regions: the countries in the Americas have on average 23.5 partner countries, Oceania 21.0, Africa 14.2, Europe 8.4, and Asia 8.8. Combining this with average number of plurilateral RTAs in these regions, it is clear that countries in the Americas have only few, yet large plurilateral RTAs, while countries in Europe have many, yet smaller plurilateral RTAs.

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procedure has been applied to British Indian Ocean Territory (OCT), Chinese Taipei, South Georgia and the South Sandwich Islands (OCT), and Netherlands Antilles (OCT).

[6] Taking out the eight Central American countries out of the calculations gives Total: 6,57/0/52/1; Plurilateral:1,29/0/3/1; Bilateral: 5,29/0/51/0. The averages for the Central American countries are Total: 12,88/2/40/9,5; Plurilateral: 4,63/2/7/5,5; Bilateral: 8,25/0/38/3.

Table 2: Overview of RTAs in the world by region

Region	*Sub-region*	*# of countries in region*	*Total # of RTAs (mean/min/ max/median)*	*# of plurilateral RTAs (mean/min/ max/median)*	*# of bilateral RTAs (mean/min/ max/median)*
World		**207**	**2788** (13,47/0/60/3,0)	**550** (2,66/0/9/2)	**2238** (10,81/0/57/1)
Africa		**52**	**318** (6,12/1/35/2)	**85** (1,64/1/3/2)	**233** (4,48/0/34/0)
Americas		**45**	**258** (5,73/0/52/2)	**93** (2,07/7/0/2)	**165** (3,67/0/51/0)
of which:	*Caribbean (CARIB)*	*19*	***33*** *(1,74/1/3/2)*	***33*** *(1,74/1/3/2)*	***0*** *(0/0/0/0)*
	Central America and Latin America (C&S AMER)	*22*	***195*** *(8,86/0/52/2)*	***55*** *(2,50/0/7/2)*	***140*** *(6,36/0/51/0,5)*
	Northern-America (N-America)	*4*	***30*** *(7,50/1/14/7,5)*	***5*** *(1,25/1/2/1)*	***25*** *(6,25/0/13/6)*
Asia		**47**	**596** (12,68/1/51/6)	**74** (1,57/0/9/1)	**522** (11,11/0/51/5)
of which:	Western Asia (ASIA-W)	18	**327** (18,17/1/48/6,5)	**31** (1,72/0/9/1)	**296** (16,44/0/48/5)
	Central Asia & Southern Asia (ASIA-C&S)	13	**62** (4,77/1/17/4)	**20** (1,54/1/5/1)	**42** (3,23/0/16/2)
	Eastern & South-Eastern Asia (ASIA-E&SE)	16	**207** (12,94/1/51/7,5)	**23** (1,44/0/3/2)	**184** (11,50/1/51/5,5)
Europe		**44**	**1575** (35,80/1/60/38)	**276** (6,27/0/9/9)	**1299** (29,52/0/57/29)
Oceania		**19**	**41** (2,16/1/11/1)	**22** (1,16/1/2/1)	**19** (1,00/0/10/0)

Source: author's calculations based on wto.org.

However, the numbers on partner countries are uncorrected for double counting though. Double counting arises because:

- some countries are involved in different RTAs which involve similar countries. For instance, the African countries Burundi, Kenya, Rwanda and Uganda are both a member of ECOWAS (Economic Community of West African States) and of EAC (East African Community). Both RTAs are seen as independent plurilateral RTAs by the WTO, implying that by the procedure we have used the number of countries counted exceeds the actual number by three for each of these countries.

- Subsets of countries of an existing RTA engage in a separate RTA with another country or with another RTA. Since the subset of countries is not an RTA itself, such RTA is seen as a new plurilateral RTA by the WTO, implying that also the countries included in the subset of countries will be seen as new members. An example is the subset of 14 countries of CARICOM that have engaged under reference to the name CARIFORUM (all CARICOM countries except Montserrat) in an RTA with the EU. Since CARIFORUM is not an RTA itself, this is seen as a plurilateral RTA between the 14 CARIFORUM countries and the EU. The CARIFORUM countries are then also seen as new partners to each other, just as the EU countries are for them.
- A further and related issue is that the WTO does not always classify (or recognize) an existing RTA as partner in other agreements. Our procedure is that we follow the WTO in this respect. Hence, if WTO says 'plurilateral', the number of partner countries is N-1 even if some of these partner countries would already be involved with each other in a different RTA (with N the number of countries involved in the agreement).

To check for the amount of double-counting we have determined for each country the number of unique partner countries. The total number of unique partner countries is 7878 worldwide, 810 less than without correcting for double-counting. Note that the number of countries double counted is not necessarily equal to the number of partner countries a country has more than one RTA with. This is because some countries have three or even more treaties involving the same partner country. For instance, Armenia has a double count of 9, but the number of countries it has more than one RTA with is 6. For the world as a whole these numbers are 810 and 680, respectively.

Of all 207 countries and OCT, 90 countries show no double-counting, 19 countries show a double count of 1-2, 49 countries a double count of 3-5, and 22 countries 6-10. For another 27 countries the double-count is more than 10. The maximum number of double count is for Liechtenstein, Norway and Iceland (31, 30 and 30 respectively), followed at some distance by a number of Central-American countries, the Russian Federation and Kazakhstan.

Obviously, correcting for double counting leads to changes for the regional averages. The average for the world, after correcting for double counting, becomes 13.1.[7] The differences between the regions remain: the countries in the Americas have on average 20.7 partner countries, Oceania 20.5, Africa 12.8, Europe 7.2, and Asia 7.5. The decline is largest in the Americas, followed by Africa, Asia, and Europe. For Oceania the change is smallest.

[7] In calculating these corrected averages we have divided the number of unique partner countries by the number of plurilateral agreements. The implicit assumption is therefore that the double-counting is due to signing a plurilateral RTA next to another RTA involving the same country or next to a bilateral treaty with that country. By analysing the exact timeline of RTAs, we could correct for this. For now, we ignore this issue, also because most double counting occurs due to overlapping plurilateral RTAs: of the 680 cases in which a country has more than one treaty with the same partner, only 21 cases are due to having a double bilateral RTA. Furthermore, in all of these cases, the doubling is due to having a bilateral treaty with another RTA. The number of cases in which a country has a bilateral as well as one or more plurilateral RTAs with the same country is 183. The remaining 476 cases are all cases of having more than one plurilateral RTA with the same partner.

Finally, we note that the world wide number of actual country-country relations as a result of RTAs is 18.5% of the number of relations that could have existed. Excluding double counting in agreements, the total number of unique country-country relations is 3939 (=7878/2). The total number of country-country relations that would arise when all countries would be linked through RTAs would be 21321 (207x206/2).

3. Towards a measure of hubness

A strict definition of a hub-country would be a country that has reciprocal trade arrangements with *n>1* other countries without any of the latter countries having reciprocal trade arrangements with each other. The *n>1* countries are then spokes of the hub[8]. Clearly, in practice this definition is far to extreme, as it relies on spokes having no ties at all with any of the other spokes of the hub-country. In this section we develop a less extreme measure of hubness.[9] Starting from the most simple measure possible, we proceed step-by-step to end up with a measure that defines the hubness of a country vis-à-vis a partner country as a value that lies between 0 (maximum spokeness) and 1 (maximum hubness) that is symmetric around ½. In all what we do, we define a hub relative to its spokes. Hence, it could very well be that a hub's spoke is a hub vis-à-vis some or all other spokes of the hub. As such, our hubness measure takes a local perspective on hubness (analogously to degree centrality in network terms) and not a global perspective (eigenvector degree centrality in network analysis terms)[10]. We refer to the country-country hubness measure as bilateral hubness. By taking all bilateral hubness values of a country together, we furthermore develop a measure for a country's overall hubness in the world.

A unweighted measure of bilateral hubness

We start with a very simple measure for hubness between country *i* and *j*:

$$H_{ij} = 1 - \frac{\frac{t_j^i}{n_i}\left(1-\frac{t_j^i}{n_j}\right)}{\frac{t_j^i}{n_j}\left(1-\frac{t_j^i}{n_j}\right)} = 1 - \frac{n_j}{n_i} \qquad (1)$$

where t_j^i is the number of RTAs ('ties') between country *i* and *j* ($i \neq j$ and typically $t_j^i = 1$) and where n_i and n_j are the number of RTAs of country *i*, respectively country *j* (including the one between *i* and j). This simple measure corrects for the size of the (potential) hub since it divides by n_i, making the

[8] Kowalczyk and Wonnacott (1992) and Wonnacott (1996) report on etymology of the concept hub-and-spoke. As they argue, the term was used independently for the first time in works by Richard Lipsey and Wonnacott in 1990. Since then it has been common to refer to star-like trade relationships as hub-and-spoke systems. Baldwin and Wyplosz (2012) use the term in their textbook on European Integration and the terms also prominently appears in the WTO report on preferential trade agreements of 2011 (WTO, 2011).

[9] Baldwin (2009) discusses hubness from the perspective of how attractive a country is for other nations in the region to be desiring preferential access. He develops a measure of hubness that is based on how much a country's exports would increase if it would gain access to the hub's market.

[10] The concept of degree centrality cannot be directly applied as it relates to the importance of a node in absolute terms (degree centrality), inequality of centrality between nodes relative to a perfect star network (Freeman's degree centrality) or to the whole network (eigenvector degree centrality).

measure to some extent independent of the size of the hub's network (not entirely, see below). Furthermore, it normalizes the value of *H* to a number between zero and one, with a number closer to one implying more hubness (since n_i and n_j are always minimally one, H_{ij} only reaches zero or one in the limit). However, these features only hold as long as $n_i > n_j$ which is not generally true of course. To mend for this issue, we convert (1) to the following expression:

$$H_{ij} = \frac{n_i - n_j}{\max(n_i, n_j)} \quad (2)$$

which yields a value for *H* between -1 and 1. This retains all features of (1) and has the additional advantage that a positive (negative) value indicates that country *i* is a hub (spoke) with respect to country *j*. The hubness measure is also symmetric in the sense that $H_{ij} = -H_{ji}$.[11]

Eq. (2) is not entirely independent of the size of the network. By dividing by $\max(n_i, n_j)$ it corrects for the size of the network of the hub, but clearly the same difference between n_i and n_j returns different values for *H* depending on the value of $\max(n_i, n_j)$. This renders a straightforward comparison between networks of different size impossible. However, it is also clear that if country *i* has x ties more than country *j*, its hubness should reduce the larger the number of ties it has. Eq. (2) picks up on that desired feature.

By considering the difference between n_i and n_j, a more important disadvantage of (2) is that it ignores that hubness actually relates to the number of non-overlapping ties. As such, if country *i* has ties with $n_i - 1$ countries but these countries are entirely different than the $n_j - 1$ ties of country *j*, country *i*'s hubness as defined by (2) would be the same as if both countries would have some or all of their ties in common. Clearly, the former would have to lead to higher hubness value than the latter. From a pure network perspective this would not matter so much (as degree centrality relates to the number of ties one has), but from the definition of RTA hubness it clearly does. Therefore, to give meaning to *H* the difference between n_i and n_j should relate to the ties both countries have *not* in common.

This can be resolved by including in (2) the inner product of the country RTA vectors $\boldsymbol{n_i} = \{t_i^i, t_j^i, t_k^i, \dots, t_N^i\}$ and $\boldsymbol{n_j} = \{t_i^j, t_j^j, t_k^j, \dots, t_N^j\}$, where $t_z^i, z \in \{i, N\}$, gets a value one in case of an RTA between country *i* and *z* and zero otherwise for each of the *N* countries in the world (for $i \neq z$; else $t_i^j = 0$ as well). This leads to:

[11] One could wonder whether symmetry around zero is warranted. Should a difference of, say, 2 ties between country A and country B, assuming $n_A > n_B$, lead to $H_{AB} = -H_{BA}$? Or does it make better sense that it leads to $H_{AB} < -H_{BA}$? The answer is that symmetry is warranted because H is a relative measure of one country to another. It thus makes sense that if country A is a hub with respect B to some extent, country B is a spoke with respect to A by the same extent (where 'extent' is taken to mean by how much H deviates from zero). This calls for a common denominator. A different issue is what the common denominator should be. For instance, why not take *min* rather than *max* in the denominator of eq. (2)? Or why not take the (weighted) average of the number of ties of both countries? The answer to both queries is that it would mean that H is no longer constrained to lie in between -1 and 1, which we deem undesirable.

(3) $$H_{ij} = \frac{(n_i - n_j) + \min(n_{i,} n_j) - \boldsymbol{n_i} \cdot \boldsymbol{n_j} - 1}{\max(n_{i,} n_j) - 1}$$

Eq. (3) effectively takes out the number of partners both countries have in common: $(n_i - n_j)$ is the number of ties countries *i* and *j* definitely have different and $\min(n_{i,} n_j) - \boldsymbol{n_i} \cdot \boldsymbol{n_j}$ adds to that the number of the partner country's ties that do not overlap with country *i*'s ties. The -1, finally, takes out their own RTA as well, as this is not included in the inner product $\boldsymbol{n_i} \cdot \boldsymbol{n_j}$. For consistency we also change the denominator in $\max(n_{i,} n_j) - 1$.

Applying (3) means that the symmetry of H_{ij} around zero is lost. The reason is of course the adding of $\min(n_{i,} n_j)$ in the numerator, which returns the same value irrespective of $n_i > n_j$ or $n_i < n_j$. Hence, all else equal, $n_i > n_j$ would lead to $H_{ij} > -H_{ji}$ rather than $H_{ij} = -H_{ji}$. To restore symmetry around zero we therefore convert (3) into:

(4) $$H_{ij} = \frac{|n_i - n_j| + \min(n_{i,} n_j) - \boldsymbol{n_i} \cdot \boldsymbol{n_j} - 1}{\max(n_{i,} n_j) - 1} \frac{(n_i - n_j)}{|(n_i - n_j)|}$$

The first term on the right-hand-side of this equation makes H_{ij} symmetric around zero again, the second term determines the sign of the hubness measure, making it positive (negative) when $n_i > (<) n_j$. Note that (4) could also be written as $H_{ij} = \frac{(\max(n_i, n_j) - 1) - \mathbf{n_i} \cdot \mathbf{n_j}}{\max(n_i, n_j) - 1} \frac{(n_i - n_j)}{|(n_i - n_j)|}$, since $|n_i - n_j| + \min(n_i, n_j) = \max(n_i, n_j)$.

By (4) we have a measure defining the hubness of a country vis-à-vis a partner country as a value between -1 (a perfect spoke) and +1 (a perfect hub) that is symmetric around zero in the sense that the value attached to the extent of 'hubness' of a country is equal, in absolute terms, to the value of 'spokeness' of its partner country. The measure is not independent of the size of the network, implying that ceteris paribus the number of non-overlapping ties, the extent of hubness increases the smaller the hub's number of ties. This makes sense from the perspective that the same number of non-overlapping ties should assign more hubness to a country that has a smaller number of ties, ceteris paribus.

However, the measure has the undesirable property that if there is no overlap in RTAs between two countries the measure always takes on a value of +1 (perfect hub) or -1 (perfect spoke), irrespective of the size of the network. But clearly in comparing values of hubness across country pairs it should matter how big the country's networks are. A country with 3 RTAs vis-à-vis its partner and no overlap should be deemed a lesser hub than country with 10 RTAs and no overlap.

To mend for this we give up on the symmetry around 0 and include in (4) the relative size of the country's network in its bilateral network $\frac{n_i}{n_i + n_j}$:

(5) $$H_{ij} = \frac{n_i}{n_i + n_j} \frac{(\max(n_i, n_j) - 1) - \mathbf{n_i} \cdot \mathbf{n_j}}{\max(n_i, n_j) - 1} = \frac{n_i}{n_i + n_j} \left(1 - \frac{\mathbf{n_i} \cdot \mathbf{n_j}}{\max(n_i, n_j) - 1}\right).$$

The tables below give an impression of hubness values for different combinations of country A and B's network sizes. Table 3a is when there is no overlap in both countries networks, Table 3b has an overlap of 1.

From the tables we infer that the measure in (5) has the following desirable properties:

1) hubness lies between zero (minimum hubness) and one (maximum hubness).
2) equal network sizes and no overlap means hubness is 1/2, indicating both partners are equally a hub and a spoke; Furthermore, this value is independent of the size of network.
3) if there is overlap in networks of equal size, hubness becomes lower than ½. But it increases again when both networks become bigger (c.p. overlap), with a limit of ½.
4) if a country's network goes up, c.p. that of its partner, the hubness value goes to one. Likewise, if the partner's network goes up, c.p. a country's own network, the hubness value goes to zero.
5) an equal difference in network size between two countries also means hubness decreases if network size goes up, c.p. positive overlap.

Table 3a: Hubness values based on eqn. (5) when no overlap

		Number of RTA's of country j								
		2	**3**	**4**	**5**	**10**	**15**	**20**	**25**	**50**
Number of RTAs of country i	**2**	*0,50*	0,40	0,33	0,29	0,17	0,12	0,09	0,07	0,04
	3	0,60	*0,50*	0,43	0,38	0,23	0,17	0,13	0,11	0,06
	4	0,67	0,57	*0,50*	0,44	0,29	0,21	0,17	0,14	0,07
	5	0,71	0,63	0,56	*0,50*	0,33	0,25	0,20	0,17	0,09
	10	0,83	0,77	0,71	0,67	*0,50*	0,40	0,33	0,29	0,17
	15	0,88	0,83	0,79	0,75	0,60	*0,50*	0,43	0,38	0,23
	20	0,91	0,87	0,83	0,80	0,67	0,57	*0,50*	0,44	0,29
	25	0,93	0,89	0,86	0,83	0,71	0,63	0,56	*0,50*	0,33
	50	0,96	0,94	0,93	0,91	0,83	0,77	0,71	0,67	*0,50*

Table 3b: Hubness values based on eqn. (5) when overlap of 1

		Number of RTA's of country j								
		2	**3**	**4**	**5**	**10**	**15**	**20**	**25**	**50**
Number of RTAs of country i	**2**	*0,00*	0,20	0,22	0,21	0,15	0,11	0,09	0,07	0,04
	3	0,30	*0,25*	0,29	0,28	0,21	0,15	0,12	0,10	0,06
	4	0,44	0,38	*0,33*	0,33	0,25	0,20	0,16	0,13	0,07
	5	0,54	0,47	0,42	*0,38*	0,30	0,23	0,19	0,16	0,09
	10	0,74	0,68	0,63	0,59	*0,44*	0,37	0,32	0,27	0,16
	15	0,82	0,77	0,73	0,70	0,56	*0,46*	0,41	0,36	0,23
	20	0,86	0,82	0,79	0,76	0,63	0,54	*0,47*	0,43	0,28
	25	0,89	0,86	0,83	0,80	0,68	0,60	0,53	*0,48*	0,33
	50	0,94	0,92	0,91	0,89	0,82	0,75	0,70	0,65	*0,49*

However, there are also some undesirable properties:

1) if overlap equals $\max(n_i, n_j) - 1$, measure goes to zero.
2) at low values of row countries network size, and given some overlap, there appears to be a non-linearity in the value of the hubness measure.
3) when there's overlap, it's hard to be a hub for low values of network size; one's network should be quite bigger than one's partner's.

We therefore make a minor change in our earlier specification by dividing $\mathbf{n_i} \cdot \mathbf{n_j}$ by $\max(n_i, n_j)$ rather than $\max(n_i, n_j) - 1$. Furthermore, we center it around ½.

$$H_{ij} = \frac{n_i}{n_i + n_j}\left(1 - \frac{1}{2}\frac{\mathbf{n_i} \cdot \mathbf{n_j}}{\max(n_i, n_j)}\right). \quad (6)$$

This is the specification we will work with in the remainder of our analysis. Tables 4a and 4b show that it retains all desirable properties of the previous specification plus that it has mend for the first two of three undesirable properties.

Table 4a: Hubness values based on eqn. (6) when no overlap

		Number of RTA's of country j								
		2	**3**	**4**	**5**	**10**	**15**	**20**	**25**	**50**
Number of RTAs of country i	**2**	0,50	0,40	0,33	0,29	0,17	0,12	0,09	0,07	0,04
	3	0,60	0,50	0,43	0,38	0,23	0,17	0,13	0,11	0,06
	4	0,67	0,57	0,50	0,44	0,29	0,21	0,17	0,14	0,07
	5	0,71	0,63	0,56	0,50	0,33	0,25	0,20	0,17	0,09
	10	0,83	0,77	0,71	0,67	0,50	0,40	0,33	0,29	0,17
	15	0,88	0,83	0,79	0,75	0,60	0,50	0,43	0,38	0,23
	20	0,91	0,87	0,83	0,80	0,67	0,57	0,50	0,44	0,29
	25	0,93	0,89	0,86	0,83	0,71	0,63	0,56	0,50	0,33
	50	0,96	0,94	0,93	0,91	0,83	0,77	0,71	0,67	0,50

Table 4b: Hubness values based on eqn. (6) when overlap of 1

		Number of RTA's of country j								
		2	**3**	**4**	**5**	**10**	**15**	**20**	**25**	**50**
Number of RTAs of country i	**2**	*0,38*	0,33	0,29	0,26	0,16	0,11	0,09	0,07	0,04
	3	0,50	*0,42*	0,38	0,34	0,22	0,16	0,13	0,11	0,06
	4	0,58	0,50	*0,44*	0,40	0,27	0,20	0,16	0,14	0,07
	5	0,64	0,56	0,50	*0,45*	0,32	0,24	0,20	0,16	0,09
	10	0,79	0,73	0,68	0,63	*0,48*	0,39	0,33	0,28	0,17
	15	0,85	0,81	0,76	0,73	0,58	*0,48*	0,42	0,37	0,23
	20	0,89	0,85	0,81	0,78	0,65	0,56	*0,49*	0,44	0,28
	25	0,91	0,88	0,84	0,82	0,70	0,61	0,54	*0,49*	0,33
	50	0,95	0,93	0,92	0,90	0,83	0,76	0,71	0,66	*0,50*

A weighted measure of bilateral hubness

The above treats all RTA links of a country as the same, but clearly some partners can be deemed more important than others. To account for this, we should weigh each tie with an appropriate weight when calculating bilateral hubness, f.i. with economic size. In that case the bilateral measure also takes into account the relative importance of (non-overlapping) partners. Weights could be relative country size (relative to the world) or a partner country's relative importance in global trade, but also weights reflecting political importance could be considered. The bottom line is that some countries can be considered to be more important to team up with than others and weighing takes this into account.

In analogy with our measure thus far, weighing leads to:

$$H_{ij}^{v} = \frac{V_i}{V_i + V_j}\left(1 - \frac{1}{2}\frac{VO_{ij}}{\max(V_i, V_j)}\right). \quad (7)$$

where V_i and V_j denote the value of country *i*'s and *j*'s ties, VO_{ij} denotes the value of the ties both countries have in common, and V_{ij} is the value of *i* and *j*'s bilateral tie. Using weights relative to the world as a whole (f.i. % of world GDP), the value of a country's ties amounts to adding the world income shares of its partners.

More specifically, consider a symmetric country-country matrix $\boldsymbol{N}$ where cell entries equal to one indicate that country *i* and *j* are linked by an RTA. The diagonal of this matrix has zero's. Denote the rows of this matrix by $\boldsymbol{n_i} = \{t_i^i, t_j^i, t_k^i, \dots, t_N^i\}$, where $t_z^i, z \in \{i, N\}$ gets a value one in case of an RTA between country *i* and *z* ($i \neq z$) and zero otherwise for each of the *N* countries in the world (including $i = z$). Then define a weight vector $\boldsymbol{w} = \{w_i, w_j, w_k, \dots, w_N\}$ with $w_i, i \in \{i, N\}$ giving the relative size of country *i* (f.i. country size as a percentage of world GDP). This defines $\boldsymbol{N^w} = \boldsymbol{w} \cdot \boldsymbol{N}$ as the weighted country-country matrix $\boldsymbol{N^w}$. Then, $V_i = \boldsymbol{n_i} \cdot \boldsymbol{w^T}$ gives the size weighted value of *i*'s ties. The maximum value of V_i is $1 - w_i$. V_i also denotes the RTA's share of world income exclusive of country *i* (since n_i is either 0 or 1). If all countries would have equal weights, $V_i = (\boldsymbol{n_i} - 1)/N$**.** For example, if $\boldsymbol{n_1} = \{0,1,1,0\}$, $V_i = w_1 \cdot 0 + w_2 \cdot 1 + w_3 \cdot 1 + w_4 \cdot 0 = w_2 + w_3$. The RTA's share of world income is thus $V_i + w_i$. If all countries would have equal weight, $V_i = (\boldsymbol{n_i} - 1)/N$. Note that $V_i = n_i$ when $w_j = 1$ for all *j*, making (7) identical to (6).

The inner product gives a matrix with zero and non-zero entries. Whenever there is a non-zero entry, it indicates that the two countries have overlapping ties. However, it does not indicate which countries are overlapping. Hence we need to take the inner product of the weighted matrix and the non-weighted matrix (the latter to prevent multiplying weights): $VO_{ij} = \boldsymbol{N^w} \cdot \boldsymbol{N}$, where $\boldsymbol{N^w}$ is the weighted country-country matrix and $\boldsymbol{N}$ the non-weighted one.

Weighing ties like this will imply that large countries with ties with many yet small countries get a lower value for H_{ij} compared to a small countries that have fewer but with large countries (because V_i is likely to get smaller for a large country). This is exactly what weighing should do. Furthermore, for countries with identical ties, the *H*-value will be different since the calculated weighted value of all of a country's ties excludes that of the country itself.

From bilateral hubness to overall hubness

The analysis so far has developed a measure for the hubness of one country vis-à-vis one partner country. This does not imply, however, that a large value of H_{ij} makes country *i* a hub. It is a *bilateral* hub with respect to one of its partner countries, and hence we refer to H_{ij} as the bilateral hubness of country *i* vis-à-vis its partner *j*. In order to determine a country's *overall* hubness we should also consider how it fares with respect to its other partner countries. The final step in developing our measure of hubness takes this into account, defining hubness as the average of a country's bilateral hubness measures. The simplest way to proceed is taking the average of all of a country's bilateral hubness measures:

$$(8) \qquad H_i = \sum_{j \in \boldsymbol{n_i}} H_{ij} / \sum_{j \in \boldsymbol{n_i}} t_j^i \text{ and } \qquad H_i^v = \sum_{j \in n_i} H_{ij}^v / \sum_{j \in \boldsymbol{n_i}} t_j^i.$$

But also here we could use the same weights as before to take into account the relative importance of a country's ties. After all, it makes sense to weigh hubness with respect to the EU more than hubness with respect to a country such as Iceland. Then, we get

$$(9) \qquad H_i = \left\{\sum_{j \in \boldsymbol{n_i}} w_j H_{ij}\right\} / \sum_{j \in \boldsymbol{n_i}} (w_j t_j^i) \qquad \text{or} \qquad H_i^v = \left\{\sum_{j \in \boldsymbol{n_i}} H_{ij}^v\right\} / \sum_{j \in \boldsymbol{n_i}} (w_j t_j^i).$$

Note that both expressions become equal to the ones in (8) when $w_j = 1$ for all $j \in \boldsymbol{n_i}$.

One issue that remains is the comparability across countries of the average hubness thus calculated. The point is that the hubness measure for two countries each having one non-overlapping tie will depend on the number of ties of their respective partner country. If the partner country has just a few ties more, hubness will be larger than if the partner country has many more ties more, see Table 4b. This becomes problematic if the number of ties a country has is very small, as it will distort the comparison of overall hubness across countries.

There are three ways to resolve this issue:

1. Go back to the calculation of bilateral hubness, adjusting it for the number of partner's ties by taking it relative to the average number of ties of all countries across the world (or the maximum, or the minimum, as long as the number is the same for all H_{ij}). The drawback of this solution is that it denies the basic idea behind the bilateral hubness measure. Bilateral hubness measures the relative importance of a country's ties by seeing it relative to the biggest (of the two) countries' number of ties. After all, it attempts to measure the difference in number of non-overlapping ties in relation to what this number could have been maximally (which is the maximum, which also scales it to a number between 0 and 1). We therefore will not pursue this solution further.

2. Calculate bilateral hubness for all country pairs, also for the country pairs that are not tied by an RTA, and then take the (weighted) average. For instance, $H_i = \sum_{j \in N, i \neq j} H_{ij} / (N-1)$. This solution effectively takes out the bias that could arise when countries only have few partners, making overall hubness measures comparable across countries.

3. Simply ignore countries with very low numbers of ties when comparing countries on hubness (say, require countries to have at least 5 ties). This solution is a practical solution, comparable to procedures that are used in econometric analysis when dealing with outliers.

In the next section we will only consider solution 2.

4. Hubness in RTAs

We are now in the position to calculate and compare hubness in RTAs of countries that are involved in RTAs. Using the database as described in Section 2, we calculate bilateral hubness according to (6) and (7). Whenever appropriate, we use country GDP in 2011 as a percentage of world GDP to weigh the relative importance of countries in RTA networks. GDP data are obtained from the World Bank Development Indicators (last updated 14 June 2016). We choose 2011 because this is the most recent year with the fewest missing values (31 in total, of which 17 OCT). For that reason we exclude the OCT from our calculations of weighted averages. The remaining missing values are given an income share of zero.

As a benchmark, we present our results on overall hubness based on (8) and (9). We do so for two different country constellations. Country constellation 1 includes all 188 countries in the dataset but not the OCT. Country constellation 2 does the same but sees the EU as one country, amounting to 160 countries in the dataset. To streamline the presentation we only report the countries that are highest and lowest ranked (top-10 and bottom-10) whenever necessary supplemented with the EU countries, the U.S.A., Japan, Brazil, Russia, India, China and South Africa (the BRICS countries) and Mexico. Whenever countries have the same average, we give them the same rank.[12] All results for country constellation 1 (all countries) are presented in Tables 5.1-5.4. The results for country constellation 2 (treating the EU as one country) are reported in Tables 6.1-6.4. Ranking is based on the weighted average in (9).

From the tables we infer the following:

- considering all countries and if we do not weigh for the gdp-size of a country's partners in RTA links (Table 5.1), Singapore, India and Egypt are on average more of a hub than the EU countries. Also other developing countries can be found in the top-10. When we correct in Table 5.2 for the potential bias that could occur because of the small RTA networks of some countries (see previous section), we see that the EU-countries are on top of the chart, followed by Egypt and then by some other developed European countries. But also some small developing countries remain.
- considering all countries and weighing for the economic size of countries by means of their share in world GDP (Table 5.3), the EU-countries disappear from the top-10 and can be found in the middle of the ranking. In fact, it should be considered a spoke in all of its bilateral relations.

[12] We also exclude Paraguay from our ranking as its RTA membership of Mercosur is currently suspended and it has therefore no links in the dataset.

Furthermore, the top-10 is a mixture of very different countries. It features Australia and Singapore as developed countries, quite some Latin-American countries, but also small state like Bahrain and Oman. Correcting in Table 5.4 for the potential bias due to small RTA networks also has an impact here. Also the position of the EU-countries improves considerably.

- turning to the tables in which we treat the EU as one country, we see that if we do not weigh with country size, the EU is firmly back on top of the charts again. This holds for both Table 6.1, where we consider the actual ties between countries, as well as for Table 6.2 where we correct for RTA size bias. Furthermore, in both tables the top-10 is for most part populated by the same countries: the EU, Switzerland, Iceland, Norway, Singapore, Liechtenstein, Egypt, and Chile appear in the top-10 of both tables. This also holds for the bottom-10 countries, though to a lesser extent.
- when treating the EU as one country and weighing the importance of RTA ties by their world GDP shares in Tables 6.3 and 6.4, the top-10 is completely turned over. In Table 6.3 only Chile remains in the top-10, while in Table 6.4 Switzerland and Singapore remain. Furthermore, both top-10s are now populated by only (Table 6.3) or mainly (Table 6.4) developing countries. Regarding the bottom-10 of both tables we also see a major change in countries listed (in comparison with Tables 6.1 and 6.2). Again weighing has severe consequences for the hubness of the EU: regarding actual RTA ties, weighing implies the EU becomes a spoke in all of its bilateral relations. When correcting for network size, its perceived position as a hub is somewhat restored again.
- Considering the BRICS-countries, we see that they take a relatively high position if we do not weigh with GDP-size and consider actual RTa ties. When correcting for network size bias, the position drop considerably, except for South-Africa. Taking into account GDP weights as well also lowers the BRICS's rankings. Though less dramatic, similar patterns hold for the USA and Japan.

5. Conclusion

This paper gives a first impression of hubness in RTAs in the world. Applying a newly constructed measure for hubness to different constellations of countries, we have shown that the common perception of the EU being a hub in RTA networks only holds true when attaching equal weight to all bilateral ties. If, however, we weigh the importance of these ties by countries' share of world GDP, quite a different picture emerges. Then, the EU cannot longer be considered a hub. Our analysis has also made clear that many developing countries could be considered hubs in RTA networks rather than spokes.

Table 5.1: Overall hubness, all countries: RTA ties, country weight = 1									
Rank	*Country name*	*Average hubness*	*min*	*max*	*Median*	*% hub*	*% spoke*	*% neutral*	*# ties*
Top-10									
1	Singapore	0,47997	0,30744	0,79487	0,52083	59%	34%	6%	32
2	India	0,44865	0,23824	0,64583	0,37879	33%	67%	0%	18
3	Egypt	0,44640	0,32477	0,69880	0,36134	33%	67%	0%	66
4	EU countries	0,43710	0,25287	0,63913	0,50714	53%	45%	2%	87
5	Mauritius	0,41924	0,26168	0,69853	0,31034	37%	63%	0%	54
6	Madagascar, Seycelles, Zimbabwe	0,41663	0,25472	0,69403	0,30895	36%	62%	2%	53
7	Libya, Sudan	0,41036	0,25253	0,50000	0,42241	0%	94%	6%	33
8	Korea, Rep. of	0,40716	0,29365	0,71538	0,29365	28%	72%	0%	50
9	Switzerland	0,39705	0,26000	0,86429	0,34778	16%	84%	0%	63
10	Côte d'Ivoire	0,39468	0,27506	0,63393	0,27506	33%	67%	0%	42
Bottom-10									
152	Angola, Mozambique	0,24049	0,18110	0,27951	0,26564	0%	100%	0%	14
153	Faroe Islands	0,22083	0,21742	0,25410	0,21742	0%	100%	0%	31
154	Canada	0,21979	0,17399	0,32143	0,21944	0%	100%	0%	15
155	Azerbaijan	0,21238	0,09556	0,30303	0,24510	0%	100%	0%	5
156	Andorra, San Marino	0,20570	0,20570	0,20570	0,20570	0%	100%	0%	28
157	Chinese Taipei	0,16831	0,13186	0,29484	0,14437	0%	100%	0%	7
158	Bolivia, Ecuador	0,15317	0,06111	0,33333	0,06508	0%	100%	0%	3
159	Hong-Kong, China	0,14586	0,09603	0,28533	0,10100	0%	100%	0%	7
160	UNMIK/Kosovo	0,12272	0,11988	0,12479	0,12228	0%	100%	0%	6
161	Macao, China	0,04762	0,04762	0,04762	0,04762	0%	100%	0%	1
Other countries									
16	Russian Federation	0,38945	0,18713	0,58824	0,42500	25%	75%	0%	12
36	China	0,41356	0,22949	0,95238	0,38889	15%	85%	0%	20
29	South-Africa	0,34699	0,27629	0,65833	0,27629	20%	78%	2%	46
43	Brazil	0,32937	0,32143	0,33333	0,33333	0%	100%	0%	3
45	United States	0,32278	0,23774	0,50000	0,29368	0%	95%	5%	20
48	Mexico	0,31617	0,26254	0,91837	0,26254	9%	91%	0%	45
54	Japan	0,30070	0,19610	0,33987	0,32086	0%	100%	0%	16

Table 5.2: Overall hubness, all countries: all possible ties, country weight = 1									
Rank	*Country name*	*Average hubness*	*min*	*max*	*median*	*% hub*	*% spoke*	*% neutral*	*# ties*
Top-10									
1	EU-countries	0,65680	0,25287	1,00000	0,75000	78%	21%	1%	187
2	Egypt	0,62007	0,32477	1,00000	0,63187	56%	43%	1%	187
3	Switzerland	0,61238	0,26000	1,00000	0,68182	56%	44%	0%	187
4	Iceland	0,60950	0,25587	1,00000	0,67816	56%	44%	0%	187
5	Norway	0,60672	0,25597	1,00000	0,67442	55%	44%	1%	187
6	Liechtenstein	0,60367	0,25606	1,00000	0,67059	55%	45%	0%	187
7	Mauritius	0,58853	0,26168	1,00000	0,61644	53%	47%	0%	187
8	Chile	0,58847	0,29054	1,00000	0,68354	53%	47%	0%	187
9	Madagascar, Seychelles, Zimbabwe	0,58527	0,25472	1,00000	0,61111	53%	47%	1%	187
10	Jordan	0,58283	0,26923	1,00000	0,62676	53%	47%	0%	187
Bottom-10									
152	UNMIK/Kosovo	0,23428	0,06229	1,00000	0,19355	7%	89%	4%	187
153	Uzbekistan	0,23093	0,06377	1,00000	0,19355	7%	90%	3%	187
154	Turkmenistan	0,23087	0,06377	1,00000	0,19355	7%	90%	3%	187
155	Bangladesh, Bhutan, Maldives, Nepal, Sri Lanka	0,23001	0,06452	1,00000	0,19355	7%	91%	2%	187
156	Azerbaijan	0,20519	0,05372	1,00000	0,16667	4%	93%	3%	187
157	Rep. of Congo[13]	0,20475	0,05404	1,00000	0,16667	4%	95%	1%	187
158	Uruguay	0,17674	0,04370	1,00000	0,13793	2%	98%	0%	187
159	Bolivia, Ecuador	0,14431	0,03295	1,00000	0,10714	1%	97%	2%	187
160	Argentina, Brazil, Venezuela	0,14312	0,03333	1,00000	0,10714	1%	98%	1%	187
161	Macao, China	0,06037	0,01136	1,00000	0,03846	1%	99%	0%	187
Other countries									
69	USA	0,44363	0,17080	1,00000	0,43750	40%	57%	3%	187
95	Japan	0,39557	0,15177	1,00000	0,32799	30%	70%	0%	187
121	Russian Federation	0,34800	0,11843	1,00000	0,32432	19%	81%	0%	187
77	India	0,42024	0,17044	1,00000	0,36765	32%	64%	4%	187
70	China	0,44042	0,18154	1,00000	0,38158	39%	58%	3%	187
22	South-Africa	0,55832	0,27629	1,00000	0,56410	53%	47%	1%	187
23	Mexico	0,55713	0,26254	1,00000	0,64286	53%	47%	0%	187

[13] And 4 more countries, notably Central African Republic, Chad, Equitorial Guinea, and Gabon.

Table 5.3: Overall hubness, all countries: RTA ties, country weight = world GDP share									
Rank	*Country name*	*Average hubness*	*min*	*max*	*median*	*% hub*	*% spoke*	*% neutral*	*# ties*
Top-10									
1	Venezuela	0,82404	0,26110	0,83552	0,26365	33%	67%	0%	3
2	Singapore	0,72415	0,31114	0,98269	0,45213	44%	56%	0%	32
3	Argentina	0,71650	0,26856	0,79453	0,30713	33%	67%	0%	3
4	Australia	0,70557	0,26840	0,80396	0,39124	24%	76%	0%	17
5	Peru	0,70554	0,25902	0,97987	0,54594	80%	20%	0%	45
6	Chile	0,69778	0,27572	0,85290	0,55537	74%	26%	0%	54
7	Costa Rica	0,69223	0,26346	0,84716	0,51955	73%	27%	0%	45
8	Oman	0,66639	0,23881	0,75541	0,43648	47%	53%	0%	19
9	Bahrain, Kingdom of	0,66421	0,23926	0,75455	0,43645	47%	53%	0%	19
10	Pakistan	0,65894	0,27354	0,69920	0,62886	88%	13%	0%	8
Bottom-10									
178	Ecuador	0,03597	0,01508	0,27359	0,02293	0%	100%	0%	3
179	Cook Islands, Nauru, Niue, Samoa	0,03013	0,00140	0,26579	0,25050	0%	100%	0%	11
180	Tuvalu	0,02982	0,00140	0,26563	0,25017	0%	100%	0%	11
181	Kiribati	0,02853	0,00139	0,26498	0,25083	0%	100%	0%	11
182	Micronesia	0,02684	0,00138	0,26414	0,25168	0%	100%	0%	11
183	Tonga	0,02519	0,00137	0,26333	0,25247	0%	100%	0%	11
184	Vanuatu	0,02346	0,00136	0,26247	0,25328	0%	100%	0%	11
185	Chinese Taipei	0,02075	0,01533	0,03444	0,02151	0%	100%	0%	7
186	Solomon Islands	0,01995	0,00134	0,25873	0,25483	0%	100%	0%	11
187	UNMIK/Kosovo	0,00942	0,00876	0,01014	0,00994	0%	100%	0%	6
Other countries									
87-115	EU-countries[14]	0,29340	0,25070	0,42618	0,31713	0%	100%	0%	87
157	USA	0,17541	0,11374	0,28560	0,17417	0%	100%	0%	20
70	Japan	0,33203	0,18561	0,45012	0,25937	0%	100%	0%	16
164	Brazil	0,14754	0,09022	0,15449	0,12611	0%	100%	0%	3
158	Russian Federation	0,17377	0,05584	0,24723	0,22104	0%	100%	0%	12
83	India	0,30818	0,17584	0,62007	0,23885	28%	72%	0%	18
150	China	0,19980	0,11736	0,38256	0,19126	0%	100%	0%	20
84	South-Africa	0,29943	0,23076	0,94036	0,27208	22%	78%	0%	46
16	Mexico	0,61618	0,26865	0,88503	0,45270	11%	89%	0%	45

[14] Each EU-country has a different value. The numbers shown are those for Denmark, the median country.

Table 5.4: Overall hubness, all countries: all possible ties, country weight = world GDP share									
Rank	*Country name*	*Average hubness*	*min*	*max*	*median*	*% hub*	*% spoke*	*% neutral*	*# ties*
Top-10									
1	Chile	0,73015	0,27572	1,00000	0,66914	90%	10%	0%	187
2	Peru	0,72611	0,25902	1,00000	0,65278	90%	10%	0%	187
3	Singapore	0,71879	0,31114	1,00000	0,74286	86%	14%	0%	187
4	Costa Rica	0,71483	0,26346	1,00000	0,62162	90%	10%	0%	187
5	Korea, Rep. of	0,69014	0,30209	1,00000	0,60501	89%	11%	0%	187
6	Australia	0,68698	0,26840	1,00000	0,69817	85%	15%	0%	187
7	Jordan	0,68246	0,26848	1,00000	0,56322	71%	29%	0%	187
8	Switzerland	0,68198	0,27880	1,00000	0,59202	70%	30%	0%	187
9	Morocco	0,67802	0,25586	1,00000	0,55398	67%	33%	0%	187
10	Mexico	0,67174	0,26865	1,00000	0,55215	72%	28%	0%	187
Bottom-10									
178	Rep. of Congo	0,02486	0,00219	1,00000	0,00767	6%	94%	0%	187
179	Gabon	0,02431	0,00214	1,00000	0,00748	6%	94%	0%	187
180	Eq. Guinea	0,02421	0,00213	1,00000	0,00744	6%	94%	0%	187
181	Cook Islands, Nauru, Niue, Samoa,	0,00578	0,00041	1,00000	0,00145	1%	99%	0%	187
182	Tuvalu	0,00578	0,00041	1,00000	0,00145	1%	99%	0%	187
183	Kiribati	0,00575	0,00041	1,00000	0,00144	1%	99%	0%	187
184	Micronesia	0,00571	0,00041	1,00000	0,00143	1%	99%	0%	187
185	Tonga	0,00568	0,00041	1,00000	0,00142	1%	99%	0%	187
186	Vanuatu	0,00564	0,00040	1,00000	0,00141	1%	99%	0%	187
187	Solomon Isl.	0,00557	0,00040	1,00000	0,00139	1%	99%	0%	187
Other countries									
36-79	EU-countries[15]	0,58265	0,25070	1,00000	0,45664	48%	52%	0%	187
118	USA	0,31625	0,11374	1,00000	0,32481	42%	58%	0%	187
107	Japan	0,46080	0,18561	1,00000	0,45734	43%	57%	0%	187
170	Brazil	0,06123	0,00894	1,00000	0,03073	10%	90%	0%	187
151	Russian Federation	0,12936	0,02201	1,00000	0,07330	20%	80%	0%	187
108	India	0,43026	0,15735	1,00000	0,41389	42%	58%	0%	187
116	China	0,32329	0,11736	1,00000	0,32595	42%	58%	0%	187
84	South-Africa	0,54463	0,19764	1,00000	0,37089	45%	55%	0%	187

[15] Each EU-country has a different value. The numbers shown are those for Denmark, the median country.

Table 6.1: Overall hubness, EU as one country: RTA ties, country weight = 1									
Rank	*Country name*	*Average hubness*	*min*	*max*	*median*	*% hub*	*% spoke*	*% neutral*	*# ties*
Top-10									
1	EU	0,71286	0,48958	0,98361	0,70667	95%	3%	2%	60
2	Switzerland	0,55146	0,26761	0,86250	0,57332	72%	28%	0%	36
3	Iceland	0,54182	0,26017	0,85897	0,56604	71%	29%	0%	35
4	Norway	0,53448	0,26046	0,85526	0,55769	68%	29%	3%	34
5	Singapore	0,51833	0,39869	0,79487	0,53000	69%	25%	6%	32
6	Liechtenstein	0,51732	0,26076	0,77500	0,54902	61%	33%	6%	33
7	Egypt	0,48554	0,31944	0,55833	0,47656	49%	51%	0%	39
8	Ukraine	0,47871	0,21538	0,69565	0,49313	50%	50%	0%	18
9	Chile	0,47121	0,27155	0,70588	0,50000	41%	48%	11%	27
10	India	0,45450	0,29813	0,64583	0,37879	33%	67%	0%	18
Bottom-10									
151	Azerbaijan	0,26443	0,19324	0,30303	0,27778	0%	100%	0%	5
152	Antigua and Barbuda[16]	0,26141	0,17667	0,27778	0,26667	0%	100%	0%	15
153	UNMIK/Kosovo	0,25656	0,24643	0,26389	0,25506	0%	100%	0%	6
154	Israel	0,22172	0,12391	0,30000	0,19156	0%	100%	0%	9
155	Bolivia, Ecuador	0,20794	0,13492	0,33333	0,15556	0%	100%	0%	3
156	Hong-Kong, China	0,19043	0,15149	0,28533	0,16439	0%	100%	0%	7
157	Faroe Islands	0,08889	0,06094	0,10062	0,09700	0%	100%	0%	4
158	Macao, China	0,04762	0,04762	0,04762	0,04762	0%	100%	0%	1
159	Andorra	0,01639	0,01639	0,01639	0,01639	0%	100%	0%	1
160	San Marino	0,01639	0,01639	0,01639	0,01639	0%	100%	0%	1
Other countries									
15	USA	0,44313	0,32309	0,65517	0,43014	10%	85%	5%	20
41	Japan	0,33478	0,26042	0,43137	0,33871	0%	100%	0%	16
45	Brazil	0,32937	0,32143	0,33333	0,33333	0%	100%	0%	3
13	Russian Federation	0,44561	0,28889	0,58824	0,44505	25%	75%	0%	12
14	China	0,44527	0,28846	0,95238	0,41429	15%	85%	0%	20
54	South-Africa	0,31039	0,22447	0,37879	0,30855	0%	100%	0%	19
20	Mexico	0,39648	0,20577	0,81818	0,35945	11%	83%	6%	18

[16] And 13 other countries, notably Bahamas, Barbados, Belize (then British Honduras), Dominica, Grenada, Guyana, Haiti, Jamaica, Saint Lucia, St Kitts and Nevis, St Vincent and the Grenadines, Suriname, Trinidad and Tobago

Table 6.2: Overall hubness, EU as one country: all possible ties, country weight = 1									
Rank	*Country name*	*Average hubness*	*min*	*max*	*median*	*% hub*	*% spoke*	*% neutral*	*# ties*
Top-10									
1	EUR	0,76426	0,48958	1,00000	0,76506	98%	1%	1%	160
2	Egypt	0,68546	0,31944	1,00000	0,71296	87%	13%	0%	160
3	Switzerland	0,67715	0,26761	1,00000	0,68750	93%	8%	0%	160
4	Iceland	0,67194	0,26017	1,00000	0,68085	92%	8%	1%	160
5	Norway	0,66686	0,26046	1,00000	0,67391	91%	8%	1%	160
6	Sudan, Libya	0,66140	0,25758	1,00000	0,68750	76%	23%	1%	160
7	Liechtenstein	0,66047	0,26076	1,00000	0,66667	88%	9%	3%	160
8	Singapore	0,65757	0,31884	1,00000	0,68085	88%	11%	1%	160
9	Swaziland	0,63436	0,29869	1,00000	0,65909	78%	21%	1%	160
10	Chile	0,62324	0,27155	1,00000	0,62798	81%	14%	4%	160
Bottom-10									
151	Azerbaijan	0,28714	0,07564	1,00000	0,25000	7%	90%	3%	160
152	Central African Republic[17]	0,28658	0,07628	1,00000	0,25000	7%	93%	1%	160
153	Uruguay	0,24935	0,06198	1,00000	0,21053	4%	96%	1%	160
154	Faroe Islands	0,24546	0,06094	1,00000	0,20351	6%	94%	1%	160
155	Bolivia, Ecuador	0,20524	0,04683	1,00000	0,16667	3%	96%	2%	160
156	Argentina, Brazil	0,20416	0,04762	1,00000	0,16667	3%	96%	1%	160
157	Venezuela	0,20416	0,04762	1,00000	0,16667	3%	96%	1%	160
158	Macao, China	0,08822	0,01639	1,00000	0,06250	1%	98%	1%	160
159	San Marino	0,08605	0,01639	1,00000	0,06250	1%	99%	1%	160
160	Andorra	0,08605	0,01639	1,00000	0,06250	1%	99%	1%	160
Other countries									
26	USA	0,56966	0,21875	1,00000	0,55714	67%	30%	3%	160
61	Japan	0,51979	0,20351	1,00000	0,51613	56%	44%	0%	160
108	Russian Federation	0,46573	0,16111	1,00000	0,44444	26%	73%	2%	160
35	India	0,55028	0,22885	1,00000	0,54545	59%	34%	6%	160
27	China	0,56841	0,23958	1,00000	0,57143	68%	28%	4%	160
37	South-Africa	0,54884	0,22447	1,00000	0,54412	67%	31%	3%	160
47	Mexico	0,54209	0,20577	1,00000	0,53030	58%	33%	9%	160

[17] And 4 more countries, notably Chad, Eq. Guinea, Gabon, and Republic of Congo.

Table 6.3: Overall hubness, EU as one country: RTA ties, country weight = world GDP share									
Rank	Country name	Average hubness	min	max	median	% hub	% spoke	% neutral	# ties
Top-10									
1	Venezuela	0,82404	0,26110	0,83552	0,26365	33%	67%	0%	0,82404
2	Costa Rica	0,77560	0,26363	0,84490	0,39337	33%	67%	0%	0,77560
3	Peru	0,77504	0,25914	0,97957	0,48072	50%	50%	0%	0,77504
4	Dominican Republic	0,76176	0,25831	0,78831	0,48964	10%	90%	0%	0,76176
5	Chile	0,76009	0,27610	0,85103	0,45960	48%	52%	0%	0,76009
6	Morocco	0,75431	0,25597	0,86390	0,48191	42%	58%	0%	0,75431
7	Jordan	0,74066	0,26889	0,86383	0,49401	46%	54%	0%	0,74066
8	Korea, Rep. of	0,73687	0,30262	0,81967	0,52794	65%	35%	0%	0,73687
9	Mexico	0,73556	0,26846	0,88280	0,33235	28%	72%	0%	0,73556
10	Panama	0,72479	0,26175	0,96991	0,34297	19%	81%	0%	0,72479
Bottom-10									
151	Ecuador	0,03636	0,01530	0,27359	0,02346	0%	100%	0%	3
152	Cook Islands, Nauru, Niue, Samoa,	0,03020	0,00147	0,26579	0,25050	0%	100%	0%	11
153	Tuvalu	0,02988	0,00147	0,26563	0,25017	0%	100%	0%	11
154	Kiribati	0,02860	0,00146	0,26498	0,25083	0%	100%	0%	11
155	Micronesia, Federated States of	0,02691	0,00145	0,26414	0,25168	0%	100%	0%	11
156	Tonga	0,02526	0,00144	0,26333	0,25247	0%	100%	0%	11
157	Vanuatu	0,02352	0,00143	0,26247	0,25328	0%	100%	0%	11
158	Chinese Taipei	0,02093	0,01533	0,03444	0,02204	0%	100%	0%	7
159	Solomon Islands	0,02001	0,00141	0,25873	0,25483	0%	100%	0%	11
160	UNMIK/Kosovo	0,00982	0,00911	0,01061	0,01039	0%	100%	0%	6
Other countries									
113	EU	0,24510	0,14117	0,39349	0,33046	0%	100%	0%	60
128	USA	0,17711	0,11508	0,28560	0,17732	0%	100%	0%	20
103	Japan	0,33274	0,18765	0,45012	0,25937	0%	100%	0%	16
137	Brazil	0,14754	0,09022	0,15449	0,12611	0%	100%	0%	3
131	Russian Federation	0,17457	0,05788	0,24723	0,22104	0%	100%	0%	12
109	India	0,30850	0,17584	0,62007	0,23885	28%	72%	0%	18
123	China	0,20006	0,11880	0,38256	0,19126	0%	100%	0%	20
55	South-Africa	0,60005	0,22759	0,93755	0,81592	58%	42%	0%	19

Table 6.4: Overall hubness, EU as one country: all possible ties, country weight = world GDP share									
Rank	*Country name*	*Average hubness*	*min*	*max*	*median*	*% hub*	*% spoke*	*% neutral*	*# ties*
Top-10									
1	Chile	0,77297	0,27610	1,00000	0,81454	89%	11%	0%	160
2	Peru	0,77079	0,25914	1,00000	0,81371	89%	11%	0%	160
3	Costa Rica	0,76255	0,26363	1,00000	0,80962	89%	11%	0%	160
4	Singapore	0,75012	0,31155	1,00000	0,79928	84%	16%	0%	160
5	Korea, Rep. of	0,73922	0,30262	1,00000	0,79001	88%	13%	0%	160
6	Jordan	0,73523	0,26889	1,00000	0,78390	83%	18%	0%	160
7	Morocco	0,73199	0,25597	1,00000	0,78655	80%	20%	0%	160
8	Switzerland	0,73025	0,27897	1,00000	0,75593	82%	18%	0%	160
9	Mexico	0,72517	0,26846	1,00000	0,77968	86%	14%	0%	160
10	Australia	0,72175	0,26840	1,00000	0,77167	83%	18%	0%	160
Bottom-10									
151	Republic of Congo	0,02644	0,00223	1,00000	0,01167	7%	93%	0%	160
152	Gabon	0,02585	0,00217	1,00000	0,01138	7%	93%	0%	160
153	Equitorial Guinea	0,02574	0,00216	1,00000	0,01133	7%	93%	0%	160
154	Cook Islands, Nauru, Niue, Samoa,	0,00609	0,00042	1,00000	0,00222	1%	99%	0%	160
155	Tuvalu	0,00609	0,00042	1,00000	0,00222	1%	99%	0%	160
156	Kiribati	0,00606	0,00042	1,00000	0,00221	1%	99%	0%	160
157	Micronesia, Federated States of	0,00602	0,00041	1,00000	0,00219	1%	99%	0%	160
158	Tonga	0,00598	0,00041	1,00000	0,00218	1%	99%	0%	160
159	Vanuatu	0,00594	0,00041	1,00000	0,00216	1%	99%	0%	160
160	Solomon Islands	0,00587	0,00040	1,00000	0,00213	1%	99%	0%	160
Other countries									
86	EU	0,37947	0,14117	1,00000	0,43585	49%	51%	0%	160
94	USA	0,33787	0,11508	1,00000	0,37857	49%	51%	0%	160
79	Japan	0,49640	0,18765	1,00000	0,52099	51%	49%	0%	160
143	Brazil	0,06702	0,00907	1,00000	0,04626	11%	89%	0%	160
124	Russian Federation	0,14187	0,02232	1,00000	0,10654	24%	76%	0%	160
80	India	0,46762	0,15910	1,00000	0,48939	50%	50%	0%	160
87	China	0,35793	0,11880	1,00000	0,40081	49%	51%	0%	160
56	South-Africa	0,60023	0,19366	1,00000	0,63855	53%	47%	0%	160

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