

Presenting GTAP results using a map

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*This document is designed to be viewed in colour.
If you have no colour printer, view it on-screen.*

Abstract

Maps are a natural way to present results from regional economic models, and are particularly useful for slideshow presentations. Unfortunately, commercial mapping (aka GIS) programs are expensive and complicated. By comparison, the ShadeMap program has limited capabilities, but is free and simple to use. To assist GTAP users, the ShadeMap package includes region boundary files (ie, maps) for versions 5, 5.4, 6pr2 and 6 of the GTAP database. We explain a simple way to aggregate or simplify one of these supplied map files to produce a map that contains the same regions as a particular GTAP simulation. The aggregation scheme (AGG) file used to prepare the simulation database can also be used to aggregate the map.

After opening the aggregated map within ShadeMap, regional results can be pasted in from a spreadsheet. Regions can be coloured or shaded (B&W) according to these results. We explore a number of presentation options. The resulting image may be pasted into Word or PowerPoint, or saved as a file for further editing by a graphics package.

The paper also covers some more complex topics, such as: adjusting colour schemes; ensuring the same colouring system is used for a series of maps; and producing maps which distinguish countries not yet separately distinguished in today's GTAP databases.

ShadeMap is an interactive Windows program, but can also be completely controlled from the command line. This means that script files or other programs (eg, BAT files or GAMS programs) can use ShadeMap to automatically generate multiple maps.

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1 Introduction to ShadeMap

ShadeMap is a free, simple-to-use program which builds maps coloured according to results from regional economic models. The map may be pasted into Word or PowerPoint, or saved as a file for further editing by a graphics package. Map outline files corresponding to the GTAP regions are included with the program. It is also easy to aggregate or simplify one of these supplied map files to produce a map that contains the same regions as a particular GTAP simulation.

This paper goes through the basic steps of producing a map to show results from a particular GTAP simulation.

The paper also covers some more complex topics, such as: adjusting colour schemes; ensuring the same colouring system is used for a series of maps; and producing maps which distinguish countries not yet separately distinguished in today's GTAP databases.

You can download ShadeMap (including April 2005 improvements and bug-fixes) from:

<http://www.monash.edu.au/policy/shademap.htm>

Tom Rutherford has developed a GAMS interface to ShadeMap, which is at:

<http://www.gamsworld.org/mpsge/debreu/shademap/index.html>

ShadeMap can also be used to map results relating to different provinces or states within a single country -- and a number of map outline files are supplied for this purpose. However, this document focuses on mapping results from a GTAP simulation.

1.1 The example

Below we follow through an example of GTAP map-making. In the example, we wish to report the real GDP results from a GTAP simulation of the effects of removing all import tariffs. Our database, which was produced by aggregating the standard GTAP version 6 data, distinguishes 24 regions. The real GDP results and the details of the region aggregation are shown in Table 1 below. The region aggregation is designed to retain maximum detail for Asia; other regions are aggregated into a few broad groups.

1.1.1 Use supplied files to run through the example yourself

The ShadeMap download includes files needed to follow the steps listed below. The files are:

- MySim.agg text file used by GTAPAgg to specify 87-to-24 region mapping
- MySim.xls worksheet with GDP results

2 Basic steps in mapping GTAP results

In order to present GTAP results on a map we must perform 4 steps:

- create a map with the same regions as our GTAP simulation.
- paste a column of numbers from our GTAP simulation into the map.
- adjust the map appearance.
- paste the map into Word or PowerPoint.

These steps are described below.

Table 1: Real GDP effects of tariff abolition

Region Code	Region Description	%Change Real GDP	Comprising old regions
1	Oceania	0.174	aus nzl xoc
2	chn	1.163	chn
3	hkg	0.053	hkg
4	jpn	0.478	jpn
5	kor	1.999	kor
6	twm	0.151	twm
7	xea	0.099	xea
8	idn	0.171	idn
9	mys	1.171	mys
10	phl	0.474	phl
11	sgp	0.035	sgp
12	tha	0.787	tha
13	vnm	3.179	vnm
14	xse	0.047	xse
15	bgd	0.795	bgd
16	ind	0.951	ind
17	lka	0.441	lka
18	xsa	0.565	xsa
19	NAFTA	0.023	can usa mex xna
20	CSAM	0.146	col per ven xap arg bra chl ury xsm xca xfa xcb
21	Europe	0.084	aut bel dnk fin fra deu gbr grc ita lux nld prt esp swe irl che xef xer alb bgr hrv cyp cze hun mlt pol rom svk svn est lva ltu
22	fsu	0.509	rus xsu
23	xme	0.213	tur xme
24	Africa	1.197	mar tun xnf bwa zaf xsc mwi moz tza zmb zwe xsd mdg uga xss

2.1 Using the aggregation scheme (AGG) file to make a map with given regions

Supplied with ShadeMap are various map boundary files showing the regions of different GTAP data releases. In particular, the file `gtmap6.MIF` divides the world into the 87 regions of the GTAP version 6 data used in our example.

We want to combine regions in `gtmap6.MIF` to make a map with the 24 regions of our simulation. The console (DOS-mode) program `AggMap` will do this job. `AggMap` requires an original map boundary (MIF) file, and a text file specifying the new regions and their relation to the original regions.

`AggMap` accepts two different formats for this text file. For GTAP purposes the most convenient format is the AGG format, used or produced by `GTAPAgg` (or `FlexAgg`) during aggregation of the GTAP database. Usually, you will already have such a file, with the suffix `AGG`.

For our example, we have the file `MySim.Agg` made by `GTAPAgg` when it produced the aggregated database underlying our simulation.

It is simplest to copy the `AGG` file into the `ShadeMap` folder where `AggMap.EXE` and `gtmap6.MIF` are located. Then open a DOS box in that folder, and type¹:

```
AggMap gtmap6 MySim /G
```

This produces new map files `MySim.MIF`, `MySim.MID`, and `MySim.OPT` which divide the world into 24 regions. Still in the DOS box, type:

¹ You could equally type "`AggMap gtmap6 MySim /GR`". The extra "R" at the end would cause the original boundaries between merged countries to remain visible.

ShadeMap MySim

to look at the aggregated map².



Figure 1: Initial view of 24-region map

2.2 Colouring the map to reflect simulation results

We assume ShadeMap is still open showing the MySim map.

To colour the map according to the GDP results of Table 1 above, open the file MySim.XLS, and select the 24 GDP changes in column J. Copy the selection to the clipboard. Then return to ShadeMap and use the **Scores** menu to **Paste scores from clipboard**.

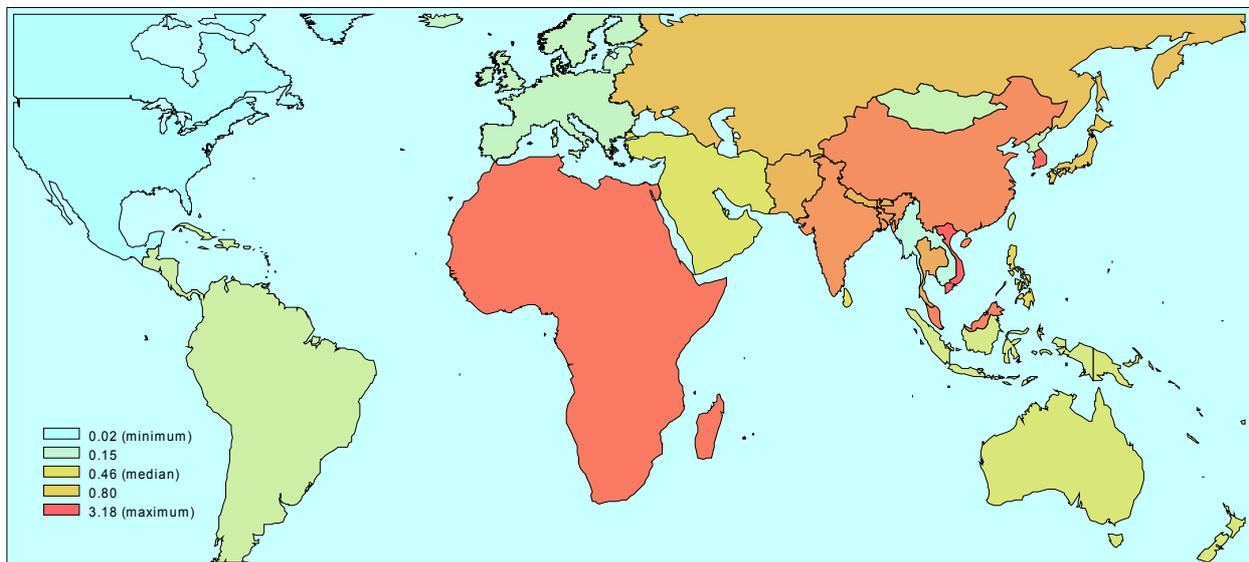


Figure 2: After pasting in the GDP Results: ordinal colouring

2.3 How the colouring works

ShadeMap can fill regions with colours, or shades of grey. Humans can distinguish hundreds of colours, but only about 20 shades of grey. Hence coloured maps convey more information. The trouble is, there is no standard way to represent a range of values by colours. Each discipline or

² You might notice that even AggMap cannot fully unite Canada and USA! The reason is explained at the end of this document.

application has its own ways³. Colour is naturally represented in three dimensions⁴ -- a colour scale is two-dimensional.

ShadeMap offers a default method which gives reasonable results. Three reference colours are used:

- the lowest scoring region is coloured with the **low** colour (by default, light blue)
- the median scoring region is coloured with the **middle** colour (by default, warm yellow)
- the highest scoring region is coloured with the **high** colour (by default, red)
- regions scoring between the minimum and the median are coloured by a weighted average of the **low** and **middle** colours.
- regions scoring between the median and the maximum are coloured by a weighted average of the **middle** and **high** colours.

In computing averages to interpolate colours, ShadeMap normally uses each region's rank (=1 for lowest scoring region, 2 for the next lowest), thus ensuring a fairly even spread of colours among the regions.

Low, **middle** and **high** colours can all be set in the Options dialog (along with many other options).

2.4 Adjusting the map's appearance

The **Shade regions according to rank** option (which is checked by default) causes ShadeMap to generate colours for regions according to their position in the scores ranking (rather than from the actual raw scores). This will make most difference if some of the region scores are outliers.

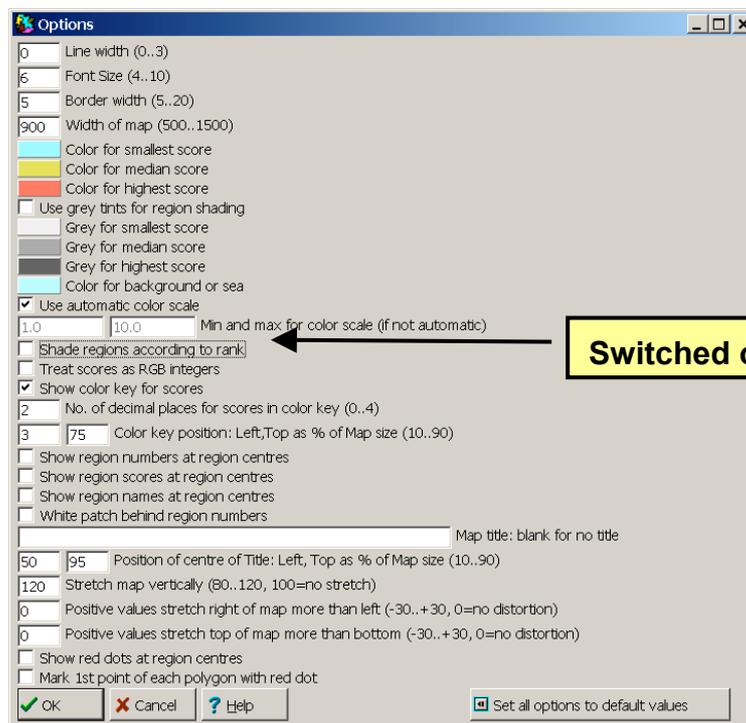


Figure 3: The Options dialog

³ For example, the Roche scale is a standard colour scale used in the salmon industry to measure the pinkness of salmon, ranging from 11 (very light pink) to 18 (very dark pink). The Hagen Colour Index (HCI) is a standard colour scale for double stars. And so on.

⁴ There are different ways to represent colour as a triple: RGB (red/green/blue), CMY (cyan/magenta/yellow) and HSV (hue/saturation/value) are the three best-known *colour models*.

In our case, Vietnam has achieved GDP growth nearly 3 times as great as the next most fortunate region. Shading by rank obscures this fact. We'll use the **Options** command to switch off this feature (see Figure 3). This leads to the map shown in Figure 4, which highlights Vietnam's outlier status. On the other hand, colour range for the other regions is compressed.

If you want to print out the map in black-and-white, select the **Use grey tints** option.

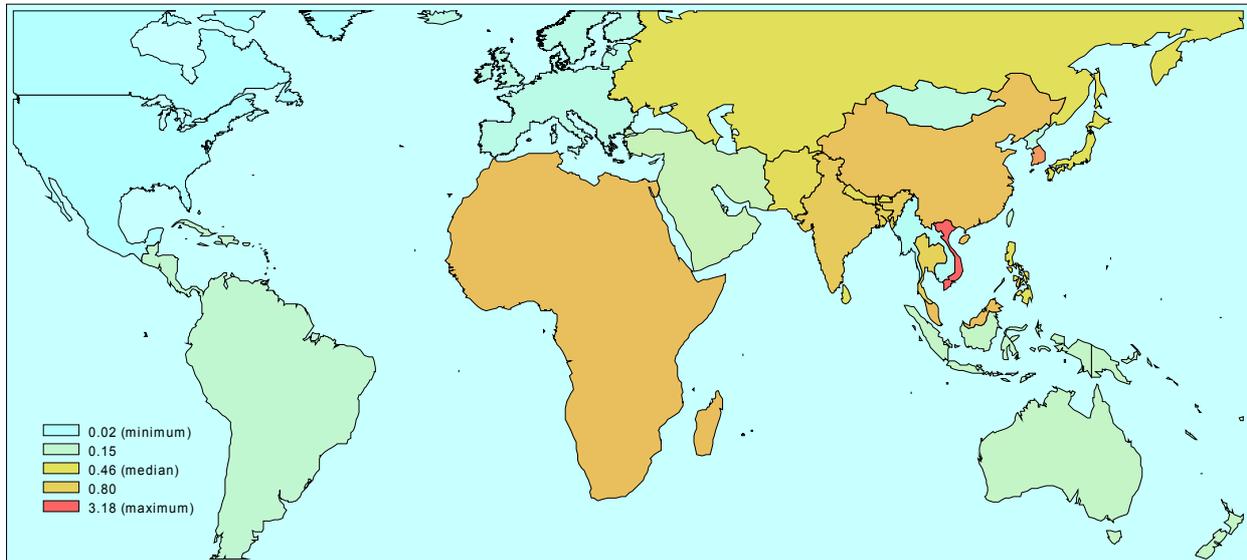


Figure 4: After adjustment: non-ordinal colouring

2.5 Exporting the map to another program

To export your map to another program, ShadeMap offers two choices (see Figure 5):

- you can place the map in the clipboard or in a file. The clipboard is quicker.
- the map can be copied/saved in metafile (EMF) or bitmap (BMP) format. EMF is a vector format which will be more compact and will survive scaling with less detail loss.

All four combinations will work if you are skilled at working with images. If you are not so skilled, it is likely that you will find one or two methods that work for you. Maps in this document were copied from ShadeMap to the clipboard in EMF format. In MsWord97 the **Paste Special..Metafile** command was used. Then I right-clicked the image, and opened the **Format Picture** dialog. From the Position tab, I switched OFF "Float over text", and from the Size tab I selected an 85% size reduction.

With other programs (even other versions of MsWord) the procedure might be different.

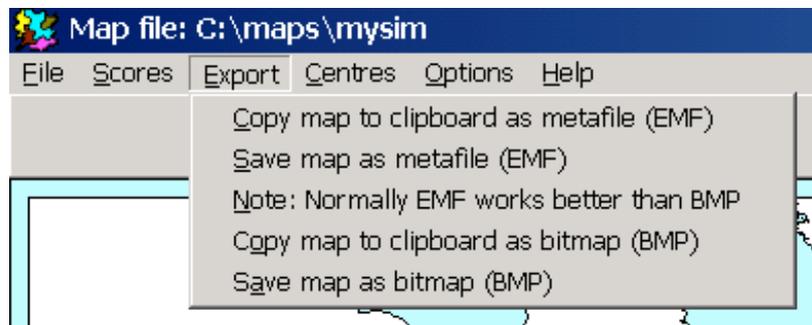


Figure 5: Options for exporting maps

2.5.1 Further map customizing

If you paste an EMF map into Word or Powerpoint, you can double-click on it, to edit it manually. It's easy to recolour or move regions, or to add arrows. However, be aware that the graphics editor built into MsOffice is rather elementary -- some would say 'alimentary'. For example, text might be

moved and fonts altered without warning. For maximum control, save the map as an EMF file, and edit it with a proper vector graphics editor⁵, then import it into your document or slideshow.

Detail will be preserved better if you paste a big map, then shrink it in Word, than if you use Word to enlarge a too-small map.

3 Advanced topics

3.1 Cropping the map

A defect of the map in Figure 4 is that the Asian countries which are the focus of our simulation seem too small. Ocean and non-Asian regions use up most map space. We'll crop the map to include only Asian regions.

Shademap's cropping facility is part of a hidden "Special" menu. To uncover the secret, choose Help...About/Diagnostics and click on the ShadeMap icon (see Figure 6 below). The Special menu should appear.

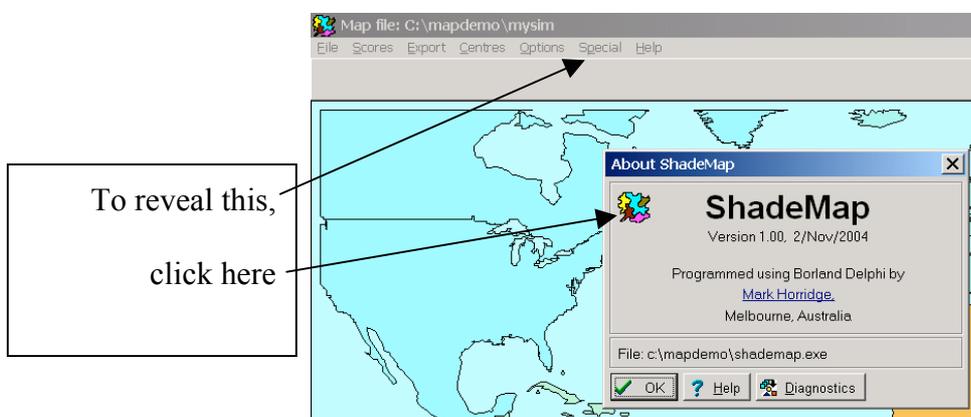


Figure 6: Activating the Special Menu

The Special menu is hidden because it is useful yet dangerous -- ShadeMap offers no "Undo" button. You can delete the most-recently-clicked region or polygon, or crop the map.



Figure 7: The Special menu

- **Crop Top Left** removes map areas **above** and to the **left** of where you last clicked.
- **Crop Bottom Right** removes map areas **below** and to the **right** of where you last clicked.

To produce the map below, click coordinates 67.3, 47.6 (in Central Asia) then crop **Top-Left**. Then click coordinates 146.1, -5.7 (in New Guinea) and crop **Bottom-Right**. Then use **Map Save As** to save the revised map with name Asia.MIF.

⁵ Adobe Illustrator or Canvas are two commercial vector graphics editors; Inkscape [<http://www.inkscape.org>] is free and open-source. All these products have a steep initial learning curve.

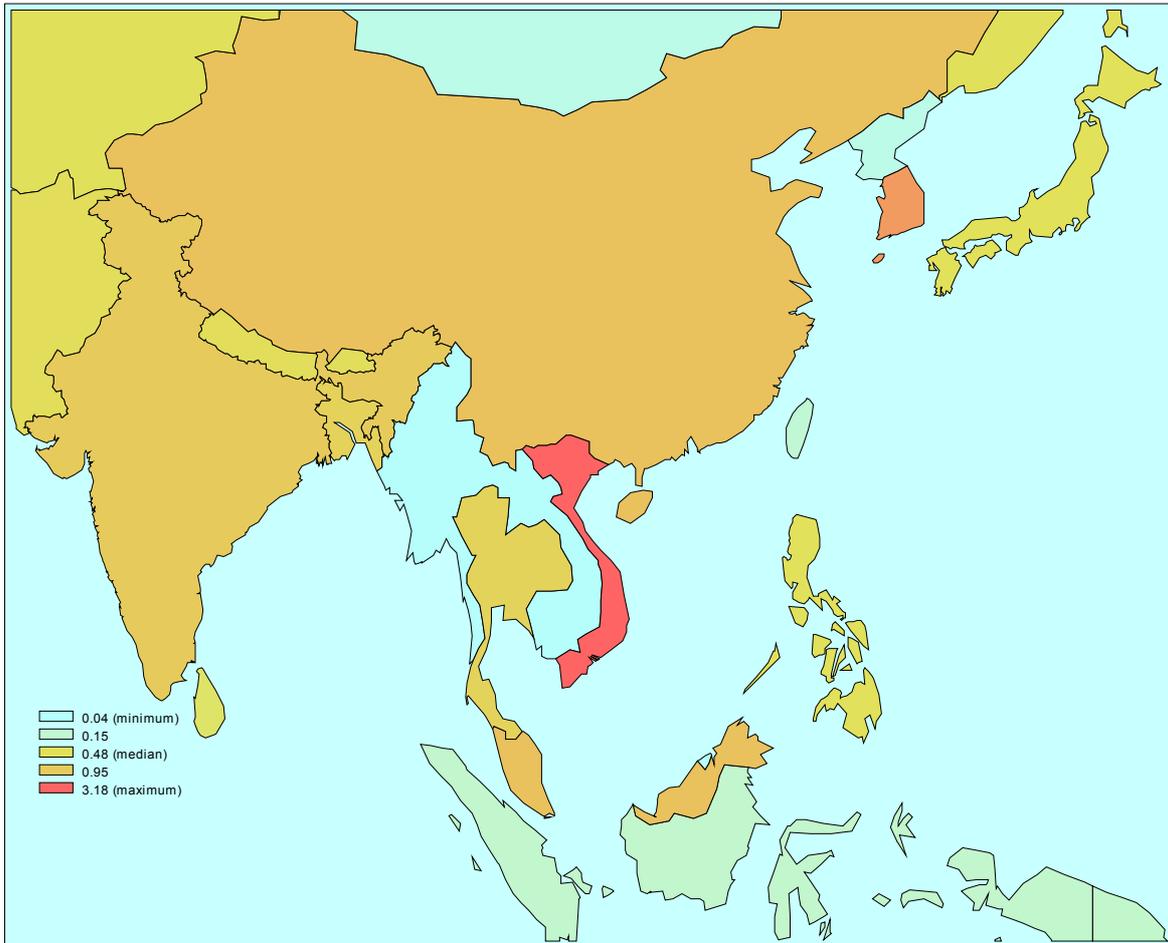


Figure 8: Cropped map with 19 Regions

Next, adjust some of the Options to improve map appearance (see Figure 9).

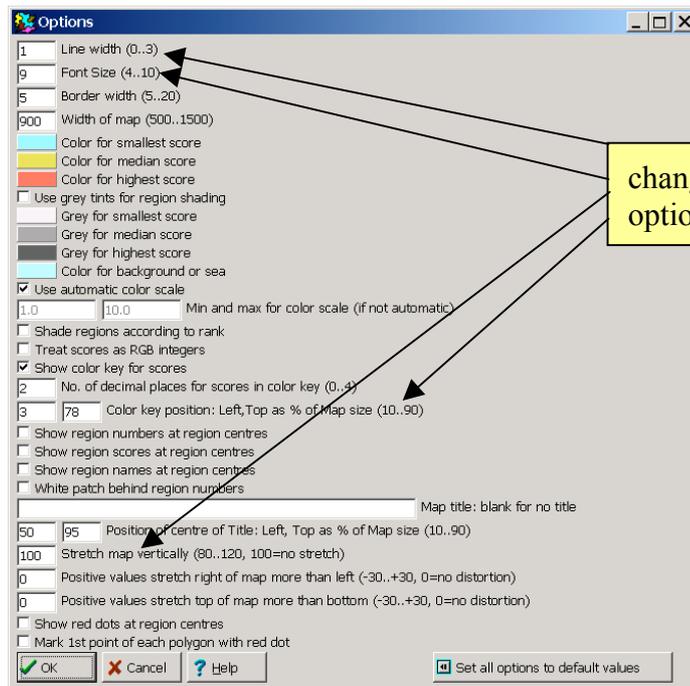


Figure 9: Adjust Options

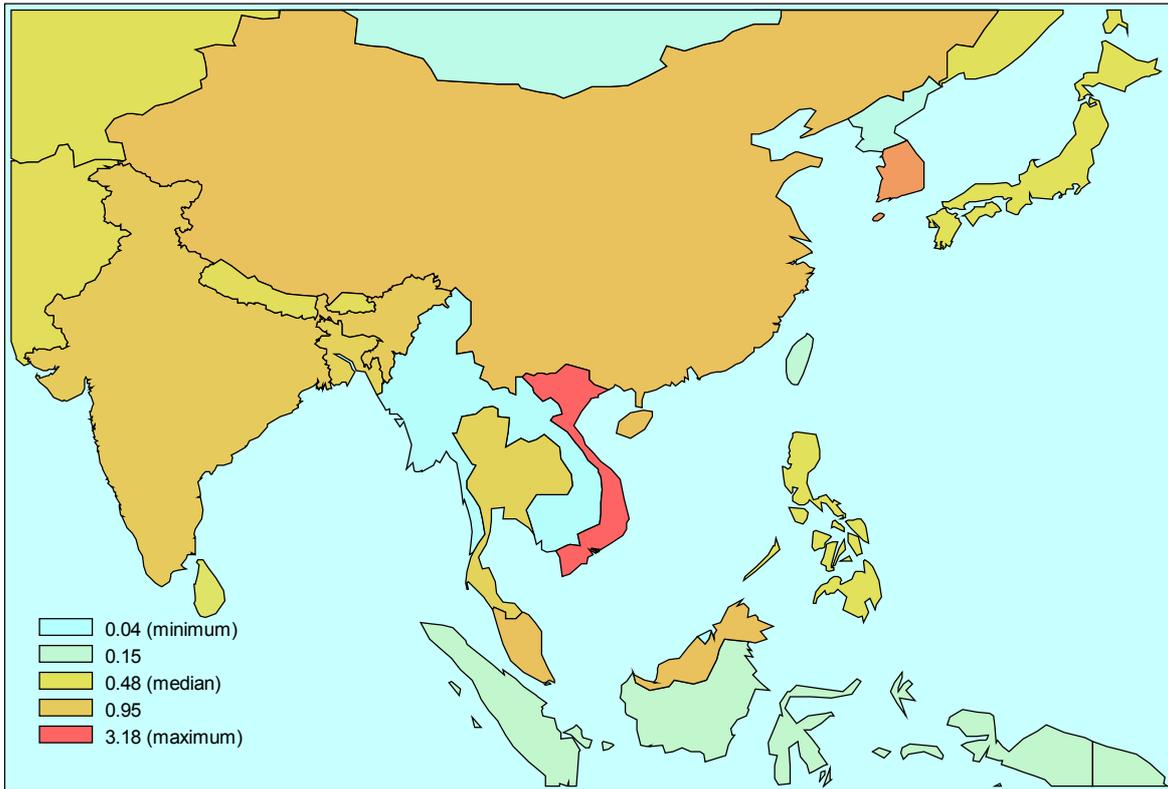


Figure 10: Effect of Adjusting Options

3.2 Labelling regions with scores

After cropping, regions are larger, so it becomes possible to label each region with its GDP result. To see this, from the Options menu, enable **Show region scores at region centres**.

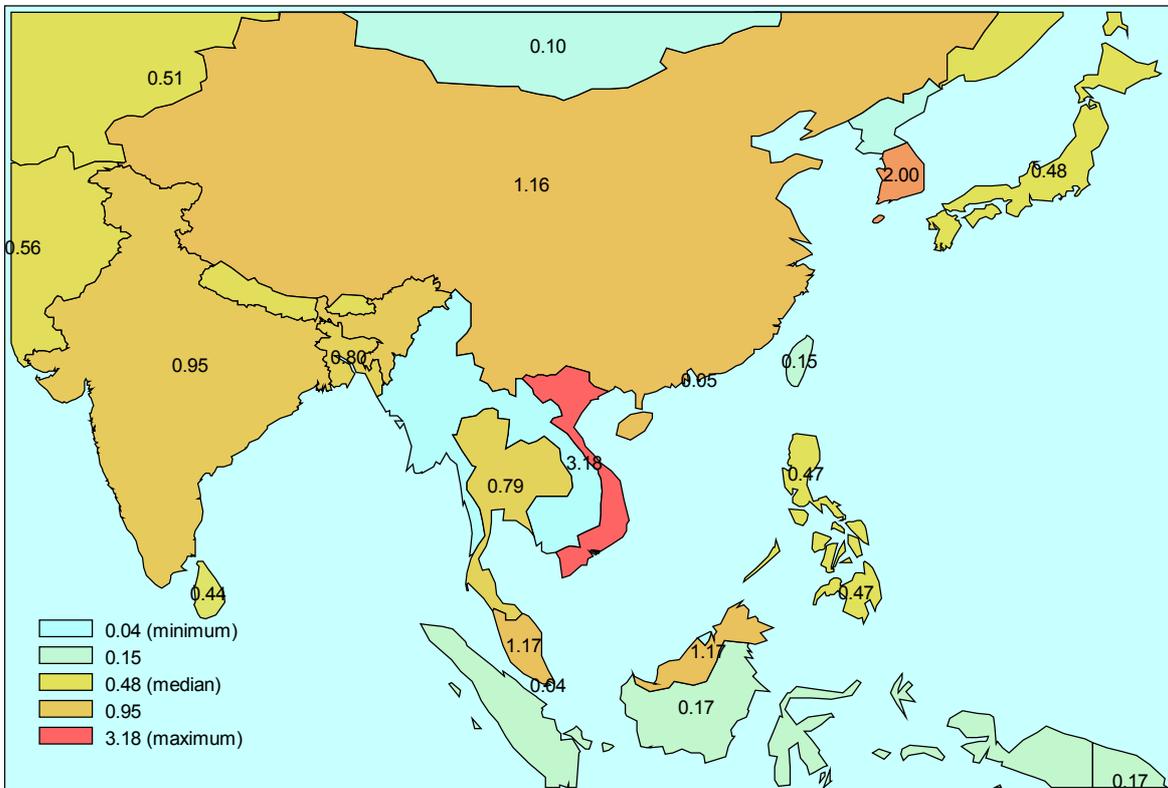


Figure 11: Scores showing, "centres" not adjusted

In ShadeMap jargon, the "centre" of each region is the spot where a label is shown. By default, the centres are positioned at region centroids⁶. As you can see above, the default positions are not always optimal. You can use the **Centres** command to **Enter Centre positioning mode**, then click on a region⁷ where you want its label to show. For small islands like Taiwan, click first on the island, then on the sea beside it⁸. When you have finished, **Exit Centre positioning mode** and save the new label positions in a CTR file (it will be named after the map).

You could also reduce the region label font size (in Options) to make scores fit into regions.

Figure 12 below shows the map with "centres" relocated. Also, the Options dialog was used to eliminate vertical stretch (setting = 100).

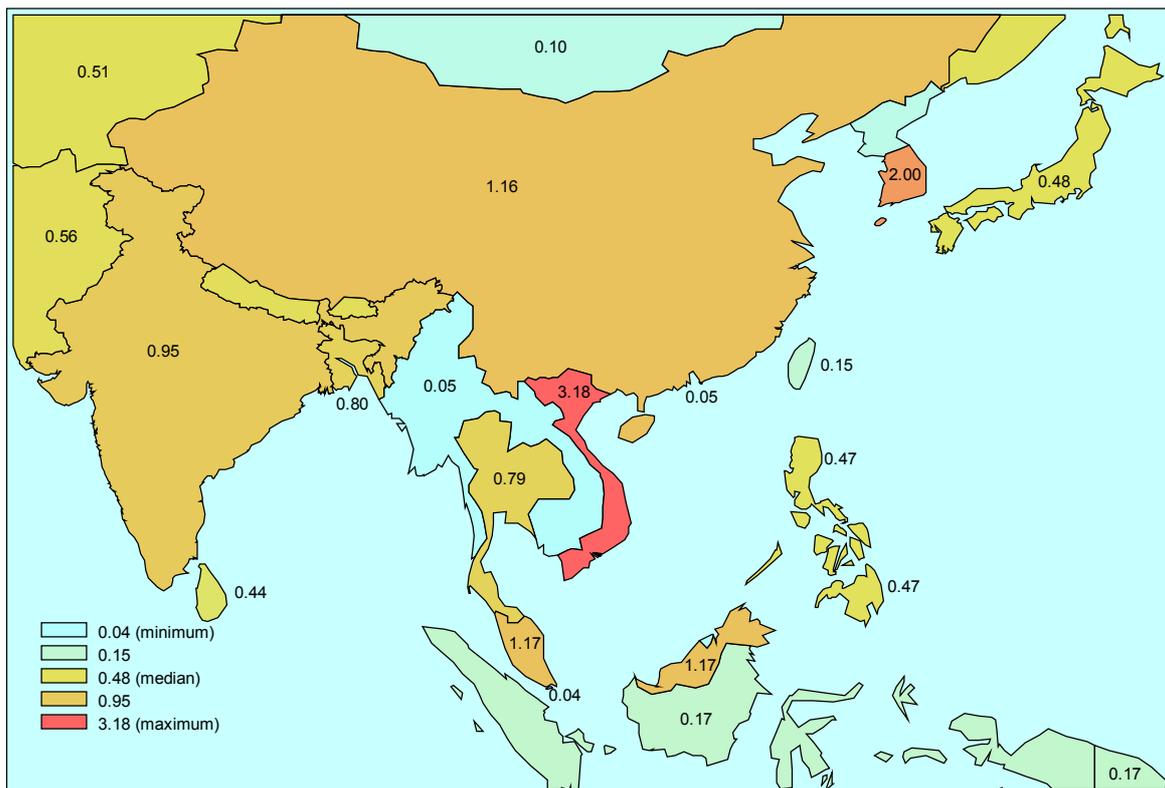


Figure 12: Scores showing, "centres" adjusted

3.2.1 With fewer regions, shorter scores vectors must be pasted in

After cropping the map there are only 19 regions instead of 24. Therefore, you cannot paste in the whole column of GDP results. To see the names and order of the new (cropped) regions use the **Scores...Copy region names/scores to clipboard** command to paste the new region names into Excel. If you want to import more results into the cropped map, you must construct a column of 19 numbers ordered in this way.

3.3 Distorting the map

In using maps to report statistics, a common problem is that important regions, such as Singapore or Washington, are too small to see, while boring regions, such as Greenland or Texas, occupy disproportionate space.

⁶ Strictly, at the centroids of polygons larger than 40% of total region area -- hence Philippines has 2 labels.

⁷ Some regions are so tiny, that they are hard to click on. The bottom panel tells if you clicked on a region or on the sea. I found it difficult to click on Singapore and Hong Kong -- so I used **Options** to display red dots (instead of scores) at region centres. Alternatively, edit the CTR file by hand.

⁸ For tiny regions surrounded by land, click first on the tiny region, then **right-click** on the surrounding region.

A **cartogram** is a map which has been distorted so that the area of each region is proportional to population (or GDP). Figure 6 compares two maps of the USA in which Republican states are coloured red and Democrat states are blue. The left-hand map suggests that most (by area) of the USA is Republican. The right-hand map, which replaces geographical area by population size, reminds us that the 2004 election was fairly close.

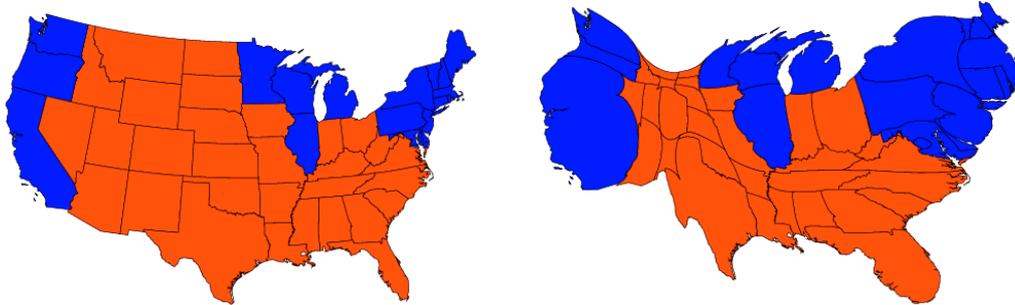


Figure 13: 2004 Election results: Normal-Sized (left) and Population-Sized (right) states⁹

Unfortunately, there is no general method of constructing cartograms¹⁰, and in practice hand tweaking is needed to produce a cartogram which is recognizable to most people. ShadeMap does **not** offer this facility. Instead ShadeMap allows you 2 ways to make smaller regions seem bigger:

- you can make the top half of the map seem bigger (or smaller).
- you can make the left half of the map seem bigger (or smaller).

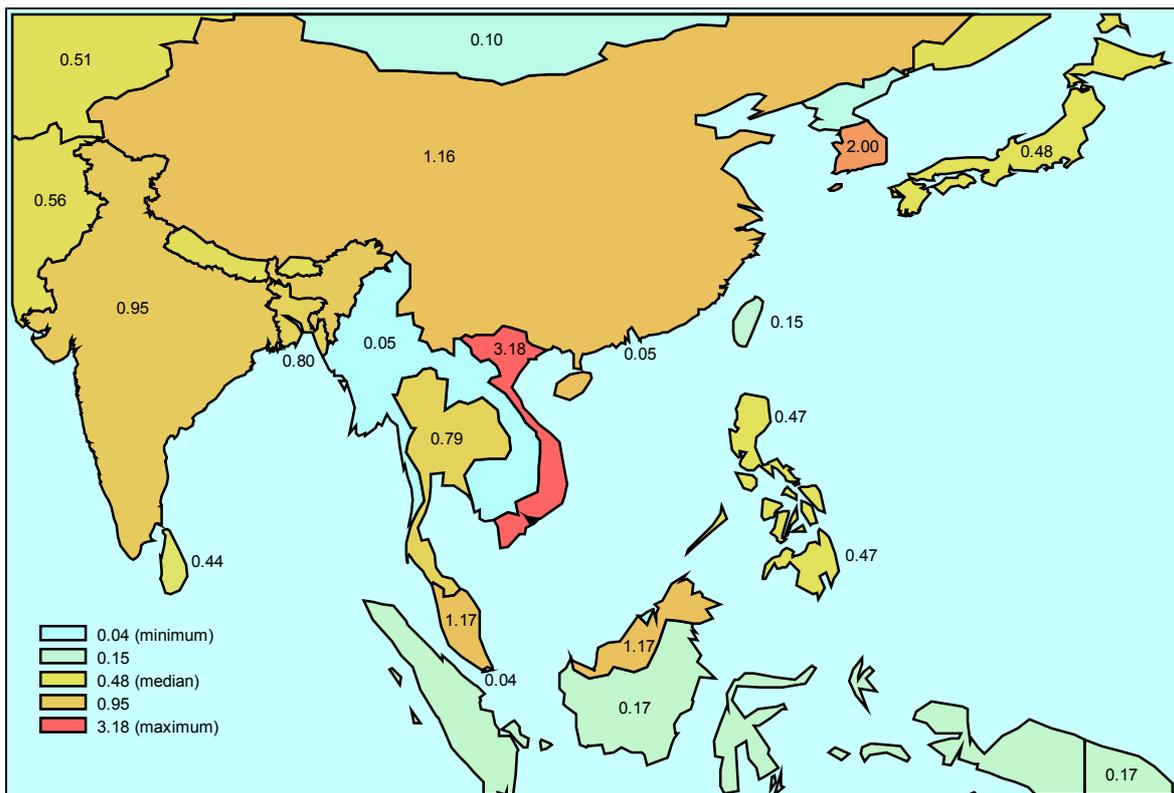


Figure 14: With 30,-30 distortion

In many cases, especially where too-small regions are clustered towards one corner of the map, these monotonic distortions of the X or Y axes are quite effective. Unfortunately, in our Asia map the smaller regions are mostly in the middle. Nevertheless, large regions dominate the left (India)

⁹ The election maps are by Gastner, Shalizi and Newman of the University of Michigan: see <http://www.cscs.umich.edu/~crshalizi/election/>

¹⁰ We can construct cases (small rich region surrounded by several desert regions) where region area cannot be made proportional to GDP without tearing regions.

and top (China) of the map. From the Options dialog we can apply a stretch of 30 to the right hand side and -30 to the top of the map -- giving rise to Figure 14 (the line thickness was also increased). The effect is to make Vietnam and Thailand somewhat bigger -- while the area of West Papua has doubled.

3.4 Making new base maps

For GTAP version 6, which distinguishes 87 regions, the ShadeMap package includes the base map `gtmap6.MIF`. If you used one of the `GTAPAgg` or `FlexAgg` programs with an `AGG` file to aggregate the GTAP 6 data, you can use the same `AGG` file to produce a map showing your aggregated regions, as described in Section 2.1 above.

From time to time GTAP releases a new database which may distinguish more regions. For example, there might in future be a GTAP database which distinguished 90 regions. The ShadeMap online help explains in detail how to produce a new base map which identifies any new regions added to the GTAP data. In brief, a 224 region world map, `globe.MIF`, is supplied which can be easily aggregated, using `AggMap`, to the current GTAP regions.

3.5 Consistent colouring between maps

Under ShadeMap's automatic colouring system, the lowest-scoring region is coloured with the assigned **low** colour and the highest-scoring region with the **high** colour. Although convenient, this system means that if you colour the same map with several different results vectors, the several resulting maps would be coloured using different schemes.

For example, suppose GDP results from three simulations were used to colour three maps, and suppose minimum and maximum GDP changes were different in all three simulations. Even if the GDP change for China were the same in all three cases, China would be coloured differently on the three maps. In general, you could compare colours *within* a map, but not *between* maps.

If colour uniformity between maps is important, you need to switch off "Use automatic colour scale" from the Options dialog. There, you have to specify your own fixed minimum and maximum values. For the example just mentioned, the minimum value should be set to the minimum GDP change of any region in all three simulations, and the maximum value should be set to the biggest GDP change of any region in any simulation. You should also switch off "Shade regions according to rank".

You could now paste in the three GDP results vectors to produce 3 maps coloured in the same way.

3.6 The ShadeMap drawing model

A little understanding of how ShadeMap works might help you work with it, especially if you alter an EMF map in a graphics editor.

Each region in ShadeMap consists of one or more simple closed curves called polygons. Points in each polygon are enumerated clockwise. Thus the border between two regions actually consists of two coincident curves running in opposite directions. To draw the map, ShadeMap first paints the whole area in the background (sea) colour. Then the regions are successively (biggest first) drawn on top. Since ShadeMap does not allow regions to be doughnut-shaped, lakes or seas entirely surrounded by one region are not shown. A small region entirely surrounded by a larger is drawn on top of (rather than within) its surrounding neighbour.

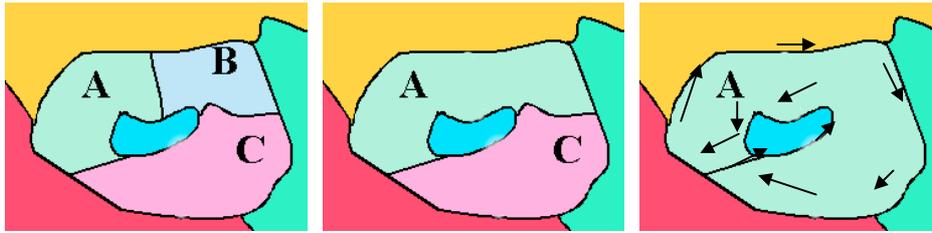


Figure 15: Effect of merging A with B, then A with C

To merge regions AggMap first regroups polygons into aggregated regions. Hence Europe, initially consisting of many one-polygon regions, becomes one many-polygon region. Next AggMap seeks to erase borders common to different polygons in the same region. For example Figure 15 shows how polygon A is merged with B, and then with C. Because of the lake between A, B and C, the merging leaves a small A-A border to the left of the lake (see the right-hand diagram, which also shows the direction of the final polygon A). Conceivably the program could be made to erase borders of one polygon with itself -- but that would cause the lake to vanish, since each polygon must be simple (not a doughnut). To avoid alarming disappearance of large seas (such as the Red, Black, Baltic or Caspian) AggMap does not erase borders between different parts of the same polygon.

Another problem with merging is that the boundaries of neighbouring regions are not always coincident. Recall that the Canada-USA border should consist of two curves (Canada's perimeter and USA's perimeter) that coincide for parts of their length. However, due to slight inaccuracies in the MIF boundary coordinates, the two curves may **not** coincide. There might be small areas of no-man's land between regions, or contested areas. In such cases AggMap may not detect that two polygons share a border. Reasons such as these explain why, in Figure 1, Canada and USA are represented by separate polygons within the same region.

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