

Using Mathematics: Making Big Economics Visible to the Human Eye

LSESU Applicable Mathematics Society and LSE Mathematics Department

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09 December 2015

OUTLINE

1. Is Empirical Analysis Only Econometrics and Calibration?
2. Cross-Over Questions
3. Illustrations
4. Conclusion

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**There are more people living inside
this circle than outside of it.**

“This is completely wrong of course...”

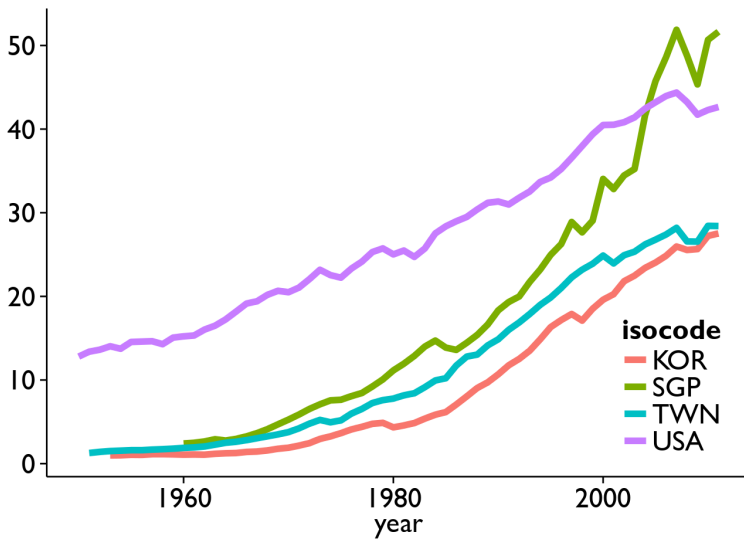
“Yes, we realize this is a compromise projection (a Winkel Tripel projection, to be exact) and that the ‘circle’ in this image is not actually a circle, but that’s beside the point. What’s truly noteworthy about this visualization is how clearly and effectively it conveys an astonishing truth about the world. More to the point: the design concept is so straightforward, a 5-year-old can wrap her head around its meaning; and yet the ideas and discussions it engenders—about population density, about government, about political ideologies, about the expansion of human populations—are effectively limitless.”

(R. Gonzalez, 2013)

Calibration and Applied Econometrics

1. Models — DSGE or otherwise
2. Causality
3. Big Data

Are these the only possible lines of attack for every interesting empirical question in economics?



April 30, 2014 1:01 am

China poised to pass US as world's leading economic power this year

By Chris Giles, Economics Editor

[Author alerts](#) ▾

The US is on the brink of losing its status as the world's largest economy, and is likely to slip behind [China](#) this year, sooner than widely anticipated, according to the world's leading statistical agencies.

The US has been the global leader since overtaking the UK in 1872. Most economists previously thought China would pull ahead in 2019.



“This is a disaster.”

“China’s rise directly challenges America. Competition between the two is inevitable. Just as America dominates the Western Hemisphere, China will aim to dominate Asia, and America and China will each seek to contain the other. As China continues its ascent, the likelihood of war with America only ever grows.”

Great Power Politics

“... if China continued its ascent, it would build formidable military forces and try to dominate Asia the way the US dominates the Western Hemisphere. Becoming a regional hegemon ... is the best way for a country to maximize its prospect for survival.”

(John Mearsheimer, 2014)

“China’s quest to enhance its world leadership status and America’s effort to maintain its present position is a zero-sum game. It is the battle for people’s hearts and minds that will determine who eventually prevails.”

(Xuetong Yan, 2011)

International Financial Architecture

“China’s leaders talk of the yuan’s internationalisation in peaceful terms. A more diverse monetary system will breed financial stability for the world, they say. But China’s rise poses a bigger threat to America than America’s did to Britain. For all the paeans to mutually beneficial development, China is a possible adversary, governed by an autocratic regime with a statist approach to the economy.”

(*The Economist*, 01 August 2015)

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Selected Questions

1. World Order: The Distribution of Power, and the Relations Across Nation States
2. Power and Legitimacy
3. Demand and Supply: Constrained Optimization for Ordering the World
4. Democracy as a Fundamental Theorem?
5. Ants

A Rational World Order

The dominant force:

- **needs** the ability to order the international system;
 - **should** design world order for good.
1. Globalized, inter-connected world economy
 2. Global Public Goods. Externalities
 3. Maximize world well-being U by allocating consumption C across the world, subject to
 - 3.1 Inter-connections \mathcal{I} ; and
 - 3.2 Resource constraints \mathcal{R} ; while
 - 3.3 Internalizing externalities \mathcal{X} , to serve up Global Public Goods G .

In other words, solve:

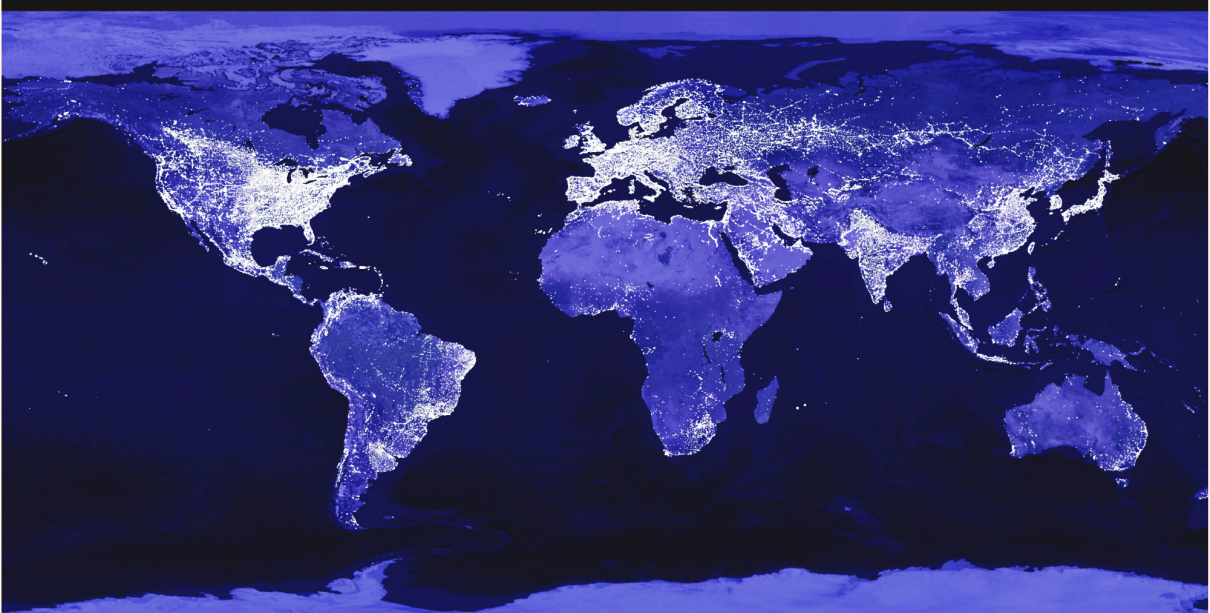
$$\text{Program } \mathfrak{M} \quad \begin{cases} \max_{C, G} & U(C, G) \\ \text{s.t. } & \mathcal{I}, \mathcal{R}, \text{ and } \mathcal{X}. \end{cases}$$

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1. Is Empirical Analysis Only Econometrics and Calibration?
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Selected Examples

1. World Economic Centre of Gravity
2. The Planet as a Spatial Distribution: World Population Clusters
3. Directional Trade: Global Exchange as a Vector Field



Source: DMSP data courtesy Marc Imhoff of NASA GSFC and Christopher Elvidge of NOAA NGDC. Image by Craig Mayhew and Robert Simmon, NASA Earth Observatory.

The world's economic centre of gravity: 1980-2050

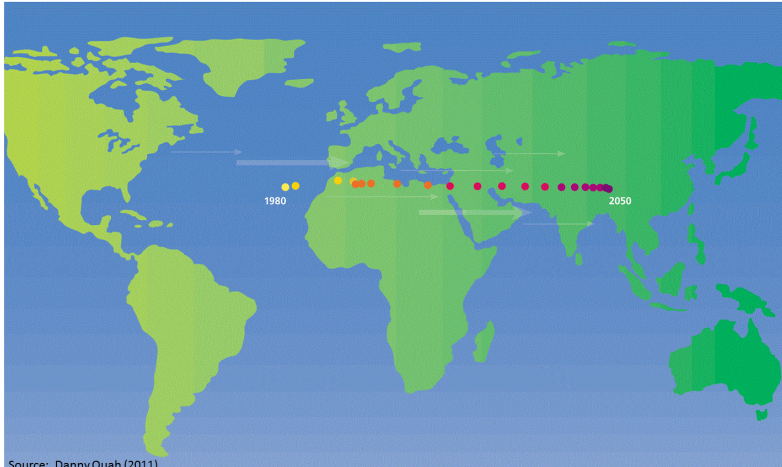
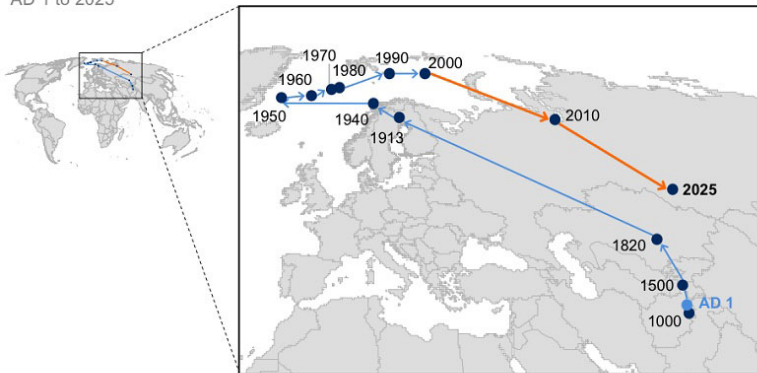


Exhibit 3

By far the most rapid shift in the world's economic center of gravity happened in 2000–10, reversing previous decades of development

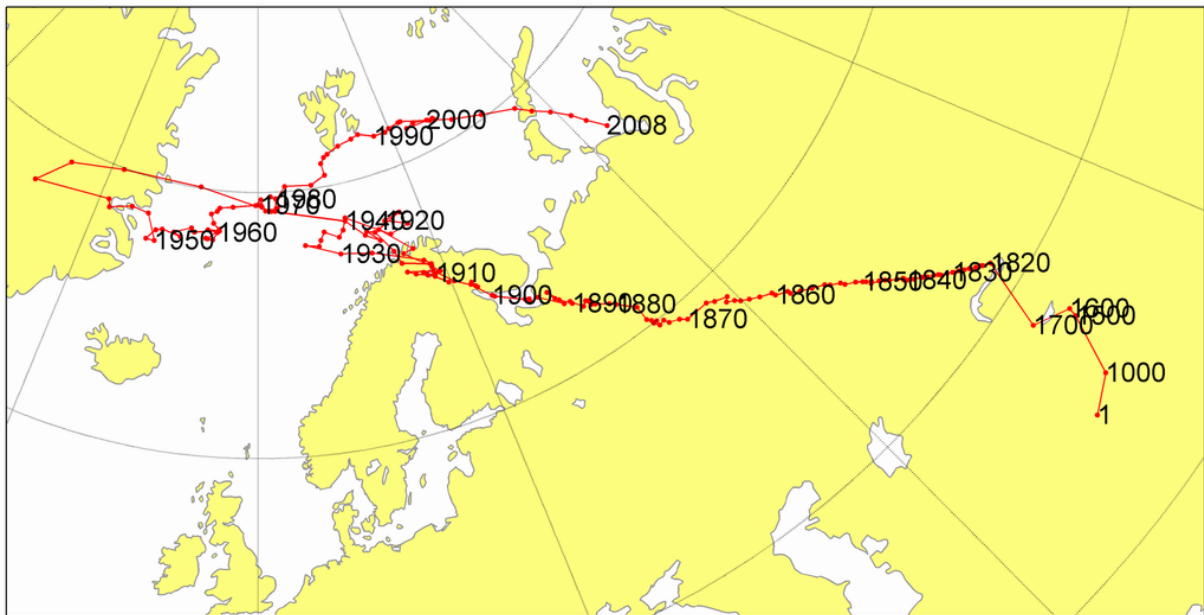
Evolution of the earth's economic center of gravity¹

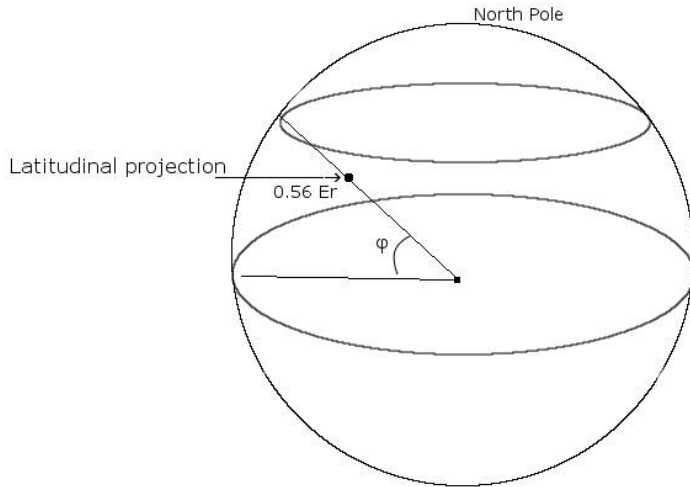
AD 1 to 2025



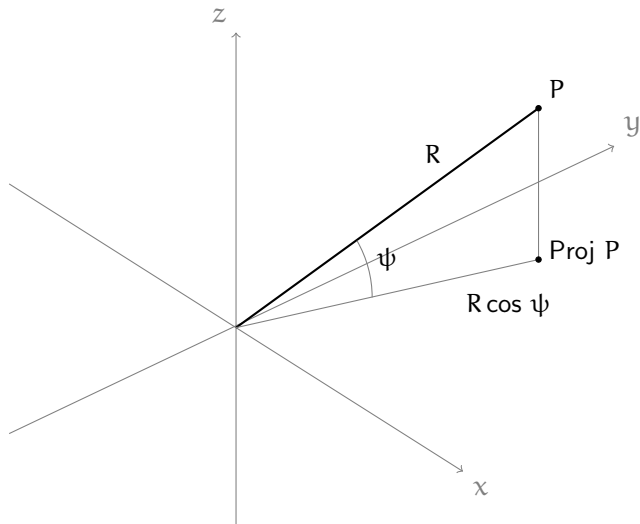
¹ Economic center of gravity is calculated by weighting locations by GDP in three dimensions and projected to the nearest point on the earth's surface. The surface projection of the center of gravity shifts north over the course of the century, reflecting the fact that in three-dimensional space America and Asia are not only "next" to each other, but also "across" from each other.

SOURCE: McKinsey Global Institute analysis using data from Angus Maddison; University of Groningen

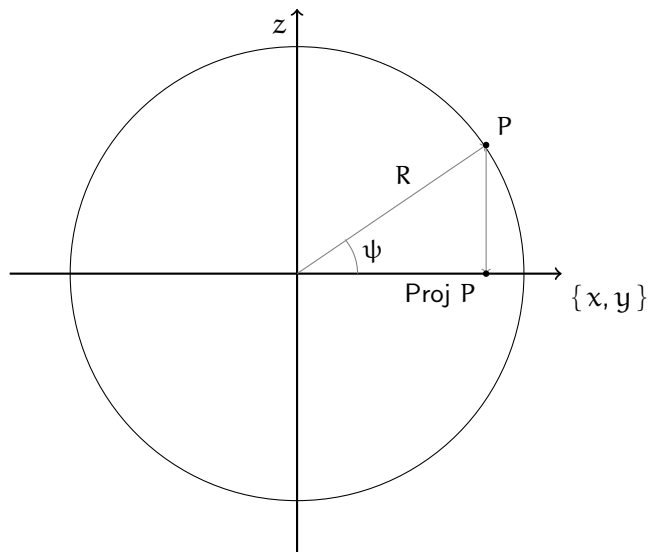




Mapping the 3D Globe



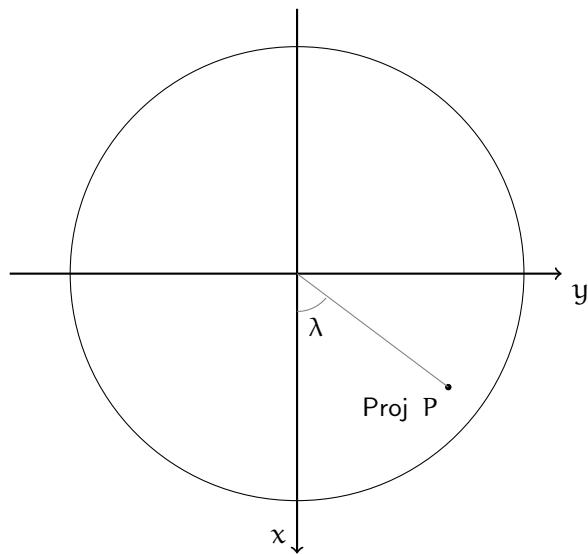
Mapping the 3D Globe — Head-on at the Equator



Latitude ψ

$$|\text{Proj } P| = R \cos \psi$$

Mapping the 3D Globe — From the North Pole

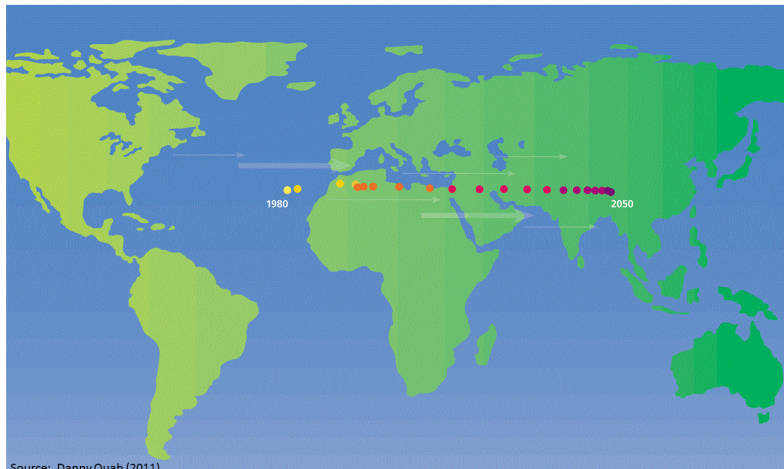


Longitude λ

$$x = |\text{Proj } P| \cos \lambda$$

$$y = |\text{Proj } P| \sin \lambda$$

The world's economic centre of gravity: 1980-2050



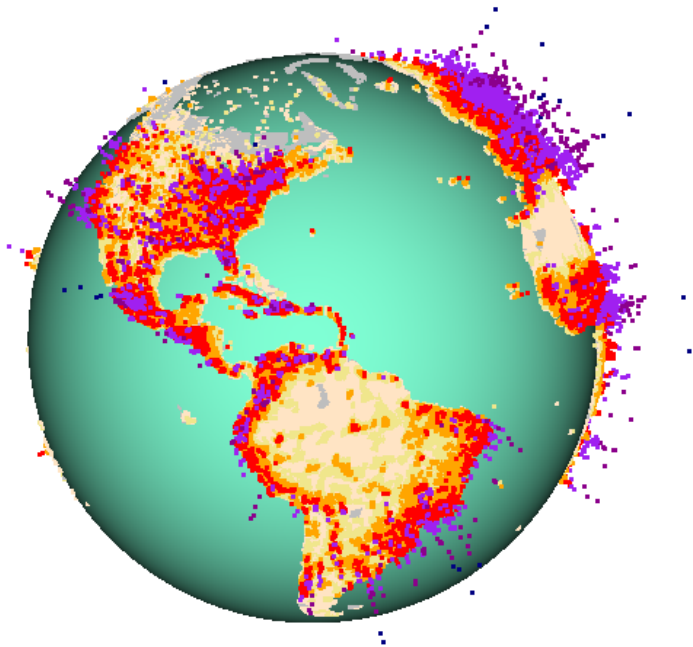
Source: Danny Quah (2011)

Selected Examples

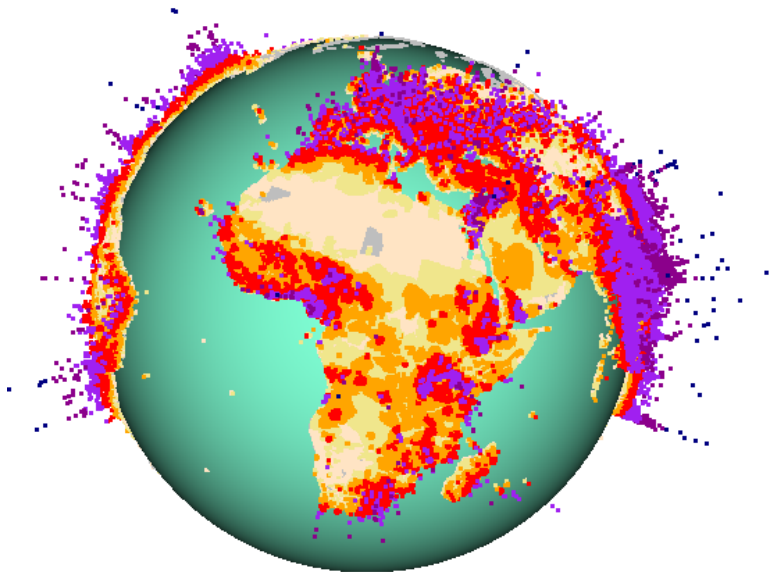
1. World Economic Centre of Gravity
2. The Planet as a Spatial Distribution: World Population Clusters
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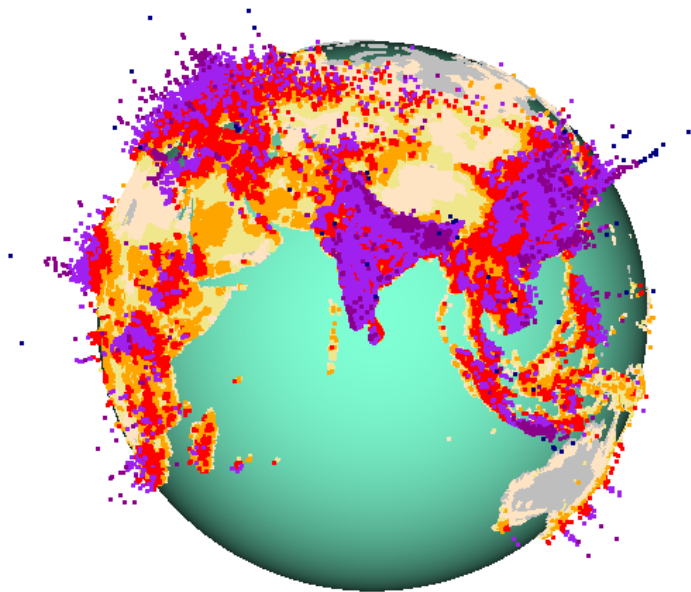
**There are more people living inside
this circle than outside of it.**



World Population (America view). Author's calculations from SEDAC Population by 100 sq km.



World Population (Africa view). Author's calculations from SEDAC Population by 100 sq km.



World Population (Asia view). Author's calculations from SEDAC Population by 100 sq km.

Tight Clusters

$\omega \in \Omega$	Locations on Earth's surface
$d(\omega, \omega') \geq 0$	Orthodromic / Great Circle distance
$\Gamma(\omega, r)$	Disk centred at ω with orthodromic radii
	$r \leq \bar{r}$
$\mu(\Gamma)$	Measure for population (or GDP, carbon emission, ...)

Tightest Clusters

Holding measure μ invariant:

- Monaco or Shanghai or Singapore or Mexico City?
- Simple majority $\mu(\Omega)/2$ or more generally $\mu(\Omega) \times \alpha$, for $\alpha \in (0, 1)$
- Seek (ω^*, r^*) such that

$$\max_{\omega \in \Omega} \mu(\Gamma(\omega, r)) \geq \mu(\Omega)/2 \implies r \geq r^*.$$

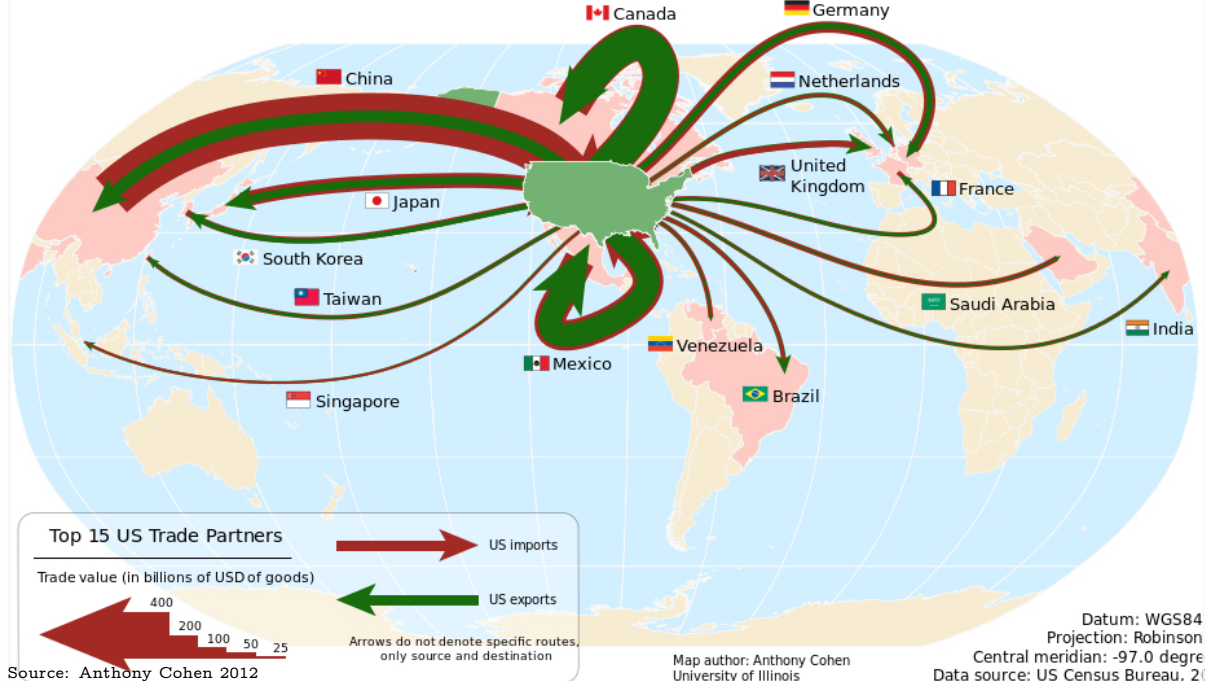
1. Discontinuous
2. Calculation



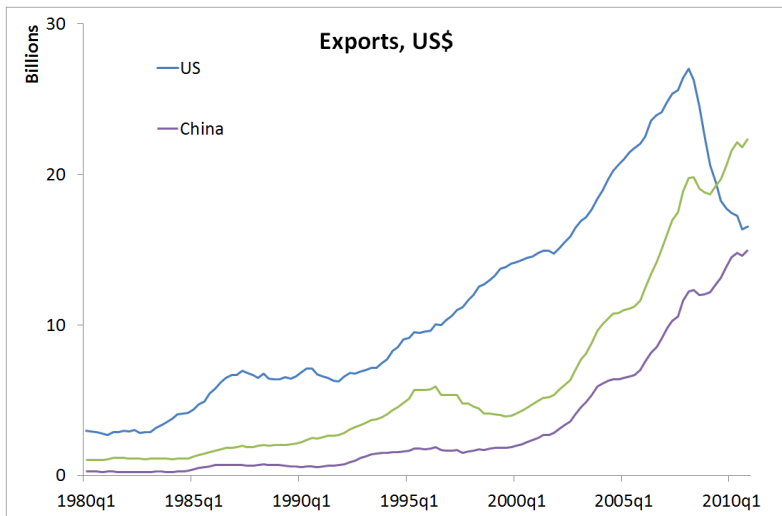
Shan State, eastern Myanmar; 3300km. Source: D. Quah (2015). Ordering the World: Truth to Power.

Selected Examples

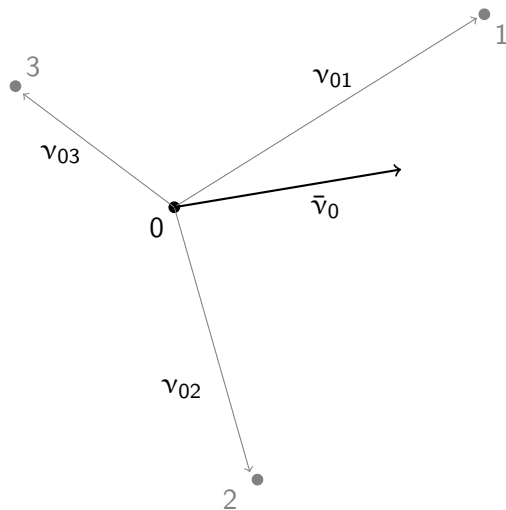
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Germany



The Average Direction of Exports



The direction of exports is the weighted average of the vector direction of exports from a given port 0 to all others 1, 2, 3, ...

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1. The Ink/Impact Ratio: Calibration. Causality.
2. Cross-Over Questions: Global Power Shift
3. WECG. Spatial Distribution. Directional Trade and Vector Field

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