UNIVERSITY OF OXFORD

OXCARRE
OXFORD CENTRE FOR THE ANALYSIS OF RESOURCE RICH ECONOMIES

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

NATURAL ASSETS:
SURFING A WAVE OF ECONOMIC DEVELOPMENT

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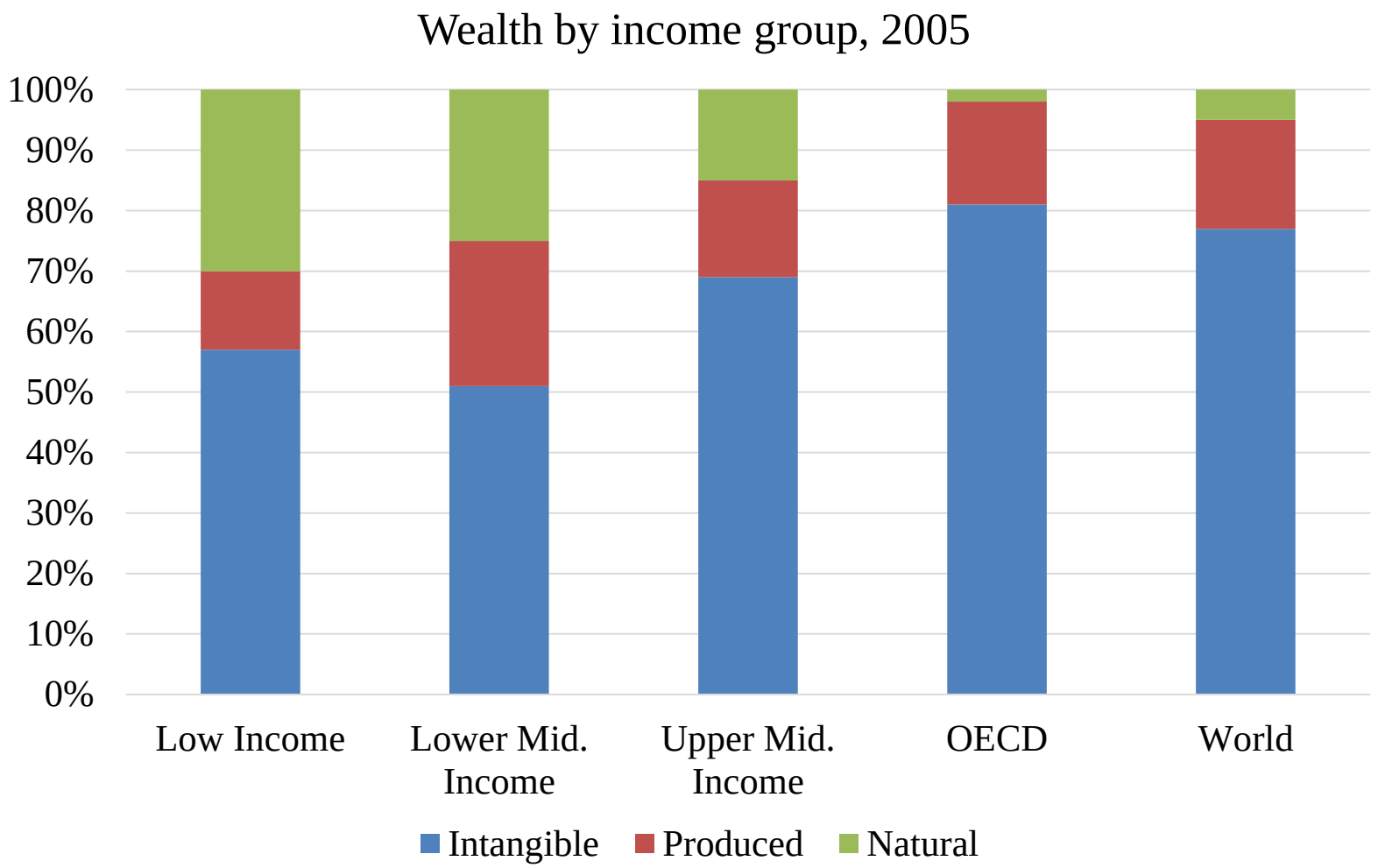
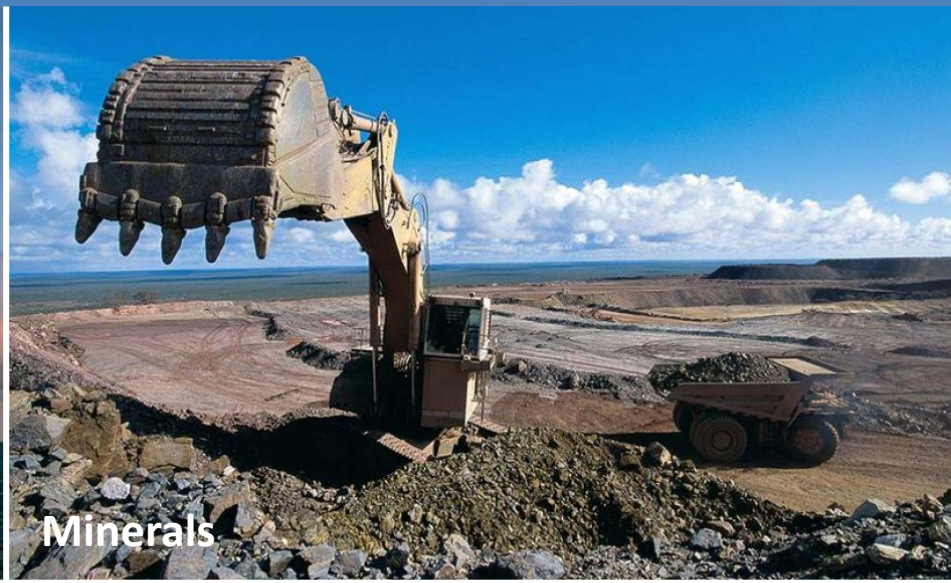
What is the value of the environment?

Natural assets are an important part of the world's capital stock, comprising 5% of global capital, and 30% in developing countries



Source: World Bank, 2005

Existing valuations of natural assets, including those used by the World Bank, focus on “market assets”



But what about other natural assets?

Bells Beach, Australia

This paper uses three natural experiments to value a particular natural asset through its effect on the local economy: surfing waves

Experiment I (Main result)

Do good waves contribute more to the local economy than bad waves?

- Exogenous spatial variation in wave quality
- Marginal contribution of good vs bad waves
- Lights proxy economic activity: 1km2
- Macroeconomic spill-overs – unlike other valuation methods

Experiment II

What happens when a new wave is discovered?

- Exogenous event study
- Wave discovery from "Surfer Magazine Google Earth Challenge" and "Rip Curl Pro Search" events

Experiment III

What happens when the surf is big?

- Exogenous temporal variation in wave size/quality
- Change in light growth for a given wave
- Use wave height anomaly and El Nino events

Why surfing? There are 35 million surfers in the world, typically from developed countries. This is set to grow as Brazil/Indonesia develop.

Pipeline Masters, Hawaii

Good, uncrowded waves are so rare that surfers are very willing to travel to them, or even to create their own.

11-time world champion Kelly Slater excited as a little kid…

We find good waves boost economic growth by over 1% p.a: amounting to $22 million per wave or $51 billion globally; and reduce poverty.

Mechanisms

- Waves with mass appeal (4/5 star) have biggest effect
- New lights, rather than redistribution
  - However, tourists displace permanent population
- New activity concentrated in existing towns/cities

Developing Countries

- Surfing has largest effect in emerging markets with adequate business and political stability
- Surfing can reduce extreme rural poverty
  - Poor move to jobs, not vice versa

Robustness

- Same for different coastlines
  - Eg. rivermouth, reefs, headlands
- Robust to alternative baselines
- Big new discoveries increase light growth by 3%pa
- El Nino events increase light growth by 3.5x, even more for 5-star waves

Experiment I (Main result)

Experiment II

Experiment III

This extends the literature on the local effects of natural assets by isolating indirect, macro-economic spillovers

Local effects of oil and mineral assets:

- Positive local spillovers: Peru: Aragon + Rud (2013); Brazil: Caselli + Michaels (2013)
- Negative environmental effects: Ghana, Aragon + Rud (2015)
- Violence: Caselli et al. (2015); Dube + Vargas (2013)
- Local Dutch disease: Cust (2014)
- Reviews: Cust + Poelhekk (2015); van der Ploeg + Poelhekke (2016)
- Surfing only generates spillovers, no direct revenue effects

Local effects of other assets:

- Bilbao Guggenheim: Plaza (2000, 2006). ~€20m public revenue. ~10% ROI
- Olympics: Trade 30% higher, Rose + Speigel (2009); review by Kasimati (2003)
- UNESCO: China: Yang, Lin, Han (2010); Cellini (2011)

We also extend the literature on valuing non-market natural assets, by including macro-economic spillovers

Non-market valuation

- Stated preferences (Freeman, 1993; Kopp and Smith, 1993)
  - Contingent valuation. Bias is an issue.
- Revealed preferences
  - Travel costs: Mavericks, California: Coffman and Burnett (2009)
  - Hedonic pricing: housing in Santa Cruz, California: Scorse et al. (2015)

Policy

- System of Economic and Environmental Accounting (UN, 2014). Market or near market assets
- World Bank: excludes most non-market assets due to lack of data (Jarvis et al, 2011)

Geographic determinants of economic activity

- Lights: Doll et al. (2006), Henderson et al. (2012), Michalopoulos and Papaioannou (2014)
- Mexican beaches: Faber and Gaubert (2015)

We hope this is a bit of fun, but with a serious point. Conserving the environment can help reduce poverty.

Outline

1. Identification
2. Data
3. Methodology
4. Results
5. Robustness

Experiment I

Experiment II

Experiment III

Experiment I

Do good waves contribute more to the local economy than bad waves?

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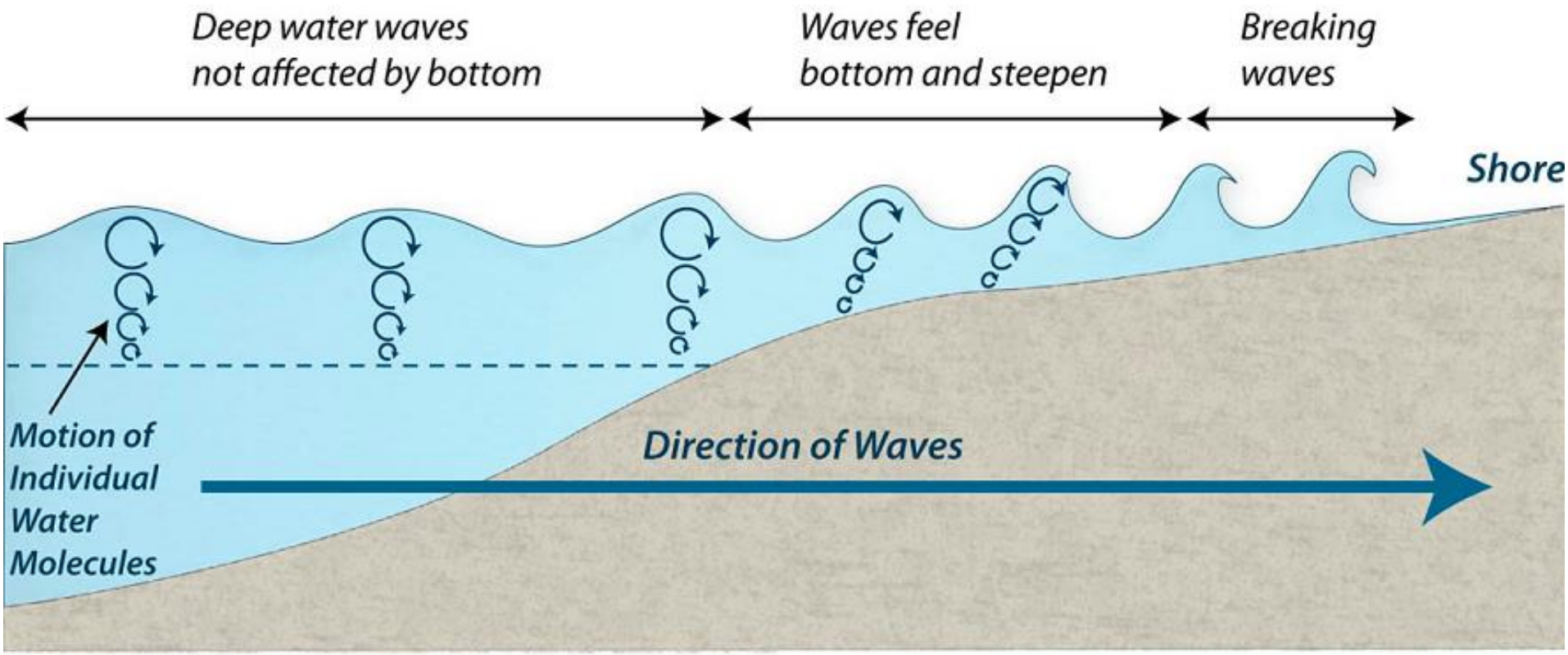
There are two major challenges when identifying the economic return to a natural asset, which we address using an experiment

Challenge	Response	Issues
Reverse Causality	• Wave location and quality is exogenous to economic activity	• Selection of low quality waves near cities into database
Omitted Variables	• Wave quality depends on a unique balance of many factors	• Some factors may affect the economy by other channels (eg rivermouths, reefs, ports, etc).

We argue that waves provide a good natural experiment, and test for robustness to potential issues

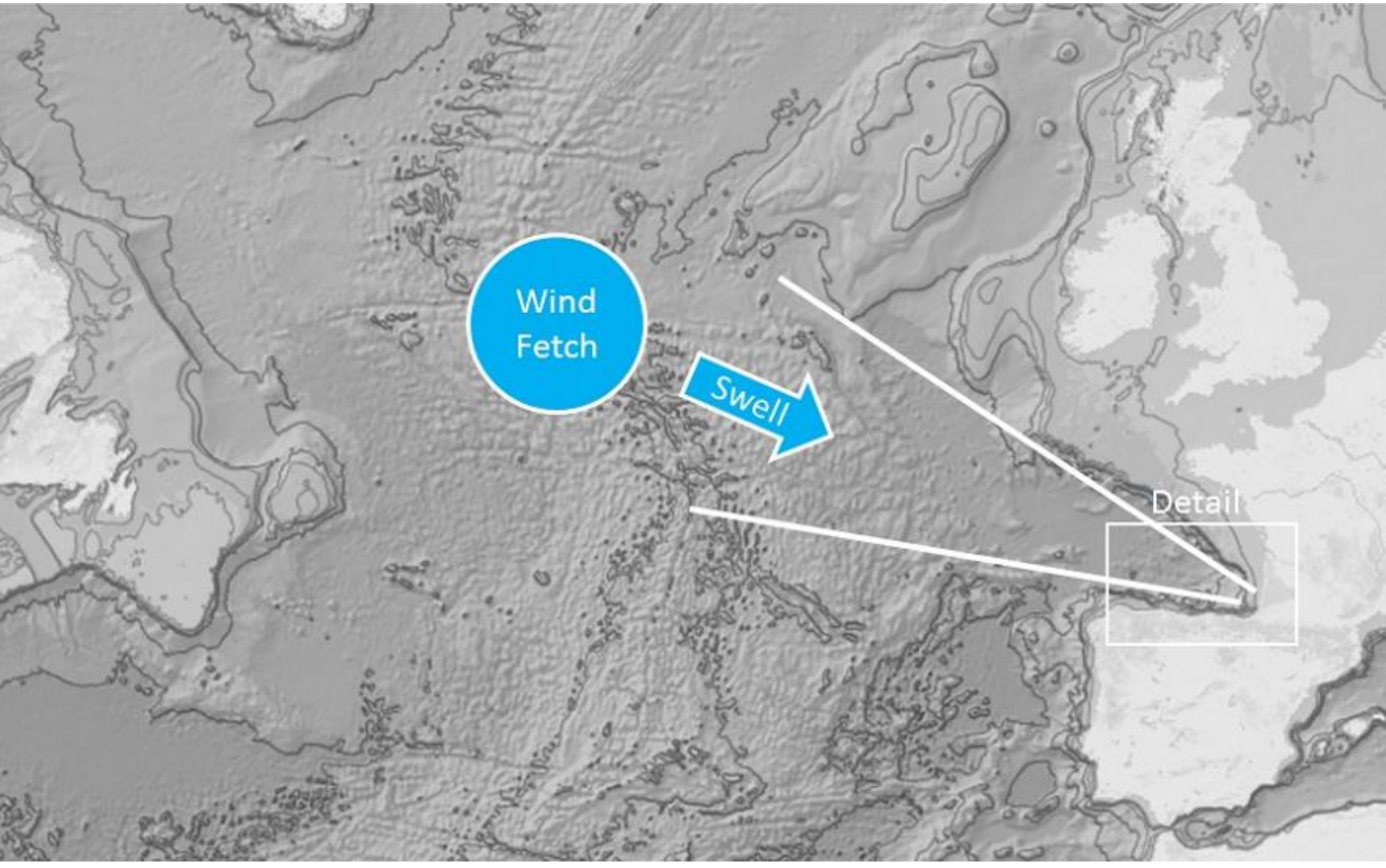
Waves form when wind acts on the surface of the ocean and break when they hit the ocean floor. Their quality depends on size, shape and length.



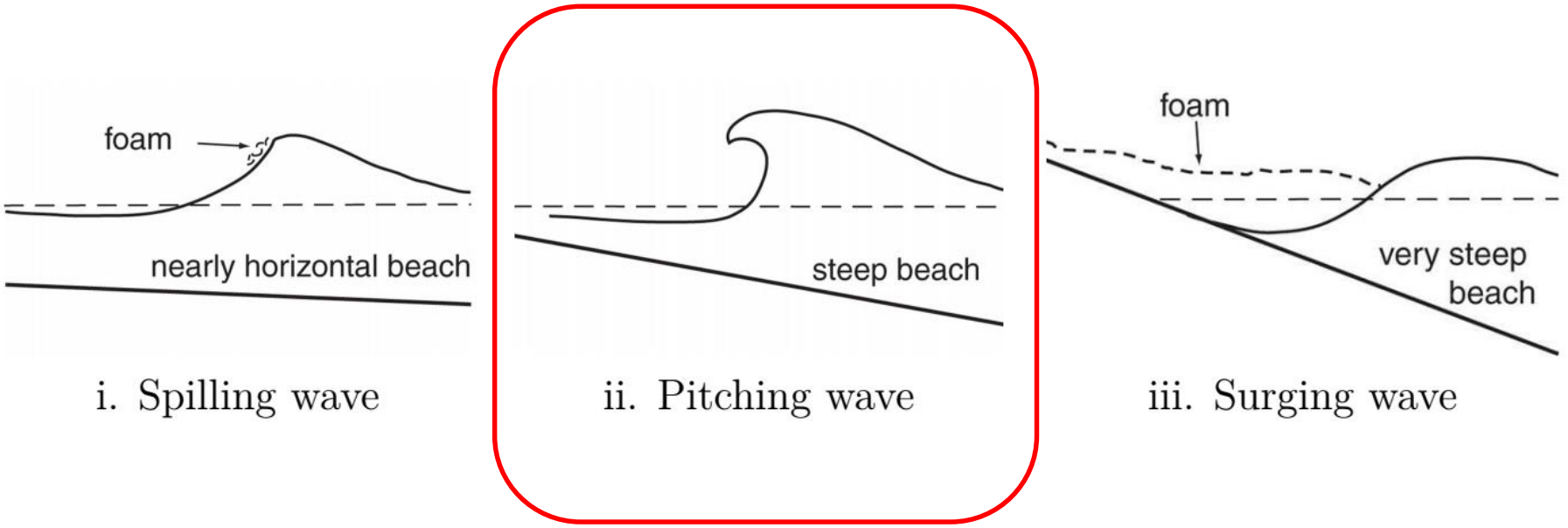
Quality

- **Size**
- **Shape**
- **Length**

Wave Size: Determined by winds far from shore



Wave Shape: Determined by gradient of the sea floor and local wind direction



Good Quality

Wave length: Determined by the shape of the coastline

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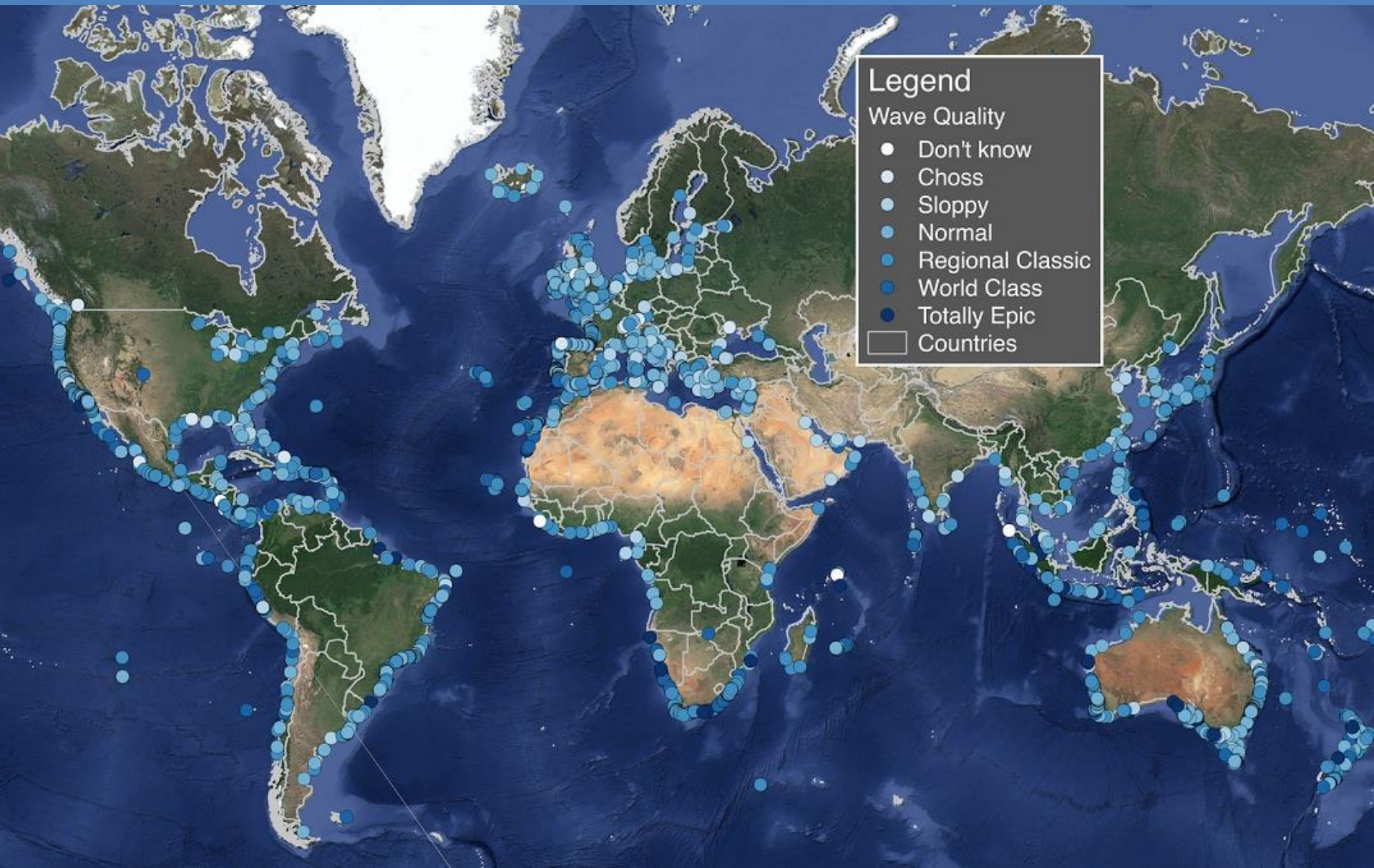
To conduct the experiment we use unique data on over 5000 waves around the world from www.WannaSurf.com



Wannasurf is a global database of surf spots and their characteristics, crowd-sourced (like Wikipedia) from around the world

BOILERS
MOROCCO, SOUTH

User rating (24)

Other places: In South

Edit this page

This is an interactive map! Use controls to pan and zoom this map.

ADD A SURF SESSION
ADD TO MY SURFED SPOTS
RATE IT! (24)
COMMENTS (10)
SESSIONS (1)
TRIPS (0)
PHOTOS (35)
VIDEOS (0)
PDF GUIDE
KML & GPS FILES (2)
SHARE
FAVOURITE

YOUR FAVOURITES AND FUTURE SURF SPOT LISTS
▷▷ add surf spots to your profile

Datum: WGS84 [Help]
Precision: Approximate
Latitude: 30° 37.467' N
Longitude: 9° 52.697' W

GPS History (2)
Weather Forecast

Tweet
Like 0

ACCESS

On the road to Essaouira from Taghazout
check out www.maps.google.com Boilers is clearly visible - follow the road along the south facing tip, when the shrub ends there is a road down and a building there to the left is boilers, plenty of car there that day!

Distance	Take a car
Walk	Don't know
Easy to find?	OK
Public access?	Private access
Special access	Don't know

SURF SPOT CHARACTERISTICS

SURF SPOT QUALITY

Wave quality	World Class
Experience	Experienced surfers
Frequency	Don't know

WAVE

Type	Reef-rocky
Direction	Right
Bottom	Boulders
Power	Normal length
Normal (50 to 150m)	
Good day length	Long (150 to 300 m)

TIDE, SWELL AND WIND

Good swell direction	Good wind direction
Swell size	Starts working at 1.5m-2m
/5ft-6ft and holds up to 4m+ / 12ft	
Best tide position	Low tide only
Best tide movement	Falling tide

MORE DETAILS

Week crowd	Empty
Week-end crowd	Crowded
Webcam url	

DANGERS

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DANGERS

ADDITIONAL INFORMATION

Hard to enter and go out the water when it's big! You really have to wait for the flat between two sets, and paddle hard to join the guys out there!

Atmosphere: Really good wave, long and fast but take care of the tide...it could be risky to get of on the bad waves in front of the rocks! I guess that 6-8ft is the best size to surf this place, because the wave is already very long and fast and tube on the 2nd section (for my part I forget to do so on the 3rd). Experts would enjoy it till 12ft+.

General: Really nice place. Check the place twice a day, because who knows, you'll find it perfect and surf it on your own (only during the week off course!)

Author: Anonymous | Contributors (3) | They surfed this spot ! (131)

PHOTOS

Show all (35)... ▷▷ Submit New Photos

Boilers
Morocco

Boilers
Morocco

Boilers
Morocco

Boilers
Morocco

VIDEOS

Show all (0)... ▷▷ Submit new video

No video available

LAST SURF SESSIONS

Show all (1)... ▷▷ Add a surf session

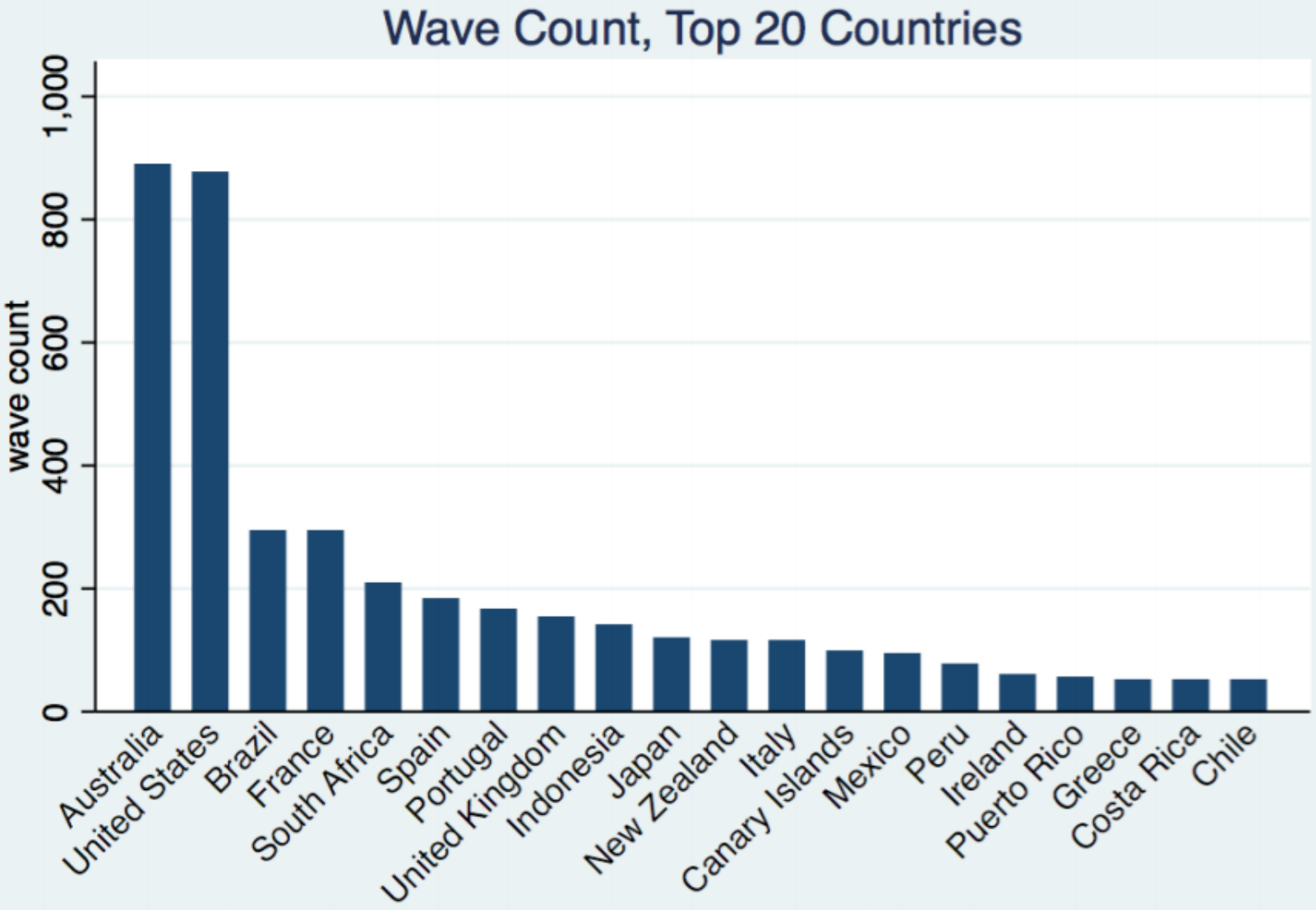
Boilers

LAST SURF TRIPS

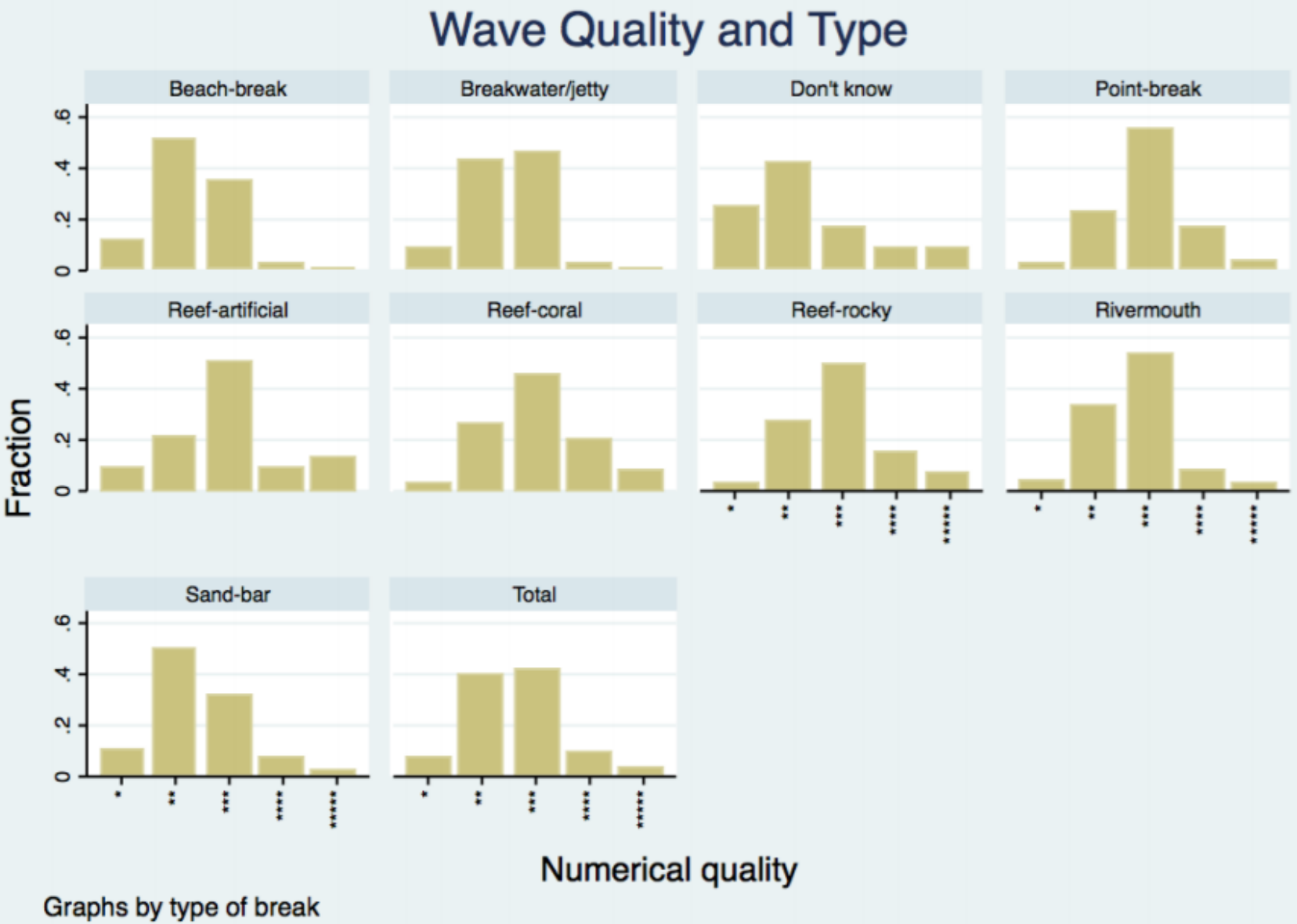
Show all (0)... ▷▷ Add trip

No surf trip

Australia and the US have the largest number of waves, though they are distributed around the world



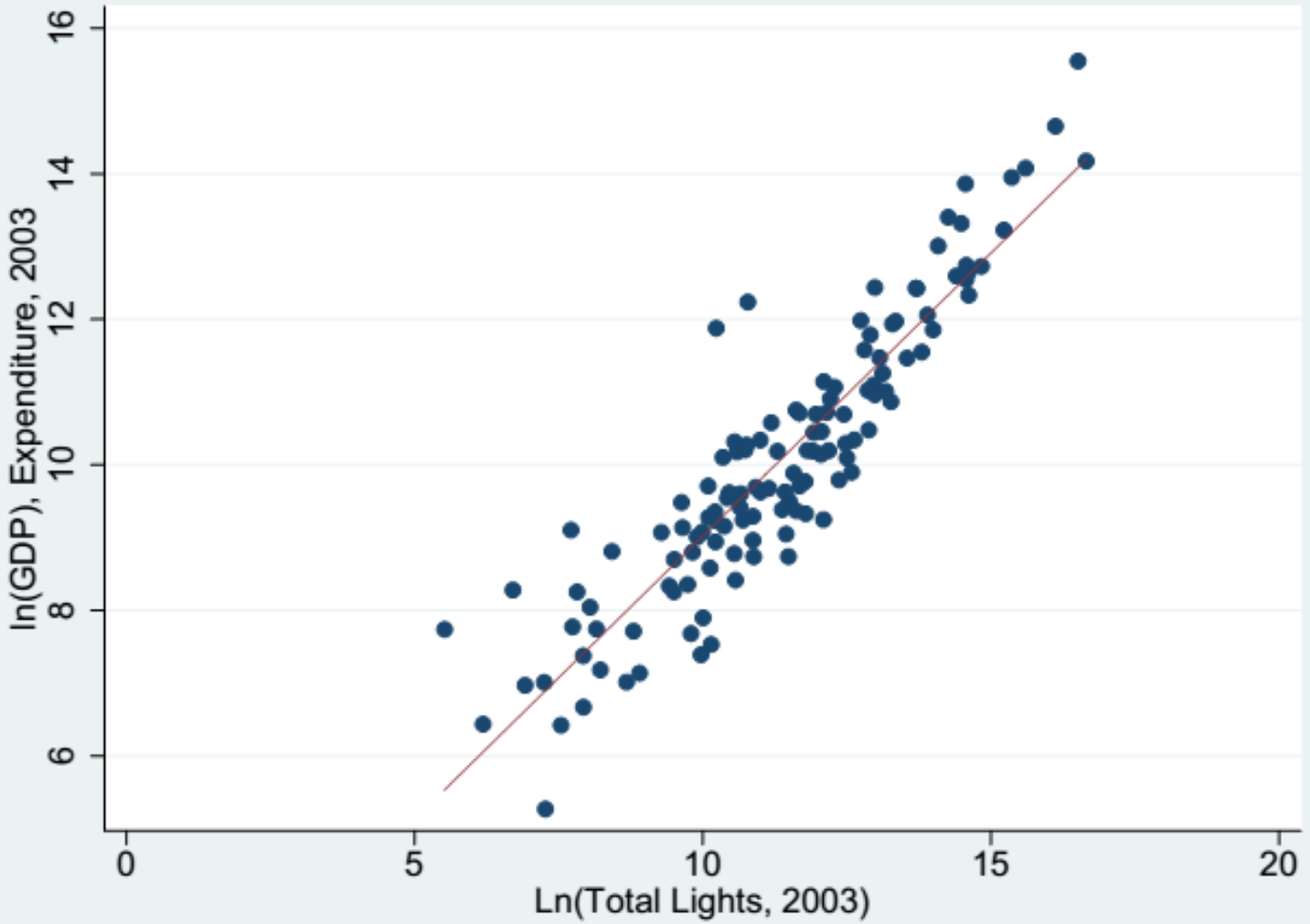
Most waves are 2 or 3 star. Reefs, rivermouths and point-breaks (headlands) are better quality on average



We proxy local economic activity using DMSP-OLS data on night-time lights from 1992-2013, at resolution of 1km^2 near the equator

Lights are strongly correlated with economic activity at a national level

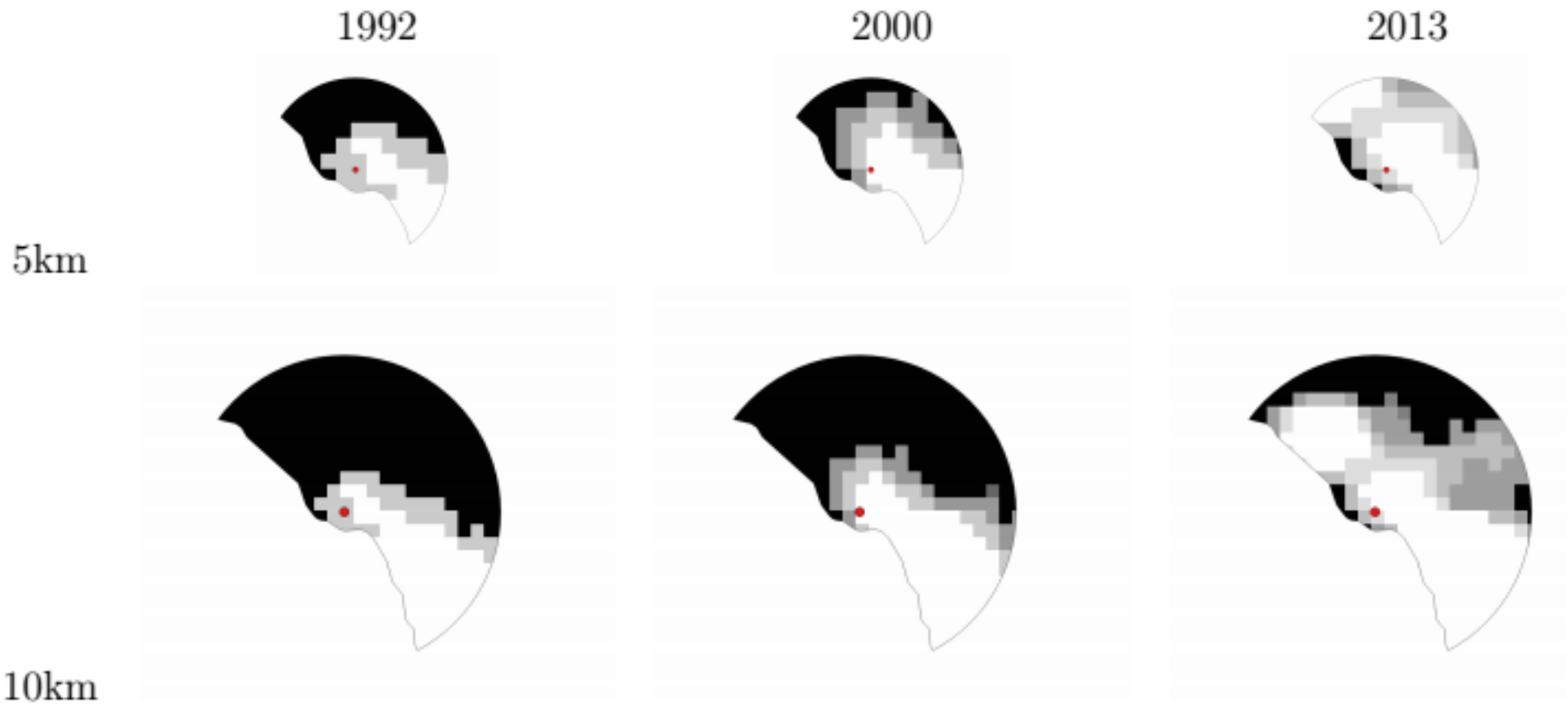
PPP adjusted GDP vs log of Total Lights, 2003



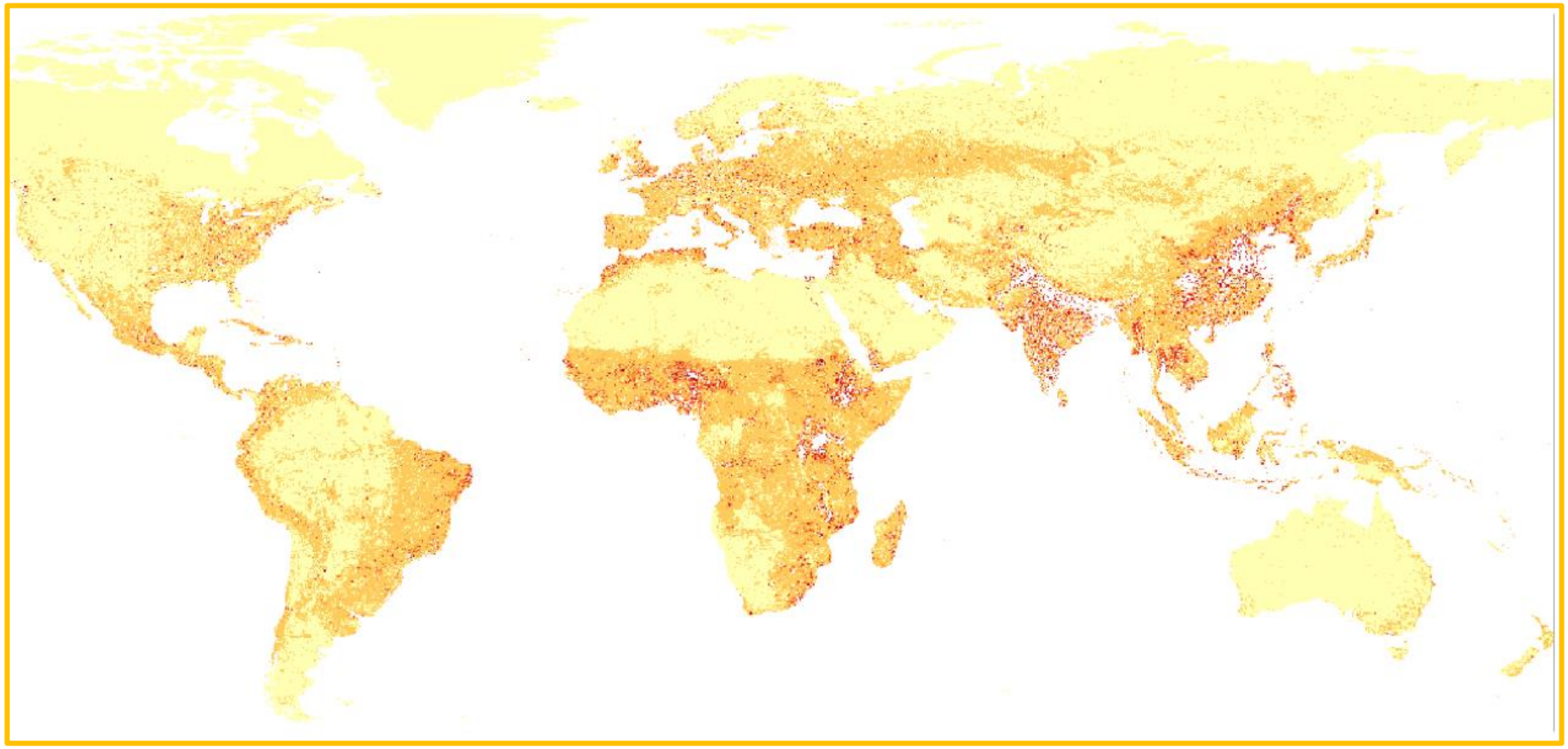
Source: PWT, DMSP-OLS, Smith and Wills (2016)

Lights grow significantly around high quality waves during our sample

Light growth in 5km and 10km surrounding Anchor Point, Morocco (4-star)



We also have LandScan data on “ambient” permanent population from 2000-2013, also at 1km^2, which excludes tourists.



LandScan constructs the dataset using (sub) national population data, and satellite data on roads, land cover, buildings, etc.

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We use a polynominal distributed lag model; with 1-star waves as the control group, and wave and time fixed effects

Polynomial distributed lag model

Wave quality indicator *Wave FE* *Time FE*

$$
\begin{aligned}
Y_{i,t} &= \alpha + \beta(t)Q_i + \gamma(t) + W_i + Z_t + \epsilon_{i,t} \\
&\text{where} \\
\beta(t) &= \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 t^4 \\
\gamma(t) &= \gamma_1 t + \gamma_2 t^2 + \gamma_3 t^3 + \gamma_4 t^4
\end{aligned}
$$

Polynomial: reduce effects of collinearity on β(t)

Distributed lag: observe time trends

Standard Errors: clustered at wave level

Control group: area surrounding 1-star waves (high hurdle: coastal, etc)

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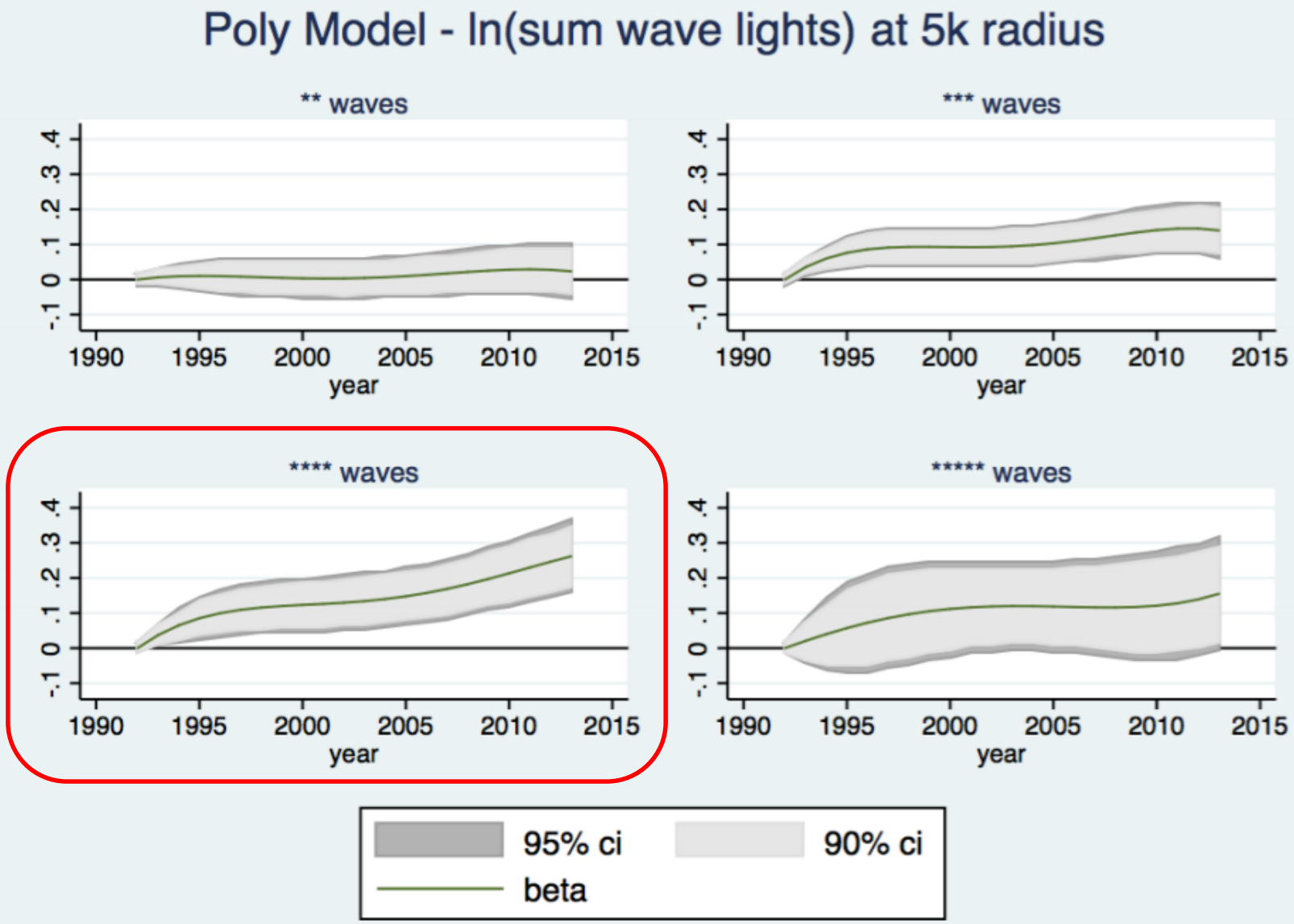
Experiment I (Main result)

Experiment II

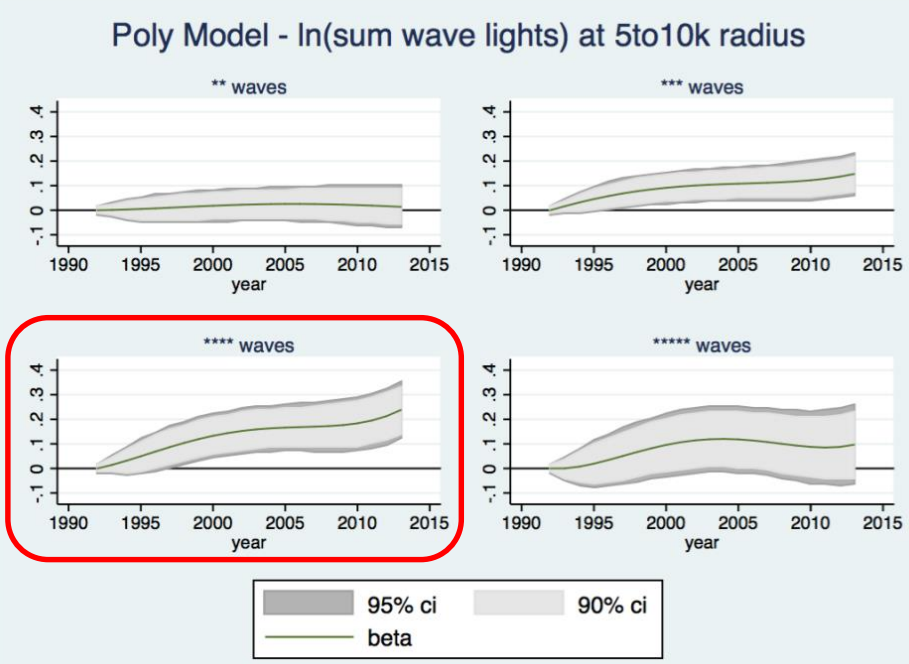
Experiment III

4-star waves increase light growth by 1.2% p.a. at 5km, amounting to $22 million per wave at 50km, or $51 billion globally.

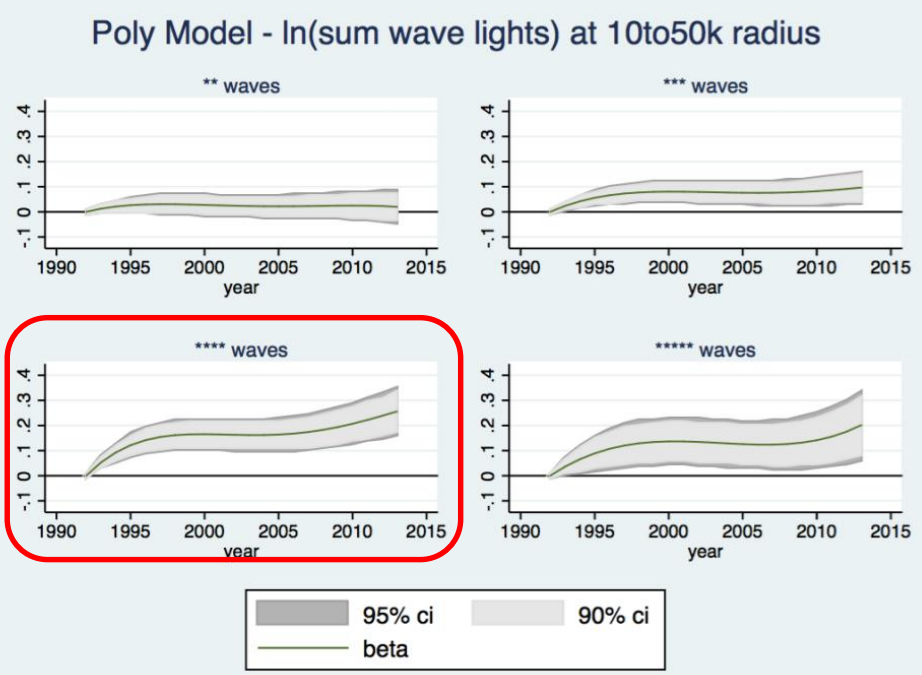


Surfing increases activity overall, rather than simply drawing it away from surrounding areas. Effects are felt at least 50km away

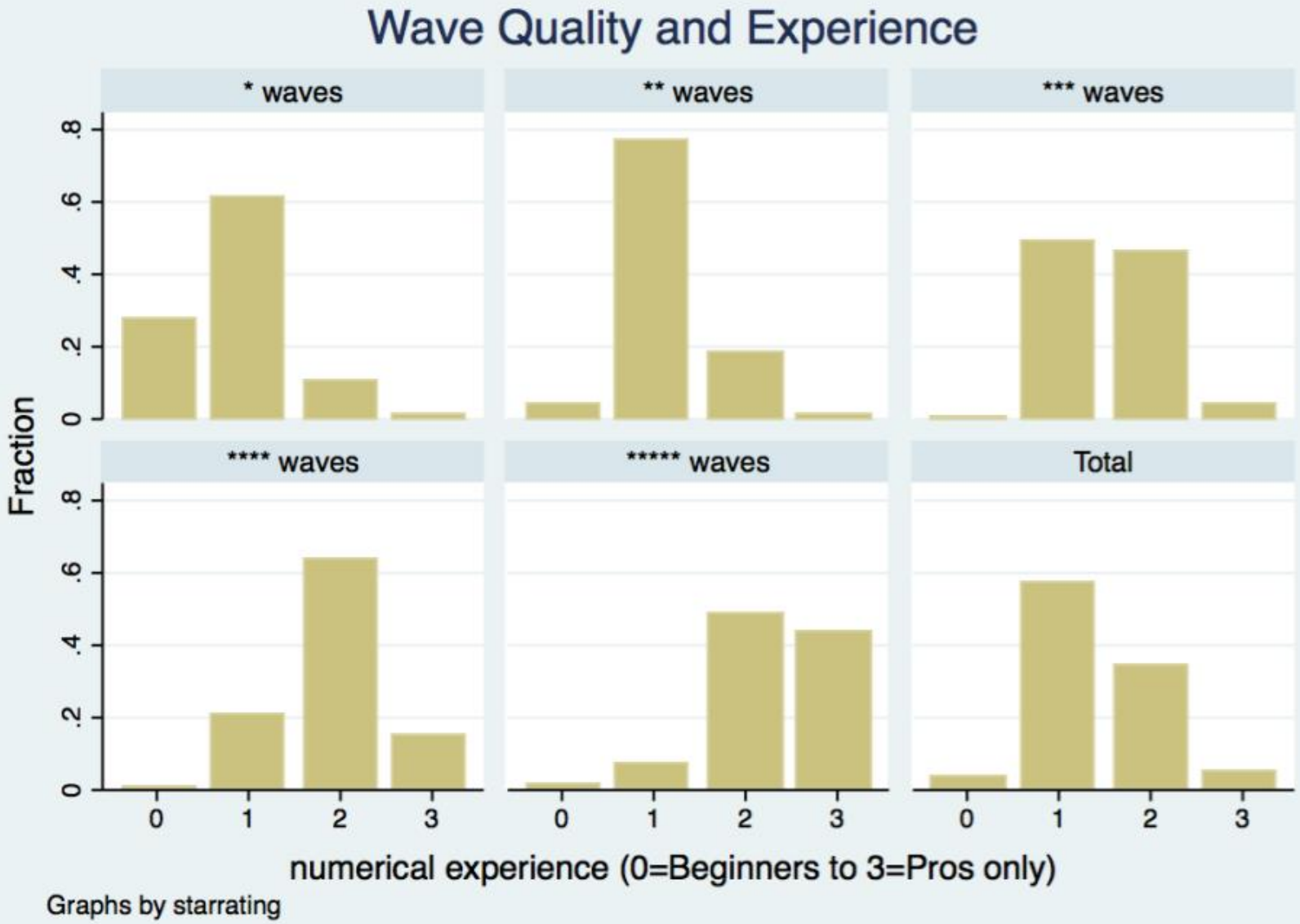
5 to 10 km



10 to 50 km

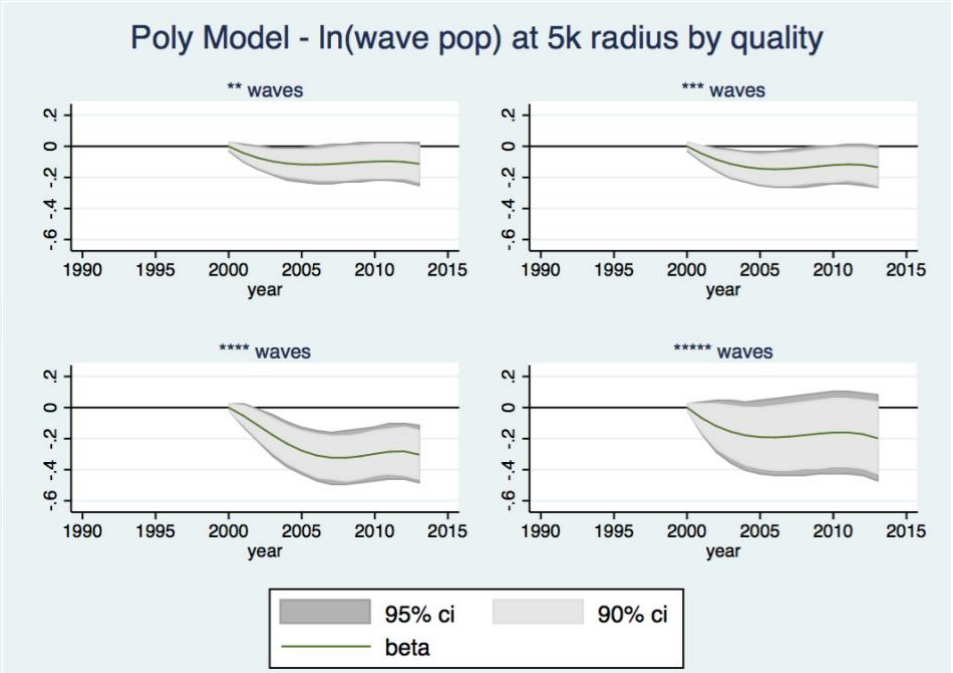


The effect peaks with 4-star waves because 5-star waves require too much experience to surf

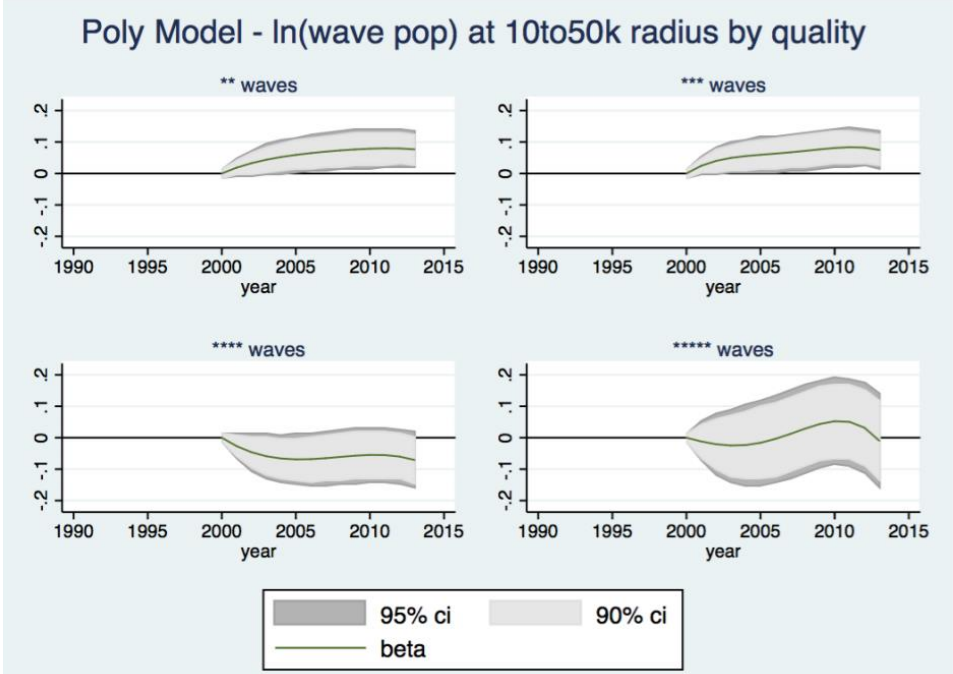


While good waves do not relocate economic activity, they do cause the permanent population to move away – consistent with tourism

0 to 5 km

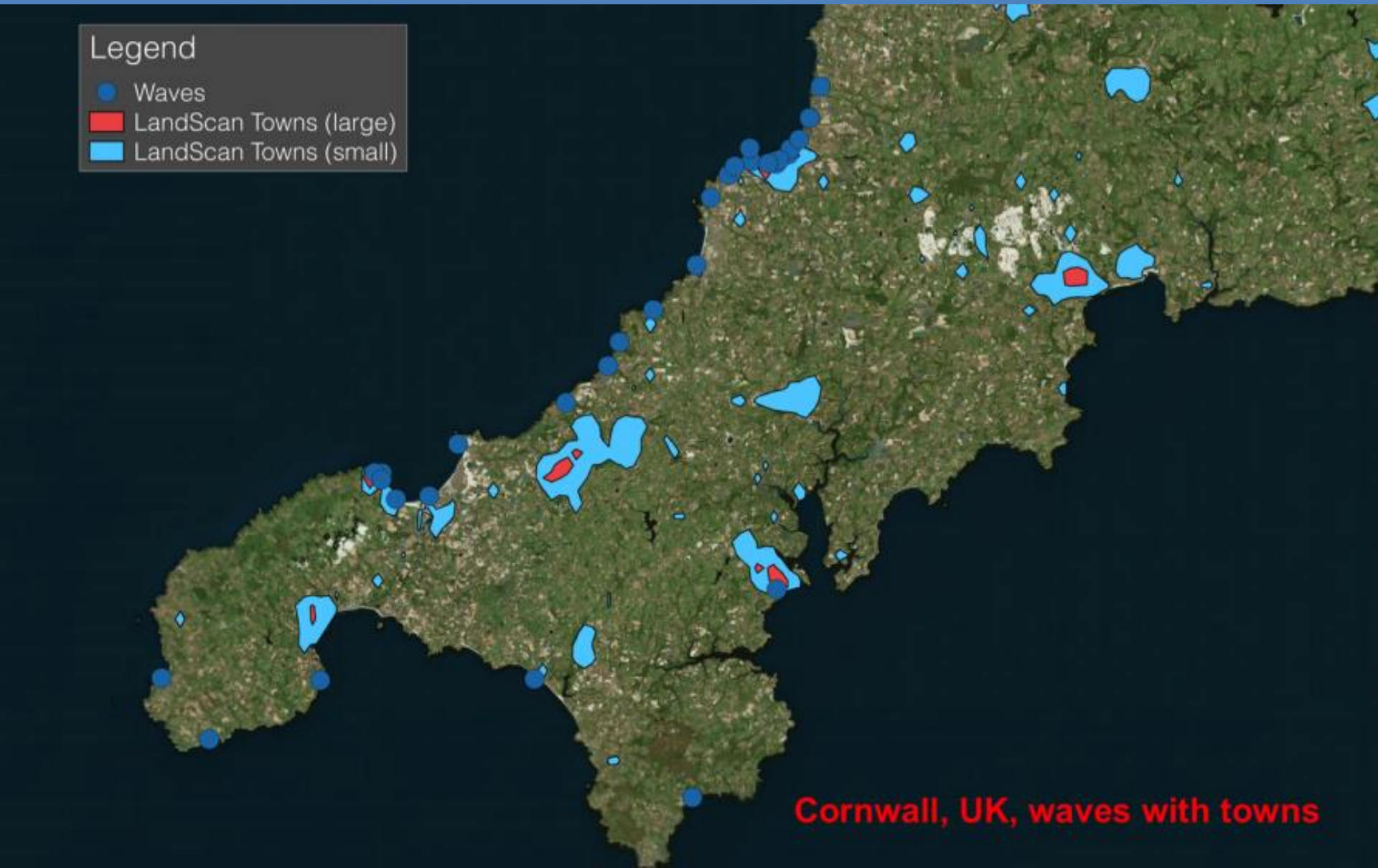


10 to 50 km



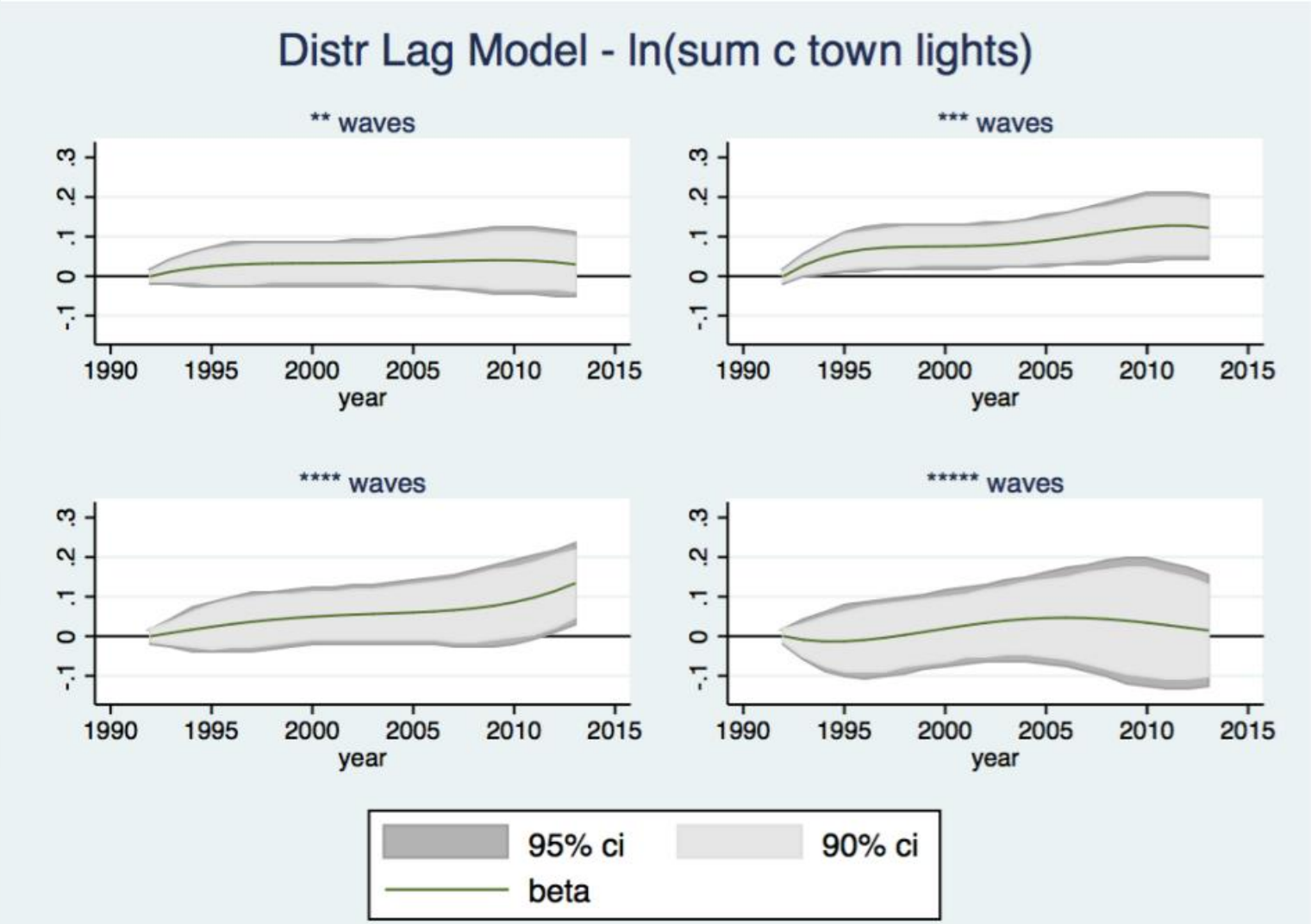
This is consistent with surf tourists driving up rents near waves

To better understand the mechanism of growth we study nearby towns, defined by population density (>300 or >600 ppkm^2)…



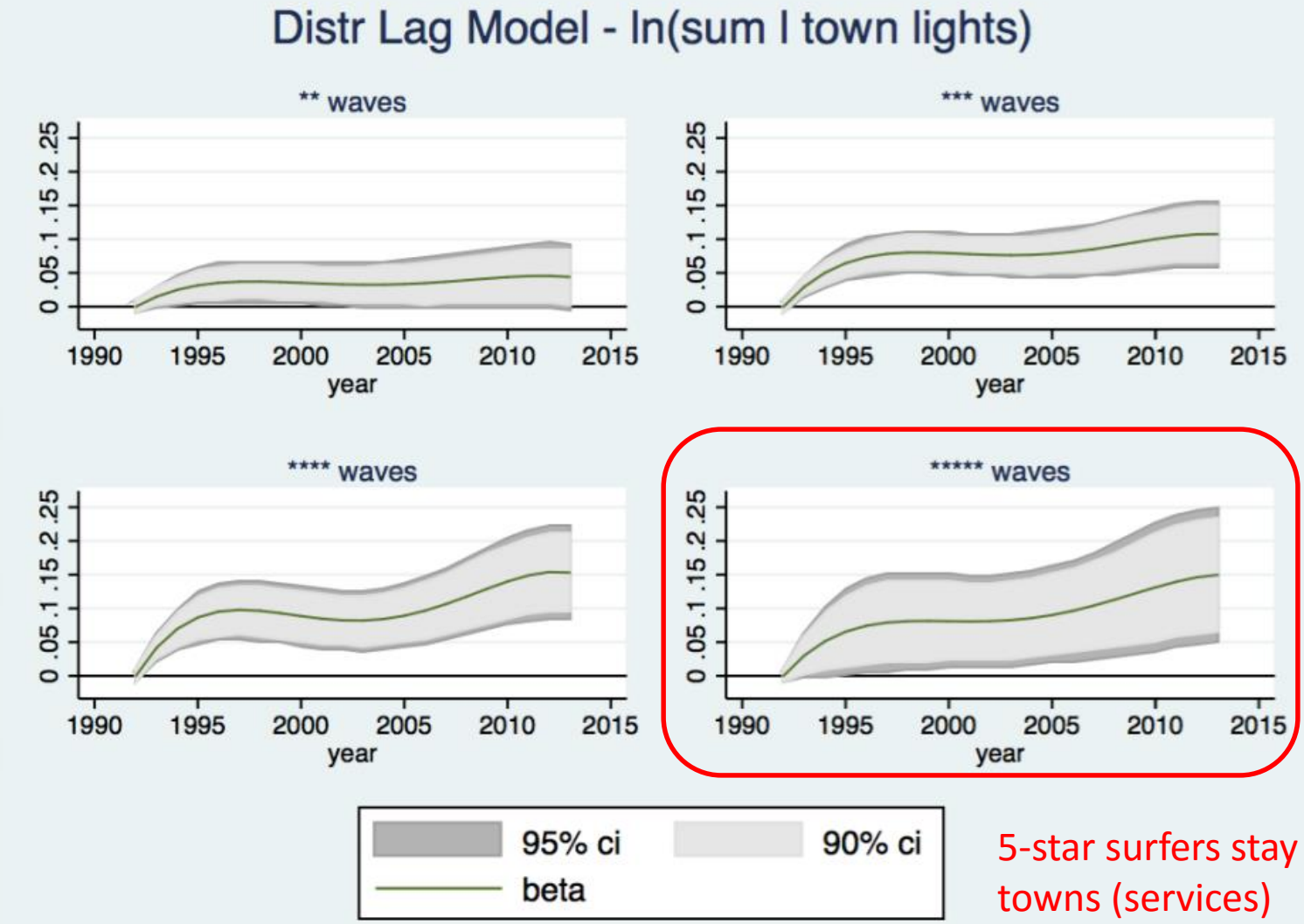
3- and 4-star waves significantly increase light growth in their closest town…

Log of light growth in closest town (>300 ppkm^2)



… and even more in the largest town within 50km.

Log of light growth in largest town within 50 km



5-star surfers stay in large towns (services)

Good waves boost economic growth by over 1% p.a: amounting to $22 million per wave or $51 billion globally; and reduce poverty.

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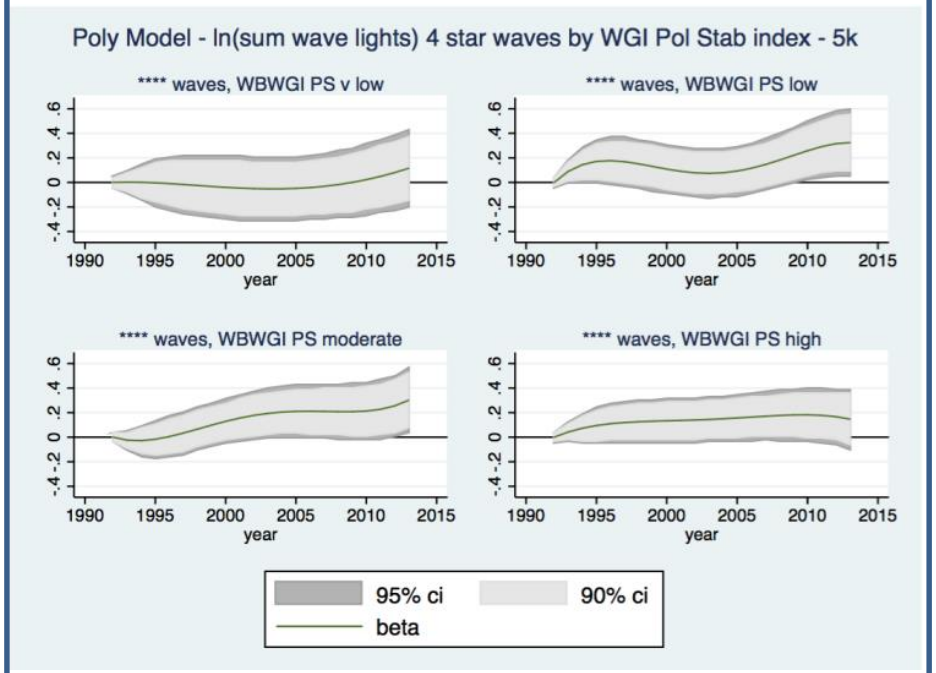
Experiment II

Experiment III

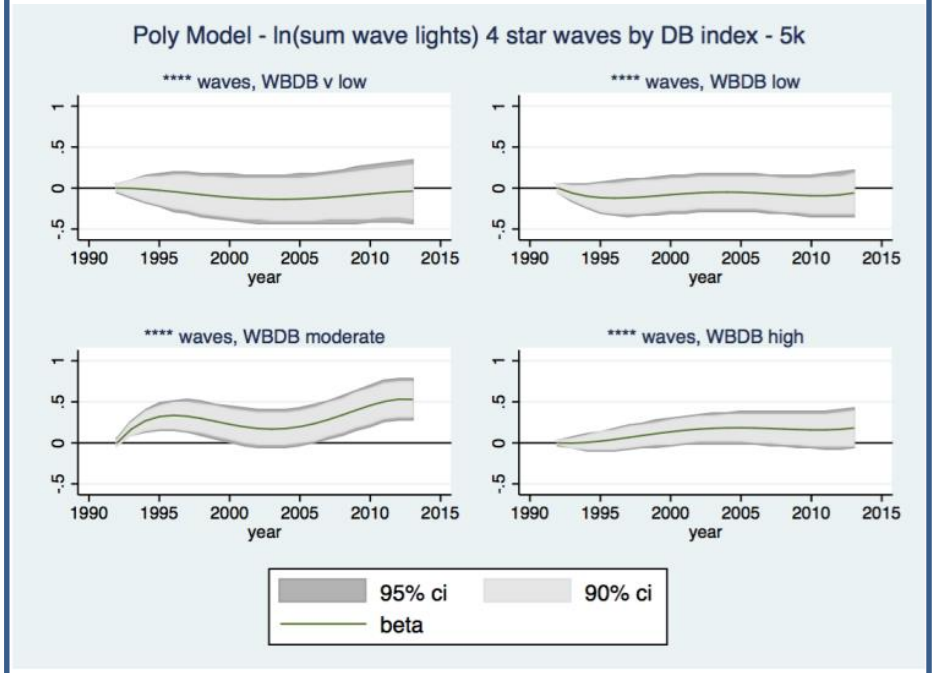
Emerging economies benefit most from surfing, provided their business and political environment is adequate

Log light growth in 5km of 4-star waves, by political stability and ease of doing business indexes

Political Stability



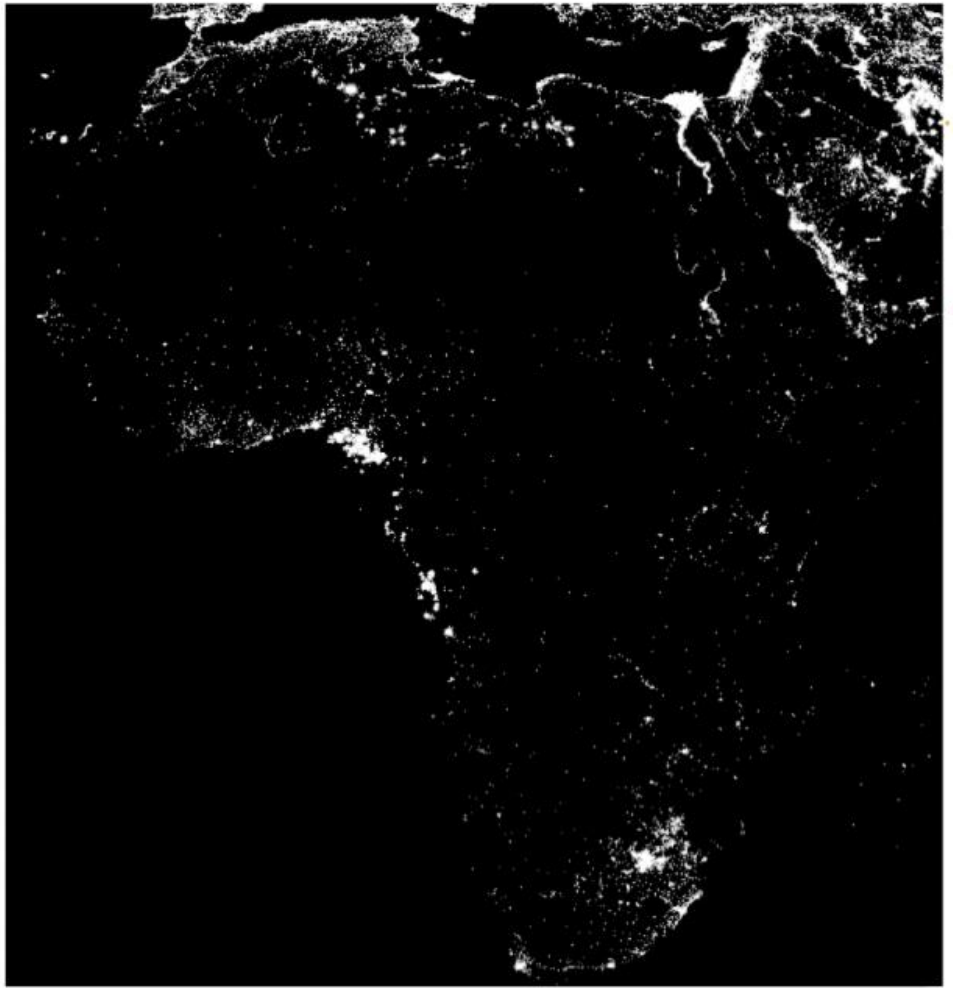
Ease of Doing Business



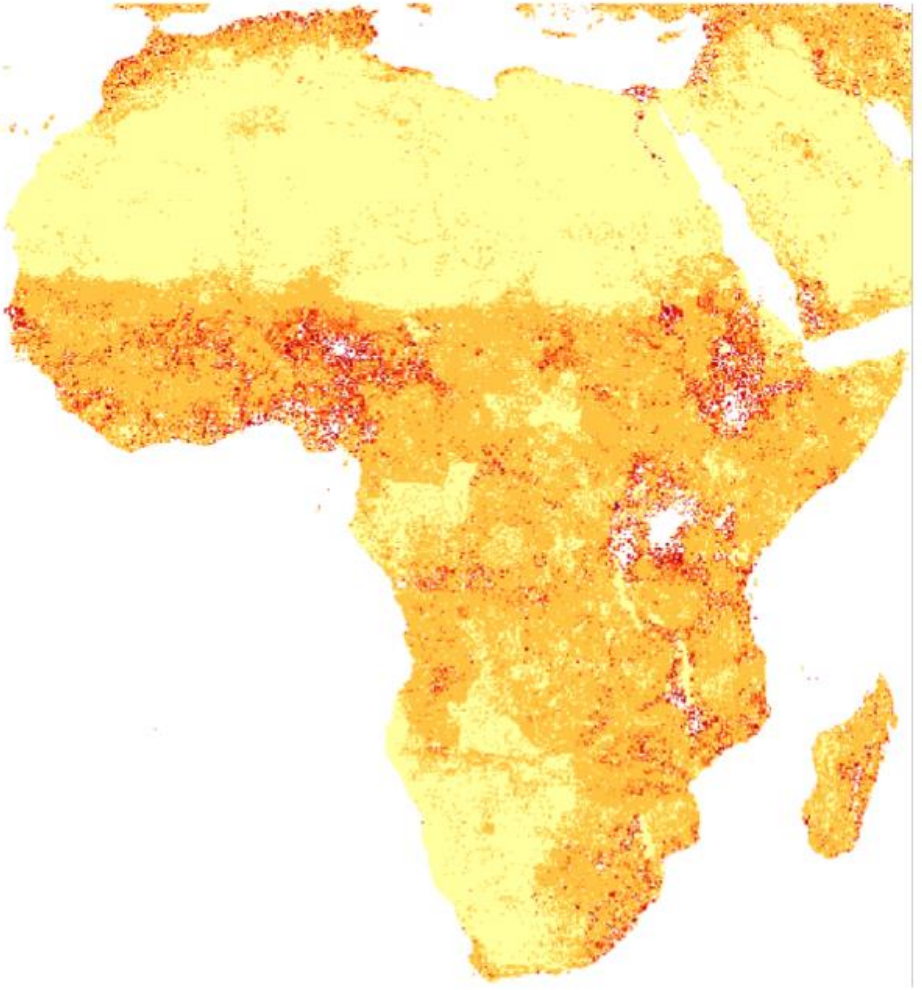
*Dropping USA and Australia

We can also identify how waves affect extreme rural poverty by studying people who live in darkness (Smith and Wills, 2016)

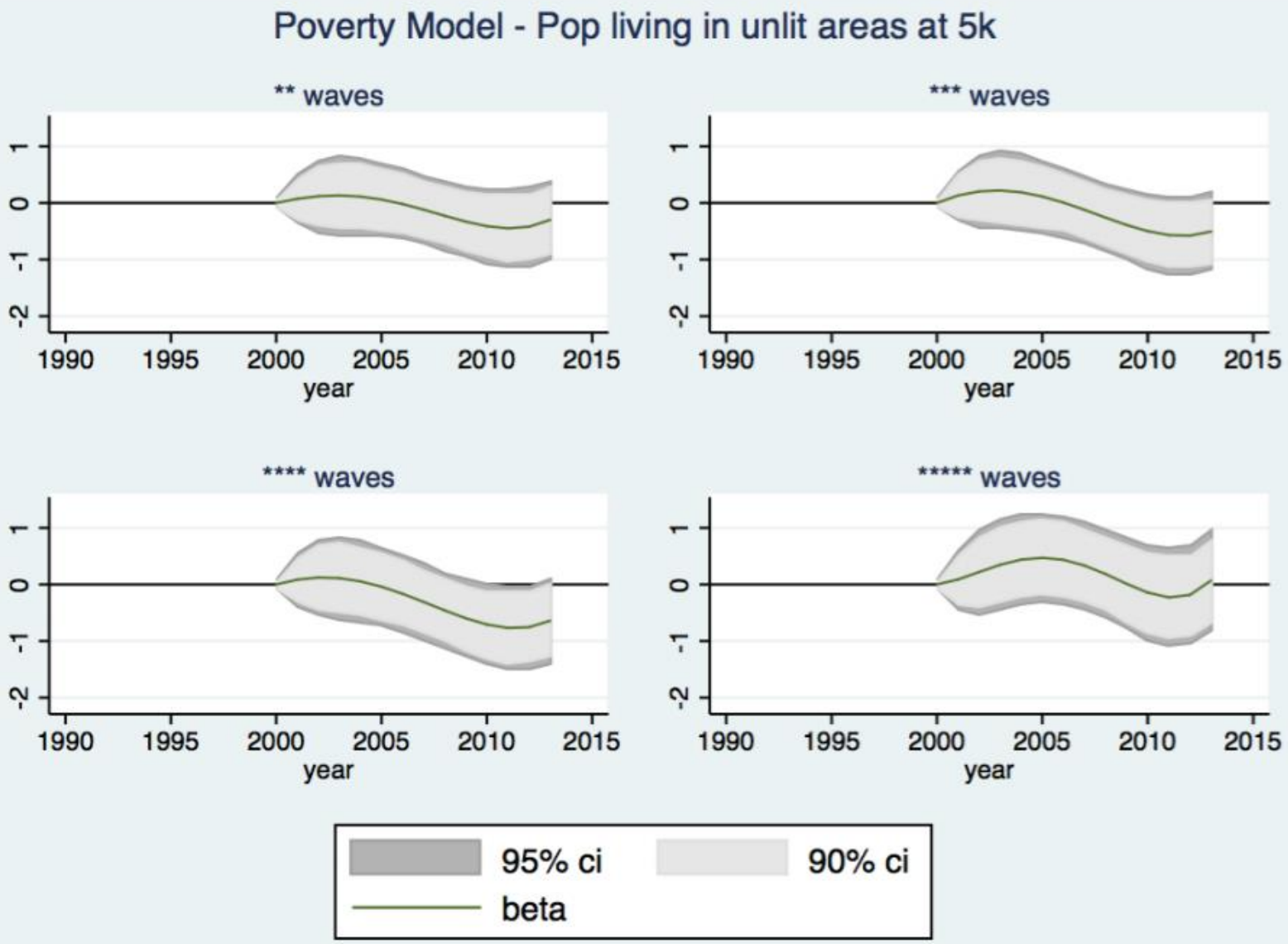
Night-time lights



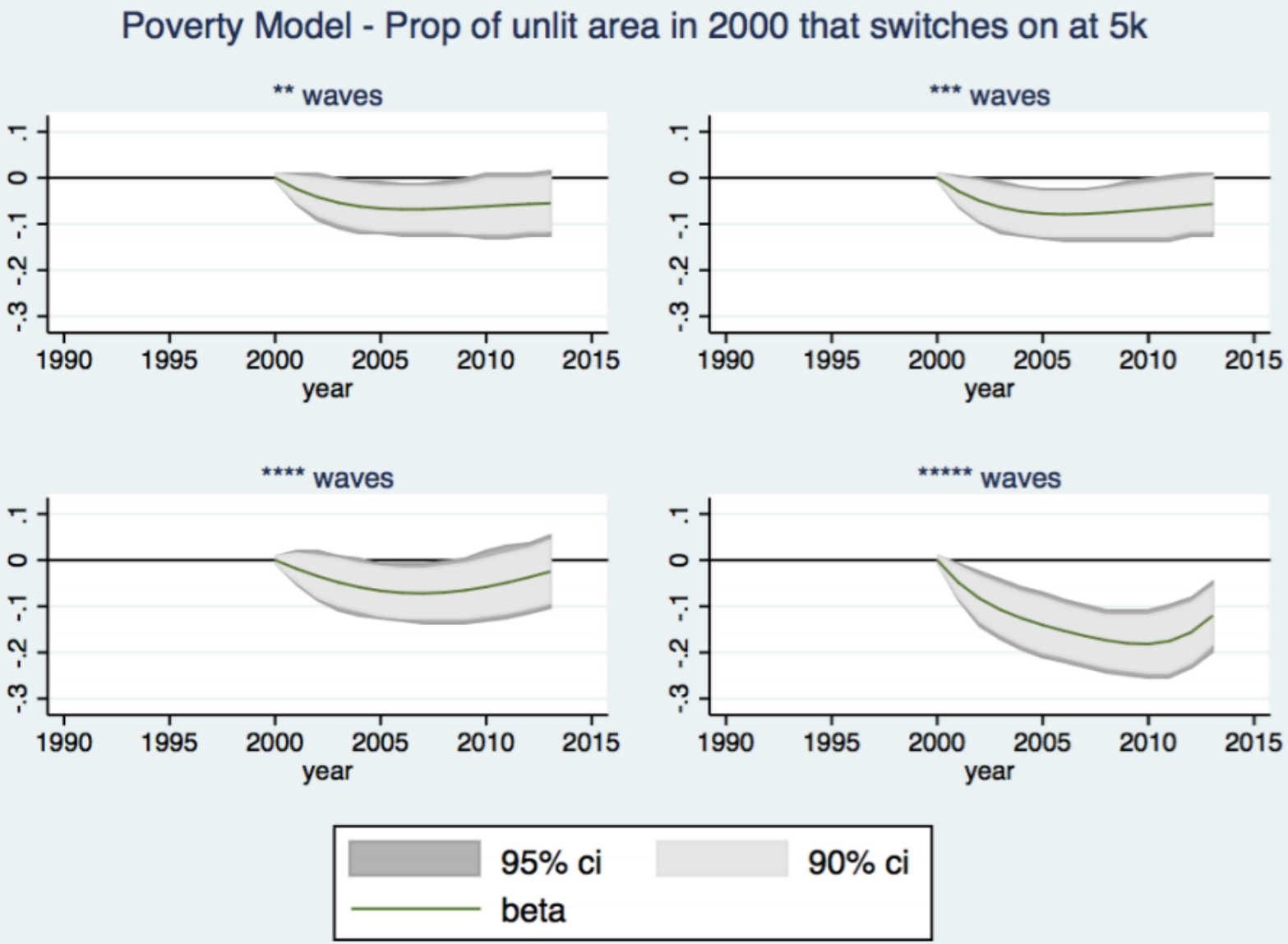
Population



Surfing waves are effective at reducing rural poverty, measured as the number of people living in unlit rural areas

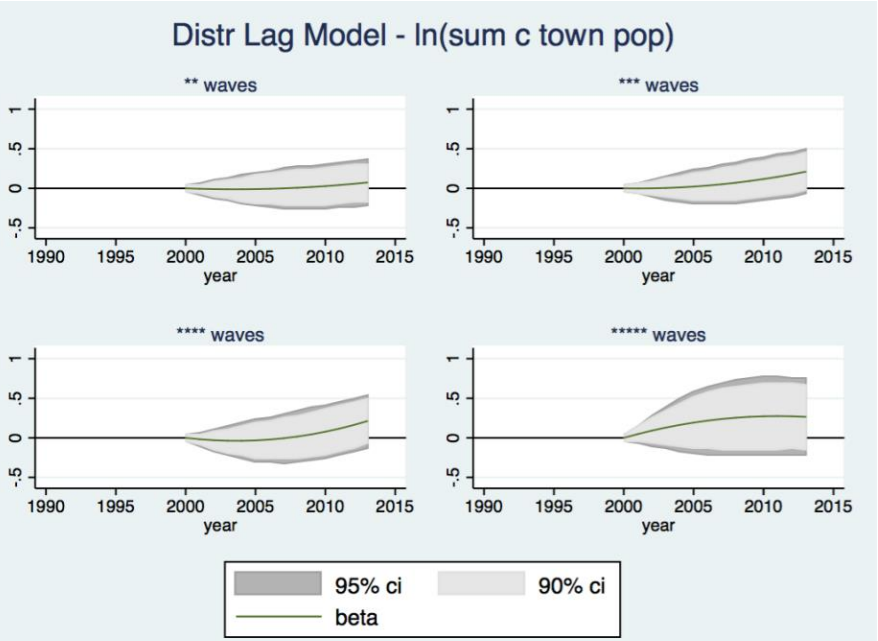


This doesn't happen by rural areas lighting up…

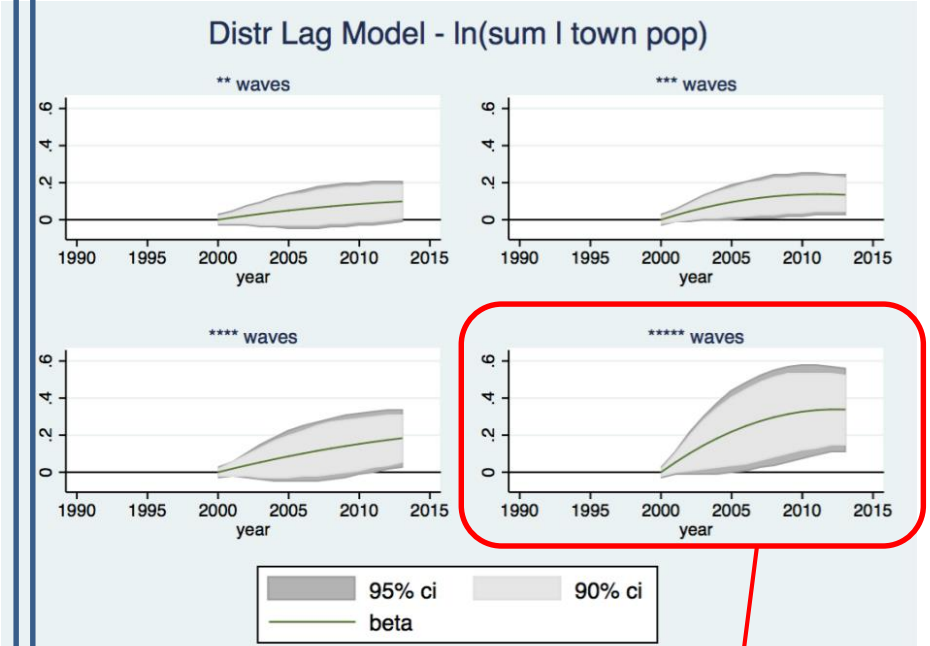


… but rather because surfing draws people from rural areas to areas with economic activity, consistent with more employment

Closest Town



Largest Town



5-star surfers need more services

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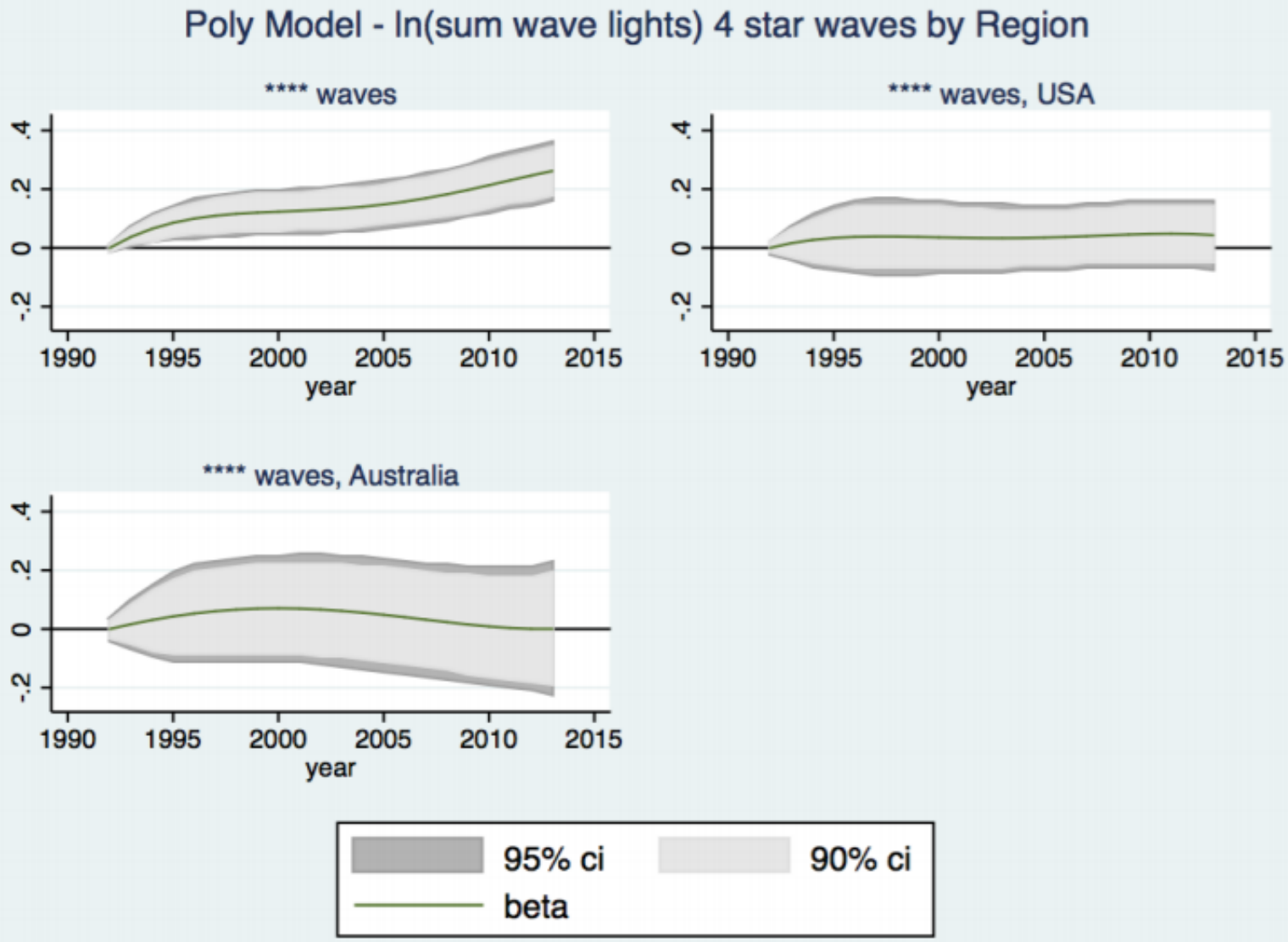
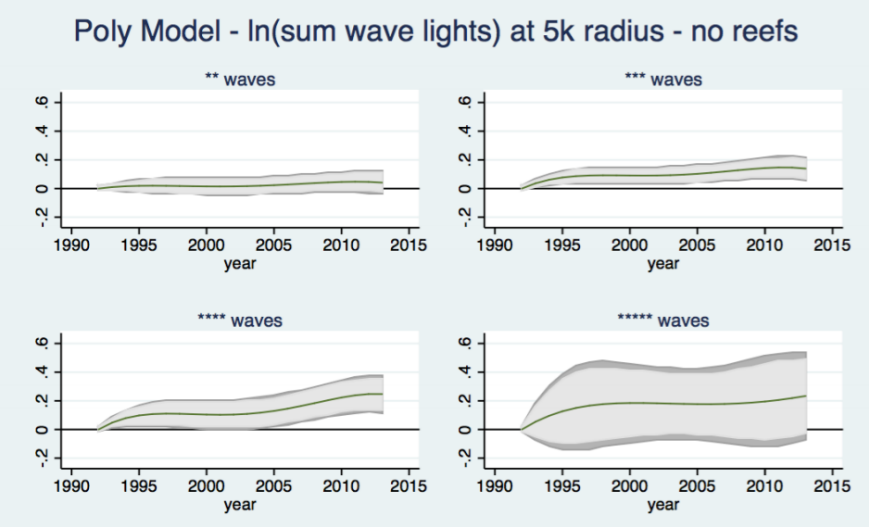
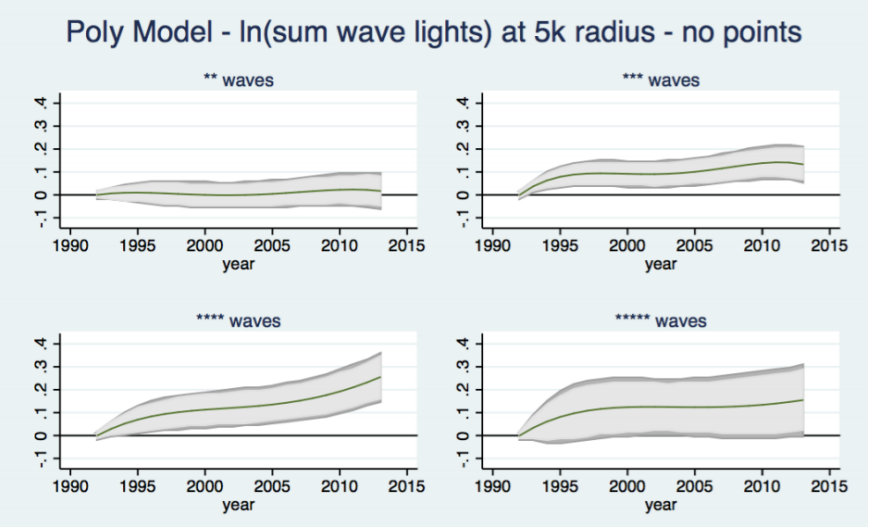
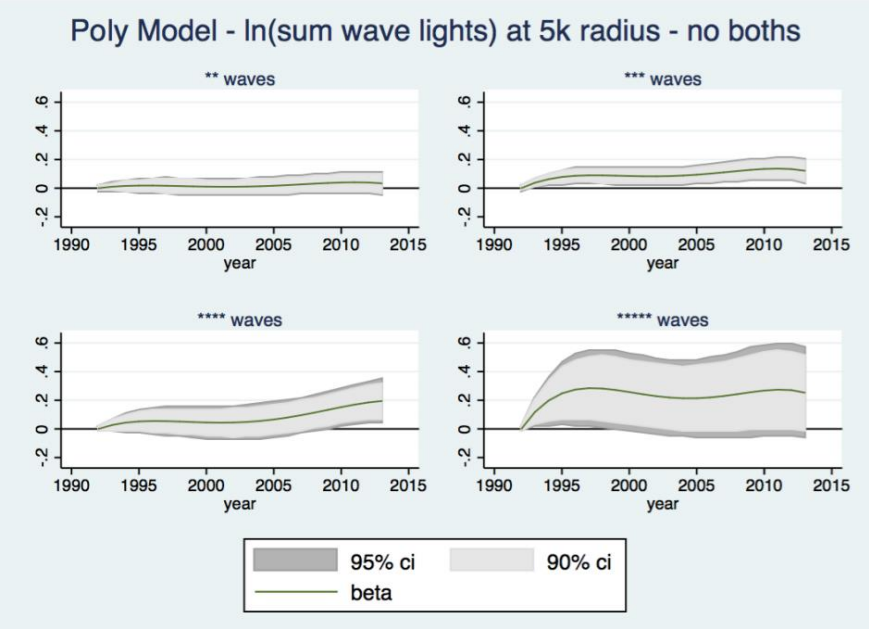
Robustness: The results aren't being driven by the USA or Australia



Robustness: There is no evidence of an omitted variable that creates both good waves and light growth (e.g. ports, reefs etc.)



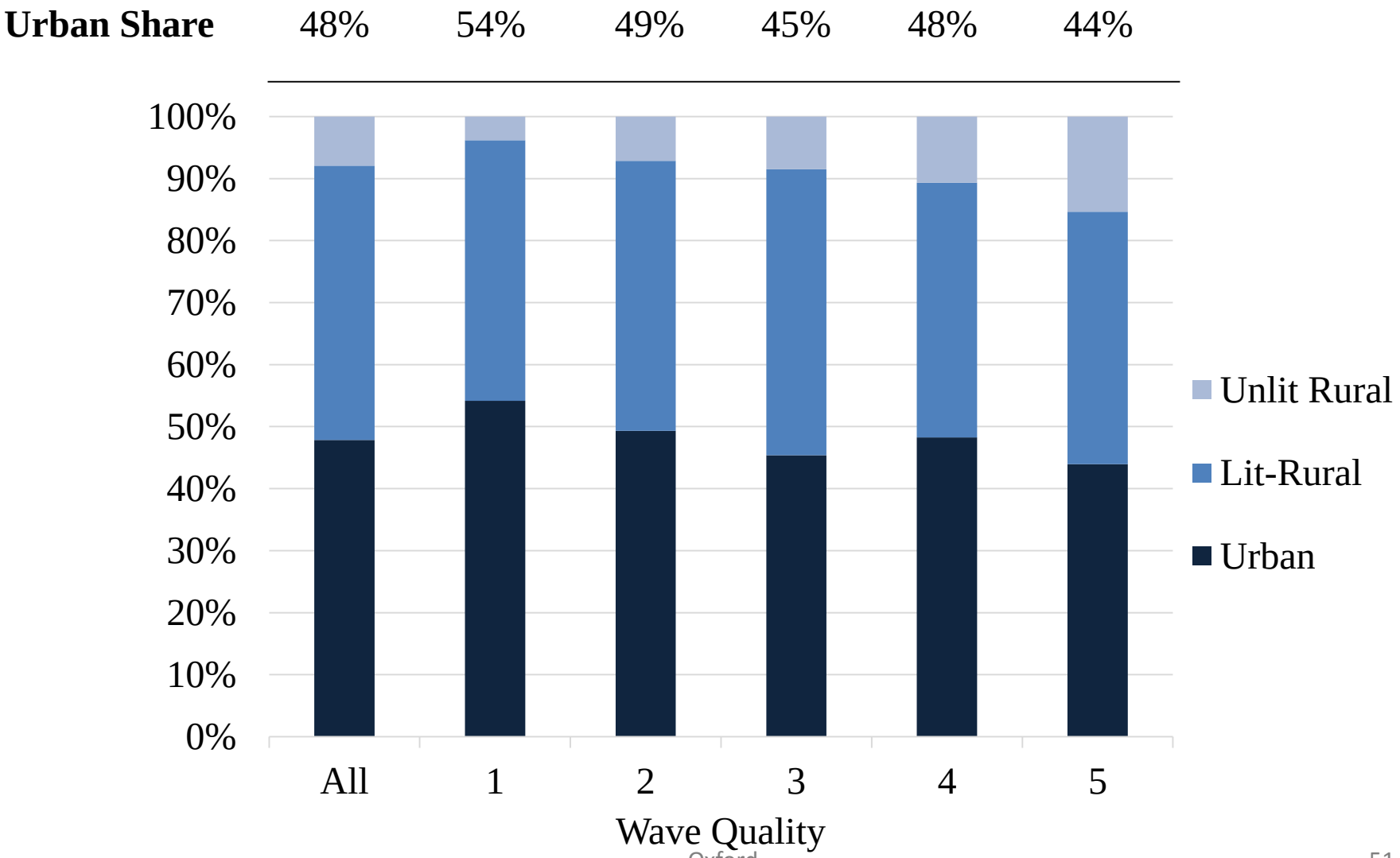




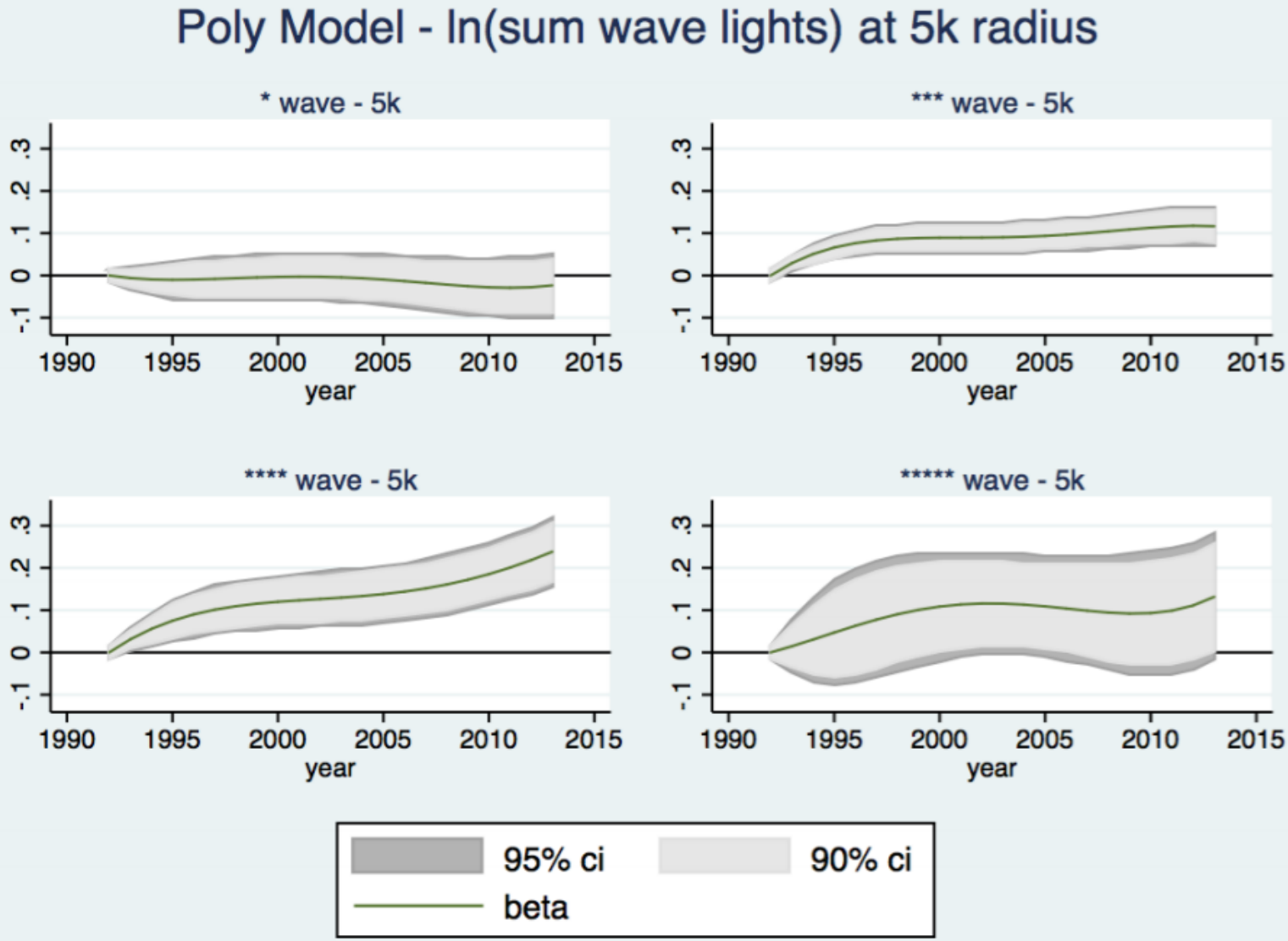
Main results hold when excluding wave types with highest average qualities (also for closest and largest nearby towns)

Robustness: 1-star waves appear more in urban areas, though 2- and 4-star waves have a similar urban/rural mix

Breakdown of 5km surrounding each wave into urban/rural areas



Robustness: The results hold with 2-star as the control group, which has the same rural/urban mix as 4-star waves



Surfing has a strong history of intrepid exploration, and bringing economic activity to developing countries

Throughout history Taghazout has been a small fishing village in southern Morocco…

…until discovered by travelling surfers in the 1960s…

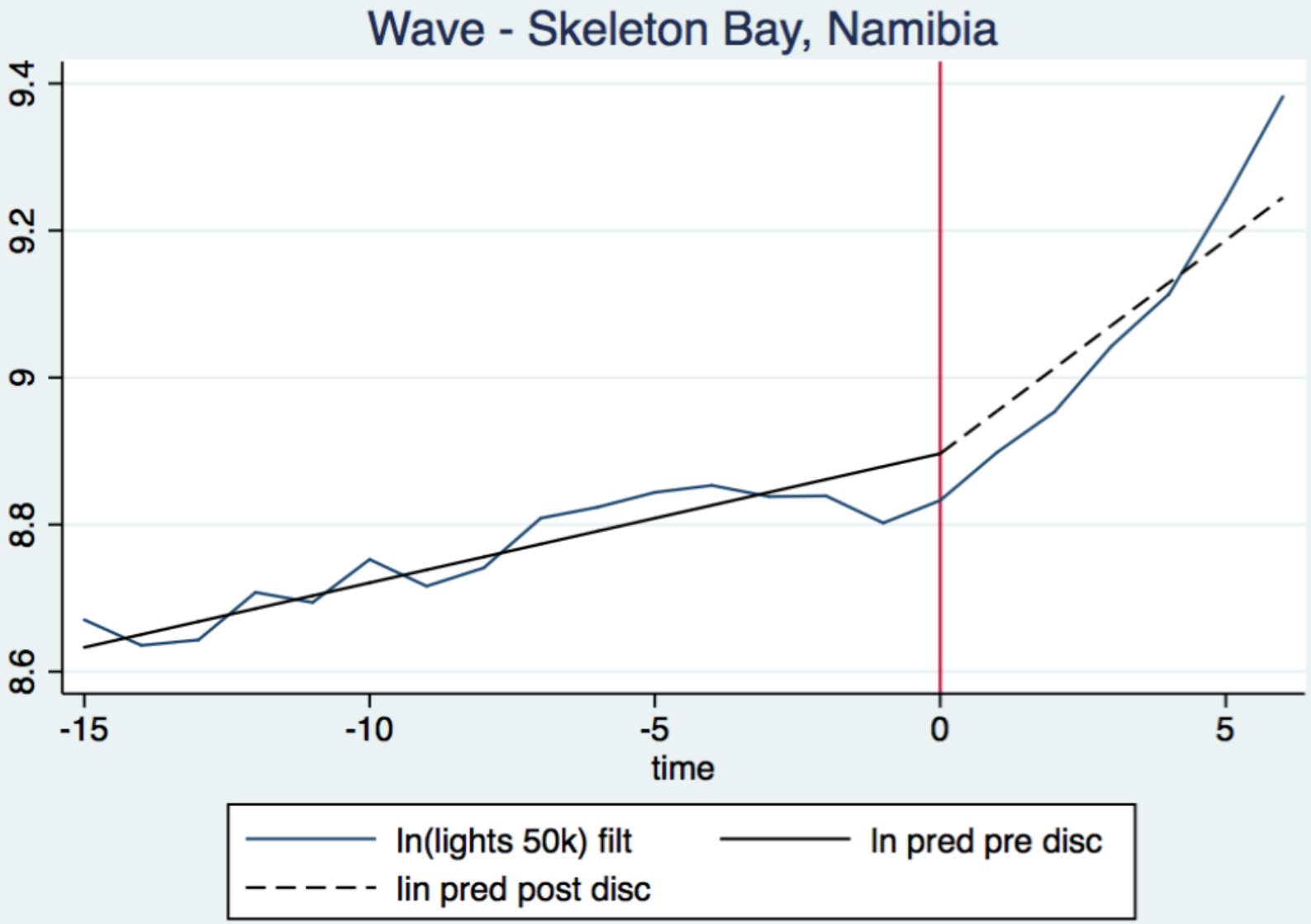
… because of its long right-hand point break

Experiment II

What happens when a new wave is discovered?

Skeleton Bay - Namibia

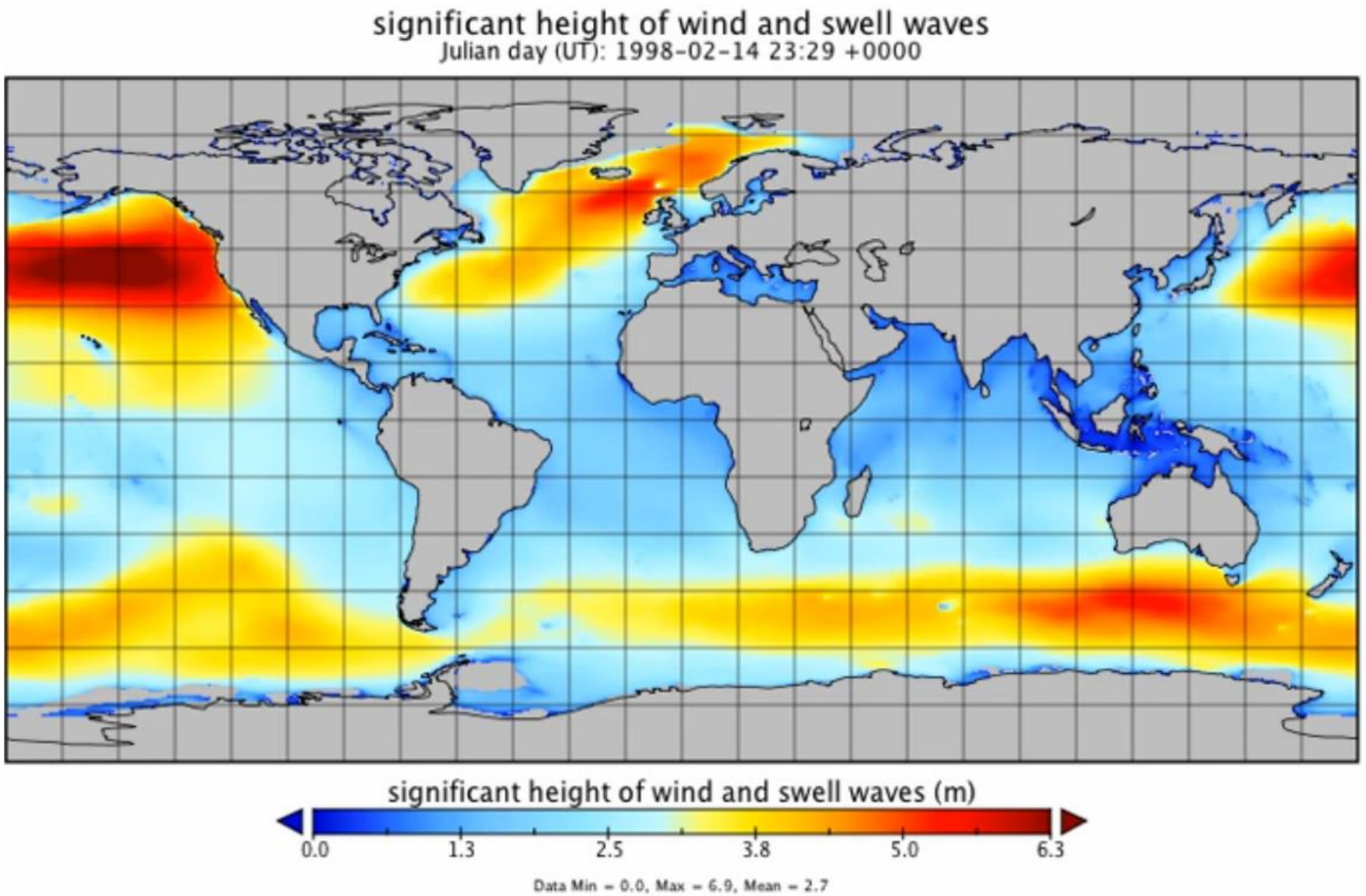
Lights grow over 3%p.a. faster when a major new wave is discovered, further supporting our hypothesis



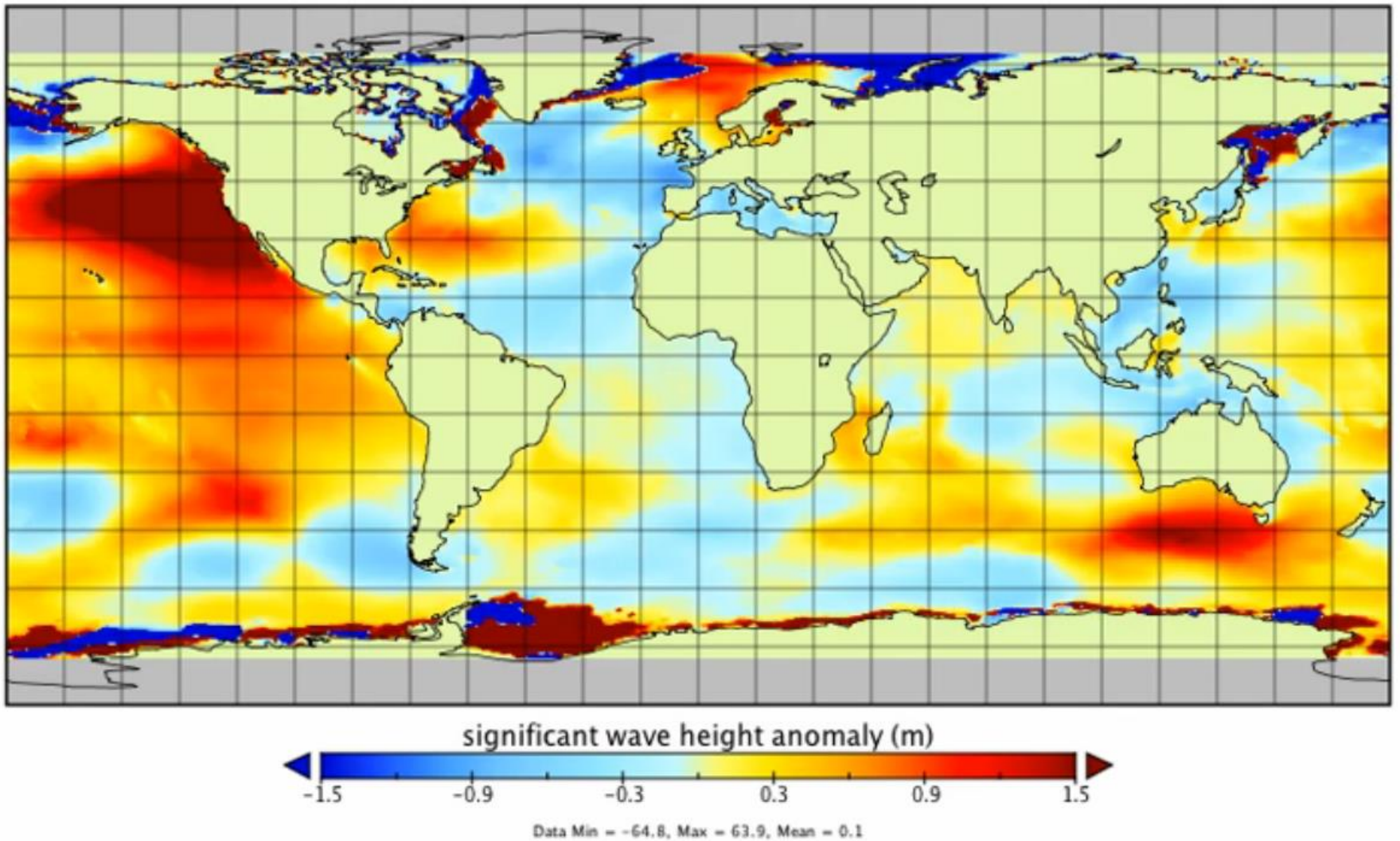
Experiment III


What happens when the surf gets big?
Navare,
Portugal

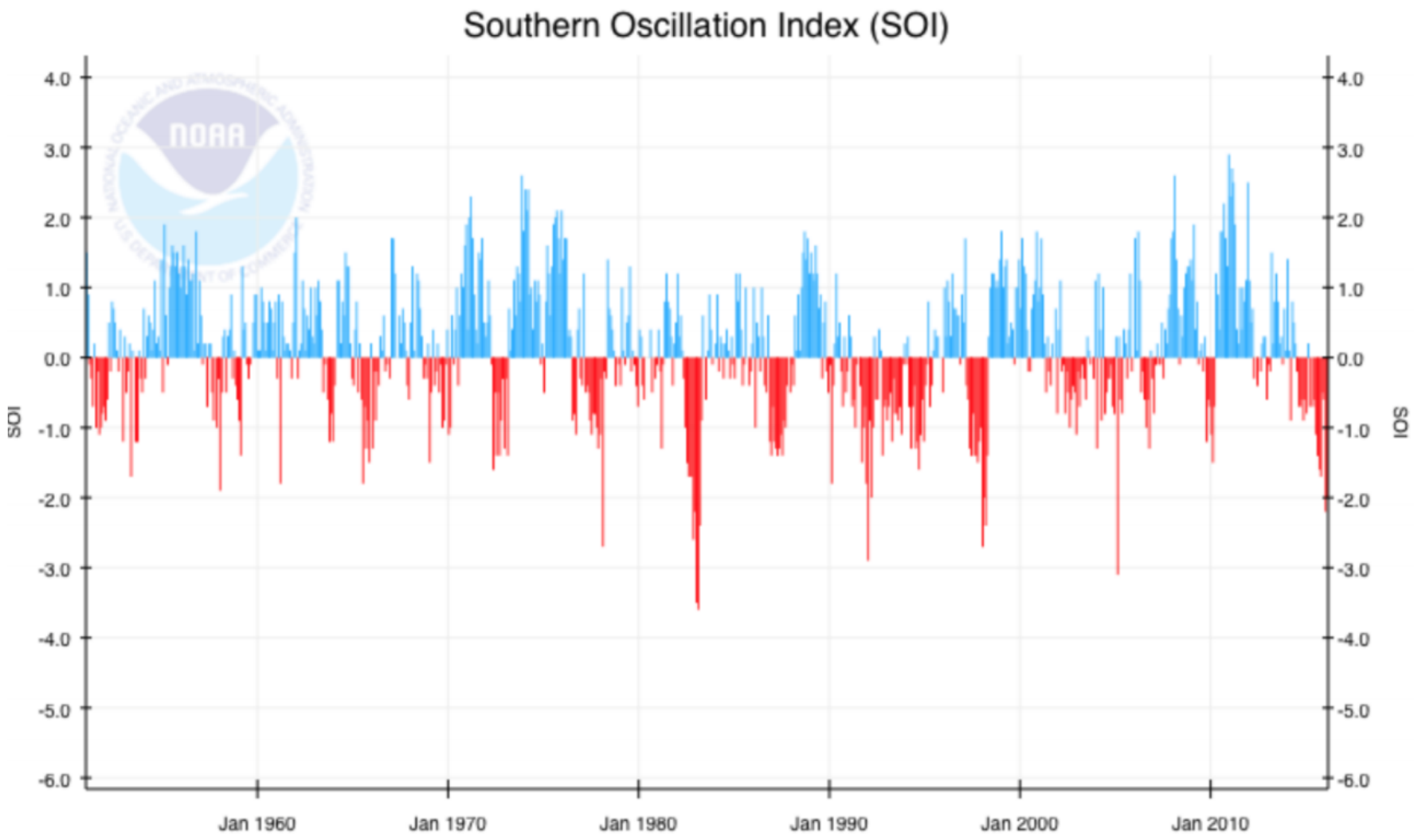
To study this we use monthly data on wave heights around the world, taken from the Australian CSIRO…



…which is de-trended to reveal the “wave height anomaly”, which varies dramatically during El Nino events (pictured)



We identify (binary) El Nino events using the Southern Oscillation Index from the NOAA (SOI<-0.7 for 3 consecutive months)



First, we test to see whether unusually large waves increase light growth (ignoring whether El Nino was the source)

Light growth at 5km

Wave quality

Wave height anomaly

$$\Delta \ln(lights_{i,t}^{5km}) = \alpha + \sum_{j=2}^{5} \beta_j Q_i + \delta wha_{i,t}$$

$$+ \sum_{j=2}^{5} \theta_i Q_i \times wha_{i,t} + C_i + Z_t + \epsilon_{i,t}$$

Interaction *Country FE* *Time FE*

Unusually large waves reduce economic growth on average, but the effect is mitigated for better quality waves

Regression results: Δln(lights) on wave quality, wave height anomaly, and interactions

VARIABLES	(1) Dlnwvltsall5k
Wave quality	
_Istar_2	0.00140
	(0.383)
_Istar_3	0.00351
	(0.956)
_Istar_4	0.00394
	(0.830)
_Istar_5	0.00822
	(1.265)
Wave height anomaly	
wha	-0.148***
	(-5.054)
Interactions	
_IstaXwha_2	0.137***
	(4.416)
_IstaXwha_3	0.133***
	(4.419)
_IstaXwha_4	0.142***
	(3.007)
_IstaXwha_5	0.114*
	(1.697)
Constant	0.184***
	(34.41)
Observations	98,770
R-squared	0.507
Sample	All Waves
Year FE	YES
Country FE	YES

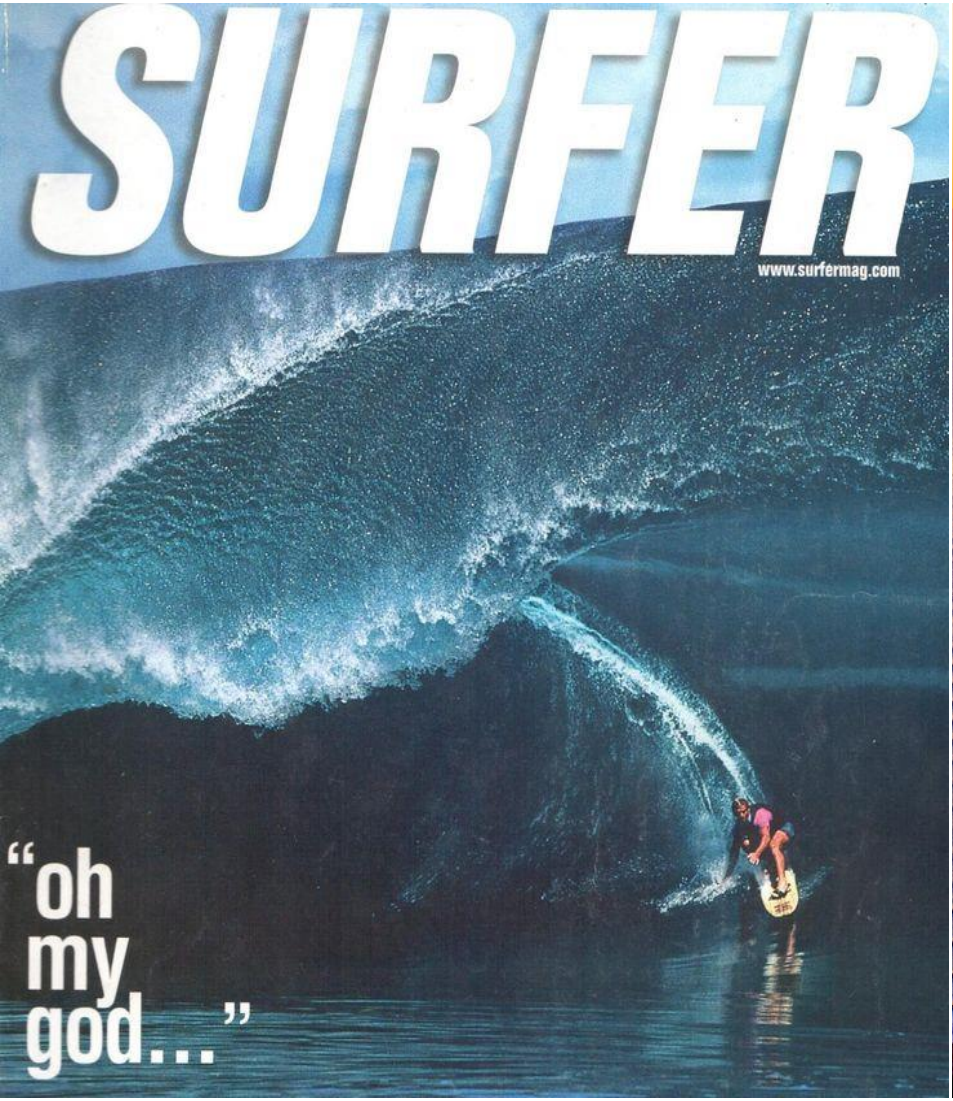
t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

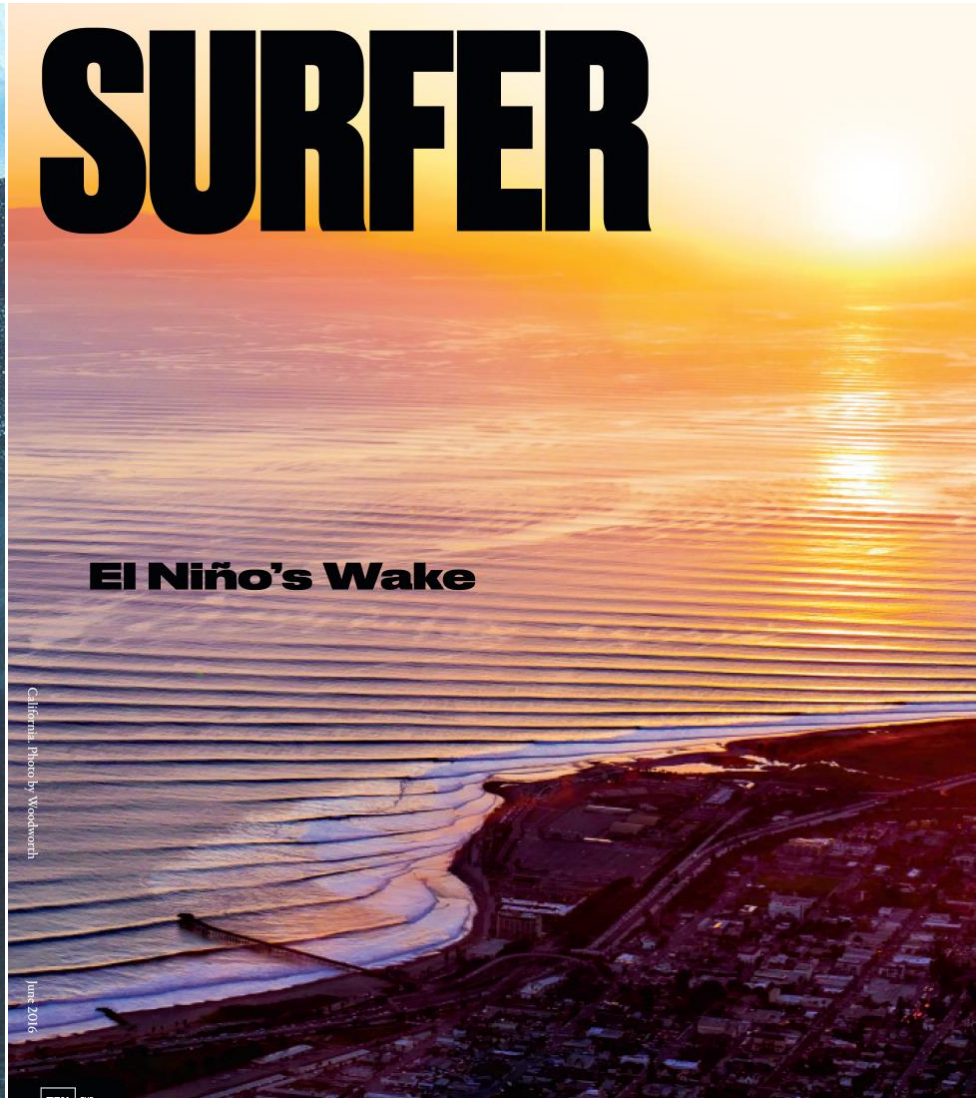
Positive *wha* reduces light growth by ~15 log points on average. "Stormy seas" effect.

The negative effect of big waves is mitigated for places with good quality surf.

Surprisingly the net effect is still negative for the highest-quality "swell-chaser" waves.

These results did not confirm our priors, because litres of ink have been spilled about professional surfers chasing large El Nino swells





We realised that not all big waves are the same. There are big waves with bad weather (wind swell) and with good weather (ground swell)

Shipstern’s Bluff, Tasmania

Big waves with bad weather
(bumpy, short-range swell)

Big waves with good weather
(groomed, long-range swell)

Shipstern’s Bluff, Tasmania

To isolate El Nino long-range swells we ran a 2-stage IV, instrumenting the wave height anomaly with El Nino events

Stage 1

Wave height anomaly *El Nino year (binary)* *Country FE* *YearFE*

$$wha_{i,t} = \alpha_i + \beta_i EN_t + C_i + Z_t + \epsilon_{i,t}$$
$$\forall i = 1, 2, \ldots, 5150$$

- Robust to replacing binary EN with continuous SOI index

Stage 2

Log light growth *Quality* *Fitted wha*

$$\Delta \ln(lights_{i,t}^{5km}) = \alpha + \sum_{j=2}^{5} \beta_j Q_i + \gamma(t) + \delta \widehat{wha}_{i,t}$$

Interaction *Country FE*

$$+ \sum_{j=2}^{5} \theta_i Q_i \times \widehat{wha}_{i,t} + C_i + \epsilon_{i,t}$$

$$where$$
$$\gamma(t) = \gamma_1 t + \gamma_2 t^2 + \gamma_3 t^3 + \gamma_4 t^4$$

← Time trend rather than Year FE because of binary EN_t

Unusually large waves due to El Nino events increase light growth by 3.5x, and significantly more in 5-star waves

Wave quality

Wv hght anom (fitted)

Interactions

Time polynomial

El Nino year

VARIABLES	(1) wha	(2) Dlnwvltsall5k
_Istar_2		0.000997
		(0.204)
_Istar_3		0.00376
		(0.763)
_Istar_4		0.00358
		(0.561)
_Istar_5		0.0112
		(1.284)
whaF		3.456***
		(27.13)
_IstaXwhaF_2		0.0352
		(0.261)
_IstaXwhaF_3		0.285**
		(2.118)
_IstaXwhaF_4		0.128
		(0.733)
_IstaXwhaF_5		1.077***
		(4.353)
t		0.0488***
		(9.592)
t_sq		-0.00803***
		(-8.996)
t_cu		0.000465***
		(7.747)
t_qu		-1.01e-05***
		(-7.454)
ENyr	0.0729***	
	(26.43)	
Constant	-0.0275***	0.0244**
	(-14.12)	(2.437)
Observations	113,300	98,770
R-squared	0.060	0.116
Sample	All Waves	All Waves
Year FE	YES	NO
Country FE	YES	YES
IV		ENyr

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Fitted *wha* increases light growth by ~3.5x on average. "El Nino" effect.

5-star waves have an even bigger "swell-chaser" effect.

El Nino events explain 6% of the variation in the wave height anomaly.

This more accurately fitted our prior that the “circus comes to town” during major swell events.

We find good waves boost economic growth by over 1% p.a: amounting to $22 million per wave or $51 billion globally; and reduce poverty.

Mechanisms

- Waves with mass appeal (4/5 star) have biggest effect
- New lights, rather than redistribution
  - However, tourists displace permanent population
- New activity concentrated in existing towns/cities

Developing Countries

- Surfing has largest effect in emerging markets with adequate business and political stability
- Surfing can reduce extreme rural poverty
  - Poor move to jobs, not vice versa

Robustness

- Same for different coastlines
  - Eg. rivermouth, reefs, headlands
- Robust to alternative baselines
- Big new discoveries increase light growth by 3%pa
- El Nino events increase light growth by 3.5x, even more for 5-star waves

Experiment I (Main result)

Experiment II

Experiment III

Valuing natural assets, like waves, can help to both conserve the environment and reduce poverty

Comments and Questions

El Nino waves: identified by positive and significant beta