Regional Prices Differences and Economic Development Gaps

Petros Milionis

University of Groningen

Groningen Growth and Development Center
25th Anniversary Conference

June 30, 2017
Growing Interest in Regional Development

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- In the recent years, though, there has been a growing interest in regional development patterns.

- This is largely driven by new data and econometric techniques.

- As a result within-country comparisons have emerged as an important testing ground for economic development theories.

(Gennaioli et al., 2013; Acemoglu et al. 2014)
Cross-country GDP comparisons are based on GDP figures adjusted for relative prices across countries and time. Regional GDP comparisons do not fully adjust for relative price differences across regions. Most available regional GDP statistics are adjusted for prices differences only at the country level. Yet, prices differ systematically also within countries across regions, as they do across countries.
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- Yet, prices differ systematically also within countries across regions, as they do across countries.
Why Study Regional Price Differences?

There is a vast literature on relative price differences and how they vary with economic development. (Rogoff, 1996; Taylor, 2002; Bergin et al., 2006; Deaton, 2010; Johnson et al. 2013, Feenstra et al., 2015; Inklaar & Prasada-Rao, 2017)

But this literature focuses on relative price differences across countries.

There is some work on price differences within countries. (Cecchetti et al. 2002, Crespo-Cuaresma et al. 2007; Rogers, 2007; Reiβ & Rumler, 2014)

The literature, however, is quite thin and mostly based on US city level data.

Beyond the US case we don’t know much about regional price differences.

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Reg. Prices Differences & Econ. Dev. Gaps

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This Paper

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- Provides some direct evidence for within-country price differences.
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- Provides some direct evidence for within-country price differences.

- Performs indirect corrections via the short-cut method.

- Constructs price-adjusted real GDP series at the regional level.

- Assesses how these price corrections affect key conclusions about regional economic development.
Main Findings

Regional price differences are found to be sizeable.

The Penn effect can be seen also at the regional level.

Adjusting for regional price differences reduces measured within-country income differences.

It also weakens evidence regarding income convergence across regions.

Current analysis focus on EU regions. Eventually it will be extended to a global level.
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Presentation Roadmap

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- Contrast NUTS-2 EU regions with US states.
- Present direct measures of price differences across EU regions.
- Use the short-cut method to indirectly correct for price differences in the absence of price data for EU regions.
- Compare income difference across EU regions with and without price adjustment.
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Present direct measures of price differences across EU regions.

Use the short-cut method to indirectly correct for price differences in the absence of price data for EU regions.

Compare income difference across EU regions with and without price adjustment.

Show how interregional price adjustment alter results about income convergence.
The US case is an interesting case because:
(a) it is a country for which we have long regional GDP series.
(b) the BEA provides properly constructed regional price indexes.

However, conclusions reached by comparing US states may not be generalizable. The US is a highly integrated and competitive economy. As a result there are strong forces leading to both price and income convergence.
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Income Convergence across US States

The chart illustrates the income convergence across US states, with each state represented by a point on the graph. The x-axis represents the regional income levels, while the y-axis shows the growth rates. The red line indicates the fitted values, showing the trend in income convergence. The states are labeled, and the plot highlights the differences in economic development across these regions.
Penn Effect across US States

![Graph showing relative regional price parities, BEA and fitted values.](image_url)
## Income and Price Differences across US States

<table>
<thead>
<tr>
<th>Year 2007</th>
<th>US States</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Relative GDP per capita (Unadjusted)</td>
<td>1</td>
</tr>
<tr>
<td>Relative GDP per capita (Adjusted)</td>
<td>1</td>
</tr>
<tr>
<td>Relative Price Index (BEA)</td>
<td>1</td>
</tr>
</tbody>
</table>
In the case of EU we focus on NUTS-2 Regions.
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Income differences across NUTS-2 regions are much larger compared to US states.
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<table>
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<tr>
<th></th>
<th>Year 2007</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US States</td>
<td>EU Regions (NUTS-2)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>St. Dev.</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Relative GDP per capita (Unadjusted)</td>
<td>1 0.1965 0.6784 1.5658</td>
<td>1 0.2997 0.0761 1.6939</td>
<td>1.1634 0.2162 0.3580 1.6939</td>
</tr>
</tbody>
</table>
Within-Country Income Differences in the EU

[Bar chart showing income differences across various EU countries]
Direct Evidence

on Regional Price Differences
Numbeo Online Price Database

Numbeo is the world’s largest database of user contributed data about cities and countries worldwide. Numbeo provides current and timely information on world living conditions including cost of living, housing indicators, health care, traffic, crime and pollution.

3,718,100 prices in 6,624 cities entered by 408,552 contributors

Select Location: Type and Pick City
Or ---Select country---

Your city is not here? Tell us about cost of living in your city!
Numbeo Online Price Database

- Crowd-sourced global database of reported consumer prices and other statistics.
- Founded by ex-Google software engineer.
- Collaborative online platform enabling user-shared information.
- Provide 3.7 million price data on a variety of goods.
- Data come primarily from cities.
### Numbeo Online Price Database

<table>
<thead>
<tr>
<th>Examples of Reported Goods</th>
<th>Meal, Inexpensive Restaurant</th>
<th>One-way Ticket (Local Transport)</th>
<th>1 Pair of Jeans (Levis 501 Or Similar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>McMeal at McDonalds</td>
<td>One-way Ticket (Local Transport)</td>
<td>Monthly Pass (Regular Price)</td>
<td>1 Summer Dress in a Chain Store</td>
</tr>
<tr>
<td>Domestic Beer (0.5 liter draught)</td>
<td>Taxi Start (Normal Tariff)</td>
<td>Taxi 1km (Normal Tariff)</td>
<td>1 Pair of Nike Running Shoes</td>
</tr>
<tr>
<td>Cappuccino (regular)</td>
<td>Volkswagen Golf 1.4 90 KW Trendline</td>
<td>Utilities (Electricity, Heating, Water, Garbage)</td>
<td>1 Pair of Men Leather Business Shoes</td>
</tr>
<tr>
<td>Coke/Pepsi (0.33 liter bottle)</td>
<td>1 min. of Prepaid Mobile Tariff Local</td>
<td>Internet (10 Mbps, Unlimited Data, Cable/ADSL)</td>
<td>Apartment (1 bedroom) in City Centre</td>
</tr>
<tr>
<td>Water (0.33 liter bottle)</td>
<td>Fitness Club, Monthly Fee</td>
<td>Price per Square Meter to Buy Apartment in City Centre</td>
<td>Apartment (3 bedrooms) in City Centre</td>
</tr>
<tr>
<td>Milk (regular), (1 liter)</td>
<td></td>
<td></td>
<td>Tennis Court Rent (1 Hour on Weekend)</td>
</tr>
<tr>
<td>Loaf of Fresh White Bread (500g)</td>
<td></td>
<td></td>
<td>Cinema, International Release, 1 Seat</td>
</tr>
<tr>
<td>Rice (white), (1kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Price Differences across EU Regions

- BuyApartCenter
- Fitted values

2011 r_y_nPPP

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Reg. Prices Differences & Econ. Dev. Gaps
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Price Differences across EU Regions

- Residuals
- Fitted values
Indirect Evidence
on Regional Price Differences
The Short-Cut Method

- This technique -referred to as the “short-cut” method- has a long history in the international comparison literature (Kravis, Heston & Summers, 1978, 1982; Prados, 2000, Klasing & Milionis, 2014).
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- The link between relative price differences and relative income levels (Penn Effect) implies that the relationship:

\[
\frac{y_{i,t}^{PPP}}{y_{j,t}^{PPP}} = f\left(\frac{y_{i,t}^{nPPP}}{y_{j,t}^{nPPP}}, \text{priceIsolation}_{i,t}\right)
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- So if $f(\cdot, \cdot)$ was known, it could be employed to predict $\frac{y_{i,t}^{PPP}}{y_{j,t}^{PPP}}$ from $\frac{y_{i,t}^{nPPP}}{y_{j,t}^{nPPP}}$ and $\text{pricelsolation}_{i,t}$. 
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\frac{y_{i,t}^{PPP}}{y_{j,t}^{PPP}} = f\left(\frac{y_{i,t}^{nPPP}}{y_{j,t}^{nPPP}}, \text{pricesolution}_{i,t}\right)
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The Short-Cut Method

Specifying a long-linear $f(\cdot, \cdot)$:

$$
\ln \frac{y_{i,t}^{PPP}}{y_{US,t}^{PPP}} = \alpha + \beta_1 \ln \frac{y_{i,t}^{nPPP}}{y_{US,t}^{nPPP}} + \beta_2 (\ln \frac{y_{i,t}^{nPPP}}{y_{US,t}^{nPPP}})^2 + \beta_2 (\ln \frac{y_{i,t}^{nPPP}}{y_{US,t}^{nPPP}})^3 + \\
+ \beta_3 \ln \frac{Pop_{i,t}}{Pop_{US,t}} + \beta_4 \ln \frac{Area_{i,t}}{Area_{US,t}} + \beta_5 \ln LandLock_i + \epsilon_{i,t}.
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$$+ \beta_3 \ln \frac{Pop_{i,t}}{Pop_{US,t}} + \beta_4 \ln \frac{Area_{i,t}}{Area_{US,t}} + \beta_5 \ln LandLock_i + \varepsilon_{i,t}.$$  

- Allow $\beta_1$ and $\beta_2$ to also vary with the level of development and the exchange rate regime.
The Short-Cut Method

- Specify a long-linear $f(\cdot, \cdot)$:

$$
\ln \frac{y_{i,t}^{PPP}}{y_{US,t}^{PPP}} = \alpha + \beta_1 \ln \frac{y_{i,t}^{nPPP}}{y_{US,t}^{nPPP}} + \beta_2 (\ln \frac{y_{i,t}^{nPPP}}{y_{US,t}^{nPPP}})^2 + \beta_2 (\ln \frac{y_{i,t}^{nPPP}}{y_{US,t}^{nPPP}})^3 + \\
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$$

- Allow $\beta_1$ and $\beta_2$ to also vary with the level of development and the exchange rate regime.

- Estimate this equation based on the Penn World Table data and alternative based on the US state data from BEA.
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Allow $\beta_1$ and $\beta_2$ to also vary with the level of development and the exchange rate regime.

Estimate this equation based on the Penn World Table data and alternative based on the US state data from BEA.

Use the estimated relationship to make out-of-sample predictions of $y_{i,t}^{PPP}$ for EU regions using the $y_{i,t}^{nPPP}$ of Eurostat.
## Short-Cut Estimation Results

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Data</th>
<th>Estimation Method</th>
<th>GLS</th>
<th>GLS</th>
<th>GLS</th>
<th>GLS</th>
<th>BEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln($y_{nPPP}$)</td>
<td>BEA</td>
<td>GLS</td>
<td>0.288***</td>
<td>0.304***</td>
<td>0.244***</td>
<td>0.328***</td>
<td>0.821***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0281)</td>
<td>(0.0309)</td>
<td>(0.0285)</td>
<td>(0.0752)</td>
<td>(0.0138)</td>
</tr>
<tr>
<td>ln($y_{nPPP}$)^2</td>
<td></td>
<td>GLS</td>
<td>-0.163***</td>
<td>-0.0475</td>
<td>0.0331</td>
<td>0.113</td>
<td>0.0986***</td>
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<tr>
<td></td>
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<td>(0.0430)</td>
<td>(0.0524)</td>
<td>(0.0409)</td>
<td>(0.0883)</td>
<td>(0.0151)</td>
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<tr>
<td>ln($y_{PPP}$)^3</td>
<td></td>
<td>GLS</td>
<td>0.0200***</td>
<td>0.00982*</td>
<td>0.0775***</td>
<td>0.0540***</td>
<td>-0.0162***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.00590)</td>
<td>(0.00580)</td>
<td>(0.00961)</td>
<td>(0.0135)</td>
<td>(0.00274)</td>
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<tr>
<td>ln(Population)</td>
<td></td>
<td>GLS</td>
<td>-0.0663***</td>
<td>-0.0225***</td>
<td>-0.0661***</td>
<td>-0.0613***</td>
<td>0.0185***</td>
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<td></td>
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<td>(0.00445)</td>
<td>(0.00439)</td>
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<tr>
<td>ln(Area)</td>
<td></td>
<td>GLS</td>
<td>-0.464***</td>
<td>-0.0192</td>
<td>0.170***</td>
<td>0.144***</td>
<td>0.0444***</td>
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<td></td>
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<td></td>
<td>(0.0255)</td>
<td>(0.0265)</td>
<td>(0.0202)</td>
<td>(0.0272)</td>
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<tr>
<td>Currency Regime</td>
<td></td>
<td>GLS</td>
<td>0.0914***</td>
<td>0.107***</td>
<td>0.0152</td>
<td>0.0541</td>
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<td></td>
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<td>(0.0144)</td>
<td>(0.0243)</td>
<td>(0.0121)</td>
<td>(0.0511)</td>
<td></td>
</tr>
<tr>
<td>ln($y_{nPPP}$) x Currency Regime</td>
<td>GLS</td>
<td>0.0402***</td>
<td>0.101***</td>
<td>-0.0437**</td>
<td>-0.00964</td>
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<td>(0.0125)</td>
<td>(0.0206)</td>
<td>(0.0221)</td>
<td>(0.0660)</td>
<td></td>
</tr>
<tr>
<td>ln($y_{nPPP}$)^2 x Currency Regime</td>
<td>GLS</td>
<td>0.000969</td>
<td>0.0162***</td>
<td>-0.0244***</td>
<td>-0.0162</td>
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<tr>
<td>Periphery</td>
<td></td>
<td>GLS</td>
<td>0.276***</td>
<td>0.283***</td>
<td>0.366***</td>
<td>0.119*</td>
<td>0.0387</td>
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<td></td>
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<td>(0.0208)</td>
<td>(0.0326)</td>
<td>(0.0226)</td>
<td>(0.0657)</td>
<td>(0.0533)</td>
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<tr>
<td>ln($y_{nPPP}$) x Periphery</td>
<td>GLS</td>
<td>0.561***</td>
<td>0.512***</td>
<td>0.594***</td>
<td>0.314***</td>
<td>0.285</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>(0.0371)</td>
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<td>ln($y_{nPPP}$)^2 x Periphery</td>
<td>GLS</td>
<td>0.227***</td>
<td>0.0605</td>
<td>0.0795*</td>
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<td>(0.530)</td>
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<td>Adj. R-squared</td>
<td></td>
<td></td>
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<td>0.914</td>
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</tbody>
</table>

GLS estimation corrects for heteroskedasticity and serial correlation within panels. Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1
Indirect Evidence on Regional Price Differences

Short-Cut Estimation Results

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Data</th>
<th>Estimation Method</th>
<th>GLS</th>
<th>GLS</th>
<th>GLS</th>
<th>GLS</th>
<th>GLS</th>
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<tr>
<td>ln(y_nPPP)</td>
<td>BEA</td>
<td>GLS</td>
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<td>0.304***</td>
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<td>ln(yPPP)^3</td>
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<tr>
<th>EU Regions (NUTS-2)</th>
<th>Shares of Variance Explained</th>
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<tr>
<td>GDP per capita Measure</td>
<td>Overall</td>
</tr>
<tr>
<td>Country-Price Adjusted</td>
<td>45.51%</td>
</tr>
<tr>
<td>Region-Price Adjusted</td>
<td>30.74%</td>
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*Petros Milionis () RuG () Reg. Prices Differences & Econ. Dev. Gaps*
## Year 2007

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### Variance Decomposition

<table>
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<tr>
<th>GDP per capita Measure</th>
<th>Overall</th>
<th>Within</th>
<th>Between</th>
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<tbody>
<tr>
<td>Nominal</td>
<td>100.00%</td>
<td>37.00%</td>
<td>63.00%</td>
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<tr>
<td>Country-Price Adjusted</td>
<td>100.00%</td>
<td>56.00%</td>
<td>43.00%</td>
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<tr>
<td>Region-Price Adjusted</td>
<td>100.00%</td>
<td>29.00%</td>
<td>71.00%</td>
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</table>
Implications for Income Convergence
Growth Regression Setup

We test for within-country income convergence using the panel growth regression setup:

$$g_{y_{i,c,t}} = \alpha_0 + \beta \ln y_{i,c,t-1} + \gamma' X_{i,c,t} + \delta_c + \delta_t + \varepsilon_{i,c,t},$$

- $y_{i,c,t}$: GDP per capita adjusted for regional price differences.
- $X_{i,c,t}$: various regional controls
- Frequency: overlapping 3-year periods
- Sample Period: 2000-2013
### Growth Regressions Results

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>3-year-average growth rate of GDP per capita Across Countries</th>
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</thead>
<tbody>
<tr>
<td>Price Adjustment</td>
<td></td>
</tr>
<tr>
<td>GDP per capita (t-1)</td>
<td>-0.00296, -0.00936***, -0.0133** (0.00269, 0.00354, 0.00582)</td>
</tr>
<tr>
<td>Pop. Growth</td>
<td>-0.0908***, -0.0948*** (0.0199, 0.0198)</td>
</tr>
<tr>
<td>Investment Share</td>
<td>0.0144***, 0.0181*** (0.00524, 0.00532)</td>
</tr>
<tr>
<td>Tert. Schooling</td>
<td>0.00671*** (0.00155)</td>
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<tr>
<td>Agricultural Share</td>
<td>-0.0706*** (0.0226)</td>
</tr>
<tr>
<td>Adj. R-squared</td>
<td>0.56, 0.59, 0.62</td>
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<tr>
<td>Observations</td>
<td>1,601, 1,601, 1,601</td>
</tr>
<tr>
<td>Number of regions</td>
<td>245, 245, 245</td>
</tr>
</tbody>
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Regression include country and time fixed effects. Driscoll-Kraay standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.
## Implications for Income Convergence

### Growth Regressions Results

### Table: Growth Regressions Results

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<td>Across Countries</td>
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Regression include country and time fixed effects. Driscoll-Kraay standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.
Summary of Findings

This paper investigates the role of regional price difference for economic development and finds that:

1. Direct and indirect measures suggest that price differences at the regional level are sizeable.

2. Richer regions tend to have higher prices in line with the Penn effect.

3. Not adjusting for regional prices differences leads to:
   (a) an overstatement of within-country income differences.
   (b) a bias towards higher convergence rates across regions.

These findings imply that proper quantification of regional income differences requires good information on regional price differences.
Next Steps

1. Extend analysis beyond EU regions to a global sample.

2. Conduct analysis at different levels of aggregation.

3. Compare with luminosity data.
