European Economic Review 92 (2017) 110–132

Contents lists available at ScienceDirect

European Economic Review

journal homepage: www.elsevier.com/locate/eer

Regional inequality, convergence, and its determinants – A view from outer space☆

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ARTICLE INFO

JEL:
D30
E01
E23 O11
O15
O57
R10

Keywords:
Regional inequality
Spatial inequality
Sigma convergence
Panel data
Luminosity data
Economic development

ABSTRACT

This paper provides a new dataset of regional income inequalities within countries based on satellite nighttime light data. First, we empirically study the relationship between luminosity data and regional incomes for those countries for which regional income data are available. Second, we use our estimation results for an out-of-sample prediction of regional incomes based on the luminosity data. These results enable us to investigate regional income differentials in developing countries that lack official income data. Third, we calculate commonly used measures of regional inequality within countries based on predicted incomes. An investigation of changes in the dispersion of regional incomes over time reveals that approximately 67–70% of all countries experience sigma-convergence. Forth, we study different major determinants of within-country changes in inequality, i.e., the determinants of the convergence process. We find evidence for an N-shaped relationship between development and regional inequality. Resources, mobility, trade openness, aid, federalism and human capital are also very important.

1. Introduction

In recent decades, the regional distribution of incomes within countries has attracted considerable interest among academics and policy makers. Important research questions include, among others the following: What are the consequences of regional inequality? What are the determinants? Are regional inequalities transient or permanent? How do interregional inequalities relate to interpersonal income inequalities, conflict, ethnicity, and geography? Because these questions are obviously important for the economy in particular and society in general, many empirical studies on these issues have been carried out with interesting and instructive results. However, all these studies are limited to a particular country sample with a general bias toward middle- and high-income economies. The major difficulty encountered in conducting this research is the availability of regional income data. Although it is easy to obtain regional data for developed countries through the regional statistics of the OECD and other public sources, doing so becomes difficult if less-developed regions of the world are under study. Recent studies by Gennaioli et al. (2013, 2014) and Lessmann (2014) have made great progress in this field. However, the poorest regions of the world remain blank spots on the map, limiting the informative value of study results to particular country samples. The aim of our study is to fill this gap using satellite nighttime light data to develop a proxy for regional incomes.

☆ We are grateful to the participants in research seminars and conferences at the Friedrich Schiller Universität Jena, the 5th Workshop on Regional Economics at the Ifo Institute Dresden and the annual meeting of the development economics group of the German Economic Association in Heidelberg for their many helpful comments. We also thank Rafael La Porta for proving us regional income data and shape files.

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http://dx.doi.org/10.1016/j.euroecorev.2016.11.009
Received 4 December 2015; Accepted 26 November 2016
Available online 21 December 2016

Our approach is based on Henderson et al. (2012), who show a striking relationship between changes in nighttime light intensities and economic growth at the country level. The idea is as follows: Most economic activities of consumption and production that take place in the evening or at night require light. We can expect that the higher a country's nighttime light intensity, the higher its level of economic activity, i.e., the higher its income. Therefore, luminosity data measured by satellites can be used as a proxy for income in those parts of the world for which we have no reliable statistical data. Although this issue might be minor for country-level income data (see also Johnson et al., 2013), it is major at the regional level. Regional data are often lacking in developing countries, whose statistical authorities have low capacities and standards. For this reason, Chen and Nordhaus (2011, 2015) show how nighttime luminosity data can be used to improve estimates of output per grid cell (1° latitude ×1° longitude), particularly in this group of countries. Consequently, recent studies, such as Besley and Reynal-Querol (2014) or Hodler and Raschky (2014), use these sorts of data to proxy regional income levels. We follow this literature to construct new data on regional income inequality within countries, which we provide at http://dx.doi.org/10.7802/1339.

We use the luminosity data to predict regional incomes per capita at a sub-national level for 180 countries from 1992 to 2012. Our prediction of regional incomes through nighttime light data uses existing regional income data to obtain an estimate of the light-income relationship at the regional level, which could be used in out-of-sample predictions for those regions for which income data are unavailable. Based on these predictions, we calculated different measures of regional income inequality, for example, the population-weighted Gini coefficient and different generalized entropy indexes, which easily translate to the inequality measures recommended by Atkinson (1970).

Our study's primary innovation is that we analyze the dynamics of regional income inequality and its determinants. Unlike previous studies, we are not limited to a particular country sample. First, we use the data on regional inequality to analyze sigma-convergence within countries. Whereas beta-convergence focuses on the (better) growth performance of initially poor regions within a country, sigma-convergence is the decrease in the dispersion of regional incomes. By comparing the changes in our inequality measures between 1992–2001 and 2002–2012, we find that more than 67% of all countries experience sigma-convergence. However, a significant number of countries—developing countries (e.g., Mozambique and Bangladesh) and industrial economies (e.g., Sweden and Russia) alike—are experiencing increasing inequality.

Next, we use our data to investigate the determinants of regional inequality and convergence. Using panel fixed-effects regressions that focus on within-country variations in the data, we find that in very poor countries—e.g., countries in the center of Africa such as Chad and the Democratic Republic of the Congo—development has an increasing effect on regional inequalities. However, in countries that could be called middle- or high-income countries in their respective country groups, such as Zambia and South Africa, development has a decreasing effect on regional inequalities. This result supports previous evidence of an inverted U-shaped relationship between economic development and regional inequality (see Williamson, 1965, Barrios and Strobl, 2009, and Lessmann, 2014). Importantly, our data on the very poorest countries in the world allow us to estimate the upward sloping part of the Kuznets curve in regional inequalities. Furthermore, we find increasing inequalities at very high levels of economic development. Therefore, the relationship is ultimately N-shaped in our data, i.e., it exhibits an inverted U with another increase in inequality after the inverted U pattern has been completed. This is in line with the findings of Amos (1988) for the case of U.S. states. We also investigate the impact of several economic and political determinants on regional inequality: natural resources, trade openness, transportation costs, aid payments and ethnic income inequality are positively correlated with regional inequality, whereas the share of arable land, federalism and human capital are negatively correlated with regional inequality. In many respects, our results support earlier studies in the field. However, we now can analyze regions of low-income countries, which helps us generalize these findings. Our empirical results do not suffer from a potential sample selection bias. Here, we emphasize that in this part of the analysis we conduct only OLS regressions; therefore, our results document only statistical correlations, which may not represent causal relationships. Therefore, we abstain from strong policy recommendations and explicitly encourage researchers to investigate this and other relevant issues in more detail.

The remainder of the paper is organized as follows. In Section 2, we first explain the methodology that we apply to construct regional income proxies from luminosity data. Thereby, we also discuss several important measurement issues that are relevant when working with satellite data in a regional context. We then use the predicted incomes to calculate different measures of regional inequality within countries. In Section 3, we analyze differences in regional inequality across countries and its changes over time, i.e., sigma-convergence. In Section 4, we regress the inequality measures on selected explanatory variables to study the determinants of the within-country variation in regional inequality. In Section 5, we summarize our main findings and conclude.

2. Measuring regional inequality with luminosity data

To obtain measures of regional inequality for those countries that lack reliable regional income data, we follow a two-step procedure. The first step of our analysis is to predict regional incomes using night light data (Section 2.2)[1]; the second step is to calculate inequality measures based on the predicted incomes (Section 2.3). In this regard, we deviate from existing studies such as Alesina et al. (2016) and Mveyange (2015), who directly focus on light dispersion measures as a proxy for income dispersion measures. We adopt this approach for two reasons. First, the previous literature finds a log-linear relationship between light density and income. A constant light-income elasticity implies that the relationship between light levels and income levels depends on the

[1] Note that we use income, output, and GDP synonymously because it is impossible to distinguish between consumption and production using the underlying data. We assume that all relevant variables are highly correlated.