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Issues in Environmental Economics: Sustainability and Eco-efficiency

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CONTENTS

Introduction

This thesis deals empirically with various research questions in environmental economics. In particular the issues of sustainability and eco-efficiency are approached on three different data-sets. The first paper deals with the analysis of eco-efficiency for 103 provincial (NUTS 3 - Nomenclature of Units for Territorial Statistics 3) capitals of Italy throughout 2000-2008. It focuses on the link among economic growth, energy consumption and air pollution, modeling cities as territorial units that ought to promote growth, while at the same time minimising its environmental impact. Subsequently, the eco-efficiency of this panel of provincial capitals is measured through panel estimates of an input-distance function. Within this procedure, considering some environmental control variables, the paper evaluates if environmental best practices correspond either to those municipalities that adopt environment-friendly policies or to cities characterised by a particular urban context. The evidence points to the existence of a significant link between economic development, energy consumption and air pollution at the provincial capital level. The most ecoefficient provincial capitals are also among the wealthier, which is consistent with an Environmental Kuznets Curve.

The second paper investigates the Ecological Footprint indicator by focusing on the notion of sustainable development and then of carrying capacity of land. The impact of man on nature is explored through an empirical analysis of the growth rate of population, and the percentage of urban and rural population, in Europe. The level of CO_2 emissions per inhabitant in the EU is compared with that of developing countries. Through a sectoral approach, the total CO_2 emissions per capita from fuel combustion, electricity and heat production, manufacturing industries and construction, transport and other sources are separately appraised.

The third paper studies the relationship between rice production and methane emissions. Rice farming is believed to be a major anthropogenic source of methane emissions, which are measured emissions at both country and world levels of aggregation. It presents a quantitative estimation of the statistical relationship between rice production dynamics and methane emissions with regression estimates computed (country-wise and globally) over a large set of countries. The evidence only partly validates the expectation of a positive statistical influence of rice production on methane emissions. In fact a Kuznets-type evidence shows up: increasing rice production is correlated with fewer emissions. This negative relationship holds for a measure of countries sufficient to emerge significantly also at the world level.

Eco-Efficiency, Energy and Air pollution: a NUTS 3 analysis for Italy

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Abstract

The aim of this paper is the analysis of eco-efficiency for 103 provincial (NUTS 3 - Nomenclature of Units for Territorial Statistics 3) capitals of Italy throughout 2000-2008. We focus on the link among economic growth, energy consumption and air pollution, modeling cities as territorial units that ought to promote growth, while at the same time minimising its environmental impact. Subsequently, we empirically assess the eco-efficiency of this panel of provincial capitals and, considering some environmental control variables, we evaluate if environmental best practices correspond either to those municipalities that adopt environment-friendly policies or to cities characterised by a particular urban context. Estimation is carried out through a parametric input-distance function. Our results confirm the existence of a significant link between economic development, energy consumption and air pollution at the provincial capital level. The most eco-efficient provincial capitals are also among the wealthier, providing evidence consistent with an Environmental Kuznets Curve. On the other hand, evidence in favor of a role of environment-friendly policies is insignificant.

Keywords: eco-efficiency; energy use; environment-friendly policy; air pollutants; Kuznets curve.

1. Introduction

The leitmotif of sustainable economic policies is to protect and to enhance the environment in the process of economic development for the benefit of a greater economic and environmental efficiency. In this paper we deal with these issues analysing the eco-efficiency of 103 Italian provincial capitals (the province being a NUTS 3 - Nomenclature of Units for Territorial Statistics 3 - territorial jurisdiction, akin to a British county) throughout the 2000-2008 period. The motivation for this territorial level of analysis comes from the increasing importance taken by the concept of sustainability with respect to the issue of urban growth. Urban areas are increasingly becoming a nodal space within the global economy, in fact the city is an important generator of: wealth, employment opportunities, productivity growth, and a driving force for each national economy. At the same time, the city is also a generator of strong environmental pressures. So, the concept of urban eco-efficiency attracts attention and assumes a central role in analysis and policy evaluation.

The paper proceeds as follows. In the next section we deal with the definition of eco-efficiency, and subsequently with the construction of a function within the economic-environmental and economic territorial systems. The construction of an "environmental function" must have as its objective the rationalization in the use and management of natural resources and the preservation of the environment in connection with economic objectives related to the idea of development, and not in conflict with that. Economy and environment are closely interconnected with each other just like it is possible to see in the concept of sustainable development. Sustainable development is "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Bruntland Report, 1987).

In the third section we describe our institutional set-up. As we want to evaluate whether the best environmental practices correspond to those provincial capitals that have adopted environment-friendly policies, we present these policies in some detail. In the fourth section, we provide our approach to the identification of eco-friendly municipalities. Some justification is provided for our choice of production set and measures of efficiency. The fifth section sets out the empirical counterpart of this approach, describing our data-set. The sixth section presents a comparative analysis of our regression results for various models (Not-per capita and Per capita models). Some concluding remarks are offered in the last section.

The fundamental contribution of Fare *et al.* (1989) analysed the harmful effects of the observed activities on the environment, taking into account the presence of undesirable outputs of the economic processes (output-environmental perspective) using econometric techniques. In particular, the most significant contributions are: Fare *et al.* (1989), Fare *et al.* (1993), Ball *et al.* (1994), Lovell *et al.* (1995).

An alternative to the classical approach is adopted by the input-environmental literature. This consists in including environmental harmful inputs in the set of production possibilities, in order to assess the environmental effects of bad inputs (input- environmental perspective). In this strand of the literature, the most significant contribution is the approach of Reinhard (1999). An alternative approach to the Reinhard (1999) model is the work of Kortelainen and Kuosmanen (2004b).

2. Defining eco-efficiency

In general terms, eco-efficiency is the optimal use of resources compatibly with the environment and involves minimizing environment-damaging while maximizing the economic outcome of production processes. Eco-efficiency reflects the capacity of a given unit (a firm, a territorial area, etc.) to transform inputs in outputs in an optimal way with respect to a benchmark, while considering at the same time also the environmental impact, through more recycling, lesser use of energy and natural resources, elimination of dangerous emissions. The definition of eco-efficiency hence naturally considers both economic and environmental parameters.

In the case of territorial systems, the areas of application of the eco-efficiency concept can be different: transport, greenhouse gases emissions and air pollution, waste, water, the share of renewable energy, investments for environmental protection. In this paper we refer to the eco-efficiency of the provincial capitals of Italy with respect to a series of environmental variables referring to energy consumption and air pollution. We model cities as territorial units that are assumed to promote economic development, while at the same time minimizing its environmental impact in terms of energy consumption and air pollution.

Urban areas are increasingly becoming a nodal space within the global economy. All along history, one of the main functions of the city has been its ability to catalyse economic activities and attract population. The city is an important generator of wealth, employment opportunities, productivity growth, and a driving force for each national economy; at the same time, the city is also a generator of strong environmental pressures. Cities in fact produce a significant part of a country GDP and, in most cases, large cities per capita GDP is higher than the national average. Cities gather half of the world population, even if they occupy only 2% of the Earth's surface, using 75% of the natural resources of the world (UNDP, 2003). However, this acceleration of urbanization in the world, albeit strengthening the economic importance of the city, and causing the concentration of population, economic activities, social and leisure facilities in the cities themselves, also generates a continuous pressure on the surrounding environment with negative externalities (OECD, 2006). For this reason, it is necessary to make cities drivers of the local economy in an environmentally sustainable manner.

Our paper proposes an econometric analysis of the features of urban environmentally sustainable growth, focusing on the economic and environmental performance of the provincial capitals of Italy, as far as energy consumption and air pollution are concerned. We aim to assess whether environmental best practices correspond either to those municipalities that adopt environmentally sustainable policies or to cities characterized by a particular urban context. One question we want to answer in this paper is if the most economically developed cities of the Italian economy have become, in the course of time, also the most environment-friendly or have, on the contrary, paid their development in terms of environmental damage. We rely on a large data-set, mostly based upon official data, covering 103 provincial capitals of Italy throughout the 2000-2008 period.

3. The institutional set-up

The aim of our research is the analysis of eco-efficiency for the provincial (NUTS 3) capitals of Italy. The Nomenclature of Units for Territorial Statistics (for French "*Nomenclature des unités territoriales statistiques*") is a standard geocode (3 is for provinces). More information about the Italian provinces is provided in Appendix A (see Figure A.1 in particular). We want to evaluate the economic and environmental performance of provincial capitals in a sustainable development perspective, in order to identify eco-friendly capitals adopting an effective and efficient political-environmental governance. Therefore, focusing on the link between economic development and its environmental impact in terms of energy consumption and air pollution, we assess the 2000-2008 period to gauge whether environmental best practices correspond to those provincial capitals that they have adopted environment-friendly policies (detailed below) or to cities characterized by a particular urban context, from an economic or territorial point of view (presence of industries, weather-climate situation, population density).

The empirical basis for our investigation is constituted by the annual provincial data for 103 provincial capitals of Italy, on a time span ranging from 2000 to 2008[1]. Our attention is focused on urban centres as the main actors in a model of sustainable development. In fact, they are important generators of wealth, opportunities of employment and productivity growth, but at the same time they are also strong generators of environmental pressures.

We now proceed to describe the set of environment-friendly policies that is of interest for our purposes (PEC and PUT). PEC stands for *Piano Energetico Comunale* (Municipal Energy Plan). Law no. 10, 1991 includes an obligation for municipalities with population of more than 50,000 inhabitants to prepare an Energy Plan. This Plan seeks to identify strategic guidelines in the energy sector, to verify the existence of conditions and resources for their implementation and to monitor over time their effective implementation. PUT stands for *Piano Urbano del Traffico* (Urban Traffic Plan). It is an administrative tool "aimed to obtain the improvement of traffic conditions and road safety, the reduction of noise and air pollution and saving energy, in agreement with the existing urban instruments and transport plans, and with respect for environmental values, establishing the priority and timing of implementation of the interventions. The urban traffic plan resorts to appropriate technological systems on the information basis of traffic regulation and control, as well as verification of the slowdown in speed and parking deterrence aimed also to allow changes to the traffic flows that they may be required with respect to the objectives to pursue" (Art. 36, Legislative Decree no. 285, 1992). The adoption of PUT is mandatory for municipalities with a resident population of more than 30,000 inhabitants. PUT should be updated every two years to adapt it to the general objectives of the socio-economic and territorial planning.

[1] The decision to consider 103 out of the current 116 provincial capitals derived from the necessity to adopt a uniform sample over the period 2000-2008 for better data comparability. We recall that there were 103 capitals from 1992 to 2005; 107 from 2006 to 2007; 111 in 2008, 116 from 2009 to 2013.

3.1 The measurement of efficiency

Currently, the issue of sustainability, especially at the local level, concerns the relationship between economic growth and environmental protection in terms of containment of polluting emissions generated by anthropogenic activities. Subsequently, we jointly consider the economic and environmental performances of the provincial capitals of Italy. Each human activity gives rise to a joint production of desirable and undesirable outputs obtained by the application of an input set. Hence the first step toward the measurement of efficiency in our analysis is the specification of the relevant inputs, good outputs and bad outputs for the provincial capitals of Italy. We assume that the main function of urban centres with an institutional and socio-economic importance is their attractor function for population and economic activities. Concentration of population and their activities generate economic development, but also determine strong environmental pressures. We model this in the following manner.

We take as good outputs (good Y), population, as a proxy of employment opportunities, and bancarization (the sum of banking loans[2] divided by the resident population), as an income proxy. This choice of proxies is essentially dictated by considerations of data availability.

In addition to these good outputs, our model incorporates some bad outputs: the environmental-damaging variables. Our undesirable output (bad Y) will consist of environmental pressures due to atmospheric emissions resulting from human activities in the phase of consumption (energy consumption and transport in particular), since the greater environmental impact at the local level is determined by the resident consumption. It is estimated that about 75% of the Italian population lives in urban areas where it consumes more than 70% of energy and from where it comes more than 80% of anthropogenic emissions of greenhouse gases. The incidence of this phenomenon allows to measure the economic development and social cohesion policies, the sustainable strategies and actions by the cities, and the global challenges of the struggle against climate change[3] (ISPRA, 2008). The decision to focus on anthropogenic pressures in the consumption phase, and not also in the production phase, mainly derives from the availability of the relevant data. Yet, consider that the major environmental pressures at the municipal level are generally ascribable for 40% to the residential sector, 35% to transport and only for 20% to industry (Cittalia-ANCI, 2010). In our particular case, therefore, we consider the environmental pressures with respect to air pollution derived from two sources of pollution: road transport and residential energy consumption. More precisely, the negative environmental pressures to the atmospheric level that we will consider in our empirical analysis are: PM_{10} surpluses[4], methane gas consumption and electricity consumption. The latter are proxies for CO_2 emissions that contribute to global warming. We would like to have measures of other fuel consumption, or, even better, direct measures of CO_2 emissions, but data of this kind are not readily available.

Obviously, cities are supposed to maximize good Y, while at the same time minimizing bad Y *and inputs*. There has not been so far any reference to a conventional input, and there will not be any. In fact, in accordance with the hypothesis of Lovell *et al.* (1985), we assume that each provincial

[2] A more usual definition of the bancarisation index is the sum of banking loans and deposits, divided by the resident population. We tried in estimation both definitions and retained the more significant one.

[3] Climate change is determined by anthropogenic activities and it is generated by gas greenhouse effect. The main GHG (greenhouse gases) associated with global climate change, are: CO_2 (carbon dioxide), CH_4 (methane), N_2O (nitrous oxide), CO (carbon monoxide). Currently, climate experts predict a trend to the acceleration of the changes in temperature and that the average temperature will increase by 2100 of 1.4°-5.8°C globally and by 2°-6.3°C at the European level.

[4] This indicator is the number of days when PM_{10} emissions were above their warning level in the municipal area). As well known, PM_{10} stands for particulate matter: tiny pieces of solid or liquid matter of the Earth's atmosphere, with diameter of 10 micro-metres or less.

capital has a fixed-amount capability "to be a provincial capital" (the so-called "ability of the helmsman", supposed as fixed for each unit of analysis, and modeled as a constant term).

Finally, the ability to transform inputs into good Y, while at the same time minimizing bad Y can be affected by given policies as well as the type of "urban environment". Such control or context variables (Z) will also be included in our production set, as they have an influence on the economic and environmental performances of the different territorial units. We consider the following Z variables: the eco-friendly policies (PEC, PUT), the local temperature (lowest, highest and average temperatures), the population density and the share of industry (local employment in industry over total local employment)[5].

The relationships singled out by our model of the environmentally sustainable production process of the Italian provincial capitals of Italy are displayed in Figure 3.1.

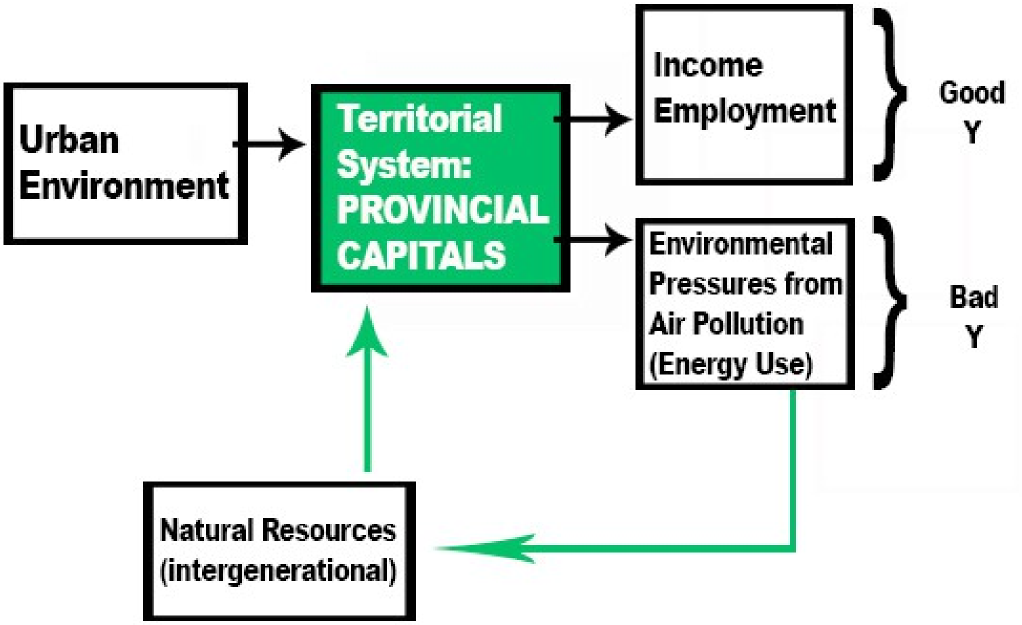

Figure 1: Environmentally Sustainable Production Process of Italian Provincial Capitals.

After having defined the production set, we need to proceed to a suitable definition of efficiency. We consider a very general concept of eco-efficiency: the relationship between inputs and outputs compared with a benchmark of optimality, also allowing for the environmental impact of the production process (this broad definition is consistent with a very large literature: Reinhard *et al.*, 1999; Kortelainen and Kuosmanen, 2004a, 2004b; Nissi and Rapposelli, 2005; Zhou *et al.*, 2008). As hinted above, cities are then supposed to maximize good Y, while at the same time minimizing bad Y *and inputs*. Best-practice cities will be defined as efficient, and underperforming cities as inefficient.

In our analysis we make two important choices: we rely on a parametric frontier approach, and model bad outputs as inputs. The motivation for the first choice mainly comes from the desire to take advantage of the panel structure of our data (more details about this are of course provided below) to deal with unobserved heterogeneity, as well as from the need to allow in the analysis for a rather rich set of control variables. The second choice, which takes the cue from some previous

[5] This variable, unavailable for provincial capitals, is taken at the local labour system level (more will be said about this when discussing our data-set).

studies (Korhonen and Luptacik, 2004; Growitsch *et al.,* 2005), comes from the idea that cities aim to minimise environment-damaging variables in the same manner as inputs must be usually minimized in the analysis of productive efficiency. Using this simplifying hypothesis should not be misleading when considering the outcome of aggregated decisions (as we are doing at the city level), and, as shown in Growitsch *et al.* (2005), lends itself straightforwardly to the parametric analysis of efficiency. Given this assumption, provincial capitals will be (eco-)efficient if they maximize their good outputs for a given level of bad outputs, or, conversely, if they minimize their bad outputs for a given level of good outputs (naturally, the control variables will impinge upon this process, and must be duly allowed for).

4. The econometric set-up

4.1 The Econometric Model

Once we have identified the variables of our production set, in order to bring this model to the data, we need to specify for it an appropriate functional form.

Summing up, our production set includes two (good) outputs: population (Y_1) and the index of "bancarization" (Y_2); three proxies (modeled as inputs) of the atmospheric environmental pressures represented by PM_{10} surpluses (P_1), methane gas consumption (P_2), electricity consumption (P_3); seven control variables: eco-policies "PEC" (Z_1), "PUT" (Z_2); the mean, highest and lowest local temperature (Z_3, Z_4 and Z_5), population density (Z_6) and the industry share (Z_7).

We choose to model this production set econometrically through an input distance function, similar to the one in Growitsch *et al.* (2005), and we estimate it through a panel fixed-effect model, including idiosyncratic time trends for each provincial capital. The inclusion of these trends allows for existence of time-varying efficiency in the production process. This is a very important point because it allows measurement of the eco-efficiency over time, while most existing empirical studies in the eco-efficiency literature use cross-sectional data. Reliance on panel data allows to investigate the changes in performance and efficiency over time, as well as to deal successfully with the possible correlation between efficiency terms and regressors.

In general terms the distance function can be written as:

$$f\,(y_1,\, y_2) = f\,(p_1\ldots,\, p_n,\, z_1\ldots\, z_n) + \varepsilon_{it} \qquad (1)$$

where the *y* represent the conventional outputs, the *p* the environment-damaging proxies (modelled as inputs), and the *z* the control variables that affect the production process of the local systems. This is our baseline model.

Following common practice, we now assume a translog functional form for the input distance function

$$\ln D_i^I = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mi} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \alpha_{mn} \ln y_{mi} \ln y_{ni} + \sum_{k=1}^{K} \beta_k \ln x_{ki} + \frac{1}{2}\sum_k \sum_l \beta_{kl} \ln x_{ki} \ln x_{li} + \frac{1}{2}\sum_k \sum_m \delta_{km} \ln x_{ki} \ln y_{mi} \qquad (2)$$

Imposing suitable restrictions (homogeneity, symmetry and monotonicity), the translog distance function can be specified as follows:

(3)

$$-\ln(x_K)_i = \alpha_0 + \sum_{m=1}^{M}\alpha_m \ln y_{m\,i} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M}\alpha_{mn}\ln y_{m\,i}\ln y_{n\,i} + \sum_{k=1}^{K}\beta_k \ln\frac{x_{k\,i}}{x_{K\,i}}$$
$$+\frac{1}{2}\sum\sum\beta_{kl}\ln\frac{x_{k\,i}}{x_{K\,I}}\ln\frac{x_{l\,i}}{x_{K\,i}} + \frac{1}{2}\sum\sum\delta_{km}\ln\frac{x_{k\,i}}{x_{K\,I}}\ln y_{m\,i} - u_{i\,t}$$

Where the *u* terms stands for inefficiency, and for the sake of generality we opt for a model with no input-output separability. Following the literature, the translog distance function becomes, in presence of panel data with time-varying efficiency:

(4)

$$-\ln(x_K)_i = \alpha_{i\,t} + \sum_{m=1}^{M}\alpha_m \ln y_{m\,i\,t} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M}\alpha_{mn}\ln y_{m\,i\,t}\ln y_{n\,i\,t} + \sum_{k=1}^{K}\beta_k \ln\frac{x_{k\,i}}{x_{K\,i}}$$
$$+\frac{1}{2}\sum\sum\beta_{kl}\ln\frac{x_{k\,i}}{x_{K\,i\,t}}\ln\frac{x_{l\,i\,t}}{x_{K\,i\,t}} + \frac{1}{2}\sum\sum\delta_{km}\ln\frac{x_{k\,i}}{x_{K\,i\,t}}\ln y_{m\,i\,t}$$

Where t = 1, ...,T, are time periods and, as shall be explained below, $\alpha_{it} = \alpha_t - u_{it}$. In our empirical analysis, we extend this model through the inclusion of the control variables, *z*:

(5)

$$m_i = \lambda_0 + \sum_{s=1}^{S}\lambda_s \ln \lambda_s z_{sit}$$

in order to allow for their role in the determination of eco-efficiency.

As already said, we estimate this function through a panel fixed-effects model under the hypothesis of efficiency variability over time. Once singled out the best practice frontier from the multi-input multi-output translog input distance function model we compute the efficiency scores as deviations from this frontier. Following Cornwell *et al.* (1990), we estimate coefficients $\alpha, \beta, \delta, \lambda,$ and technical efficiency through a within estimator. In this model each provincial capital has its own intercept, that changes over time according to a linear trend with unit-specific time-variation coefficients. The technical inefficiency of a provincial capital in a particular period is obtained from the estimated intercepts through a normalization operation.

The time-variation structure is the same for each α_{it} and is specified as:

(6)

$$\alpha_{it} = \theta_i' z_{it}$$

where:

θ_i = vector of time-variation coefficients of individual intercepts $z_{it} = (1, t, t^2)$, hence:

$$\alpha_{it} = \theta_{i0} + \theta_{i1} + \theta_{i2}t^2$$

Note that the time-variation pattern becomes specific for each provincial capital, because coefficients vary across them. After estimating α_{it}, the normalization operation is carried out, finally obtaining:

$$\hat{\alpha}_t = \max_i \hat{\alpha}_{it} \qquad\qquad \hat{u}_{it} = \hat{\alpha}_t - \hat{\alpha}_{it}$$

3.4.2 The data

Subsequently to our definition of inputs and outputs, we construct a panel data-set (through 2000-2008) for 103 Italian provincial capitals, mainly based upon the *Indicatori Ambientali Urbani* data-set of Istat). In particular, we recover the data from the following sources:

- The *Indicatori Ambientali Urbani* - Urban Environmental Indicators (ISTAT)[6] for environment-damaging proxies (PM_{10} surpluses, and residential energy - methane gas and electricity - consumption), and for some control variables (PEC, PUT, industry share, population density);
- The *Andamento meteo-climatico in Italia* – Weather and Climate Trend in Italy (ISTAT)[7] for the context variables related to local temperatures (lowest, highest and mean local temperatures);
- The *Atlante Statistico dei Comuni* - Statistical Atlas of Municipalities (ISTAT)[8] for the population and the bancarisation variables (for 2008, this information was complemented by data from the *Bollettino Statistico* - Statistical Bulletin; Bank of Italy);
- The *Sistemi locali del lavoro* (Local Labour Systems) database from ISTAT[9] for the industry share.

Summing up, all the data are at provincial capital level, but for the industry share, which is measured at the local labour system level. In the construction of the data-set, the main problem was to integrate the missing data of the PM_{10} surpluses. For this purpose we adopted an imputation procedure based upon the MCMC method (Cameron and Trivedi, 2005)[10], to complete the series with the imputed values of PM_{10} from 2000 to 2002 for all territorial units and in some cases for other years, where it was necessary. In this imputation procedure we used as regressors the PM_{10} surpluses of the following two years, the motorisation rate, and the local lowest temperature. However, for seven provincial capitals (Chieti, Foggia, Crotone, Cosenza, Catanzaro, Trapani, Ragusa) it was not possible to make any imputation for the total missing data.

For the electricity measures, we computed total consumption of electricity multiplying the

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6 http://www.istat.it/it/archivio/67990

7 http://www.istat.it/it/archivio/5679

8 http://www.istat.it/it/archivio/113712

9 http://www.istat.it/it/archivio/sistemi+locali+del+lavoro. The *Sistemi locali del lavoro* (Local Labour Systems) are groups of municipalities (akin to the UK's Travel-to-Work-Areas) adjacent to each other geographically and statistically comparable, characterised by common commuting flows of the working population. They are an analytical tool appropriate to the investigation of socio-economic structure at a fairly disaggregated territorial level.

10 For an application of this technique to the imputation of missing values when measuring efficiency in the public sector, see Destefanis and Ofrìa (2009). This imputation obtains estimates of the missing values by regressing the variables of interest (for the available observations) on some correlated variables that, for the corresponding observations, have no missing values.

per-person values provided by ISTAT (kwh for inhabitant) by the resident population. The same applies to the methane consumption: after excluding four provincial capitals whose gas measures are non-existent or abnormal (Nuoro, Oristano, Reggio Calabria, Sondrio), we calculate total gas consumption multiplying the ISTAT per capita values (m^3 per capita) by the resident population.

3.5. The econometric evidence

We now take our model to the data[11]. To repeat, our sample is composed of 103 provincial capitals observed from 2000 to 2008: the total number of observations is therefore of 927 observations, being a balanced panel. We already stressed that the panel nature of our analysis allows us to deal with changes in the efficiency levels. More particularly, we consider here the hypothesis of time-varying efficiency, both through idiosyncratic time trends and the influence of context variables changing over time.

In order to better evaluate eco-efficiency and its variations over time, in addition to the baseline model (also to labelled below as the *Not-per capita model*), we analyse an additional model for purposes of comparison, a *Per capita model*[12]. The Per capita model considers only one output (bancarisation) and takes all the bad outputs in terms of per capita variables. In fact, the baseline Not-per capita model should be in principle more informative, allowing us to measure the eco-efficiency in a more articulated way. However, we have observed some anomalies in its results, suggesting the advisability of further comparisons. The choice to rely upon the Per capita model stems from the possibility (to be expounded below) that there are measurement problems linked to population growth.

All the three models are estimated through the input distance function with fixed-effects and idiosyncratic time trends for each provincial capital (we finally relied upon a linear time trend specification, as the quadratic term was not significant).

Table 3.1: Specification of Not-per capita, Per-capita and Without PM_{10} models.

VARIABLES	Not-per capita	Per capita	Without PM_{10}
Good Outputs			
Population	X		X
Bancarisation	X	X	X
Bad Outputs (Inputs)			
PM_{10} surpluses	X	X	
Gas consumption	X	X	X
Electricity consumption	X	X	X
Control Variables			
PEC	X	X	X

[11] The econometric analysis is carried out through STATA 12.

[12] We also estimated a Without PM_{10} model, not considering the PM_{10} surpluses among the bad outputs. This Without PM_{10} model finds its justification in the problems of data collection about this pollutant. We wanted to be able to judge how much the final results were driven by its inclusion in the estimated equation, but found that in fact excluding this pollutant had virtually no influence on the results. Results from this specification are available on request.

Table 3.2: Specification of Not-per capita, Per-capita and without PM_{10} models.

VARIABLES	Not-per capita	Per capita	Without PM_{10}
PUT	X	X	X
Local temperatures	X	X	X
Population density	X	X	
Industry share	X	X	X

Note: in this model not only bancarisation, but also the bad outputs are expressed in per capita terms.

We will now present the main results of the estimates (the detailed results are provided in Appendix A). Broadly speaking, we find that the translog distance function seems to work well. There is a significant link between economic development, energy consumption and air pollution at the provincial capital level, and the input and output coefficients have the right signs. The evidence from the Not-per capita and Per capita models ranks is broadly compatible, also as far as the lack of significance of the policy variables and the other controls is concerned. None of the latter turns out to be significant. In the estimates reported in Appendix A, we want to highlight the scant role played by the eco-friendly plans (PEC and PUT). To verify the relevance of eco-plans in the process of city and eco-efficiency development, we considered not only intercept dummies but also trend dummies for PEC and PUT. We never found significant values for these variables. There was even some evidence (see Table A.1) of PEC coming out with the “wrong” sign.

An important point is that we do not want to rely, when interpreting the evidence, upon fixed effects that are affected by many unobserved geographical and institutional (fixed) factors. This leads us to consider only time-varying eco-efficiency in our following comments. In Appendix B, we report in detail the results for the idiosyncratic efficiency trends, all provinces departing from a conventional value of 100 for year 2000. We also single out some best practices, labeling as eco-efficient the municipalities that have in 2008 a score above the value of 101 for the Not-per capita model and above the value of 104 for the Per capita model.

As shown in Figure 3.2, the 2008 eco-efficiency values from the Not-per capita and Per capita models are pretty close.

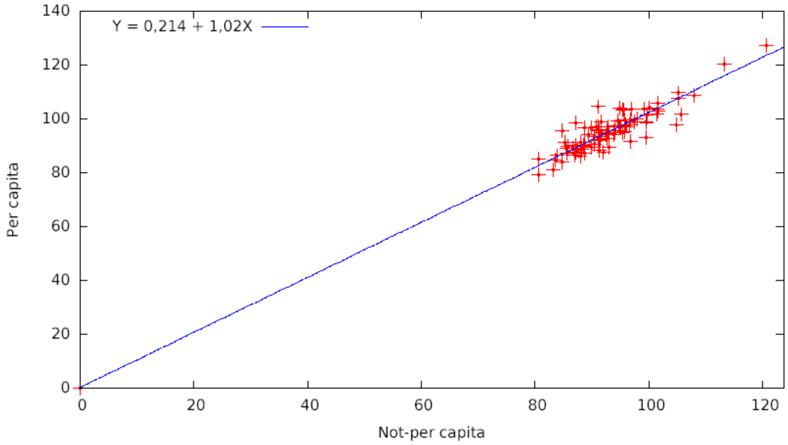


Figure 2: Not-per capita and Per capita Eco-efficiency, 2008.

While the two sets of results are similar, and from a strictly econometric point of view, the

Not-per capita model must be preferred for its goodness of fit, perusal of the results elicits some perplexities about this model. For some observations, e.g. in Naples and Bologna, the eco-efficiency results of the Not-per capita model are not confirmed in the Per capita model. This leads us to speculate that the Not-per capita model may be affected by some distortions. Arguably population is connected to some relevant institutional factors such as the substitution by methane of other fuel. A larger population is likely to be correlated with a larger users/population ratio for methane gas, and a with a smaller users/population ratio for other fuel. The neglect of this important link creates a measurement error for population and gas consumption that affects estimation of our baseline model. The data at our disposal not allow, however, to take account of the substitution of other fuel by methane in the provincial capitals. Hence, even if the Not-per capita model makes more econometric sense (it has higher goodness of fit), we prefer to draw our final comments of the evidence mainly referring to the Per capita model.

Indeed, from the comparative analysis in Appendix B of our two models (Not-per capita and Per capita), it clearly appears that the Per capita ranking is more informative because it highlights not only the best practices, but also a more understandable regional pattern for these success cases. The best performers overwhelmingly show up in North-eastern Italy: Trentino Alto Adige, Emilia Romagna and eastern Lombardy, with two outsiders represented by Biella and Siena (yet Siena, the headquarter of the important Montepaschi bank, may have unduly benefited from the inclusion of the bancarisation among outputs). More in detail, the most eco-efficient provincial capitals of Italy are: Bergamo, Biella, Bologna, Bolzano, Brescia, Cagliari, Lecco, Naples, Parma, Piacenza, Reggio nell'Emilia, Sassari, Siena, Trento and Verona. The analysis of these best practices with respect to the energetic plans does not show so much (recall that the PEC is compulsory for the municipalities with at least 50,000 inhabitants and the PUT for municipalities with at least 30,000 inhabitants). However, it is also true two eco-efficient municipalities (Lecco and Biella) have adopted the PEC without it being compulsory for them. All in all, our analysis seems to imply that if a greater wealth implies more consumption and emissions, on the other hand more economic resources probably also allow the realization of eco-friendly policies that lead to a greater eco-efficiency. This would explain why the more eco-efficient Italian capital provinces belong to the more economically advantaged regions of Italy. This impression is validated by an exploratory statistical analysis. Table 3 below provides Spearman rank correlation coefficients for the level of eco-efficiency in 2008 Not-per capita and Per capita, the (natural log of the) provincial value added per capita (these are mean values for 2000-2007, taken from ISTAT territorial statistics), and a provincial index of social capital (taken from Santini, 2005). Notice that value added per capita and social capital are available for provinces, not provincial capitals.

Table 3: Spearman correlations among eco-efficiency and other variables

	Not-per c. e.e.	Per-c. e.e.	y per c.
Per-c. e.e.	0.8258		
y per c.	0.2890	0.4591	
social K	0.1801	0.3296	0.7321

Clearly, there is a sizable correlation between our Not-per capita and Per-capita eco-efficiency measures (as well as between value added and social capital). Some correlation also emerges between eco-efficiency and the other indicators (especially value added per c.).

Yet, when allowance is made for the simultaneous influence of value added per c. and social capital over eco-efficiency, correlation between the later and social capital apparently vanishes, leaving value added per c. to rule the roost. Table 3.4 provides the results from two robust regressions (Verardi and Croux, 2009) including the above considered variables that rather support this story.

Table 4: Robust regressions among eco-efficiency and other variables

Non-per c. Eco-eff. on y per c., social K		
	Coeff	t-ratio
y per c.	8.778637	2.11
social K	-13.29471	-0.83
pseudo-R sq	0.04	
Per-c. Eco-eff. on y per c., social K		
	Coeff	t-ratio
y per c.	15.34428	4.37
social K	-3.466137	-0.21
pseudo-R sq	0.19	

The above results (strongly supported by standard OLS regressions, available upon request) are of course consistent with the approach of the Environmental Kuznets Curve (for recent analyses of this approach, see Halkos and Tzeremes, 2013; Carillo and Maietta, 2014). Greater wealth is likely to bring about stronger claims for protection of the environment, and possibly to more environmentally sustainable behaviours. The results from Table 3.4 also validate our former contention to the effect that the Per-capita measure of eco-efficiency is much less noisy.

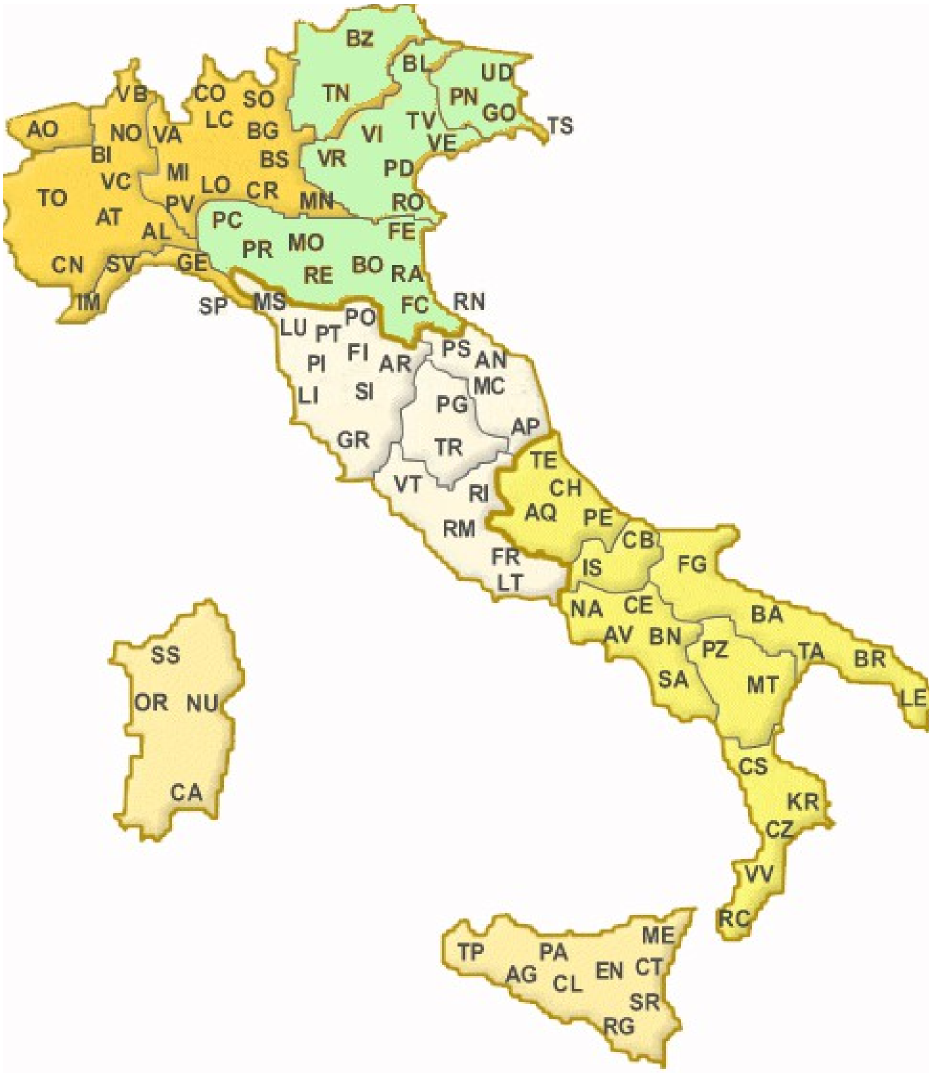
Concluding Remarks

In this paper we have analyzed 103 Italian provincial capitals over the 2000-2008 period. We find a significant link between economic development, energy consumption and air pollution at the provincial capital level. Also, if greater wealth leads to more energy consumption and pollution, on the other hand, greater economic resources probably also allow the creation of environmentally sustainable policies that lead to a greater eco-efficiency. Consistently with the approach of the Environmental Kuznets Curve, this would explain why the more eco-efficient provincial capitals of Italy belong to the more economically advantaged regions.

Our study naturally lends itself to further development and research. It would be interesting to put more emphasis on the decoupling between development and pollution that takes place in the richest regions by considering the consumption of various kinds of fuel. Moreover, it would also be interesting to assess the economic and environmental performance of the capitals of Italy taking into consideration the CO_2 emission, dioxide carbon being the gas that most contributes to the climate change (around 75% of global emissions of greenhouse gases) and therefore the target of reference of all international agreements on this field. At present, however, we believe that our study, although limited to residential energy consumption and to only one pollutant (PM_{10}), provides a significant first analysis of the links among development, consumption and air pollution emissions in urban areas of the provincial capitals of Italy.

APPENDIX A

Figure A.1: Map of Provinces (names are abbreviated).



Legend of Figure A.1: Legend of Province Abbreviations (in alphabetical order).

Abbreviation	Province	Abbreviation	Province	Abbreviation	Province
AG	Agrigento	LI	Livorno	TP	Trapani
AL	Alessandria	LO	Lodi	TN	Trento
AN	Ancona	LU	Lucca	TV	Treviso
AO	Aosta	MC	Macerata	TS	Trieste
AR	Arezzo	MN	Mantova	UD	Udine
AP	Ascoli Piceno	MS	Massa-Carrara	VA	Varese
AT	Asti	MT	Matera	VE	Venice
AV	Avellino	ME	Messina	VB	Verbania
BA	Bari	MI	Milan	VC	Vercelli
BL	Belluno	MO	Modena	VR	Verona
BN	Benevento	NA	Naples	VV	Vibo Valentia
BG	Bergamo	NO	Novara	VI	Vicenza
BI	Biella	NU	Nuoro	VT	Viterbo
BO	Bologna	OR	Oristano		
BZ	Bolzano	PD	Padova		
BS	Brescia	PA	Palermo		
BR	Brindisi	PR	Parma		
CA	Cagliari	PV	Pavia		
CL	Caltanissetta	PG	Perugia		
CB	Campobasso	PU	Pesaro e Urbino		
CE	Caserta	PE	Pescara		
CT	Catania	PC	Piacenza		
CZ	Catanzaro	PI	Pisa		
CH	Chieti	PT	Pistoia		
CO	Como	PN	Pordenone		
CS	Cosenza	PZ	Potenza		
CR	Cremona	PO	Prato		
KR	Crotone	RG	Ragusa		
CN	Cuneo	RA	Ravenna		
EN	Enna	RC	Reggio di Calabria		
FE	Ferrara	RE	Reggio nell'Emilia		
FI	Florence	RI	Rieti		
FG	Foggia	RN	Rimini		
FC	Forlì-Cesena	RM	Rome		
FR	Frosinone	RO	Rovigo		
GE	Genova	SA	Salerno		
GO	Gorizia	SS	Sassari		
GR	Grosseto	SV	Savona		
IM	Imperia	SI	Siena		
IS	Isernia	SR	Syracuse		
SP	La Spezia	SO	Sondrio		
AQ	L'Aquila	TA	Taranto		
LT	Latina	TE	Teramo		
LE	Lecce	TR	Terni		
LC	Lecco	TO	Turin		

Table A.1: Regression Results for the Not-per capita and the Per-capita models

Not-per capita model (dep. var.: - Lpm10_)				Per-capita model (dep. var.: - (Lpm10_ - Lpop_)) in the Per-c. Model, all y's and p's are deviations from Lpop_		
Var.	*Coeff.*	T-*ratio*		*Var.*	*Coeff.*	T-*ratio*
Lbanc_	-0.035916	-2.36		Lbanc_	-0.046716	-4.03
Lpop_	-0.424270	-4.59		~		
bancq	0.008018	1.11		bancq	0.004327	0.59
popq	0.137141	4.44		~		
bancpop	-0.007161	-0.38		~		
gas_pm10	0.133607	6.24		gas_pm10	0.139450	9.02
ele_pm10	0.858141	39.44		ele_pm10	0.855846	54.24
gas_pm10q	0.015856	3.26		gas_pm10q	0.018108	3.72
ele_pm10q	0.018617	3.48		ele_pm10q	0.017789	3.81
gas_ele	-0.031356	3.37		gas_ele	-0.035069	-3.94
gas_pm10_b~c	0.045464	2.79		gas_pm10_b~c	0.047303	3.66
ele_pm10_b~c	-0.045283	-2.71		ele_pm10_b~c	-0.050506	-3.88
gas_pm10_pop	-0.009305	-0.55		~		
ele_pm10_pop	0.000712	0.04		~		
PEC_	-0.007001	-1.38		PEC_	-0.007890	-1.58
PUT_	0.006368	0.93		PUT_	0.007497	0.97
Tr1	0.009024	2.80		Tr1	0.010700	3.53
Tr2	0.011699	12.19		Tr2	0.015506	4.16
Tr3	0.004101	3.34		Tr3	0.000639	0.23
Tr4	0.001973	0.62		Tr4	-0.000021	-0.08
Tr5	0.002743	3.11		Tr5	0.004637	1.93
Tr6	0.000327	0.28		Tr6	-0.002432	-0.54
Tr7	0.012858	12.15		Tr7	0.011523	4.68
Tr8	-0.002158	-1.91		Tr8	-0.001439	-0.64
Tr9	0.008389	5.08		Tr9	0.006386	2.66
Tr10	0.012285	6.91		Tr10	0.010244	3.18
Tr11	-0.004719	-2.96		Tr11	-0.007006	-2.94
Tr12	0.016893	3.49		Tr12	0.017797	3.28
Tr13	0.023774	12.54		Tr13	0.020626	6.17
Tr14	0.016864	11.84		Tr14	0.013534	3.19
Tr15	0.036102	27.39		Tr15	0.038308	9.44
Tr16	0.020797	7.62		Tr16	0.019673	5.24
Tr17	0.000926	0.37		Tr17	-0.005128	-1.84
Tr18	0.021325	5.04		Tr18	0.013322	3.24
Tr19	0.001825	1.13		Tr19	-0.003712	-1.51
Tr20	-0.000102	-0.08		Tr20	-0.003165	-0.91
Tr21	0.005147	3.17		Tr21	0.006362	1.92
Tr22	0.011610	2.63		Tr22	0.001713	0.37
Tr23	—	—		Tr23	—	—

Not-per capita model (dep. var.: - Lpm10_)				Per-capita model (dep. var.: - (Lpm10_ - Lpop_)) in the Per-c. Model, all y's and p's are deviations from Lpop_		
Var.	*Coeff.*	T-*ratio*		*Var.*	*Coeff.*	T-*ratio*
Tr24	—	—		Tr24	—	—
Tr25	0.006894	5.05		Tr25	0.008053	3.36
Tr26	—	—		Tr26	—	—
Tr27	0.011454	10.31		Tr27	0.009095	3.15
Tr28	—	—		Tr28	—	—
Tr29	0.009665	9.13		Tr29	0.008292	3.20
Tr30	-0.008722	-4.75		Tr30	-0.014355	-5.16
Tr31	0.007153	5.73		Tr31	0.005821	2.11
Tr32	0.005276	1.53		Tr32	0.004024	1.30
Tr33	—	—		Tr33	—	—
Tr34	-0.001812	-1.83		Tr34	-0.000489	-0.19
Tr35	0.002830	1.95		Tr35	-0.001211	-0.40
Tr36	0,014784	6,63		Tr36	0,010059	2,33
Tr37	0,014683	11,06		Tr37	0,010420	3,47
Tr38	0,003319	3,03		Tr38	0,007587	3,70
Tr39	0,009349	4,33		Tr39	0,007975	2,59
Tr40	0,001196	0,56		Tr40	-0,001780	-0,59
Tr41	--	--		Tr41	--	--
Tr42	0,006873	7,98		Tr42	0,005505	1,70
Tr43	-0,008673	-6,65		Tr43	-0,006416	-2,12
Tr44	0,005450	4,46		Tr44	0,010356	1,93
Tr45	0,016875	10,92		Tr45	0,015618	4,19
Tr46	0,006474	4,96		Tr46	0.004630	2.17
Tr47	0.006690	3.22		Tr47	0.006638	1.35
Tr48	0.001595	1.24		Tr48	-0.000182	-0.07
Tr49	0.011593	7.26		Tr49	0.010917	3.94
Tr50	0.005213	2.57		Tr50	0.002129	0.71
Tr51	-0.000657	-0.58		Tr51	-0.001480	-0.34
Tr52	0.001636	1.80		Tr52	-0.000380	-0.10
Tr53	0.005160	2.22		Tr53	-0.002274	-0.60
Tr54	0.010044	1.96		Tr54	0.015036	2.82
Tr55	-0.004388	-2.49		Tr55	-0.004830	-1.73
Tr56	0.020406	8.82		Tr56	0.008907	3.06
Tr57	0.010740	11.34		Tr57	0.008358	4.30
Tr58	—	—		Tr58	—	—
Tr59	—	—		Tr59	—	—
Tr60	0.009125	4.56		Tr60	0.008498	2.80
Tr61	0.014653	5.55		Tr61	0.003586	1.05
Tr62	0.009310	5.81		Tr62	0.015795	5.75
Tr63	0.010382	8.48		Tr63	0.006227	2.29
Tr64	0.001856	1.39		Tr64	0.007630	2.01
Tr65	0.008334	7.65		Tr65	0.005464	1.57

Not-per capita model (dep. var.: - Lpm10_)				Per-capita model (dep. var.: - (Lpm10_ - Lpop_)) in the Per-c. Model, all y's and p's are deviations from Lpop_		
Var.	*Coeff.*	T-*ratio*		*Var.*	*Coeff.*	T-*ratio*
Tr66	0.005393	3.51		Tr66	0.005673	1.39
Tr67	0.015340	14.66		Tr67	0.016013	6.80
Tr68	-0.005210	-2.40		Tr68	-0.011918	-4.48
Tr69	0.001031	0.93		Tr69	0.001310	0.60
Tr70	0.014793	18.11		Tr70	0.013107	5.33
Tr71	-0.003124	-2.67		Tr71	-0.007786	-2.39
Tr72	0.004787	4.04		Tr72	0.008335	3.77
Tr73	—	—		Tr73	—	—
Tr74	-0.000135	-0.06		Tr74	0.009946	3.17
Tr75	—	—		Tr75	—	—
Tr76	0.004819	2.12		Tr76	0.016430	7.53
Tr77	0.003992	4.51		Tr77	0.003761	1.13
Tr78	-0.002560	-1.81		Tr78	0.001155	0.39
Tr79	-0.003088	-0.91		Tr79	0.006380	1.48
Tr80	0.004938	5.84		Tr80	0.002566	1.07
Tr81	0.006673	3.28		Tr81	0.003072	1.00
Tr82	0.010182	1.72		Tr82	0.015272	2.66
Tr83	0.010632	10.55		Tr83	0.008845	3.86
Tr84	0.020828	5.77		Tr84	0.021707	4.80
Tr85	0.008243	3.43		Tr85	0.004854	1.40
Tr86	—	—		Tr86	—	—
Tr87	0.005997	2.66		Tr87	-0.003316	-1.50
Tr88	0.001835	2.05		Tr88	0.001305	0.42
Tr89	0.010373	10.29		Tr89	0.011152	2.70
Tr90	0.004436	2.20		Tr90	0.008214	3.50
Tr91	—	—		Tr91	—	—
Tr92	0.029114	22.87		Tr92	0.032170	13.94
Tr93	0.007209	4.44		Tr93	0.005404	1.78
Tr94	0.007215	4.63		Tr94	-0.000824	-0.23
Tr95	0.008284	3.81		Tr95	0.008429	3.08
Tr96	0.017011	17.46		Tr96	0.014781	5.57
Tr97	0.003442	1.69		Tr97	-0.000817	-0.24
Tr98	0.005171	2.25		Tr98	0.002348	0.81
Tr99	0.010008	8.52		Tr99	0.005617	1.65
Tr100	0.014312	4.65		Tr100	0.015477	6.56
Tr101	-0.000227	-0.07		Tr101	-0.004415	-1.16
Tr102	0.004882	3.69		Tr102	0.006841	1.02
Tr103	-0.002124	-1.44		Tr103	-0.003792	-1.56
Dumy2	-0.027535	-8.64		Dumy2	-0.026319	-7.46
Dumy3	-0.057116	-13.20		Dumy3	-0.052888	-11.07
Dumy4	-0.100227	-15.80		Dumy4	-0.090137	-13.73
Dumy5	-0.118979	-18.06		Dumy5	-0.099054	-13.42

Not-per capita model (dep. var.: - Lpm10_)				Per-capita model (dep. var.: - (Lpm10_ - Lpop_)) in the Per-c. Model, all y's and p's are deviations from Lpop_		
Var.	*Coeff.*	T-*ratio*		*Var.*	*Coeff.*	T-*ratio*
Dumy6	-0.123022	-12.90		Dumy6	-0.099248	-9.10
Dumy7	-0.125561	-14.55		Dumy7	-0.100134	-9.65
Dumy8	-0.107629	-10.48		Dumy8	-0.077625	-6.54
Dumy9	-0.136958	-13.14		Dumy9	-0.103627	-8.14
_cons	-0.060271	-1.07		_cons	0.027575	0.50
sigma_u	0.674632			sigma_u	0.146593	
sigma_e	0.021063			sigma_e	0.021833	

Legend of Table A.1: Legend of the variables.

Lbanc_ = logarithmic deviation of the bancarisation with respect to the geometric mean;
Lpop_= logarithmic deviation of the population with respect to the geometric mean;
Lgas_ = logarithmic deviation of the gas with respect to the geometric mean;
Lele_ = logarithmic deviation of the electricity with respect to the geometric mean;
Lpm10_ = logarithmic deviation of the PM_{10} with respect to the geometric mean;
bancq= $Lbanc^2$
popq= $Lpop^2$
bancpop= Lbanc_*Lpop_
gas_pm10=Lgas_-Lpm10_
ele_pm10= Lele_*-Lpm10_
gas_pm10q= gas_pm10_^{2}
ele_pm10q=ele_pm10_^{2}
gas_ele= gas_pm10*ele_pm10
gas_pm10_b~c=gas_pm10*Lbanc_
ele_pm10_b~c= ele_pm10*Lbanc_
gas_pm10_pop= gas_pm10*Lpop_
ele_pm10_pop= ele_pm10*Lpop_
PEC_= dummy *piano energetico comunale*
PUT_= dummy *piano urbano del traffico*
tr1 - tr103 = provincial capital trend dummies
dumy2 - dumy9 = year dummies.

Numerals for the provincial capital (in alphabetical order):

1) Agrigento; 2) Alessandria; 3) Ancona; 4) Aosta; 5) Arezzo; 6) Ascoli; 7) Asti; 8) Avellino; 9) Bari; 10) Belluno; 11) Benevento; 12) Bergamo; 13) Biella; 14) Bologna; 15) Bolzano; 16) Brescia; 17) Brindisi; 18) Cagliari; 19) Caltanissetta; 20) Campobasso; 21) Caserta; 22) Catania; 23) Catanzaro; 24) Chieti; 25) Como; 26) Cosenza; 27) Cremona; 28) Crotone; 29) Cuneo; 30) Enna; 31) Ferrara; 32) Florence; 33) Foggia; 34) Forlì; 35) Frosinone; 36) Genoa; 37) Gorizia; 38) Grosseto; 39) Imperia; 40) Isernia; 41) L'Aquila; 42) La Spezia; 43) Latina; 44) Lecce; 45) Lecco; 46) Livorno; 47) Lodi; 48) Lucca; 49) Macerata; 50) Mantova; 51) Massa; 52) Matera; 53) Messina; 54) Milan; 55) Modena; 56) Naples; 57) Novara; 58) Nuoro; 59) Oristano; 60) Padova; 61) Palermo; 62) Parma; 63) Pavia; 64) Perugia; 65) Pesaro; 66) Pescara; 67) Piacenza; 68) Pisa; 69) Pistoia; 70) Pordenone; 71) Potenza;

72) Prato; 73) Ragusa; 74) Ravenna; 75) Reggio Calabria; 76) Reggio nell'Emilia; 77) Rieti; 78) Rimini; 79) Rome; 80) Rovigo; 81) Salerno; 82) Sassari; 83) Savona; 84) Siena; 85) Syracuse; 86) Sondrio; 87) Taranto; 88) Teramo; 89) Terni; 90) Turin; 91) Trapani; 92) Trento; 93) Treviso; 94) Trieste; 95) Udine; 96) Varese; 97) Venice; 98) Verbania; 99) Vercelli; 100) Verona; 101) Vibo Valentia; 102) Vicenza; 103) Viterbo.

In order to avoid perfect collinearity, we exclude year 2000, and L'Aquila (the latter was chosen randomly). Standard errors are heteroskedasticity-robust.

APPENDIX B

Legend of Eco-efficiency Results (Tables B.1 and B.2)

In Tables B.1 and B.2 we provide some detail for the eco-efficiency results of all the provincial capitals (PC's), both for the Not-per capita and the Per-capita models.

By convention, we put eco-efficiency to 100 for the year 2000 for all PC's. Then, we label as eco-efficient each municipality that shows in 2008 a score respectively above the value 101 for the Not-per capita model and the value 104 for the Per capita model. In Table B.1 provincial capitals are ordered according to the ISTAT conventional order (roughly from North-West to South-East), while in Table B.2 they are in alphabetical order.

More in detail, the eco-efficiency scores are obtained as follows. Recall that the scores for each capital must be calculated as deviations from L'Aquila's ones. This also means that the year dummies represent the evolution through time of L'Aquila's eco-efficiency. In order to obtain the eco-efficiency of a given provincial capital in an year *t*, we then add to the value of the dummy for year *t*, the value of the relevant provincial time trend multiplied by the years past 2000 (2 in 2001, 3 in 2002, up to 9 in 2008).

Table B.1: Eco-efficiency results by provincial capital: 1) Not-per capita model; 2) Per capita model.

PC	Mod. 1)	Mod. 2)		Mod. 1)	Mod. 2)
Turin			Siena	Eco-efficient	Eco-efficient
Vercelli			Grosseto		
Biella	Eco-efficient	Eco-efficient	Perugia		
Verbania			Terni		
Novara			Pesaro e Urbino		
Cuneo			Ancona		
Asti			Macerata		
Alessandria			Ascoli Piceno		
Aosta			Viterbo		
Varese			Rieti		
Como			Rome		
Lecco	Eco-efficient	Eco-efficient	Latina		
Sondrio			Frosinone		
Milan			L'Aquila		
Bergamo	Eco-efficient	Eco-efficient	Teramo		
Brescia	Eco-efficient	Eco-efficient	Pescara		
Pavia			Chieti		
Lodi			Isernia		

PC	Mod. 1)	Mod. 2)		Mod. 1)	Mod. 2)
Cremona			Campobasso		
Mantova			Caserta		
Bolzano	Eco-efficient	Eco-efficient	Benevento		
Trento	Eco-efficient	Eco-efficient	Naples	Eco-efficient	--
Verona	Eco-efficient	Eco-efficient	Avellino		
Vicenza			Salerno		
Belluno			Foggia		
Treviso			Bari		
Venice			Taranto		
Padova			Brindisi		
Rovigo			Lecce		
Pordenone			Potenza		
Udine			Matera		
Gorizia			Cosenza		
Trieste			Crotone		
Imperia			Catanzaro		
Savona			Vibo Valentia		
Genoa			Reggio di		
La Spezia			Trapani		
Piacenza	Eco-efficient	Eco-efficient	Palermo		
Parma	Eco-efficient	Eco-efficient	Messina		
Reggio nell'Emilia	Eco-efficient	Eco-efficient	Agrigento		
Modena			Caltanissetta		
Bologna	Eco-efficient	--	Enna		
Ferrara			Catania		
Ravenna			Ragusa		
Forlì-Cesena			Syracuse		
Rimini			Sassari	Eco-efficient	Eco-efficient
Massa-Carrara			Nuoro		
Lucca			Oristano		
Pistoia			Cagliari	Eco-efficient	Eco-efficient
Florence					
Prato					
Livorno					
Pisa					
Arezzo					

Table B.2: Eco-efficiency results in detail: 1) Not-per capita model; 2) Per capita model.

PC	Mod.	Mod. 2	PC	Mod.	Mod.	PC	Mod. 1	Mod. 2	PC	Mo	Mod. 2
Agrigento	99.06	99.51		91.79	96.03		99.07	100.43		109	113.95
	97.04	99		89.38	94		97.39	98.86		113	118.3
	93.79	95.38	**Ascoli**	97.35	96.93	**Beneven**	96.37	96.05		109	113.95
	92.88	95.55		94.54	94.16		93.12	92.88		113	118.3
	93.34	96.56		90.58	90.5		88.77	88.86		119	125.71
	93.95	97.51		88.93	89.47		86.71	87.45		120	127.27
	96.52	100.8		88.6	89.24		85.96	86.82	**Brescia**	101	101.31
	94.58	99.27		88.4	88.94		85.33	86.14		100	100.61
Alessandria	99.59	100.47		90.03	90.75		86.47	87.49		98.	98.86
	97.82	99.37		87.46	88.2		83.57	84.65		98.	99.93

PC	Mod.	Mod. 2	PC	Mod.	Mod.	PC	Mod. 1	Mod. 2	PC	Mo	Mod. 2
	94.8	97.23	**Asti**	99.82	99.67	**Bergam**	100.63	100.93		100	101.9
	94.13	97.87		98.16	98.18		99.36	100.05		102	103.83
	94.85	99.38		95.24	95.69		96.79	98.12		106	108.3
	95.73	100.84		94.68	95.94		96.61	99		105	107.62
	98.61	104.75		95.52	97.03		97.86	100.76	**Brindisi**	97.	96.41
	96.88	103.66		96.51	98.07		99.27	102.47		94.	93.4
Ancona	98.09	97.53		99.52	101.47		102.79	106.69		90.	89.53
	95.62	95.03		97.9	100.01		101.52	105.82		89.	88.28
	91.96	91.61	**Avellino**	96.87	97.12	**Biella**	102.02	101.5		88.	87.81
	90.62	90.86		93.84	94.44		101.43	100.9		88.	87.28
	90.63	90.9		89.69	90.86		99.49	99.24		90.	88.81
	90.77	90.88		87.83	89.92		99.99	100.41		87.	86.09
	92.79	93.01		87.29	89.77		101.98	102.48	**Cagliari**	101	100.03
	90.48	90.68		86.88	89.56		104.17	104.52		100	98.72
Aosta	97.67	97.4		88.26	91.47		108.61	109.13		98.	96.38
	95.01	94.84		85.52	89		108	108.55		98.	96.81
	91.18	91.37	**Bari**	98.93	98.65	**Bologna**	100.62	100.07		100	98.09
	89.66	90.56		96.86	96.68		99.35	98.78		102	99.31
	89.48	90.54		93.55	93.74		96.78	96.46		106	102.94
	89.43	90.46		92.59	93.51		96.59	96.91		105	101.64
	91.22	92.52		92.99	94.09		97.84	98.21	**Caltanisset**	97.	96.68
	88.76	90.14		93.53	94.61		99.25	99.46		94.	93.8
Arezzo	97.82	98.31		96.03	97.38		102.77	103.11		91.	90.03
	95.23	96.18		94.04	95.49		101.49	101.83		89.	88.9
	91.46	93.09	**Belluno**	99.7	99.42	**Bolzano**	104.57	105.16		89.	88.56
	90.01	92.69		97.99	97.81		105.25	106.4		89.	88.15
	89.89	93.11		95.02	95.2		104.52	106.51		91.	89.82
	89.91	93.46		94.41	95.33		106.35	109.69		88.	87.19
Campobasso	97.26	96.79	**Como**	98.63	98.98		95.13	97.14		85.	89.76
	94.42	93.95		96.42	97.17	**Enna**	95.6	94.65	**Frosinone**	97.	97.17
	90.43	90.23		92.99	94.37		92.01	90.85		95.	94.5
	88.74	89.15		91.9	94.29		87.36	86.28		91.	90.94
	88.37	88.85		92.16	95.03		84.99	84.3		90.	90.02
	88.14	88.49		92.56	95.72		83.92	83.08		89.	89.9
	89.72	90.22		94.89	98.69		82.98	81.82		89.	89.71
	87.12	87.62		92.78	96.93		83.74	82.49		91.	91.64
Caserta	98.29	98.65	**Cosenza**				80.62	79.23		89.	89.18
	95.92	96.68				**Ferrara**	98.69	98.54	**Genoa**	100	99.38
	92.35	93.74					96.5	96.52		98.	97.75
	91.1	93.5					93.09	93.53		95.	95.13
	91.2	94.08					92.02	93.24		95.	95.24
	91.44	94.59					92.3	93.77		96.	96.19

PC	Mod.	Mod. 2	PC	Mod.	Mod.	PC	Mod. 1	Mod. 2	PC	Mo	Mod. 2
	93.57	97.36					92.73	94.23		97.	97.07
	91.34	95.47					95.08	96.94		101	100.29
Catania	99.57	97.74	**Cremon**	99.54	99.19		93	95.01		99.	98.7
	97.8	95.34		97.75	97.47	**Florence**	98.32	98.19	**Gorizia**	100	99.45
	94.76	92.01		94.7	94.77		95.96	96		98.	97.86
	94.09	91.35		94.02	94.78		92.39	92.86		95.	95.27
	94.8	91.49		94.72	95.63		91.16	92.41		95.	95.41
	95.67	91.56		95.56	96.42		91.27	92.76		96.	96.39
	98.54	93.81		98.41	99.51		91.52	93.06		97.	97.32
	96.81	91.56		96.67	97.85		93.67	95.56		100	100.58
Catanzaro			**Crotone**				91.44	93.48		99.	99.02
						Foggia			**Grosseto**	97.	98.89
										95.	97.03
										91.	94.2
										90.	94.07
										90.	94.77
										90.	95.41
										92.	98.32
Chieti			**Cuneo**	99.18	99.03					89.	96.53
				97.23	97.24	**Forlì**	96.93	97.31	**Imperia**	99.	98.97
				94.03	94.46		93.94	94.71		97.	97.15
				93.18	94.4		89.81	91.2		93.	94.34
				93.7	95.17		87.98	90.35		93.	94.25
				94.37	95.88		87.47	90.29		93.	94.99
				97.01	98.88		87.09	90.16		94.	95.67
	94.86	96.86		91.58	98.96		96.79	99.46		95.	103.22
Isernia	97.52	97.06	**Lecco**	100.62	100.49	**Mantova**	98.3	97.82	**Modena**	96.	96.47
	94.79	94.34		99.35	99.4		95.94	95.46		93.	93.48
	90.9	90.73		96.78	97.27		92.37	92.16		88.	89.63
	89.32	89.77		96.6	97.93		91.13	91.54		86.	88.41
	89.06	89.59		97.85	99.45		91.23	91.72		86.	87.97
	88.94	89.35		99.26	100.92		91.48	91.83		85.	87.46
	90.66	91.22		102.78	104.85		93.62	94.12		86.	89.02
	88.14	88.72		101.5	103.76		91.39	91.9		83.	86.32
L'Aquila	97.28	97.4	**Livorno**	98.55	98.31	**Massa**	97.16	97.11	**Naples**	101	99.15
	94.45	94.85		96.3	96.18		94.26	94.43		100	97.42
	90.46	91.38		92.84	93.09		90.23	90.84		98.	94.69
	88.78	90.57		91.7	92.69		88.49	89.9		98.	94.69
	88.42	90.55		91.93	93.1		88.08	89.75		99.	95.52
	88.2	90.47		92.29	93.45		87.8	89.54		101	96.29
	89.8	92.53		94.57	96.02		89.33	91.44		105	99.37
	87.2	90.16		92.43	93.99		86.69	88.96		104	97.68

PC	Mod.	Mod. 2	PC	Mod.	Mod.	PC	Mod. 1	Mod. 2	PC	Mo	Mod. 2
La Spezia	98.63	98.48	**Lodi**	98.59	98.7	**Matera**	97.6	97.33	**Novara**	99.	99.04
	96.42	96.43		96.36	96.76		94.91	94.74		97.	97.26
	92.98	93.42		92.92	93.84		91.06	91.24		94.	94.49
	91.89	93.1		91.8	93.63		89.51	90.4		93.	94.43
	92.15	93.59		92.05	94.23		89.3	90.35		94.	95.21
	92.55	94.03		92.43	94.77		89.22	90.23		95.	95.92
	94.87	96.7		94.73	97.58		90.98	92.25		97.	98.93
	92.76	94.74		92.61	95.71		88.49	89.85		96.	97.2
Latina	95.61	96.16	**Lucca**	97.59	97.37	**Messina**	98.29	96.96	**Nuoro**		
	92.02	93.04		94.9	94.8		95.92	94.2			
	87.38	89.07		91.04	91.31		92.35	90.55			
	85.01	87.71		89.49	90.49		91.1	89.55			
	83.94	87.13		89.27	90.45		91.2	89.32			
	83	86.5		89.19	90.36		91.44	89.04			
	83.78	87.9		90.95	92.4		93.58	90.86			
	80.65	85.1		88.46	90.01		91.35	88.33			
Lecce	98.35	99.44	**Macerat**	99.57	99.55	**Milan**	99.26	100.38	**Oristano**		
	96.01	97.84		97.79	98.01		97.34	99.23			
	92.46	95.25		94.76	95.46		94.17	97.05			
	91.24	95.38		94.08	95.65		93.36	97.64			
	91.36	96.36		94.79	96.68		93.92	99.1			
	91.63	97.27		95.66	97.66		94.62	100.51			
	93.8	100.52		98.52	100.98		97.31	104.36			
	95.45	103.22					88.67	96.56		88.	91.23
Modena	96.43	96.47	**Padova**	99.08	99.07	**Pesaro**	98.92	98.47	**Pordenone**	100	99.99
	93.21	93.48		97.07	97.3		96.84	96.42		98.	98.65
	88.89	89.63		93.83	94.54		93.53	93.4		95.	96.3
	86.86	88.41		92.93	94.5		92.56	93.08		95.	96.7
	86.13	87.97		93.4	95.29		92.96	93.57		96.	97.96
	85.53	87.46		94.02	96.02		93.5	94		97.	99.16
	86.7	89.02		96.6	99.04		95.99	96.67		101	102.76
	83.82	86.32		94.66	97.32		93.99	94.7		99.	101.44
Naples	101.34	99.15	**Palermo**	100.18	98.1	**Pescara**	98.34	98.51	**Potenza**	96.	95.9
	100.41	97.42		98.69	95.87		95.99	96.48		93.	92.66
	98.16	94.69		95.92	92.7		92.44	93.48		89.	88.58
	98.32	94.69		95.53	92.21		91.21	93.18		87.	87.11
	99.94	95.52		96.55	92.52		91.33	93.69		86.	86.42
	101.74	96.29		97.73	92.77		91.59	94.14		86.	85.67
	105.72	99.37		100.96	95.22		93.75	96.83		87.	86.94
	104.78	97.68		99.49	93.11		91.54	94.88		84.	84.05
Novara	99.4	99.04	**Parma**	99.11	100.53	**Piacenza**	100.31	100.57	**Prato**	98.	99.04
	97.54	97.26		97.12	99.45		98.9	99.52		95.	97.25

PC	Mod.	Mod. 2	PC	Mod.	Mod.	PC	Mod. 1	Mod. 2	PC	Mo	Mod. 2
	94.43	94.49		93.9	97.34		96.19	97.43		92.	94.48
	93.68	94.43		93.01	98.01		95.86	98.12		90.	94.42
	94.31	95.21		93.5	99.55		96.95	99.68		91	95.2
	95.09	95.92		94.14	101.05		98.2	101.2		91.	95.91
	97.85	98.93		96.74	104.99		101.52	105.18		93.	98.91
	96.05	97.2		94.82	103.93		100.11	104.13		91.	97.18
Nuoro			**Pavia**	99.33	98.62	**Pisa**	96.28	95.11	**Ragusa**		
				97.44	96.64		92.98	91.52			
				94.3	93.69		88.6	87.13			
				93.51	93.43		86.5	85.33			
				94.11	94		85.7	84.3			
				94.85	94.5		85.04	83.23			
				97.57	97.26		86.13	84.12			
				95.74	95.35		83.21	80.99			
Oristano			**Perugia**	97.65	98.9	**Pistoia**	97.48	97.66	**Ravenna**	97.	99.36
				94.98	97.04		94.74	95.22		94.	97.72
				91.14	94.21		90.84	91.86		90.	95.09
				89.61	94.09		89.24	91.16		88.	95.19
				89.41	94.79		88.97	91.27		88.	96.12
				89.35	95.44		88.84	91.3		88.	96.99
				91.14	98.36		90.54	93.51		89.	100.19
	87.1	98.6		84.81	95.48		105.18	109.61		95.	99.67
Reggio			**Rovigo**	98.25	97.9	**Syracus**	98.9	98.35	**Turin**	98.	99.02
				95.86	95.58		96.81	96.24		95.	97.21
				92.27	92.32		93.5	93.17		92.	94.43
				91	91.74		92.52	92.79		90.	94.37
				91.08	91.96		92.91	93.23		90.	95.13
				91.3	92.11		93.44	93.6		90.	95.83
				93.41	94.45		95.92	96.2		93.	98.82
				91.16	92.26		93.92	94.18		90.	97.07
Reggio	98.23	100.66	**Salerno**	98.59	98	**Sondrio**			**Trapani**		
	95.82	99.64		96.36	95.73						
	92.22	97.59		92.91	92.51						
	90.95	98.32		91.79	91.97						
	91.02	99.93		92.04	92.24						
	91.23	101.5		92.42	92.44						
	93.33	105.53		94.72	94.83						
	91.07	104.52		92.6	92.68						
Rieti	98.06	98.14	**Sassari**	99.29	100.42	**Taranto**	98.46	96.76	**Trento**	103	103.88
	95.59	95.92		97.38	99.3		96.16	93.91		103	104.46
	91.92	92.77		94.22	97.14		92.66	90.18		101	103.93
	90.57	92.29		93.42	97.76		91.48	89.08		102	106.37

PC	Mod.	Mod. 2	PC	Mod.	Mod.	PC	Mod. 1	Mod. 2	PC	Mo	Mod. 2
	90.57	92.62		93.99	99.24		91.66	88.77		105	109.83
	90.7	92.89		94.72	100.68		91.98	88.4		108	113.32
	92.71	95.36		97.42	104.56		94.21	90.11		113	119.69
	90.39	93.26		95.57	103.44		92.04	87.51		113	120.43
Rimini	96.79	97.63	**Savona**	99.37	99.14	**Teramo**	97.64	97.66	**Treviso**	98.	98.46
	93.73	95.18		97.51	97.4		94.97	95.22		96.	96.4
	89.54	91.8		94.39	94.67		91.13	91.86		93.	93.38
	87.65	91.09		93.63	94.66		89.6	91.16		92.	93.05
	87.08	91.18		94.25	95.49		89.4	91.26		92.	93.54
	86.63	91.21		95.01	96.25		89.34	91.3		92.	93.96
	87.98	93.39		97.77	99.32		91.12	93.5		95.	96.62
	85.21	91.1		95.96	97.63		88.65	91.22		93.	94.65
Rome	96.69	98.65	**Siena**	101.42	101.72	**Terni**	99.32	99.6	**Trieste**	98.	97.24
	93.58	96.68		100.54	101.23		97.43	98.08		96.	94.61
	89.35	93.74		98.32	99.67		94.3	95.55		93.	91.08
	87.42	93.51		98.53	100.95		93.51	95.76		92.	90.2
	86.8	94.09		100.19	103.15		94.1	96.82		92.	90.11
	86.31	94.6		102.04	105.32		94.84	97.82		92.	89.95
	87.6	97.38		106.08	110.08		97.57	101.17		95.	91.92
	93.05	89.49		94.6	94.1						
Udine	98.91	99.06		97.28	96.78						
	96.82	97.28		95.42	94.83						
	93.51	94.51	**Verona**	100.11	100.46						
	92.54	94.47		98.59	99.36						
	92.93	95.25		95.79	97.22						
	93.47	95.97		95.37	97.86						
	95.95	98.99		96.35	99.36						
	93.95	97.26		97.49	100.82						
Varese	100.65	100.32		100.69	104.73						
	99.39	99.15		99.19	103.63						
	96.83	96.95	**Vibo**	97.24	96.55						
	96.66	97.52		94.38	93.6						
	97.93	98.95		90.38	89.78						
	99.35	100.33		88.68	88.59						
	102.89	104.15		88.3	88.18						
	101.63	102.98		88.06	87.72						
Venice	97.96	97.24		89.63	89.32						
	95.43	94.62		87.02	86.64						
	91.72	91.08	**Vicenza**	98.24	98.74						
	90.32	90.2		95.84	96.82						
	90.27	90.11		92.25	93.92						
	90.35	89.96		90.98	93.72						

PC	Mod.	Mod. 2	PC	Mod.	Mod.	PC	Mod. 1	Mod. 2	PC	Mo	Mod. 2
	92.3	91.93		91.05	94.35						
	89.94	89.5		91.27	94.91						
Verbania	98.3	97.86		93.37	97.74						
	95.92	95.52		91.12	95.88						
	92.35	92.24	**Viterbo**	96.87	96.67						
	91.11	91.64		93.85	93.78						
	91.21	91.84		89.7	90						
	91.45	91.97		87.84	88.87						
	93.59	94.29		87.3	88.51						
	91.35	92.08		86.9	88.1						
Vercelli	99.25	98.5		88.28	89.77						
	97.33	96.46		85.55	87.13						
	94.16	93.46									
	93.34	93.15									
	93.9	93.66									

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How Much Land Does it Take To Support Each Person?

The Ecological Footprint and the Sustainability

How Much Land Does it Take To Support Each Person? The Ecological Footprint and the Sustainability

Abstract

This paper investigates the Ecological Footprint indicator by focusing on a sustainable development and then a carrying capacity of land. The impact of man on nature is a theme explored in order to conduct an empirical analysis on the growth rate of population, the percentage of urban and rural population, in Europe. It's an ongoing study the impact of CO_2 emissions on the environment, especially following the growth of urban population. Thanks to an indicator, it's possible to compare the level of CO_2 emissions per inhabitant in the EU with levels in developing countries. Through a sectoral approach, we can see the total CO_2 emissions per capita from fuel combustion, electricity and heat production, manufacturing industries and construction, transport, and other sources are separately appraised.

Keywords: ecological footprint, sustainable development, carrying capacity, growth rate of population, urban population, rural population, CO_2 emissions.

1 Introduction

This research project is aimed at investigating the Ecological Footprint indicator, the relationship between the dynamics of urban and rural population, and the European level of CO_2 emissions. The analysis of the relationship between these dynamics allows to evaluate the sustainability of macroeconomic and demographic trends. In particular, this paper *i)* recalls the definition of Ecological Footprint (EF) and the related methodology; *ii)* analyses the growth rate of urban and rural population; *iii)* examines the the impact of CO_2 emissions on the environment, especially following the growth of urban population.

Sustainable development is "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Bruntland Report, 1987). The possibilities for future generations to meet their own needs depends on: *i)* the availability of a composite capital, as used by the present generation; *ii)* the degree of substitutability of factors; *iii)* the minimum level of critical natural capital, that it's necessary for the reproducibility of the biological system; *iv)* the carrying capacity of the system, i.e. the amount of pollution and waste that the planet is able to withstand.

The concepts of sustainable development that require a strong or very strong sustainability are based on assumptions increasingly pessimistic about the carrying capacity of land, and then on the closeness level of critical natural capital and on the substitutability factors. Connected to the notion of sustainable development is that of intergenerational equity, which is the concern to ensure equal opportunities for subsequent generations. To get an economy truly "sustainable" in relation to the regenerative and assimilative capacities of natural systems that allow us to live, you must rely on the principle of equity. It's possible to prevent the continued social and economic iniquity of which is so abundant in today's world and to manage our progress to sustainability through the attribution of value of what we measure rather than measuring what we value (Wackernagel *et al.*, 2000).

In summary, to monitor progress towards sustainable development, you must be able not only to define, but also to measure the various aspects of sustainability: the limits that nature imposes, our impact on it and our quality of life. The measurability is not the only problem, but progress towards that greatly help progress towards sustainability. The indicators (environmental, social, economic, aggregates, etc) allow today to provide timely, accessible and reliable information, very useful to make decisions. Among the sustainability indicators of aggregate type, they are cited: *i) TMR*, Total Material Requirements, summary of flows of matter and energy in the economy; *ii) LPI*, Living Planet Index (average of indexes related to biodiversity); *iii) HDI*, Human Development Index (average of longevity, aspects cultural and income); *iv) GPI*, Genuine Progress Index, supplemented by factors such as GDP taking into account the quality of life, pollution and consumption of non-renewable resources; *v) ESI*, Environmental Sustainability Index, which measures the progress towards environmental sustainability based on a set of twenty indicators, each of which sums up to eight variables.

2 Ecological Footprint

An indicator for evaluating sustainability is the Ecological Footprint (EF hereafter). The EF method has been developed at the turn of the eighties and nineties by ecologist William Rees of the University of British Columbia's School of Community and Regional Planning in Canada and his colleagues, first of all, then Ph.D. student Mathis Wackernagel. The method has undergone continual refinement over the last decade and, still, it's the subject of further analysis and research to improve its effectiveness. The analysis of the EF aims to overcome some problems related to the evaluation of carrying capacity used in the ecology of the human species, completely inverting the traditional question: instead of asking "how many people can the Earth support?", the EF method asks "how much land does it take to support each person?". In other words, the footprint does not focus on the number of heads, but the size of the feet (Wackernagel *et al*., 2000). Therefore, it becomes crucial not only the number of people but also the types of production technologies and consumption patterns. The EF is then defined as the total area of terrestrial and aquatic ecosystems required to produce the resources that a given human population (an individual, family, community, region, nation, and so on) consumes and to assimilate waste that the same population produces. The calculations are based on EF chance to estimate the resources we consume, the waste we produce and the possibility that these flows of resources and waste can be converted to an equivalent area of biologically productive land, necessary to ensure these functions. If the bioproductive space required is greater than what is available, we can reasonably say the rate of consumption is not sustainable.

The EF of a person is the sum of six different components: *i)* the surface of cultivated land needed to produce the foods and natural resources; *ii)* the grazing area necessary for the breeding and to produce animal products; *iii)* the surface of forest necessary for harvest timber and paper; *iv)* the sea surface required to produce fish and seafood; *v)* the area of land required to accommodate housing and infrastructure; *vi)* and the area of forest needed to absorb emissions of carbon dioxide resulting from the energy consumption of the individual taken into account. It's measured in global hectares: a global hectare is equivalent to one hectare of bioproductive space in relation to the average global productivity.

Table 1. Ecological Footprint and Biocapacity (2008)

Country/region	Population (millions)	Income Group	Cropland Footprint	Grazing Footprint	Forest Footprint	Fish Footprint	Carbon Footprint	Built up land	Total Ecological Footprint	Cropland	Grazing land	Forest land	Fishing ground	Built up land	Total biocapacity	Biocapacity (Deficit) or Reserve
			Ecological Footprint 2008 (global hectares per person)							Biocapacity 2008 (global hectares per person)						
World	6739,6		0,6	0,2	0,3	0,1	1,5	0,1	2,7	0,6	0,2	0,8	0,2	0,1	1,8	(0,9)
Belgium	10,6	HI	1,8	1,0	0,5	0,2	3,3	0,4	7,1	0,5	0,1	0,3	0,0	0,4	1,3	(5,8)
Bulgaria	7,6	UM	1,0	0,2	0,5	0,0	1,7	0,2	3,6	1,2	0,2	1,0	0,1	0,2	2,6	(0,9)
Czech Republic	10,4	HI	1,2	0,2	0,8	0,0	2,9	0,2	5,3	1,2	0,1	1,2	0,0	0,2	2,7	(2,6)
Denmark	5,5	HI	2,8	0,7	1,2	0,8	2,5	0,3	8,3	2,4	0,0	0,3	1,9	0,3	4,8	(3,4)
Estonia	1,3	HI	0,8	0,1	1,6	0,2	1,9	0,2	4,7	0,8	0,4	3,3	4,1	0,2	8,7	4,0
Finland	5,3	HI	1,1	0,2	0,4	0,3	4,2	0,1	6,2	0,9	0,0	8,6	2,5	0,1	12,2	6,0
France	62,1	HI	1,2	0,4	0,6	0,2	2,2	0,2	4,9	1,5	0,2	0,9	0,2	0,2	3,0	(1,9)
Germany	82,5	HI	1,2	0,3	0,4	0,0	2,5	0,2	4,6	0,9	0,1	0,6	0,1	0,2	2,0	(2,6)
Greece	11,3	HI	1,3	0,5	0,4	0,1	2,5	0,1	4,9	1,0	0,1	0,1	0,2	0,1	1,6	(3,3)
Hungary	10,0	HI	1,3	0,0	0,4	0,0	1,6	0,2	3,6	1,8	0,1	0,6	0,0	0,2	2,7	(0,9)
Ireland	4,4	HI	1,3	0,5	0,5	0,0	3,7	0,2	6,2	0,6	0,8	0,2	1,6	0,2	3,4	(2,8)
Italy	59,9	HI	1,0	0,4	0,5	0,1	2,4	0,1	4,5	0,6	0,1	0,3	0,1	0,1	1,1	(3,4)
Latvia	2,3	UM	0,8	0,1	1,2	0,3	1,5	0,1	4,0	1,0	0,7	3,0	1,9	0,1	6,6	2,7
Lithuania	3,4	UM	1,0	0,1	1,0	0,4	1,6	0,2	4,4	1,4	0,8	1,7	0,3	0,2	4,3	(0,1)
Netherlands	16,5	HI	1,3	1,1	0,5	0,1	3,1	0,2	6,3	0,3	0,1	0,1	0,4	0,2	1,0	(5,3)
Poland	38,2	UM	1,0	0,0	0,7	0,1	2,0	0,1	3,9	1,0	0,1	0,7	0,1	0,1	2,0	(1,9)
Portugal	10,6	HI	1,0	0,0	0,1	1,0	2,0	0,1	4,1	0,3	0,2	0,6	0,1	0,1	1,3	(2,8)
Romania	21,6	UM	0,9	0,1	0,4	0,0	1,2	0,2	2,8	0,9	0,2	1,0	0,1	0,2	2,3	(0,5)
Slovakia	5,4	HI	1,1	0,3	0,9	0,0	2,3	0,2	4,7	1,0	0,1	1,6	0,0	0,2	2,9	(1,8)
Slovenia	2,0	HI	0,9	0,3	0,6	0,0	3,2	0,2	5,2	0,4	0,2	1,8	0,0	0,2	2,6	(2,6)
Spain	45,1	HI	1,3	0,3	0,3	0,4	2,4	0,1	4,7	1,0	0,1	0,2	0,1	0,1	1,5	(3,3)
Sweden	9,2	HI	1,0	0,5	1,0	0,2	3,0	0,1	5,7	0,6	0,0	6,4	2,4	0,1	9,5	3,8
United Kingdom	61,5	HI	0,9	0,4	0,5	0,1	2,6	0,1	4,7	0,5	0,1	0,1	0,5	0,1	1,3	(3,4)

Source: Global Footprint Network

The footprint can be compared with the biological ability of which locally has; it's represents the total of the biologically production areas of a country or region, giving rise to an ecological deficit or surplus. Calculations of this type, as far easier if referring to the entire world or nations, it's possible to implement even for smaller entities. In particular, in recent years, increasingly estimates are made for determine the EF of cities and towns or groups of municipalities, provinces or regions. It's shown that in most cases the cities "consume" much more soil than they would have if there were no phenomena of "transfer" of natural capital. A distinction between the different measurement systems for sustainability based on the level of concentration of information that the nature of the indicator aggregated or not.

3 Methodology

There are two complementary approaches to calculate the EF: compound and component method. The compound method is most extensive and robust if we consider as the unit of analysis nation, since it refers to trade flows and energy data. The calculation is divided into three parts: *i)* the first part consists in the consumption of the population, taking into account more than fifty food items and not. The consumption is calculated adding to domestic production, imports and subtracting exports; *ii)* the second part of the calculation determines the energy balance, considering both energy generated locally and those incorporated in the products sold. Once the fuel used, it's converted to carbon content. This part is used to calculate the energy footprint, i.e. the amount of area forest needed to absorb CO_2; *iii)* the third section summarizes the calculation of EF in six types of land and provides the total per capita. Multiplying the value per capita for the population under consideration is obtained by the total footprint.

In the component method is pre-calculated values of EF of some activities, using the characteristic data for the region or country concerned. Any set of data based on the life cycle of products can be combined and transformed to determine the footprint of the products consumed. The purpose is to compute the majority of consumption through a series of analyses of the components that form the products, for considering the possible impacts of human activities. Furthermore, depending on the level of specificity required, some components may be divided or omitted in the case the information is non-existent.

In both methods, data sources are rarely congruent, the estimates are based on assumptions, methods and different samples. The two methods, using different information sources, have different sensitivity analysis in the determination of quantitative values.

Through the use of conversion factors or productivity defined by Wackernagel, we can express the result in terms of world biologically productive land on average. This makes the result comparable with the values obtained from different studies on the footprint of other populations. In addition, to the conversion factors Wackernagel has also introduced the equivalence factors which assign different types of land by a percentage proportionate to their productivity. The total should then be compared with biocapacity of the country or region surveyed. In biologically productive land must be subtracted 12% for the sustenance of biodiversity, the remaining 88% is considered as an area available.

The analysis is further based on the European data collection about growth rate of population, urban and rural population, CO_2 emissions. The main sources are the World

Bank and Eurostat websites, and the International Energy Agency (IEA) and the European Energy Agency (EEA). The graphs are plotted with Gretl, a software package for econometric tasks and statistical analysis of time series.

4 Carrying capacity and growth rate of population

The analysis of the EF is a calculation tool that allows you to estimate the resource consumption and waste assimilation required by a given human population or a certain economy and to express these quantities in terms of corresponding surface area production. The EF is among the aggregate indicators and it measures human impact on the Earth in an unambiguous and comprehensive quantitative pattern. From a theoretical point of view, there is no difficulty in conceptually defining the impact of man on nature and it's calculated as

$$I = P \cdot A \cdot T$$

where I is human impact on the biosphere, P is people on the planet, A is affluence (average consumption of each person), and T is technology, i.e. a measure of the technical quality of the produced goods.

The carrying capacity is defined as the ability of an habitat and its resources to support a number of individuals without cracking the productivity habitat itself. The ecological weight is equally dependent on cultural factors and ecological productivity: in fact, the total ecological weight of any population varies when some factors change as average income per person, the expectations of consumption, energy and materials efficiency. Moreover, the global economy allows to everyone to have access to resources around the world (Wackernagel and Rees, 2000). Now the question is: how much does the population (P in the EF equation) grow each year? In the matter of that, we analyse the growth rate of European population. The growth rate of human population measures as it changes the relative abundance of populations over time. The units of measurement of the growth rate of population are the existing individuals at a given historical moment. The population size can be changed only by four factors: *i)* the number of births, that adds new individuals in a population, *ii)* the dead, that removes individuals from a population, *iii)* immigration, adding new individuals in a population *iv)* emigration, that removes individuals in a population. The growth rate of population is positive when in a population other individuals are add, it's negative when removed individuals are more than added individuals, equal to zero when an equal number of individuals is added and removed. The population size is known as a carrying capacity of the terrestrial globe and it's the size beyond which a significant increase can not occur due to limitations such as lack of food, water, space, etc.

5 Data analysis in Europe

5.1 Growth rate of population

We can verify empirically the growth rate of the population of all European countries in the fifty years 1961-2011. The analysed data are extrapolated from the site of the World Bank and they are related to the growth rate of human population for the following countries: *i)* Austria; *ii)* Belgium; *iii)* Bulgaria; *iv)* Cyprus; *v)* Denmark; *vi)* Estonia; *vii)* Finland; *viii)* France; *ix)* Germany; *x)* Great Britain; *xi)* Greece; *xii)* Ireland; *xiii)* Iceland; *xiv)* Italy; *xv)* Latvia; *xvi)* Liechtenstein; *xvii)* Lithuania; *xviii)* Luxembourg; *xix)* Malta; *xx)* Norway; *xxi)* Netherlands; *xxii)* Poland; *xxiii)* Portugal; *xxiv)* Czech Republic; *xxv)* Romania; *xxvi)* Slovakia; *xxvii)* Slovenia; *xxviii)* Spain; *xxix)* Sweden; *xxx)* Switzerland; *xxxi)* Turkey; *xxxii)* Hungary. As it can be seen from the list, the data on the growth rate of world population have been modified in order to obtain a table containing only European states, and only for those years (eliminating, therefore, the data relating to 1960).

Table 2. Growth rate of European population (A-La).

Country Name	Austria	Belgium	Bulgaria	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia
1961	0,54847	0,33221	0,95816	0,60411	-0,160042501	0,698142	1,17759	0,70571	1,31495	0,76985	0,7929	0,45324	1,94872	-0,1485	0,66838	1,48363
1962	0,6129	0,39805	0,87526	0,22508	0,395694491	0,778455	1,26428	0,68	1,39359	0,87943	0,59578	0,32266	1,85337	0,41248	0,67662	1,33381
1963	0,64236	0,74761	0,81038	0,03876	0,477058972	0,787727	1,2485	0,70698	1,40236	0,92588	0,37089	0,26018	1,77979	0,58532	0,72955	1,33561
1964	0,66655	0,94648	0,81609	0,12415	0,58890324	0,799213	1,2331	0,55632	1,32204	0,80514	0,36261	0,3156	1,77777	0,48727	0,82262	1,33457
1965	0,64973	0,90814	0,73191	0,40456	0,528566073	0,77924	1,09423	0,33337	1,1824	0,85319	0,46779	0,27729	1,73268	0,37502	0,84211	1,12265
1966	0,7014	0,67546	0,6547	0,74482	0,425318535	0,803006	1,0479	0,3748	1,01812	0,83456	0,7378	0,30224	1,69345	0,39968	0,7773	0,7605
1967	0,74743	0,55665	0,62975	1,01939	0,323870353	0,78842	1,12044	0,54155	0,87584	0,45721	0,81441	0,37216	1,61344	0,47251	0,72378	0,7854
1968	0,51925	0,39339	0,71196	1,2091	0,237687869	0,608832	1,10802	0,44897	0,77882	0,44472	0,65053	0,38306	1,3677	0,45134	0,63174	0,96865
1969	0,34533	0,28317	0,76851	1,26693	0,204663762	0,552993	1,09514	-0,058	0,74811	0,79298	0,36542	0,4175	0,92922	0,58651	0,56606	0,83801
1970	0,34922	0,09861	0,65473	1,23137	-0,389873238	0,751423	1	-0,3787	0,76295	0,33266	0,2282	0,37978	0,52427	0,83883	0,52888	0,68013
1971	0,44625	0,18225	0,55	1,17469	-0,317563701	0,694896	1,07038	0,1262	0,79349	0,18348	0,43384	0,28618	0,8087	1,17677	0,46645	0,72748
1972	0,58119	0,39159	0,46521	1,14529	0,41450322	0,571991	1,12391	0,5952	0,80496	0,47848	0,65004	0,2981	1,46378	1,4973	0,56771	0,80825
1973	0,55404	0,31466	0,52063	1,12729	0,552141692	0,604488	0,96003	0,56791	0,78607	0,31494	0,45413	0,32228	1,50909	1,61681	0,67819	0,83737
1974	0,17021	0,31463	0,66797	1,13247	0,664900388	0,465594	0,86527	0,52354	0,72317	0,03897	0,36818	0,44633	1,35292	1,67047	0,65439	0,88057
1975	-0,2653	0,28898	0,48274	1,14856	0,699965182	0,288269	0,78546	0,44386	0,63235	-0,37285	0,93866	0,58808	1,27891	1,65896	0,59725	0,77428
1976	-0,1767	0,17867	0,43316	1,18799	0,667037111	0,251351	0,71274	0,30145	0,53291	-0,42877	1,55321	0,55018	0,99286	1,52059	0,49885	0,60315
1977	0,03839	0,12348	0,5191	1,2077	0,598799763	0,311446	0,73604	0,27974	0,45318	-0,22638	1,30111	0,46458	0,74443	1,36347	0,42472	0,56836
1978	-0,081	0,0933	0,1118	1,15157	0,541813438	0,310596	0,68561	0,28712	0,40823	-0,08703	1,2966	0,34492	0,78054	1,42892	0,35631	0,51568
1979	-0,1705	0,08988	0,13501	0,99652	0,489354496	0,24563	0,55625	0,25558	0,41134	0,04421	1,2467	0,18075	0,97848	1,3412	0,28915	0,32103
1980	0,00011	0,11021	0,40249	0,78791	0,115087338	0,121604	0,60335	0,31108	0,44885	0,20743	0,98222	0,06509	1,0589	1,15747	0,206	0,22911
1981	0,25502	-0,0026	0,33327	0,54627	-0,034962755	-0,02841	0,70472	0,42652	0,49613	0,15231	0,89662	0,00678	1,14058	1,17792	0,12005	0,30689
1982	0,07172	-0,0272	0,29581	0,36595	0,138100551	-0,07348	0,71988	0,56029	0,53359	-0,09511	0,61646	-0,059	1,33661	0,9499	0,07408	0,4617
1983	-0,1616	-0,0079	0,24955	0,3397	0,087505593	-0,06867	0,6871	0,59599	0,56143	-0,26215	0,58172	-0,1502	1,32404	0,71146	0,03629	0,58817
1984	-0,0063	-0,0015	0,23397	0,52244	0,06155688	-0,05238	0,65219	0,53434	0,57255	-0,34567	0,49816	-0,2001	1,06363	0,62163	0,02235	0,62787
1985	0,04695	0,02979	-0,0015	0,85193	0,066820435	0,040527	0,66706	0,41707	0,57062	-0,22349	0,38829	-0,1818	0,78767	0,1602	0,0289	0,65459
1986	0,06355	0,03565	-0,0265	1,22079	0,049411624	0,133728	0,74351	0,32479	0,56983	0,04577	0,33076	-0,1706	0,73259	0,04545	0,00545	0,81174
1987	0,06328	0,08525	0,14711	1,53754	0,049213263	0,126664	0,7781	0,28363	0,5712	0,15362	0,33436	-0,1678	1,09563	0,01037	0,01021	1,02139
1988	0,14157	0,31793	0,11237	1,7942	0,076879259	0,048593	0,62162	0,29069	0,56174	0,39068	0,3632	-0,1533	1,56622	-0,4268	0,04832	1,01709
1989	0,45051	0,36325	-1,17	1,95875	0,055917204	0,059988	0,39814	0,36102	0,53894	0,77334	0,52185	-1,089	1,2384	-0,3955	0,07501	0,50827
1990	0,762	0,29824	-1,8038	2,05085	-0,267830773	0,162456	0,06649	0,44338	0,50752	0,86197	0,66584	-1,0331	0,77766	0,08445	0,08371	-0,1427
1991	0,99842	0,37159	-0,9904	2,13267	-0,240064842	0,259518	-0,5022	0,54617	0,47456	0,72861	0,97379	-0,0057	1,15915	0,57658	0,06923	-0,4731
1992	1,10055	0,40571	-1,0739	2,2121	0,102241165	0,330671	-1,8242	0,56191	0,44659	0,76035	1,10127	-0,0391	1,25663	0,68459	0,06792	-1,3768
1993	0,82463	0,39064	-0,7977	2,24156	0,103947042	0,333166	-2,5743	0,48385	0,42538	0,65739	0,91827	-0,114	1,01681	0,50109	0,06114	-1,9719
1994	0,38487	0,3082	-0,3396	2,21583	0,036121766	0,337707	-2,1386	0,43105	0,41403	0,34686	0,83267	-0,1369	0,86684	0,39497	0,02037	-1,6738
1995	0,15311	0,20944	-0,4454	2,15283	-0,061314063	0,520962	-1,7854	0,38166	0,41188	0,2939	0,76791	-0,1392	0,54247	0,51401	0,00159	-1,4258
1996	0,13502	0,19539	-0,5157	2,06555	-0,116381299	0,565926	-1,4754	0,32804	0,40748	0,28947	0,7008	-0,1718	0,53991	0,79441	0,0281	-1,1264
1997	0,11332	0,24199	-0,6088	1,982	-0,107762749	0,415565	-1,1409	0,29738	0,40657	0,14631	0,62675	-0,2015	0,8192	1,00786	0,05291	-0,9968
1998	0,10973	0,21353	-0,6673	1,92366	-0,094744752	0,363163	-0,9606	0,26547	0,42698	0,01514	0,54024	-0,2327	1,07086	1,04854	0,02877	-0,9429
1999	0,19456	0,22919	-0,5606	1,90291	-0,102175934	0,330886	-0,7605	0,23212	0,32487	0,06463	0,43928	-0,2833	1,20924	1,13368	0,01682	-0,814
2000	0,24047	0,24252	-0,4939	1,90396	-0,112258212	0,334234	-0,4473	0,20761	0,68458	0,13543	0,3202	-0,2598	1,36919	1,34197	0,0453	-0,7346
2001	0,3828	0,34395	-1,8516	1,90978	-0,34942087	0,358316	-0,3961	0,22769	0,72733	0,16823	0,29702	-0,2294	1,3293	1,60489	0,06164	-0,7603
2002	0,49198	0,44827	-1,911	1,89481	-0,309549365	0,319487	-0,4008	0,24238	0,72668	0,16813	0,34266	-0,2848	0,8926	1,69943	0,31575	-0,6983
2003	0,48713	0,41864	-0,5724	1,84635	0,024583319	0,27201	-0,3751	0,23846	0,70817	0,05536	0,32685	-0,2864	0,6925	1,64229	0,77945	-0,5696
2004	0,62041	0,43279	-0,5434	1,75501	0,084746025	0,258432	-0,3157	0,29035	0,7357	-0,02171	0,34582	-0,2214	0,87794	1,84513	0,98576	-0,54
2005	0,68127	0,55006	-0,5317	1,63607	0,193742982	0,275482	-0,2369	0,34225	0,75321	-0,05678	0,38135	-0,1989	1,58289	2,20261	0,73938	-0,5335
2006	0,4948	0,65956	-0,5296	1,51	0,32485824	0,328645	-0,1896	0,38378	0,69662	-0,1128	0,39991	-0,1557	2,34742	2,38548	0,56905	-0,5476
2007	0,38803	0,73433	-0,5112	1,39774	0,63122155	0,443466	-0,1397	0,42543	0,61817	-0,13372	0,3966	-0,1549	2,53009	2,24187	0,73327	-0,5192
2008	0,43441	0,78998	-0,4759	1,30598	0,868815999	0,587548	-0,0743	0,46555	0,55843	-0,19014	0,39529	-0,1751	1,85957	1,56567	0,76655	-0,4406
2009	0,33946	0,8046	-0,5032	1,24312	0,601029549	0,535079	-0,0301	0,47825	0,54182	-0,25338	0,40556	-0,1549	0,34124	0,74869	0,60074	-0,4981
2010	0,2924	0,91547	-0,6725	1,20086	0,310506715	0,444197	-0,0082	0,45749	0,54753	-0,1532	0,28983	-0,226	-0,1439	0,34509	0,48176	-0,7043
2011	0,34778	1,02463	-0,7767	1,1636	0,248820586	0,473257	-0,012	0,43995	0,55318	-0,0623	-0,1018	-0,2907	0,30108	0,28219	0,47275	-0,8526

Source: World Bank

Table 3. Growth rate of European population (Li-U).

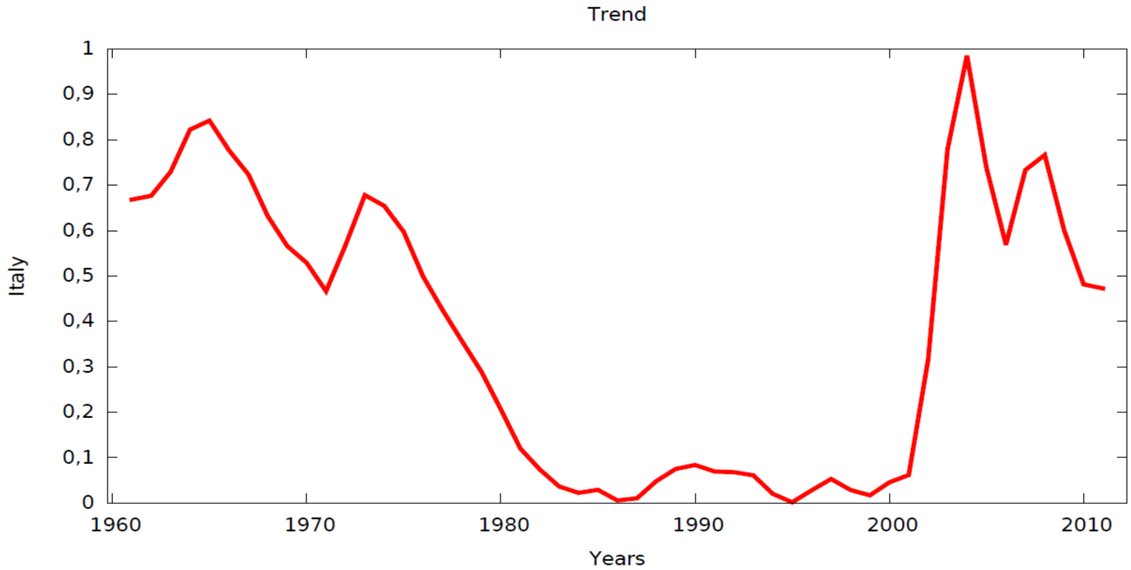
Country Name	Liechtenstein	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovak Rep.	Slovenia	Spain	Sweden	Switzerland	Turkey	U.K.
1961	2,357121988	1,606575	0,91152554	-0,4	1,31529459	0,794354	1,09579	0,80509	0,80269	2,99236759	0,5921	0,929	0,47108	1,97861506	2,57236	0,76
1962	2,366215648	1,399731	1,22493082	-0,42	1,42447507	0,803402	1,14315	0,72162	0,6516	1,10373126	0,59529	0,92	0,55153	2,53501254	2,52619	0,849
1963	2,407149543	1,235633	1,03901067	-0,42	1,34849197	0,756124	1,32253	0,40357	0,64738	1,02883409	0,8273	0,877	0,56363	2,13766282	2,46764	0,748
1964	2,498741886	1,242699	1,11990125	-0,4	1,33778133	0,755403	1,3822	0,05546	0,64309	1,05291054	0,93215	0,994	0,74712	1,65425825	2,39386	0,65
1965	2,608937754	1,227446	1,1376687	-0,77	1,37266111	0,777327	0,97629	-0,4078	0,59261	1,0034661	1,039	1,086	0,94185	1,15484251	2,3137	0,642
1966	2,735132162	1,224198	0,71987627	-1,14	1,30517073	0,79838	0,74787	-0,7541	0,96151	0,92644693	1,25007	1,024	0,95157	1,04515174	2,23102	0,551
1967	2,79889099	1,201181	0,32890341	-1,16	1,13314407	0,836537	0,96173	-0,6343	1,64543	0,8509443	1,16825	1,231	0,76723	1,23904725	2,16252	0,539
1968	2,757110604	1,125231	0,25490254	-1,18	1,03854696	0,840602	0,95673	-0,4276	1,35045	0,77347099	0,88496	1,308	0,562	1,25925635	2,12392	0,487
1969	2,582542439	0,920479	0,49008786	-1,18	1,15796911	0,814728	0,78234	-0,8974	1,05158	0,77072118	0,54575	0,985	0,70275	1,12542046	2,12263	0,416
1970	2,3257413	1,036281	0,49388947	-0,54	1,23893266	0,726516	0,35576	-0,8863	1,19852	0,43317652	0,64076	1,111	0,93348	0,72240383	2,14622	0,399
1971	2,043772043	1,245583	0,95365692	0,017	1,18913354	0,701293	0,36426	-0,4234	1,03739	0,42275114	0,77639	1,109	0,6881	0,52479184	2,17987	0,418
1972	1,804799528	1,081907	1,21304031	-0,08	1,01117285	0,764803	0,82672	-0,1543	0,95522	0,85586487	0,79632	0,906	0,2955	0,76247999	2,20585	0,339
1973	1,639930405	0,95435	1,10466657	-0,08	0,82733102	0,699505	0,90811	0,03093	0,85664	0,97040543	0,82207	0,907	0,17236	0,73822553	2,2171	0,193
1974	1,578575156	0,903796	1,30405817	-0,07	0,78367225	0,620349	0,95979	1,39488	0,92559	1,03264553	0,53263	0,964	0,29016	0,53852083	2,20721	0,063
1975	1,584105837	0,844285	1,09244784	0,734	0,89138996	0,551889	0,9936	3,80041	1,24829	1,04961039	0,97762	1,065	0,39728	-0,043738	2,1847	-0,01
1976	1,605895691	0,814807	0,49494252	0,509	0,78499339	0,469014	0,9978	2,8441	1,20459	1,05791841	1,47591	1,144	0,36369	-0,5715958	2,15148	-0,02
1977	1,605466965	0,789148	0,17366285	0,39	0,594626	0,422661	0,96387	1,06175	0,94424	1,05907444	1,20833	1,191	0,35516	-0,3390109	2,12712	-0,03
1978	1,600562178	0,726941	0,1794392	1,041	0,61526458	0,381789	0,79406	1,07896	0,89398	1,01996378	1,08889	1,372	0,29115	0,00897881	2,13102	0,005
1979	1,579375514	0,540861	0,23425127	1,014	0,69028225	0,340566	0,80219	1,07199	0,63133	0,99395493	1,07078	0,887	0,21822	0,20080949	2,17121	0,09
1980	1,550852459	0,451033	0,35598093	1,049	0,79133181	0,321226	0,92327	1,08143	0,68646	0,82353269	0,98925	0,637	0,203	0,39707442	2,22987	0,12
1981	1,523261697	0,576822	0,29477314	0,735	0,6860468	0,34408	0,90787	0,86708	0,77262	0,72609944	0,27396	0,802	0,11992	0,54706491	2,29693	0,035
1982	1,511949717	0,703386	0,08210743	2,145	0,45855986	0,367278	0,92028	0,61133	0,44611	0,77437007	0,19927	0,534	0,05719	0,58429168	2,33897	-0,04
1983	1,478056965	0,80702	0,02653365	1,409	0,3792226	0,33106	0,93769	0,46397	0,32547	0,72675486	0,62552	0,472	0,04527	0,42878792	2,32715	0,034
1984	1,445318546	0,829019	0,10278561	0,021	0,39693319	0,282203	0,90459	0,38455	0,29683	0,68746266	0,51021	0,409	0,09087	0,35911165	2,24785	0,158
1985	1,406305064	0,859591	0,19325682	1,757	0,46632652	0,299472	0,80359	0,27354	0,43816	0,67395444	0,4898	0,366	0,16517	0,44144267	2,12559	0,227
1986	1,357727029	0,965016	0,448671	1,671	0,55495773	0,356689	0,68107	0,09095	0,4553	0,61937665	1,24492	0,304	0,23257	0,52039161	1,992	0,232
1987	1,325192261	1,041053	0,64808339	0,689	0,63452688	0,46805	0,5642	-0,0269	0,39364	0,55683923	1,20394	0,247	0,33368	0,62811576	1,87855	0,213
1988	1,300779197	1,063957	0,72561458	0,821	0,64609623	0,537923	0,41446	-0,104	0,4705	0,53002787	0,27202	0,22	0,4596	0,73494306	1,79367	0,222
1989	1,294561999	0,795883	0,97262775	0,973	0,59990721	0,412808	0,36166	-0,1459	0,44915	0,48156477	0,05787	0,195	0,66718	0,80853606	1,74883	0,26
1990	1,302169554	0,367999	1,25174571	0,978	0,68860382	0,344151	0,3924	-0,2179	0,17418	0,4396171	0,09062	0,152	0,7726	1,02687307	1,732	0,299
1991	1,316079041	0,170117	1,33968317	0,999	0,78803104	0,476504	0,35468	-0,1538	-0,8687	0,07747244	0,06344	0,228	0,68164	1,24982602	1,71913	0,309
1992	1,319146475	-0,10859	1,32834757	0,983	0,75605659	0,57718	0,30668	0,02081	-0,9035	0,03246512	-0,1467	0,33	0,58653	1,10252107	1,69831	0,27
1993	1,315237439	-0,47411	1,34238703	0,949	0,69699133	0,595229	0,25445	0,12668	-0,1361	0,38171989	-0,2383	0,311	0,58084	0,91071557	1,67812	0,24
1994	1,30143675	-0,694	1,36184014	0,884	0,60293847	0,569388	0,21101	0,21504	-0,1454	0,39405443	-0,1157	0,269	0,71071	0,79715841	1,6563	0,255
1995	1,275021339	-0,76973	1,40474246	0,675	0,49392737	0,519126	0,13572	0,2625	-0,2023	0,29263221	0,02156	0,234	0,5247	0,66824233	1,63287	0,265
1996	1,24301011	-0,76034	1,36114394	0,607	0,46139575	0,506882	0,07607	0,27364	-0,2881	0,2116744	-0,0625	0,231	0,15915	0,44163641	1,61324	0,255
1997	1,21198222	-0,73783	1,25350248	0,682	0,514767	0,54222	0,06546	0,33013	-0,2879	0,18462999	-0,1345	0,264	0,05726	0,24089121	1,59406	0,258
1998	1,191236657	-0,72444	1,2438708	0,606	0,61664053	0,59541	0,03575	0,37754	-0,207	0,1341216	-0,2181	0,35	0,05551	0,29713577	1,56616	0,291
1999	1,177213099	-0,70949	1,35062129	0,487	0,66549319	0,684759	-0,0083	0,42026	-0,157	0,10205316	0,07143	0,515	0,07793	0,47691993	1,52683	0,333
2000	1,172647885	-0,70339	1,344083	0,527	0,71477036	0,649045	-0,5356	0,52836	-0,1294	-0,1353765	0,29607	0,84	0,16058	0,56195462	1,48078	0,357
2001	1,168082034	-0,52269	1,19045635	3,013	0,75484006	0,506047	-0,5363	0,65465	-1,3954	-0,1830123	0,1575	1,129	0,26847	0,63277124	1,43099	0,365
2002	1,157569196	-0,35169	1,04766082	0,746	0,63829167	0,539291	-0,0463	0,72991	-1,497	0,00351369	0,12392	1,447	0,32544	0,75646915	1,38666	0,368
2003	1,123740238	-0,42942	1,21520088	0,658	0,4718144	0,586533	-0,0675	0,69845	-0,2807	0,01024291	0,0603	1,658	0,37209	0,7419196	1,35566	0,404
2004	1,050162494	-0,54034	1,42133257	0,672	0,34747541	0,590931	-0,0585	0,58153	-0,2631	0,05261082	0,06407	1,623	0,3933	0,68742596	1,34232	0,505
2005	0,958580196	-0,62153	1,53005466	0,638	0,23366315	0,681073	-0,0439	0,45084	-0,2332	0,0847398	0,17321	1,641	0,39994	0,64060154	1,34034	0,594
2006	0,858078761	-0,59403	1,59505192	0,635	0,16061367	0,805393	-0,0634	0,33047	-0,2161	0,08179315	0,31911	1,642	0,56248	0,62755847	1,34158	0,615
2007	0,771413284	-0,54549	1,54438685	0,648	0,2175216	1,034735	-0,0543	0,22641	-0,1891	0,10954028	0,55921	1,714	0,74155	0,89369098	1,33648	0,643
2008	0,72047439	-0,51986	1,78749663	0,706	0,38929246	1,246333	0,01364	0,13262	-0,1544	0,17230749	0,15814	1,497	0,77903	1,27061807	1,32134	0,665
2009	0,70413936	-0,55719	1,85177523	0,494	0,51428455	1,261127	0,06776	0,09475	-0,1545	0,22103956	0,90388	0,772	0,8519	1,24948463	1,29228	0,678
2010	0,724196803	-1,58874	1,8254058	0,483	0,5129231	1,245666	0,08405	0,04574	-0,1976	0,21217318	0,43608	0,353	0,85252	1,05745474	1,2533	0,678
2011	0,752049552	-2,58327	1,96245774	0,72	0,48395547	1,275221	0,0846	-0,0033	-0,2242	0,1821695	0,16666	0,355	0,79522	1,02773693	1,2122	0,656

Source: World Bank

By way of an example, the reported analysis concerns only the growth rate of Italian, Portuguese and Lithuanian population: the first for reasons of nationality of the author and curiosity of study, the second because it's the European country in the fifty years under review with the highest growth rate of population, and finally the third because it's the European country in the fifty years under review with the lowest growth rate of population.

The time series is used to order the variables with respect to the time factor and it's possible to express its dynamics graphically. It's considered the growth rate of Italian population as variable.

Figure 1. Time series Growth rate of Population: Italy (1961-2011).

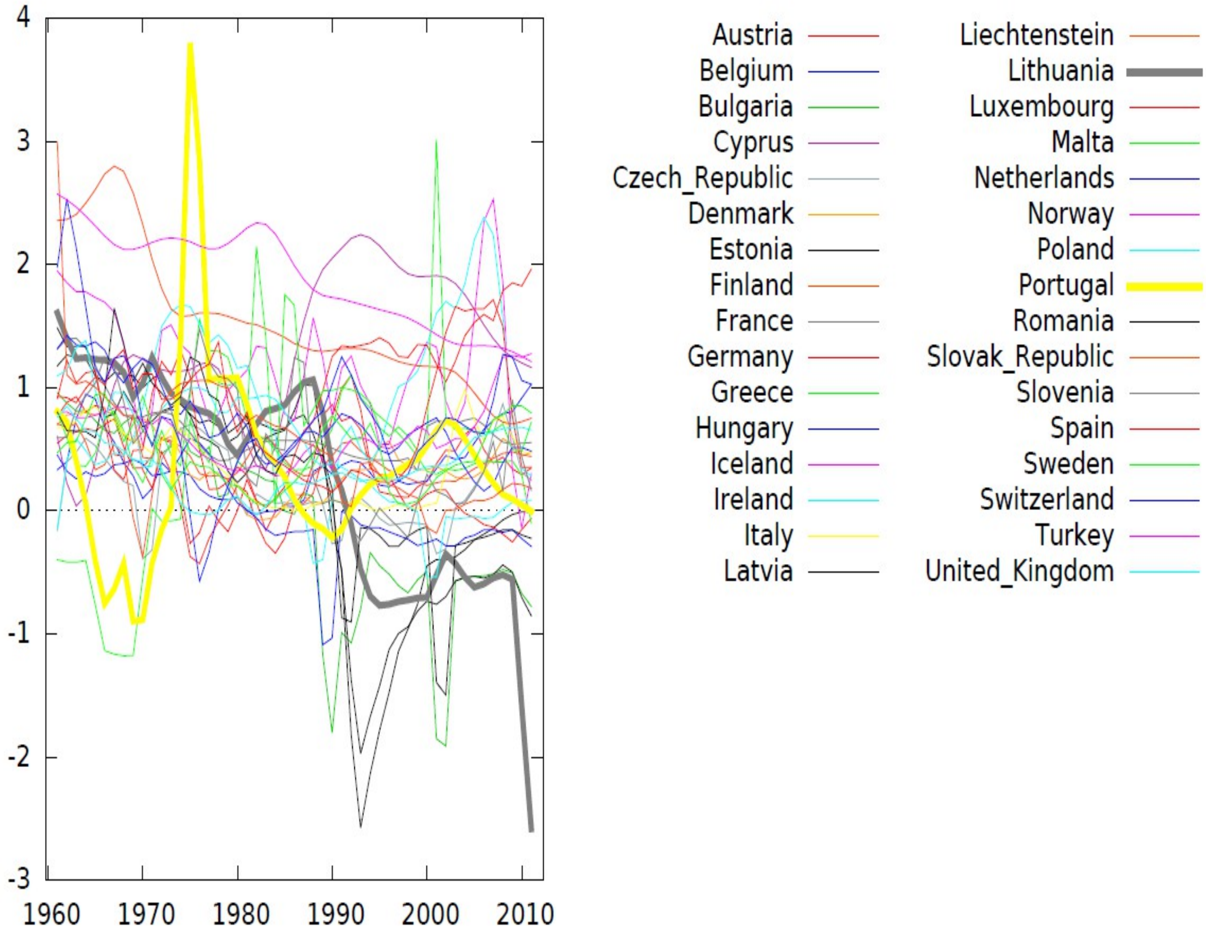


Source: World Bank

The data analysis covers the period from 1961 to 2011 and it has an annual frequency. The initial value is 0.668383 percentage points, while the final value is 0.472755 percentage points: the variation of considered time horizon is given, then, by subtraction between the initial and final value which corresponds, in the case of the growth rate of population is equal to - 0.195628 percentage points. The growth rate of population varies within a range of values starting from the minimum value of 0.0015886 percentage points in 1995, and then arrive at the maximum value of 0.98576 percentage points in 2004. Therefore the width of the variation interval is of 0.9841714 percentage points. The dynamic is monotonically decreasing until 1999, after which there is a continuous and steady growth until 2004.

As a demonstration, we propose a graph (Figure 2) that includes all European countries, highlighting through a thicker line those in which the growth rate of population has been particularly high (Portugal) or particularly low (Lithuania), along the considered span of time, and then we analyse them jointly through a graphical representation (Figure 3).

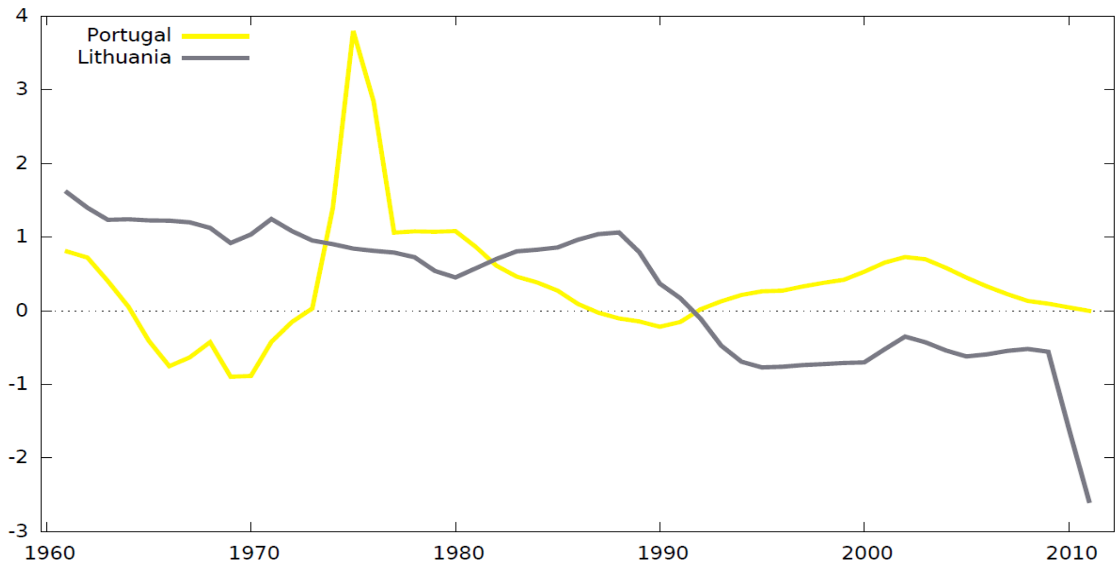
Figure 2. Growth rate of European Population.



Source: World Bank

The empirical analysis allows us to understand the growth rate trend of European population, which is a decreasing trend in most cases.

Figure 3. Time series Growth Rate of Population: Portugal and Lithuania (1961-2011).

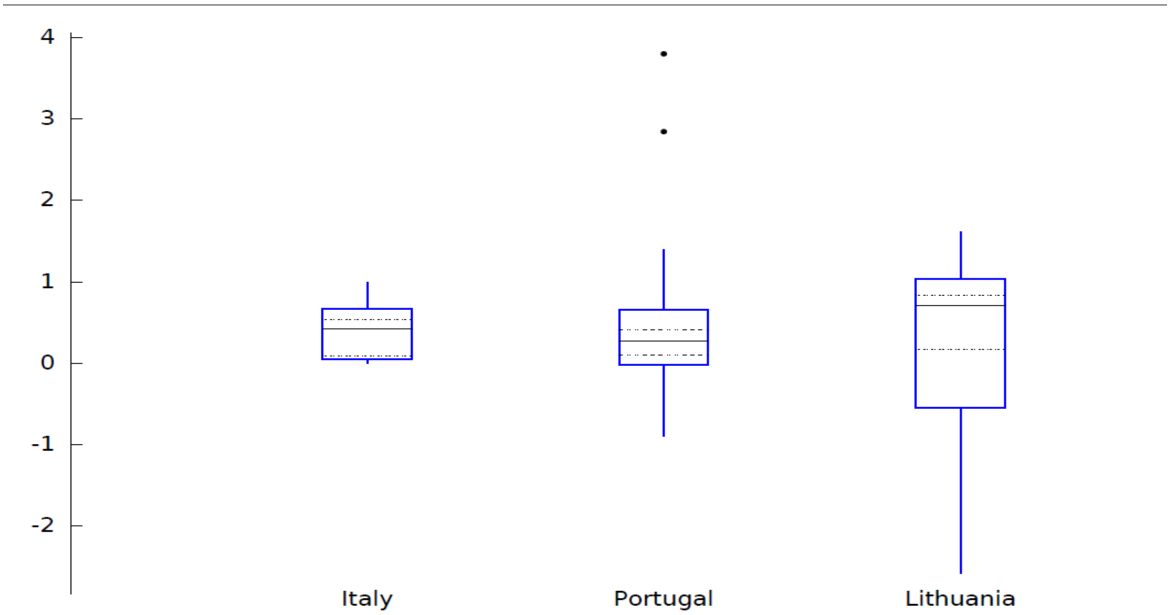


Source: World Bank

Figure 3 shows, through time series, the growth trend of the population simultaneously in Portugal and Lithuania: if in this last State, during the fifty years, the trend is monotonically decreasing, in the first country it places particular emphasis on a fluctuation between the mid-'70s and the '80s.

The measure of central tendency attempts to identify the more central portions of the data: the mean of all European States corresponds to a growth rate of 0.57%, value very close to the median value (the middle number, less sensitive to outliers: 0.54%). Therefore, on average the growth rate of European population is positive, slightly higher than 0, although the trend is decreasing in almost all European countries. The mean of the growth rate of Italian population is 0.37%; the mean of the growth rate of Portuguese population is 0.36%; the mean of the growth rate of Lithuanian population is 0.28%. The construction of box-plots can visually represent some key features of a statistical distribution: the degree of dispersion of data, the symmetry and the presence of outliers. The centre line of the box represents the median of the distribution, the horizontal lines of the box represent the first and third quartiles. The interquartile distance (distance between first and third quartiles) provides a measure of the dispersion of the distribution, while the distance from the median of the quartiles provides information about the shape of the distribution.

Figure 4. Box-plot (Italy, Portugal, Lithuania).



Source: World Bank

The distribution of values (Figure 4) is asymmetric for Italy because the distance of quartiles respect to the median is not equal. There are not present outliers, i.e. values that are extremely high or extremely low compared to the distribution.

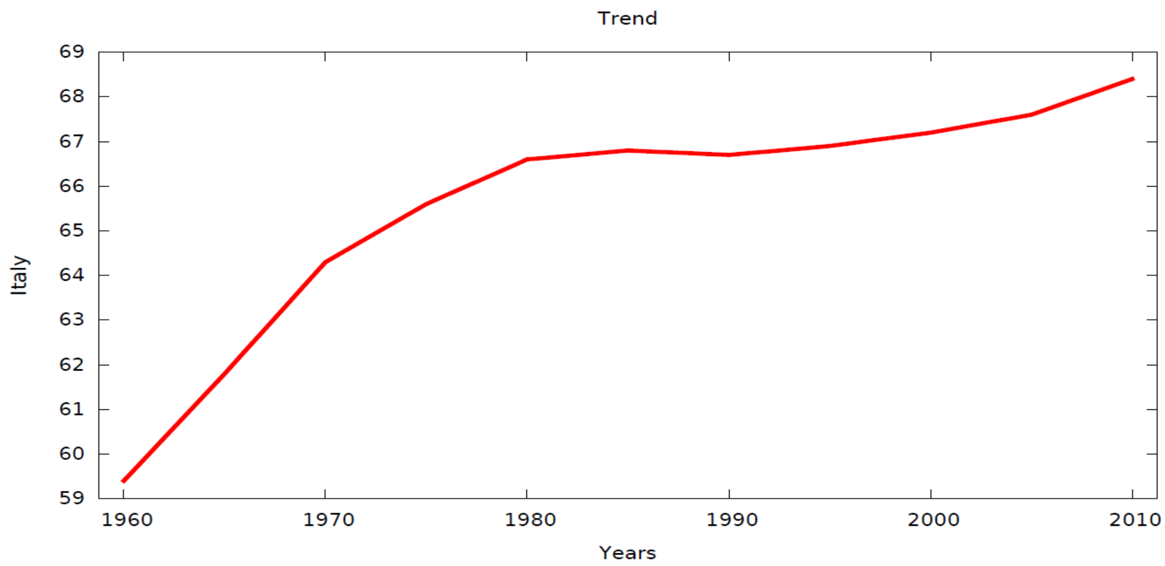
As for Italy, even in the case of the other two countries the distribution of values is asymmetric because the distance of quartiles respect to the median is not equal. In the case of Portugal, the interquartile interval is not very large, then half of the observations is highly concentrated around the median. Moreover, it's found also the presence of out of limit values (outliers). These values constitute a "fault" compared to the most of the observed values and therefore it's necessary to identify them to be able to analyse the characteristics and the possible causes which have determined them. We point out outliers for other European countries: Belgium, France, Greece, Hungary, Liechtenstein, Malta, Norway, Slovakia, Switzerland.

5.2 Urban Population

The urban population refers to people living in urban areas and in this analysis it's calculated as ratio of the total number of individuals living in urban areas, including metropolitan and suburban areas of a country, divided by the total population of that country. We can verify empirically the percentage of urban population of all European countries in the fifty years 1960-2010. The analysed data are extrapolated from the site of the World Bank yet and they are related to the urban population for the following countries: *i)* Austria; *ii)* Belgium; *iii)* Bulgaria; *iv)* Cyprus; *v)* Denmark; *vi)* Estonia; *vii)* Finland; *viii)* France; *ix)* Germany; *x)* Great Britain; *xi)* Greece; *xii)* Ireland; *xiii)* Iceland; *xiv)* Italy; *xv)* Latvia; *xvi)* Liechtenstein; *xvii)* Lithuania; *xviii)* Luxembourg; *xix)* Malta; *xx)* Norway; *xxi)* Netherlands; *xxii)* Poland; *xxiii)* Portugal; *xxiv)* Czech Republic; *xxv)* Romania; *xxvi)* Slovakia; *xxvii)* Slovenia; *xxviii)* Spain; *xxix)* Sweden; *xxx)* Switzerland; *xxxi)* Turkey; *xxxii)* Hungary. Once again the data have been modified in order to obtain a table containing only European states.

By way of an example, the reported analysis concerns only the percentage of urban population of Italy, Belgium and Liechtenstein population: the first for reasons of nationality of the author and curiosity of study, the second because it's the European country in the fifty years under review with the highest percentage of urban population, and finally the third because it's the European country in the fifty years under review with the lowest percentage of urban population. The time series is used to order the variables with respect to the time factor and it's possible to express its dynamics graphically. It's considered the urban Italian population as variable.

Figure 5. Time series Urban Population: Italy (1960-2010).

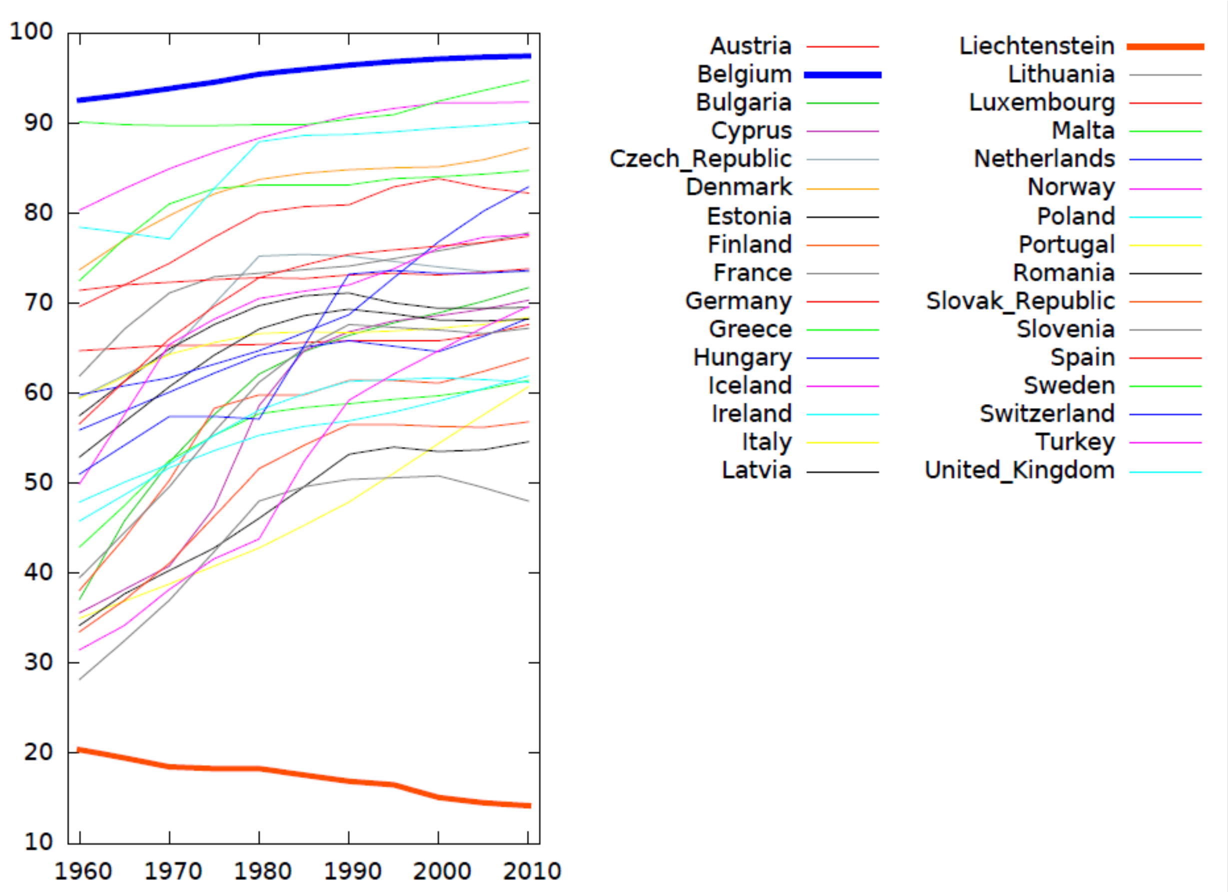


Source: World Bank

The data analysis covers the period from 1960 to 2010 and it has an annual frequency. The initial value is 59.4 percentage points, while the final value is 68.4 percentage points: the variation of considered time horizon is given, then, by subtraction between the initial and final value which corresponds, in the case of urban population is equal to - 9 percentage points. The percentage of urban population varies within a range of values starting from the minimum value of 59.4 percentage points in 1960, and then arrive at the maximum value of 68.4 percentage points in 2010. Therefore the width of the variation interval is of 9 percentage points. The dynamic is monotonically increasing.

As a demonstration, we propose a graph (Figure 6) that includes all European countries, highlighting through a thicker line those in which the percentage of urban population has been particularly high (Belgium) or particularly low (Liechtenstein), along the considered span of time, and then we analyse them jointly through a graphical representation (Figure 7).

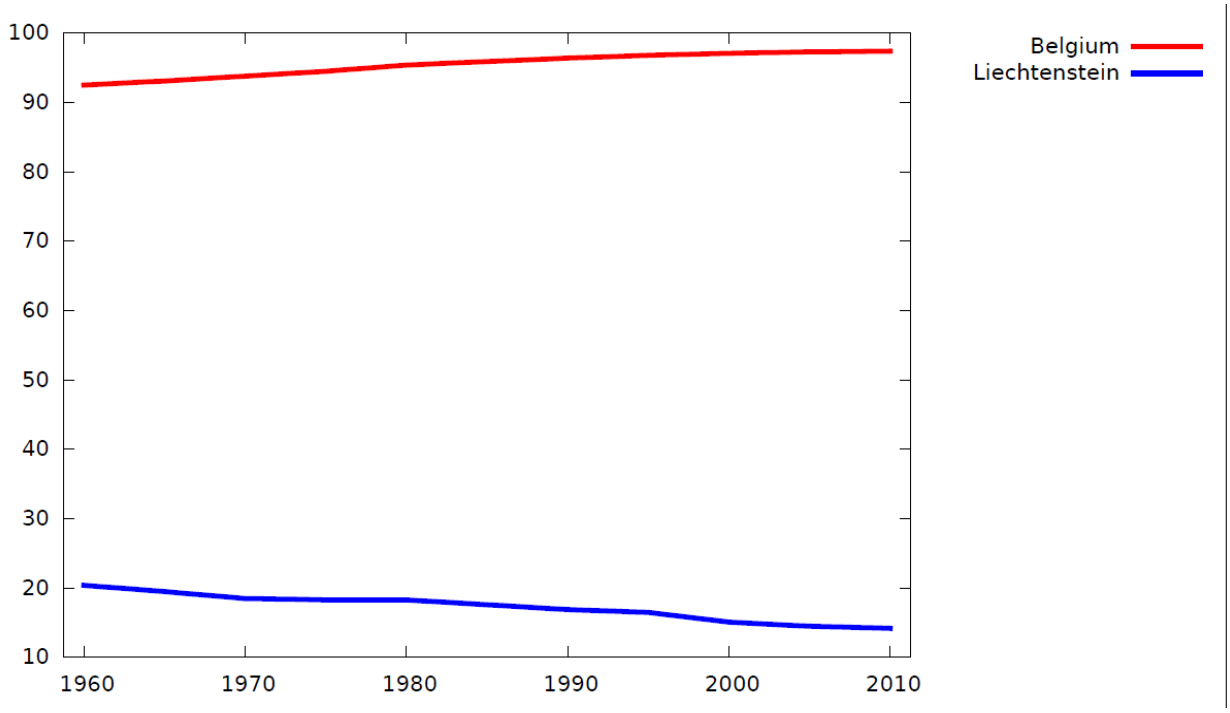
Figure 6. Percentage of Urban Population.



Source: World Bank

The empirical analysis allows us to understand the percentage of urban population of Europe, which is an increasing trend in most cases.

Figure 7. Time series Urban Population: Belgium and Liechtenstein (1960-2010).



Source: World Bank

Figure 7 shows, through time series, the trend of urban population (%) simultaneously in Belgium and Liechtenstein: in both States, during the fifty years, the dynamic tends to be stationary.

The mean of all European States corresponds to a percentage of urban population of 65.11%, value very close to the median value (66.7%). The mean of the urban Italian population is 65.7%; the mean of the urban Belgian population is 95.51%; the mean of the Liechtensteiner population is 17.25%.

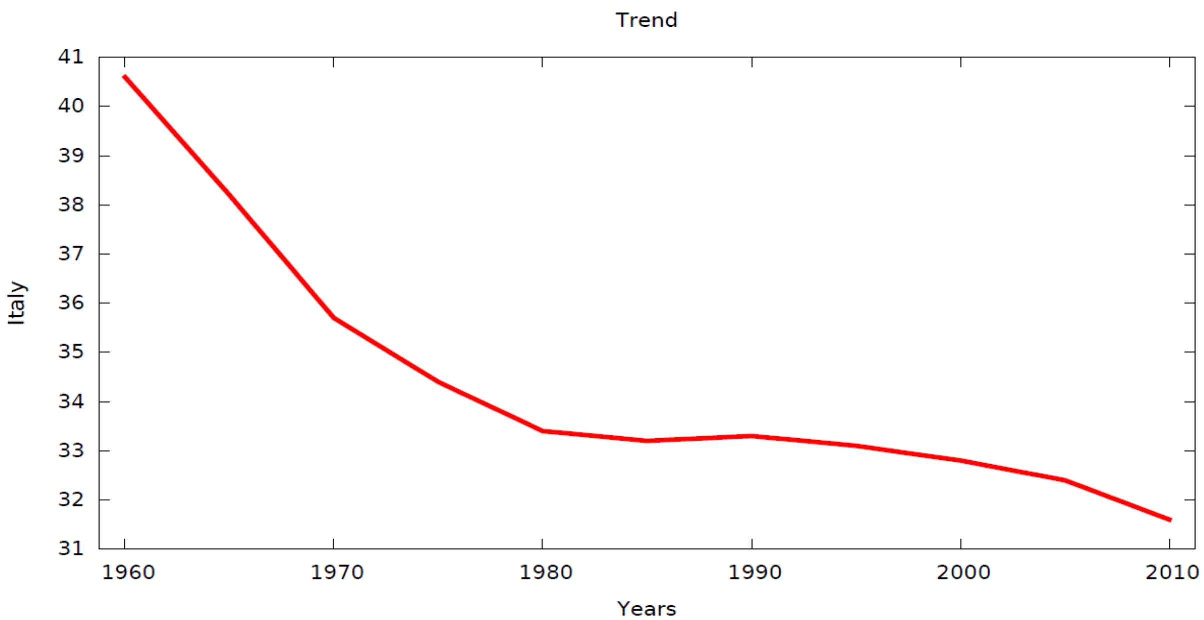
5.3 Rural Population

The rural population refers to people living in rural areas and in this analysis it's calculated as the difference between total population and urban population. The survey is conducted in a perfectly specular way on urban population. We can verify empirically the percentage of rural population of all European countries in the fifty years 1960-2010. The analysed data are extrapolated from the site of the World Bank yet and they are related to the rural population for the following countries: *i)* Austria; *ii)* Belgium; *iii)* Bulgaria; *iv)* Cyprus; *v)* Denmark; *vi)* Estonia; *vii)* Finland; *viii)* France; *ix)* Germany; *x)* Great Britain; *xi)* Greece;

xii) Ireland; *xiii)* Iceland; *xiv)* Italy; *xv)* Latvia; *xvi)* Liechtenstein; *xvii)* Lithuania; *xviii)* Luxembourg; *xix)* Malta; *xx)* Norway; *xxi)* Netherlands; *xxii)* Poland; *xxiii)* Portugal; *xxiv)* Czech Republic; *xxv)* Romania; *xxvi)* Slovakia; *xxvii)* Slovenia; *xxviii)* Spain; *xxix)* Sweden; *xxx)* Switzerland; *xxxi)* Turkey; *xxxii)* Hungary. Once again the data have been modified in order to obtain a table containing only European states.

By way of an example, the reported analysis concerns only the percentage of rural population of Italy, Liechtenstein and Belgium population: the first for reasons of nationality of the author and curiosity of study, the second because it's the European country in the fifty years under review with the highest percentage of rural population, and finally the third because it's the European country in the fifty years under review with the lowest percentage of rural population. The time series is used to order the variables with respect to the time factor and it's possible to express its dynamics graphically. It's considered the rural Italian population as variable.

Figure 8. Time series Rural Population: Italy (1960-2010).

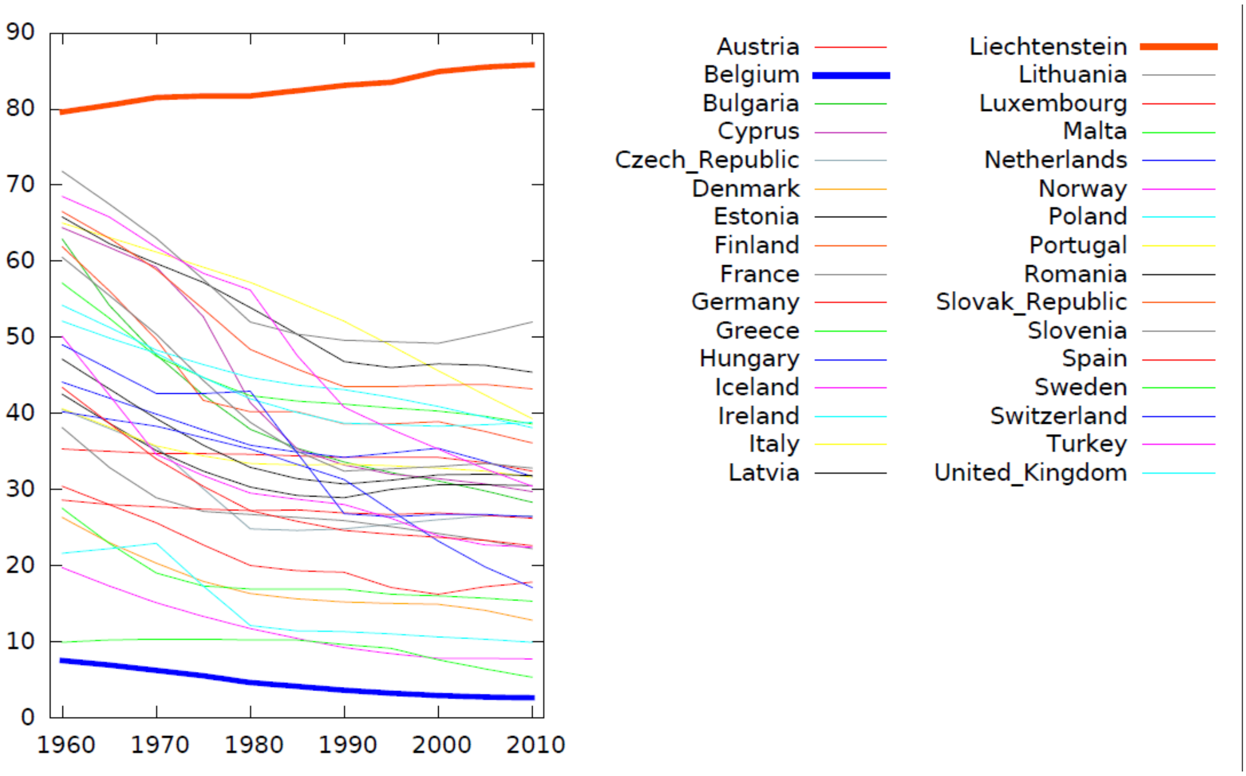


Source: World Bank

The data analysis covers the period from 1960 to 2010 and it has an annual frequency. The initial value is 40.6 percentage points, while the final value is 31.6 percentage points: the variation of considered time horizon is given, then, by subtraction between the initial and final value which corresponds, in the case of rural population is equal to 9 percentage points. The percentage of rural population varies within a range of values starting from the minimum value of 31.6 percentage points in 2010, and then arrive at the maximum value of 40.6 percentage points in 1960. Therefore the width of the variation interval is of 9 percentage points. The dynamic is monotonically decreasing.

As a demonstration, we propose a graph (Figure 9) that includes all European countries, highlighting through a thicker line those in which the percentage of rural population has been particularly high (Liechtenstein, this time in red) or particularly low (Belgium, this time in blue), along the considered span of time, and then we analyse them jointly through a graphical representation (Figure 10).

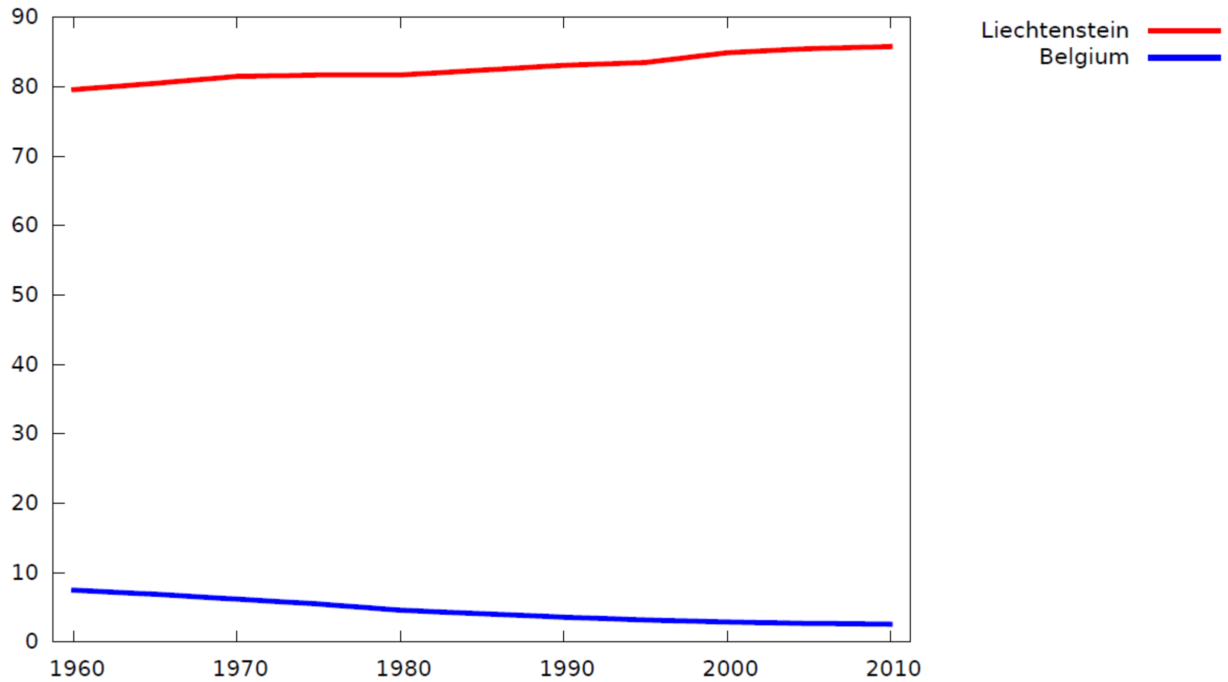
Figure 9. Percentage of Rural Population.



Source: World Bank

The empirical analysis allows us to understand the percentage of rural population of Europe, which is a decreasing trend in most cases.

Figure 10. Time series Rural Population: Liechtenstein and Belgium (1960-2010).



Source: World Bank

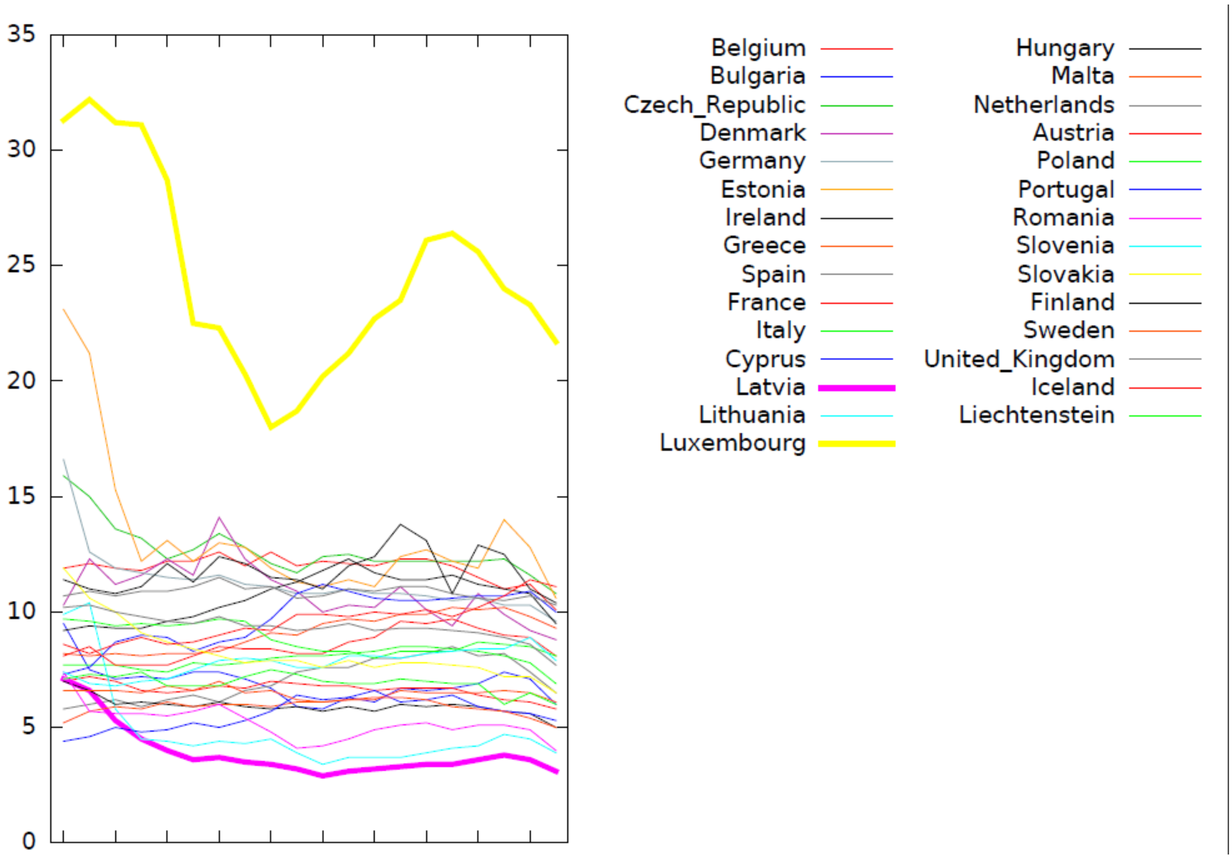
Figure 10 shows, through time series, the trend of rural population (%) simultaneously in Liechtenstein and Belgium: in both States, during the fifty years, the dynamic tends to be stationary.

The mean of all European States corresponds to a percentage of rural population of 34.89%, value very close to the median value (33.93%). The mean of the rural Italian population is 34.3%; the mean of the urban Belgian population is 4.49%; the mean of the Liechtensteiner population is 82.75%.

5.4 CO_2 Emissions

The problems of urban development are closely connected to its impact on the environment. To get an idea of CO_2 emissions per inhabitant in the EU, we show a graph (Figure 11).

Figure 11. CO_2 Emissions per Inhabitant in the EU (1990-2009).



Source: European Environmental Agency (EEA)

The indicator compares the level of CO_2 emissions per inhabitant in the EU with levels in developing countries, in tonnes per inhabitant. We can see a CO_2 quantitative particularly high in Luxembourg.

$$g_t = \frac{\Delta x_t}{x_{t-1}} = \frac{x_t - x_{t-1}}{x_{t-1}} = \frac{x_t}{x_{t-1}} - 1$$

This ratio shows the growth rate of CO_2 emissions in the European Union and the analyses suggests the rate tends to negative (or slightly positive) in all countries under review.

The sectoral approach contains total CO_2 emissions (in million tonnes of CO_2) from fuel combustion and it includes emissions only when the fuel is actually combusted, and other considerable sectors.

Table 4. CO_2 Emissions from different sectors in the UE (2008).

Region/ Country/ Economy	Total CO_2 emissions from fuel combustion	Electricity and heat production	Other energy industries	Manufacturing industries and construction	Transport	of which: road	Other sectors	of which: residential
Austria	69,32	15,2	8,43	12,57	22,09	20,81	11,02	7,38
Belgium	110,96	22,97	5,26	27,44	27,09	26,56	28,2	18,6
Czech Republic	116,83	63,71	2,8	20,72	17,83	16,92	11,79	6,74
Denmark	48,41	21,77	2,47	4,83	13,7	12,76	5,63	2,92
Finland	56,58	24,32	2,7	12,16	12,7	11,52	4,72	1,89
France	368,23	50,79	18,86	70,53	124,7	118,67	103,35	58,54
Germany	**803,86**	337,27	26,01	118,14	148,36	139,86	174,08	121,43
Greece	93,39	46,38	3,49	9,19	22,06	18,96	12,28	8,33
Hungary	53,01	18,4	1,53	7,01	12,85	12,56	13,22	8,61
Iceland	**2,2**	0,02	0	0,69	0,91	0,83	0,59	0,01
Ireland	43,75	14,27	0,48	5,04	13,4	13,02	10,56	7,05
Italy	430,1	146,89	17,63	67,98	117,01	109,65	80,59	48,88
Luxemb.	10,4	1,06	0	1,48	6,44	6,4	1,42	1,34
Netherl.	177,86	57,15	10,85	37,78	34,96	33,84	37,12	16,82
Norway	37,61	0,76	11,8	8,01	14,04	10,43	3,01	0,5
Poland	298,69	158,41	8,38	37,73	44,16	42,67	50,01	31,29
Portugal	52,44	18,85	2,07	8,42	18,71	18,15	4,4	1,98
Slovak Republic	36,23	8,65	4,74	9,31	7,05	5,77	6,48	3,07
Spain	317,63	101,39	18,26	55,14	109,07	95,23	33,76	19,44
Sweden	45,87	7,96	2,52	9,64	23,26	22,02	2,49	0,42
Switzerl.	43,7	1,97	1,09	6,51	17,25	16,97	16,89	10,8
Turkey	263,53	104,12	8,42	38,51	45,1	39,52	67,37	39,61
United Kingdom	510,63	194,87	32,49	58,78	124,8	114,93	99,7	76,46

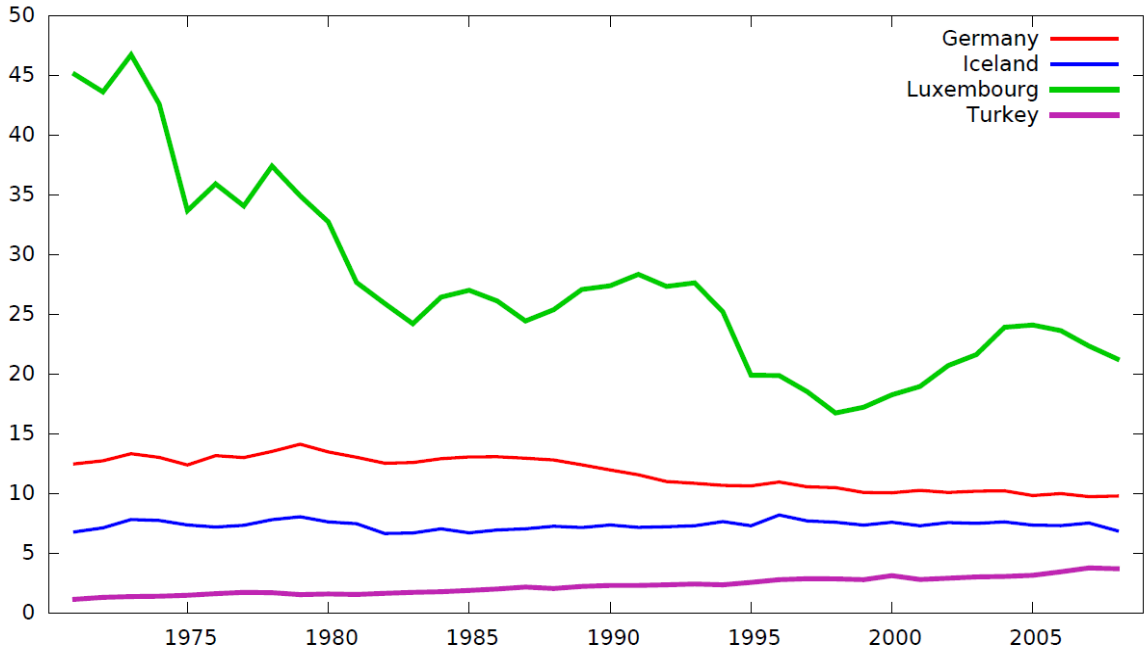
Source: International Energy Agency (IEA)

Table 4 shows a leading CO_2 emission from fuel combustion in each European country compared to other sectors in 2008. It's particularly high in Germany and the lowest CO_2 emission is in Iceland. In each European country, how does the situation change if we study the emission of carbon dioxide per capita? It's interesting to note that Germany is not the European country with the highest CO_2 emissions per capita and Iceland is not the European country with the fewest CO_2 emissions per capita, but they are, respectively, Luxembourg and Turkey.

$$\frac{Carbon\,Dioxide}{Population}$$

This ratio is expressed in tonnes of CO_2 per capita and it's calculated from 1971 to 2008.

Figure 12. CO_2 per capita in Germany, Iceland, Luxembourg, Turkey (1971-2008).



Source: European Energy Agency (EEA)

Then, we can examine CO_2 emissions per capita through a sectoral approach.

Table 5. CO_2 Emissions per capita from different sectors in the UE (2008).

Region/ Country/ Economy	Total CO_2 emissions from fuel combustion	Electricity and heat production	Other energy industries	Manufacturing industries and construction	Transport	of which: road	Other sectors	of which: residential
Austria	8315	1823	1012	1508	2649	2496	1322	886
Belgium	10362	2146	491	2563	2530	2480	2634	1737
Czech Republic	11202	**6108**	268	1986	1709	1622	1130	646
Denmark	8815	3965	450	880	2494	2324	1026	532
Finland	10650	4577	507	2289	2390	2168	888	356
France	5743	792	294	1100	1945	1851	1612	913
Germany	9789	4107	317	1439	1807	1703	2120	1479
Greece	8311	4127	310	818	1963	1688	1093	741
Hungary	5281	1833	152	699	1280	1252	1317	858
Iceland	6888	**46**	-	2148	2844	2604	1850	**29**
Ireland	9847	3212	**108**	1134	3016	2931	2377	1587
Italy	7182	2453	294	1135	1954	1831	1346	816
Luxemb.	**21269**	2177	-	**3023**	**13166**	**13089**	**2903**	**2750**
Netherl.	10819	3476	660	2298	2126	2059	2258	1023
Norway	7888	160	**2476**	1677	2944	2187	630	105
Poland	7836	4156	220	990	1159	1119	1312	821
Portugal	4937	1775	194	792	1761	1709	415	187
Slovak Republic	6702	1599	876	1722	1305	1068	1199	567
Spain	6967	2224	401	1209	2392	2089	741	426
Sweden	4956	860	273	1042	2513	2379	**269**	45
Switzerl.	5668	256	141	844	2237	2201	2190	1401
Turkey	**3707**	1465	118	**542**	**634**	**556**	948	557
United Kingdom	8323	3176	530	958	2034	1873	1625	1246

Source: International Energy Agency (IEA)

Thanks to the investigation, we can see in Luxembourg the highest total CO_2 emissions from fuel combustion, from manufacturing industries and construction, from transport, from road and from residential; in Norway the highest CO_2 emissions from other energy industries; and in Czech Republic the highest CO_2 emissions from electricity and heat production (all coloured in red in Table 5). On the other hand, we can highlight the lowest total CO_2

emissions from fuel combustion, from manufacturing industries and construction, from transport and from road in Turkey; the lowest CO_2 emissions from electricity and heat production and from residential in Iceland; the lowest CO_2 emissions from other energy industries in Ireland; and the lowest CO_2 emissions from other sector in Sweden (all coloured in blue in Table 5).

Following the analysis of the growth rate of carbon dioxide emissions from 1971 to 2008 (International Energy Agency), it has emerged a significantly negative rate in 2008, in all European countries.

6 Results and Conclusions

The current human consumption of agricultural products, wood fibre and fossil fuels causes a by nearly 30% excess of EF compared to the amount of ecologically productive land. Sustainability requires that human activities remain within the carrying capacity, but there are not concrete strategies for sustainability. The average global biocapacity is 1.78 global hectares per capita, but the data show that we are consuming resources faster than we could. Nowadays humanity uses the equivalent of about a planet and a half, that is, our planet needs a year and six months to regenerate what we use all in one year! Most human settlements are located in the most fertile areas in the world, therefore built-up land often lead to the irrevocable loss of those that were previously agricultural areas. For this reason, it's interesting to see how fast the population is growing and what percentage is spilled into the city rather than in the countryside. In all European countries, although not occur a high growth rate of population (positive, but slightly higher at 0.5%), the percentage of urban population is growing and this trend is affecting the environment and particularly the CO_2 emissions. Only in Belgium, France, Greece, Hungary, Liechtenstein, Malta, Norway, Portugal, Slovakia, Switzerland there is the outliers presence about the growth rate of European population in some years. In Italy, the dynamic is monotonically decreasing until 1999, then it's in a continuous and steady growth; on the other hand, in Portugal the trend presents some fluctuations along the time span considered. Belgium is the European country with the highest percentage of urban population, while Liechtenstein is the European country with the highest percentage of rural population. The highest CO_2 emissions from fuel combustion are in Germany; instead the lowest are in Iceland. There is a different situation if we study the CO_2 emissions per capita: this time, the highest are in Luxembourg, the lowest in Turkey. Nevertheless, the analysis carried out shows that CO_2 emissions per capita and CO_2 emissions for each sector are down in all European countries in a particular year: 2008.

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Methane emissions and rice production: evidence from a large set of countries

Methane emissions and rice production: evidence from a large set of countries

Abstract

This paper studies the relationship between rice production and methane emissions. Rice farming is believed to be a major anthropogenic source of methane emissions, which are measured emissions at both country and world levels of aggregation. at both country and world levels of aggregation. It presents a quantitative estimation of the statistical relationship between rice production dynamics and methane emissions with regression estimates computed (country-wise and globally) over a large set of countries. The evidence only partly validates the expectation of a positive statistical influence of rice production on methane emissions. In fact a Kuznets-type evidence shows up: increasing rice production is correlated with fewer emissions. This negative relationship holds for a measure of countries sufficient to emerge significantly also at the world level.

Keywords: methane emissions; rice production; regression analysis; agriculture.

1 Introduction

Methane is an important greenhouse gas, with a global warming potential (GWP) 23 times higher than carbon dioxide over a period of 100 years. We must reduce the amount of methane emissions to stabilize the concentration of atmospheric methane. The irrigated rice is one of the few major sources of methane that is manageable and is, accordingly, a nodal fulcrum for mitigation efforts of methane emissions (Sass and Fisher, 1997). Methane emissions from rice fields are governed by a complex set of biogeochemical characteristics of irrigated land and are affected by the management of the agricultural practices (Neue *et al.*, 1990; Yagi *et al.*, 1996; Neue, 1997; Wassmann *et al.*, 2000b). Furthermore, the addition of vegetable residues/straw in restricted soils, it increases methane emissions (Yagi and Minami, 1990; Cicerone *et al.*, 1992; Liou *et al.*, 2003). Using experimental data collected from different areas of the world, Denier van der Gon and Neue (1995) have developed a relationship between methane emissions and added organic matters. Rice farming is a major anthropogenic source of methane emissions. Methane accounts for 95 per cent of total greenhouse gases (GHGs) emissions from rice paddies (Naser *et al.*, 2005). Rice can be farmed over a wide set of ecosystems. The intensity of methane emissions from rice fields changes across ecosystems (Neue and Sass, 1998). The intensity is highest in flooded and irrigated fields, while almost null in upland rice. The emission process has been thoroughly characterized in its metabolic and quantitative aspects by a multitude of studies that aim to estimate global emission flows from the distribution of farming across ecosystems (Cicerone *et al.*, 1992; Neue and Sass, 1994; Wassmann *et al.*, 2000b; Jacobson, 2005). Still, aggregate analyses of the relationship between rice production dynamics and directly measured methane emissions at both country and world levels of aggregation is lacking. Most of the scientific studies has focused on the differences of methane emissions from rice production in small and limited field sites (Schtz *et al.*, 1989; Yagi and Minami, 1990; Sass and Fisher, 1995; Wassmann *et al.*, 2000a). In fact, only few studies have addressed the problem of increasing analysis at regional or national levels (Wang, 1995; Siriratpiriya, 1994).

The aim of the present study is a first step towards filling such gap by undertaking a quantitative estimation of the statistical relationship between rice production dynamics and methane emissions. In particular, regression estimates are computed (country-wise and globally) over a large set of countries.

The results partly confirm the expectation of a positive statistical influence of rice production on methane emissions. Unexpectedly though, most of the evidence reveals a diffused negative relationship with increasing rice production correlated with fewer emissions that overcompensates the positive one at the world level, where externalities are absent. Such evidence is statistically significant and suggests that rice farming practices may have undergone improvements (mostly in the South Asian region) with time that enhanced productivity by way of more efficient plant metabolism (with less methane as a waste product of plant metabolism). The study of the exact nature of such improvements is beyond the scope of the present paper and is left for future research.

The paper is organized as follows. Section 2 describes the process of data collection and methodology adopted to process data so as to substitute for non available entries and tune frequencies for both types of time series. Section 3 discusses the evidence resulting from regression analysis with a summary of results and Conclusions end the paper.

2 Data collection and methodology

This Section accomplishes a regression analysis between rice milled production and methane emissions.

Data on methane emissions are collected from the site of the International Energy Agency (IEA) (http://www.iea.org/stats/index.asp). IEA provides a series of irregular weighted averages. The weighted average is expressed as a percentage of the total emissions (total methane emissions over the aggregate of GHGs emissions). The agency claims that original (not available) data are direct measurements (instead of estimates) of methane emissions with yearly frequency from 1961 to 2014 for a set of 258 countries. In fact, data available are averages associated with the irregular sequence of years 1990, 2000, 2005, 2008 and 2010. Upon skimming countries with insufficient data out of set, a subset of 166 countries (the aggregate World included) is left. In order to match the yearly regular frequency of data on rice production, intermediate observations are linearly approximated between consecutive available data pairs (used as extremes of a segment). This method is a natural way of constructing a regular time series at the cost of enhancing autocorrelation in the time series.

Data on rice production are elaborations of FAO data collected from the site of the United States Department of Agriculture
(https://apps.fas.usda.gov/psdonline/psdQuery.aspx). They are expressed in thousands of metric tons (1000 MT) and are a regular time series with yearly frequency from 1961 to 2014 for a set of 115 countries (the aggregate World included).

Regression analysis was performed for countries in the subset resulting from the intersection of the sets of countries for which data on both methane emissions and rice production are available. The set of years over which regression analysis is applied is the restricted time interval where methane emissions data are available. Calculations and graphs were carried out using the R software for Statistical Computing. A regression line is drawn for each country in the set, with intercept and angular coefficient estimated by the least squares method. Hence, the regression line is the linear interpolation of the scatterplot of methane emissions vs. rice production time series, for each country. The regression line is also interpreted as depicting the statistical conditioning of rice production (as independent variable) on methane emissions (dependent variable).

3 Results

The results partly confirm the expectation of a positive statistical influence of rice production on methane emissions. Unexpectedly though, most of the evidence reveals a diffused negative relationship with increasing rice production correlated with fewer emissions that overcompensates the positive one at the world level, where externalities are absent. The following table provides a summary of the qualitative relationship between rice production and methane emissions by grouping countries accordingly. The detailed results and time series are in the appendix.

COUNTRY SIGN+	COUNTRY SIGN-
Australia	Bangladesh
Benin	Bolivia
Bulgaria	Dominican Republic
Brunei Darussalam	Egypt, Arab Rep.
Congo, Rep.	Indonesia
Colombia	India
European Union	Japan
Hungary	Mozambique
Kazakhstan	Malaysia
Cambodia	Nicaragua
Mexico	Nepal
Myanmar	Pakistan
North America	Peru
Nigeria	Philippines
Romania	Korea, Dem. Rep.
Sudan	South Asia
El Salvador	Senegal
Tajikistan	Togo
Turkmenistan	Thailand
Trinidad and Tobago	Turkey
United States	Tanzania
Uzbekistan	Vietnam
	World
	Zambia

Even if China is the country with the highest rice production in the world, its regression analysis shows the lack of relationship between methane emissions and rice production. This is an anomaly compared to other major rice-producing countries. We look at the cases of India and Indonesia, respectively second and third in the ranking of rice producers. For both a significant relationship holds, although it's negative: rice production increases decrease methane emissions. The difference is in the order of magnitude: the Indian regression analysis gives a coefficient equal to -0.3026, while in the Indonesian case it is -1.8355 (about six times the Indian coefficient). The negative relationship between methane emissions and rice production is evident in the South Asian region too, where we have a coefficient of -0.1958. Analysing other world regions, we can see examples of significant positive relationship with rice production increases associated to higher methane emissions. European Union regression analysis shows a significant and positive relationship between methane emissions and rice production. The angular coefficient is 0.6080. However, for different years, we have an increasing methane emissions percentage, while milled rice production is always less than 1000 MT. In the graph, this value that is less than 1000 MT corresponds to 0. This is also evident in the graph of other countries, such as Bulgaria, Colombia, Romania. Also in North America the regression analysis is significant and positive, with a coefficient of 2.6135. Nevertheless, the aggregate World regression analysis is significant and negative: at global level, counter-intuitively, when milled rice production increases, methane emissions percentage decreases. Finally, there are abnormal results of the regression analysis in those countries where we have an identical quantity of milled rice over time (for example Algeria) or that varies a very limited number of times (for example Brunei Darussalam).

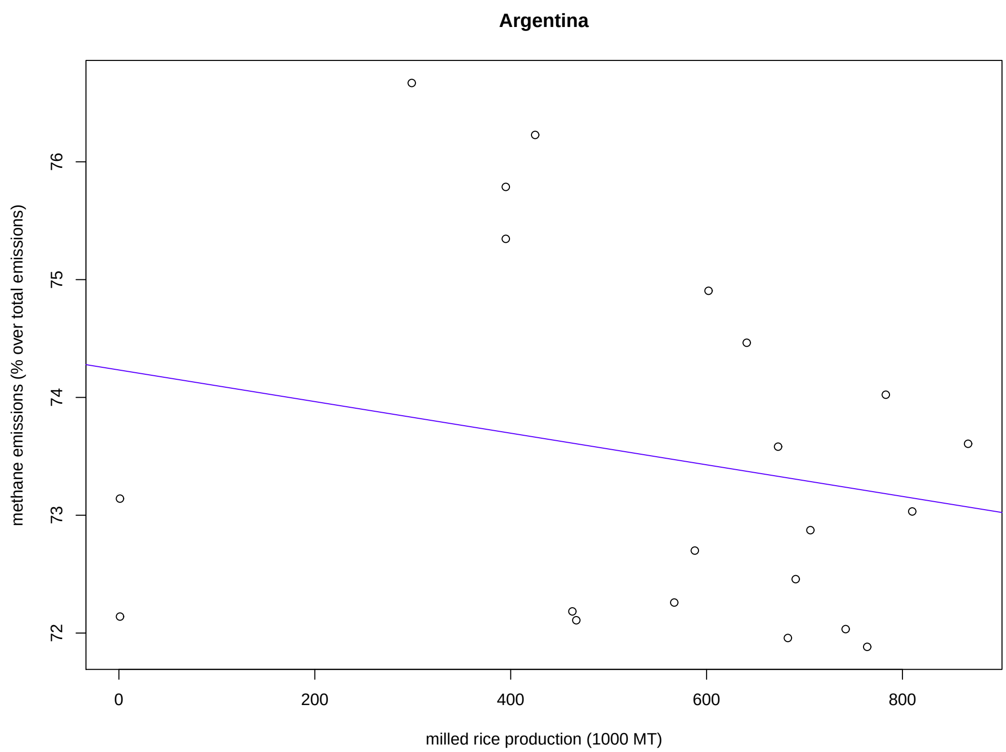
The statistical significance of the results suggests that rice farming practices may have undergone improvements (mostly in the South Asian region) enhancing productivity by way of more efficient plant metabolism (with less methane as a waste product of plant metabolism). The study of the exact nature of such improvements is beyond the scope of the present paper and is left for future research.

4 Conclusions

This paper studies the relationship between rice production dynamics and directly measured emissions at both country and world levels of aggregation. It presents a quantitative estimation of the statistical relationship between rice production dynamics and methane emissions with regression estimates computed (pointwise and universally) over a large set of countries. The results partly confirm the expectation of a positive statistical influence of rice production on methane emissions. Still, most of the evidence shows how increasing rice production is correlated with fewer emissions. This negative relationship holds for a measure of countries sufficient to emerge significantly also at the world level, where externalities are absent. We can suppose two interpretations to understand this negative relationship: *i)* technological innovation interference reduces the coefficient of methane emissions from rice production; *ii)* rice production growth goes to the detriment of other sources of agricultural methane emissions (animals, animal waste, agricultural waste burning and savannah burning). This would be an important additional motivation (beyond the health issues) to push for a change of diet, then to try, through information campaigns, to work on the demand side which may affect the processes of agricultural production. In this paper we don't analyse these aspects, but it's a first step in that direction with a quantitative analysis that goes beyond most of the scientific studies and a starting point for future researches.

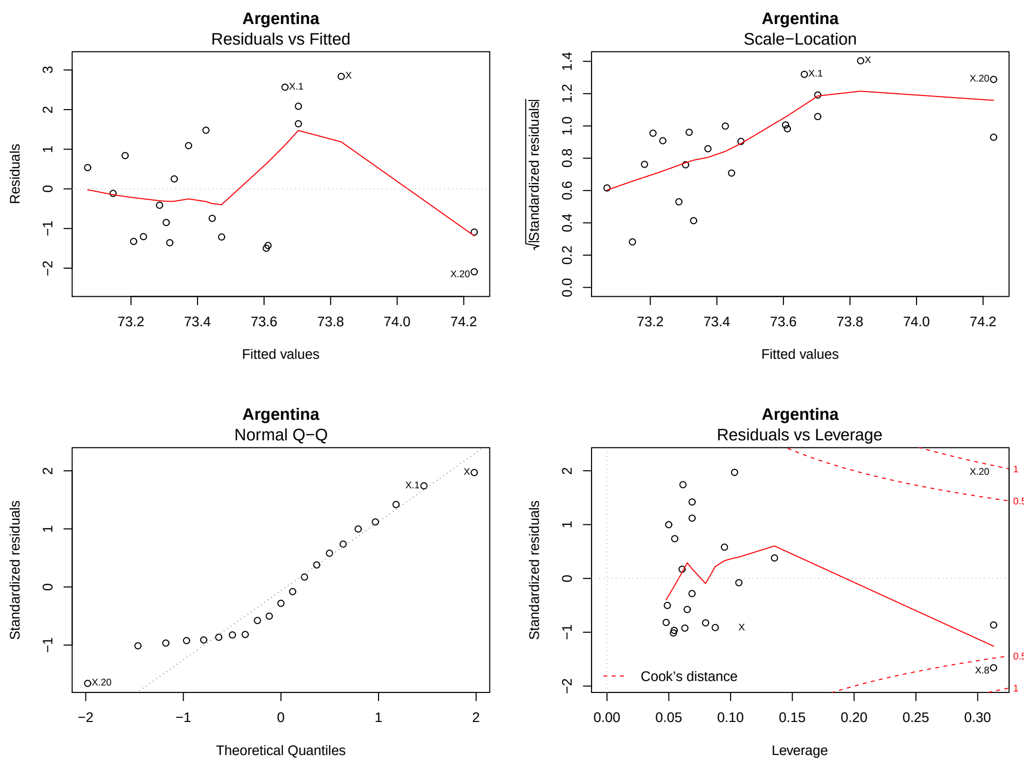
A Appendix, Regression analysis across countries

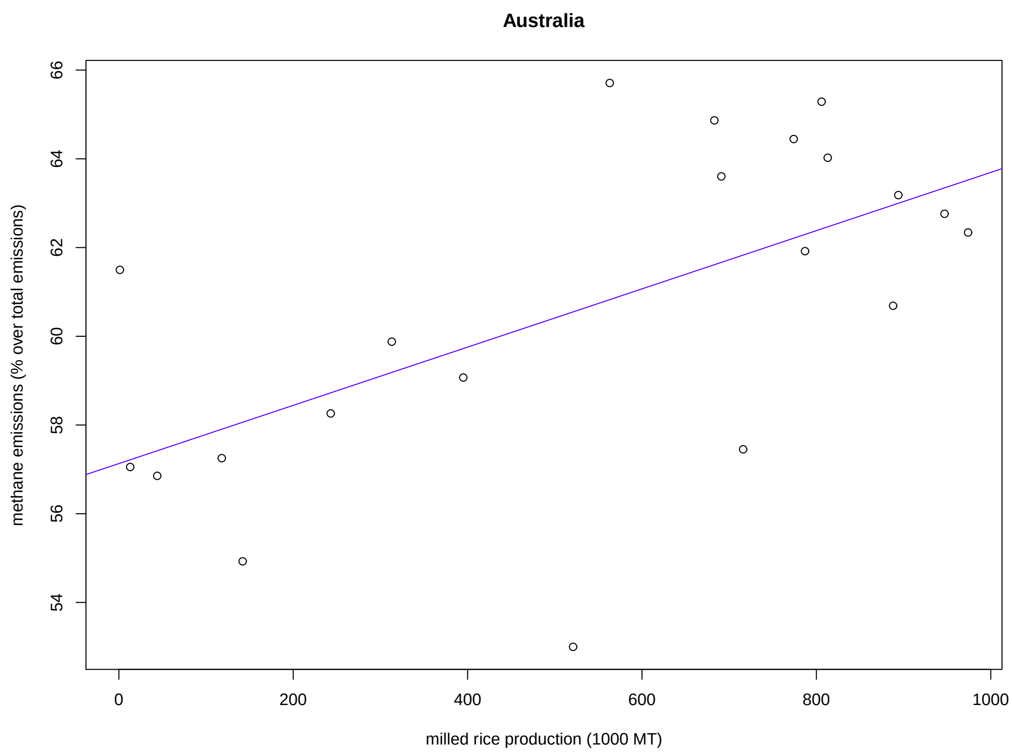
The following is a regression analysis between rice milled production and methane emissions, country by country, over the set of countries for which both time series are available. The set of countries is thus a subset of the set of countries with methane amissions data. The set of years over which regression analysis is applied is the restricted time interval where methane emissions data are available, upon linear approximation that tunes methane emissions data in the same (yearly) frequency of rice production data.



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	74.2331	0.8521	87.12	0.0000
h[, j]	-0.0013	0.0014	-0.94	0.3583

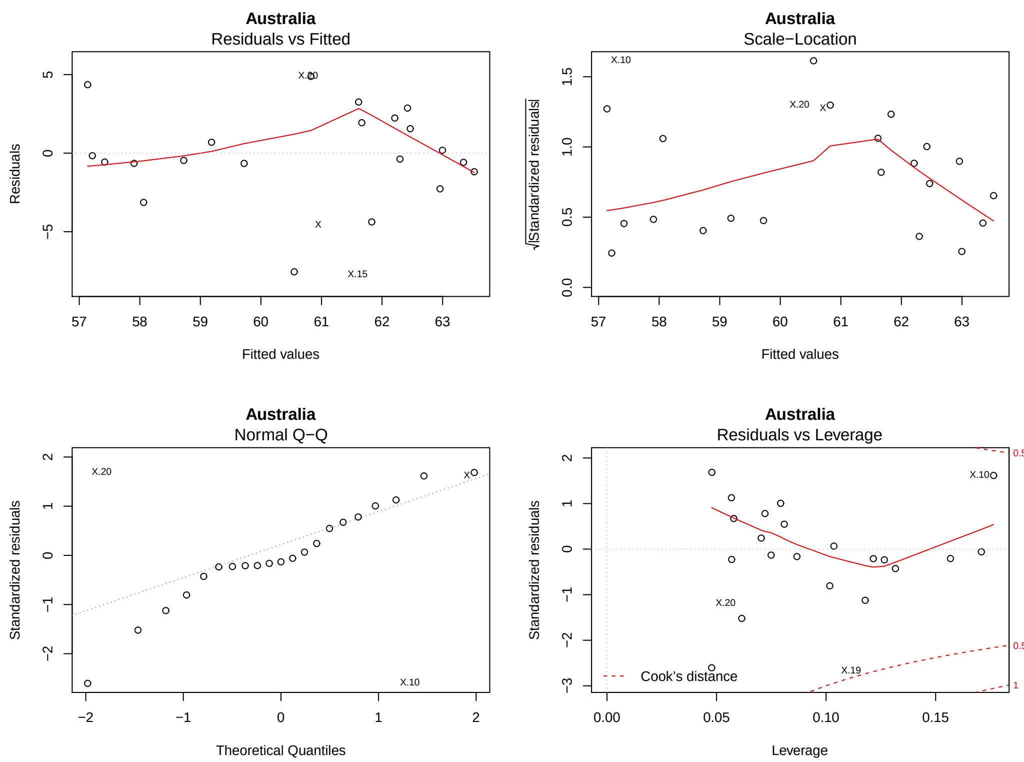
Table 1: Regression results

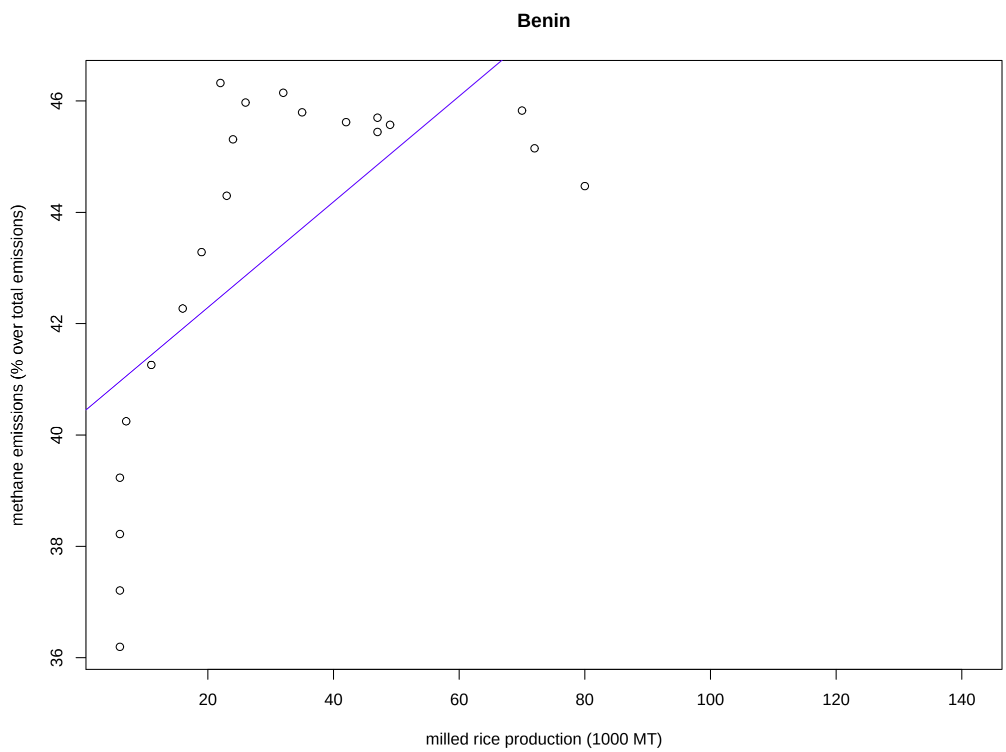

Argentina
Residuals vs Fitted
Fitted values
Residuals
Argentina
Scale−Location
Fitted values
√|Standardized residuals|
Argentina
Normal Q−Q
Theoretical Quantiles
Standardized residuals
Argentina
Residuals vs Leverage
Leverage
Standardized residuals
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	57.1305	1.2504	45.69	0.0000
h[, j]	0.0066	0.0020	3.31	0.0037

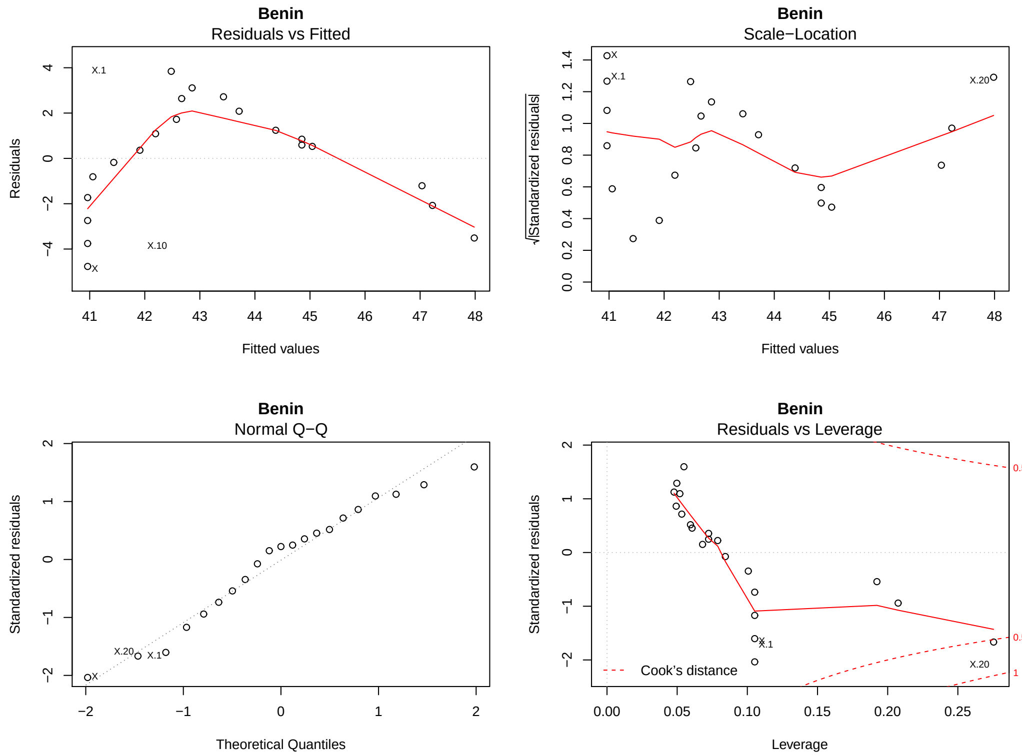
Table 2: Regression results

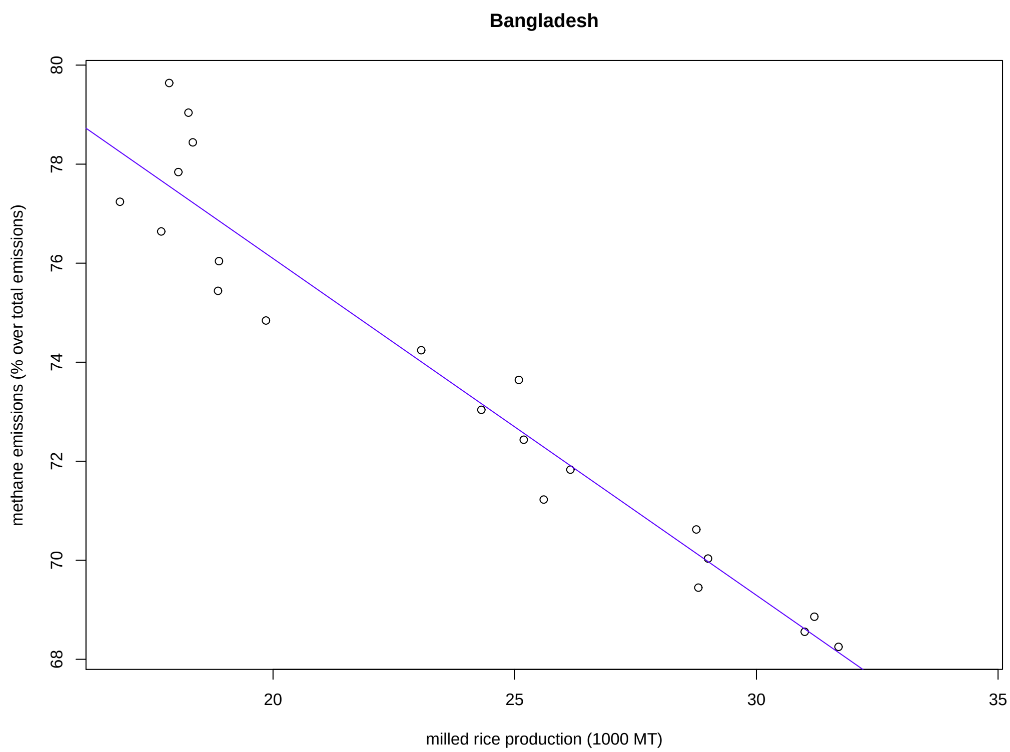

Australia
Residuals vs Fitted
Residuals
Fitted values
X.15
Australia
Scale−Location
√|Standardized residuals|
Fitted values
X.10
X.20
Australia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20
X.10
Australia
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.10
X.20
X.19
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	40.3932	0.9148	44.16	0.0000
h[, j]	0.0949	0.0240	3.95	0.0009

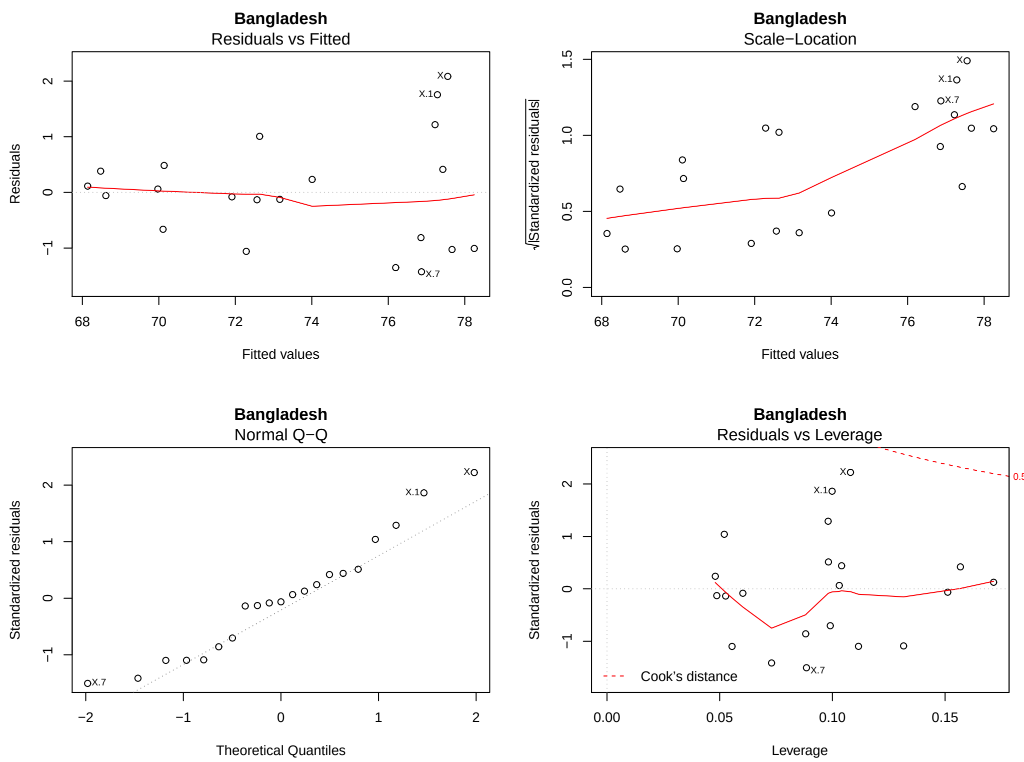
Table 3: Regression results

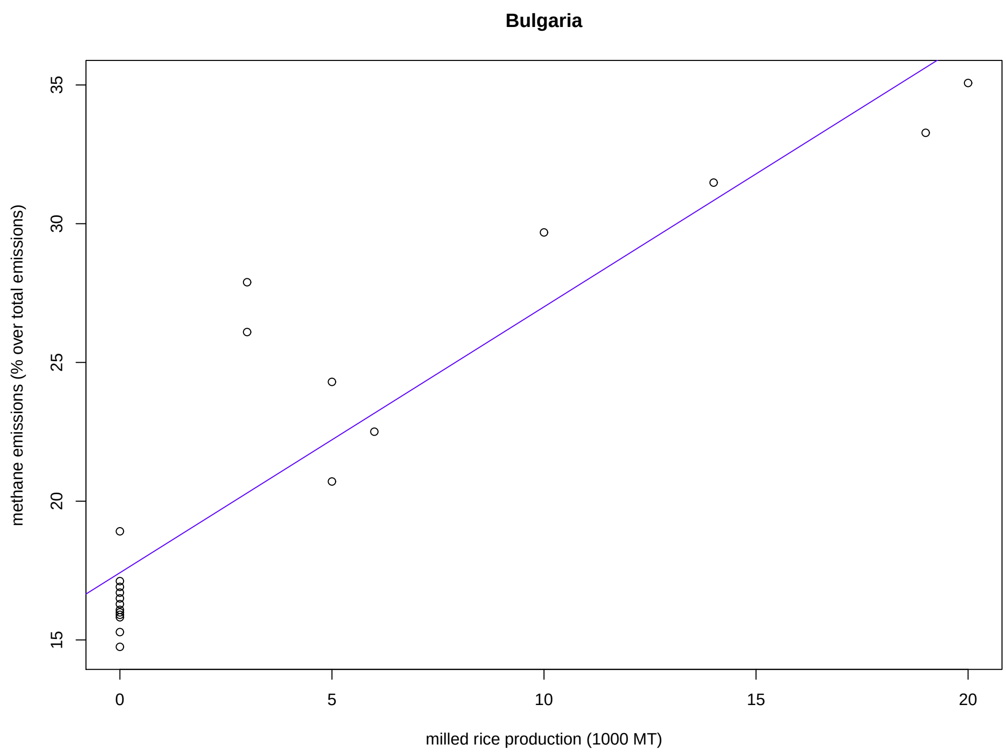

Benin
Residuals vs Fitted
Residuals
Fitted values
X.1
X.10
X
Benin
Scale−Location
√|Standardized residuals|
Fitted values
X
X.1
X.20
Benin
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20
X.1
X
Benin
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.1
X.20
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	89.6955	1.0324	86.88	0.0000
h[, j]	-0.6800	0.0429	-15.86	0.0000

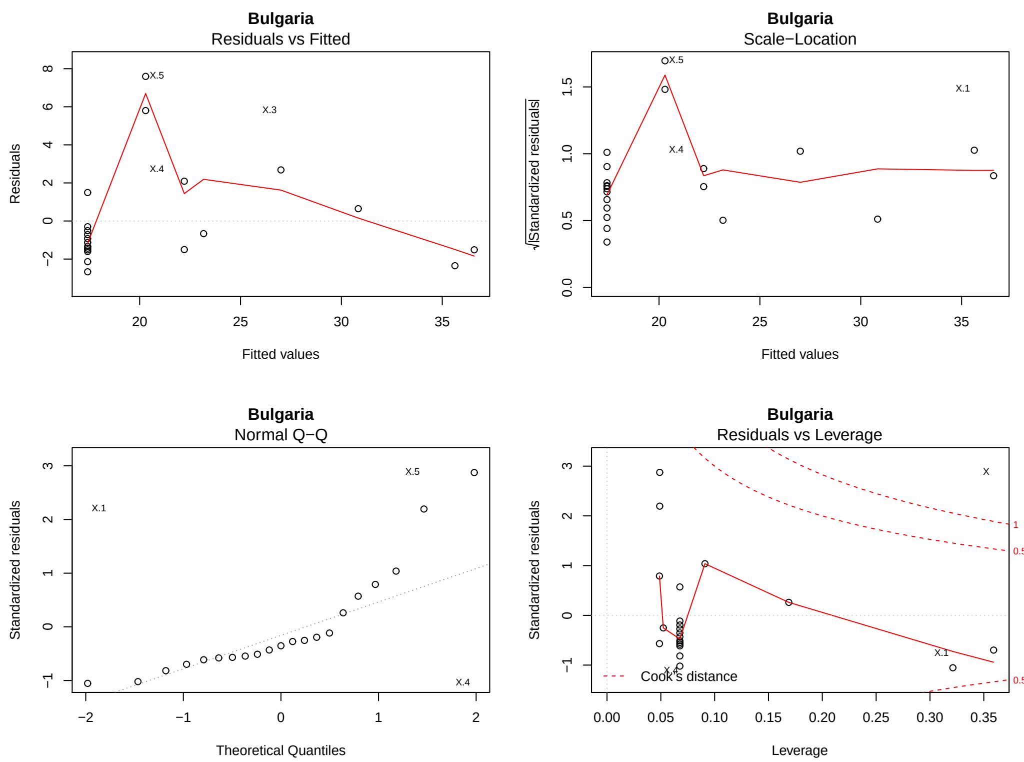
Table 4: Regression results

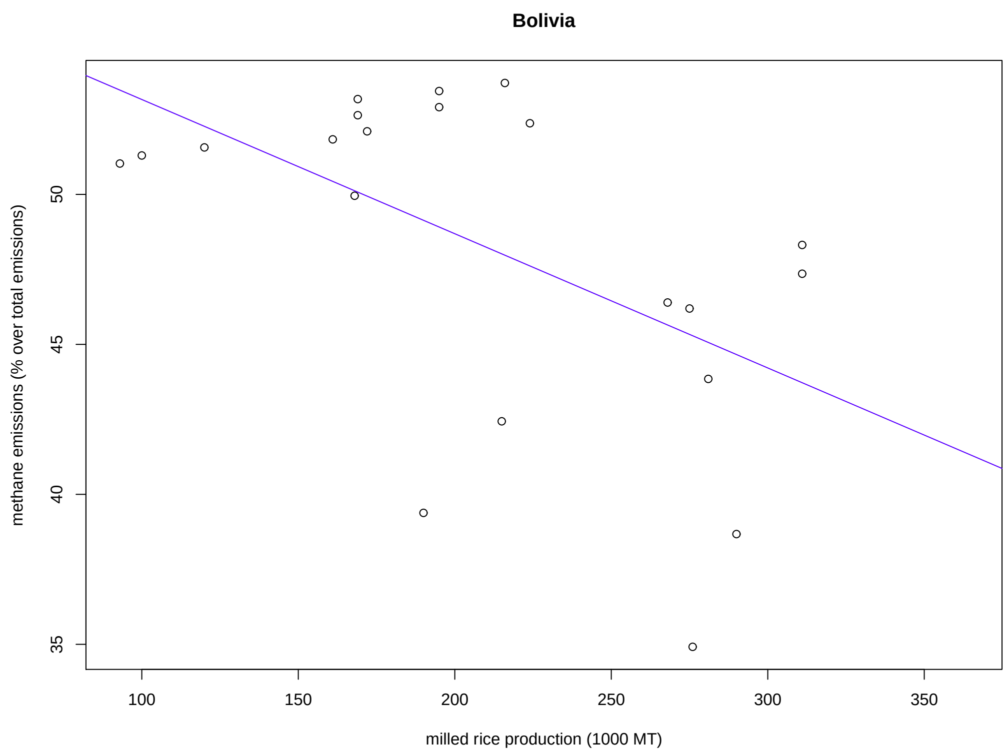

Bangladesh
Residuals vs Fitted
Residuals
Fitted values
X
X.1
X.7
Bangladesh
Scale−Location
√|Standardized residuals|
Fitted values
X
X.1
X.7
Bangladesh
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X
X.1
X.7
Bangladesh
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
X
X.1
X.7



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	17.4203	0.7047	24.72	0.0000
h[, j]	0.9583	0.0948	10.11	0.0000

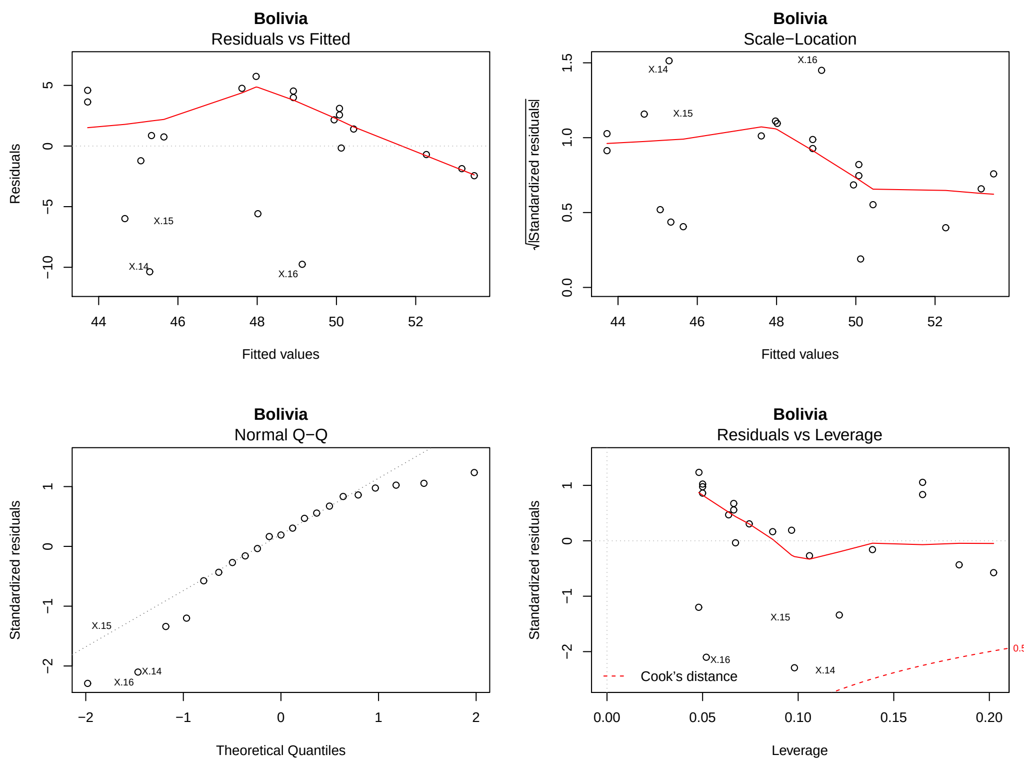
Table 5: Regression results


Bulgaria
Residuals vs Fitted
Residuals
Fitted values
X.5
X.3
X.4
Bulgaria
Scale−Location
√|Standardized residuals|
Fitted values
X.5
X.1
X.4
Bulgaria
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.5
X.1
X.4
Bulgaria
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.1
1
0.5
0.5

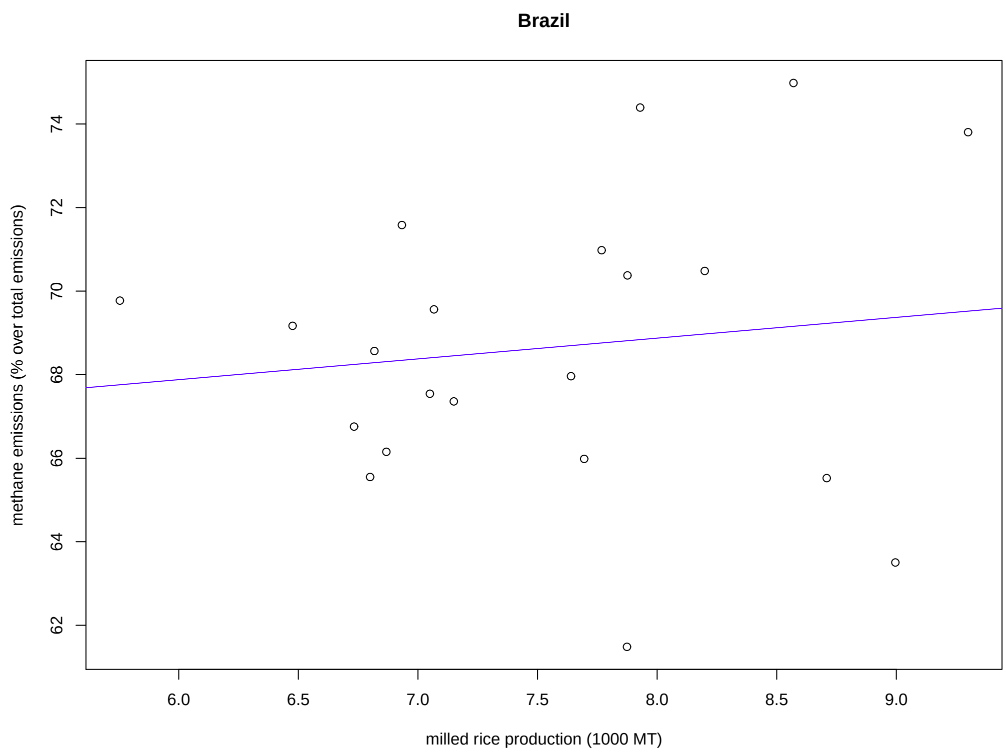


	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	57.6390	3.5277	16.34	0.0000
h[, j]	-0.0448	0.0161	-2.78	0.0119

Table 6: Regression results

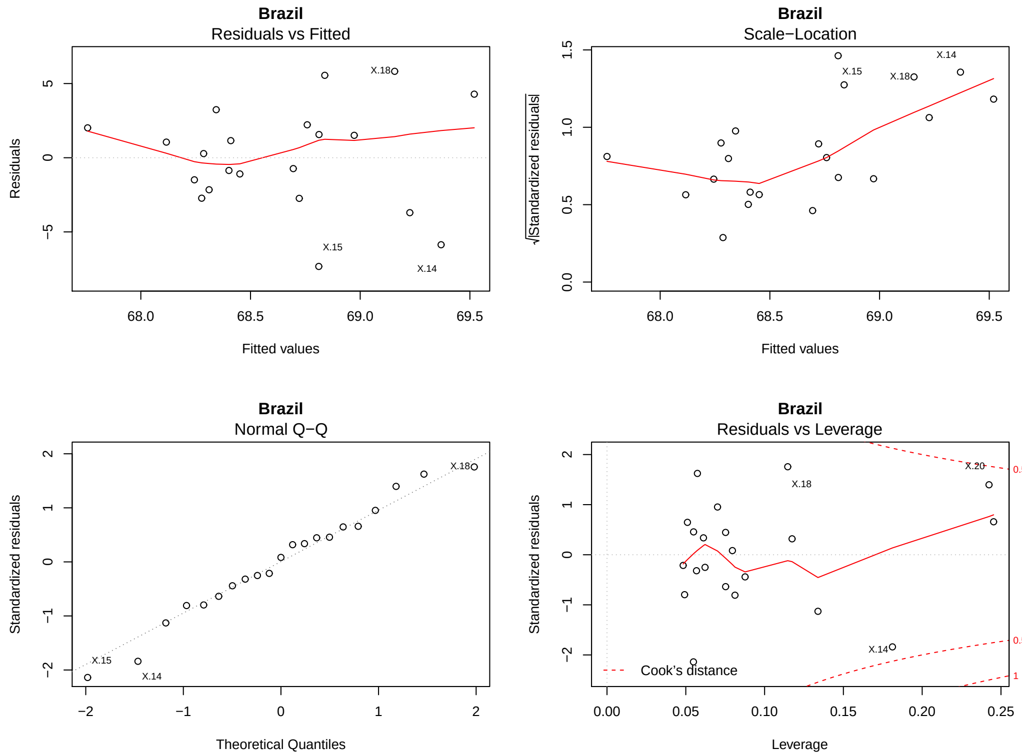


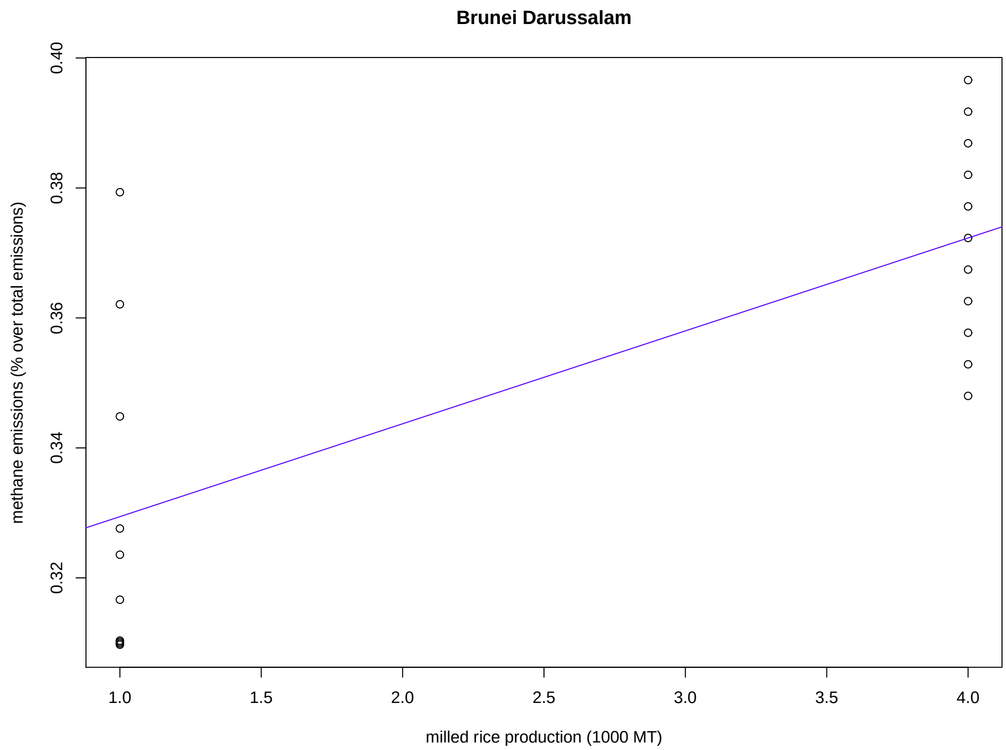
Bolivia
Residuals vs Fitted
Residuals
Fitted values
X.15
X.14
X.16
Bolivia
Scale−Location
√|Standardized residuals|
Fitted values
X.14
X.16
X.15
Bolivia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.15
X.14
X.16
Bolivia
Residuals vs Leverage
Standardized residuals
Leverage
X.15
X.16
X.14
Cook's distance
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	64.8977	6.6776	9.72	0.0000
h[, j]	0.4970	0.8805	0.56	0.5790

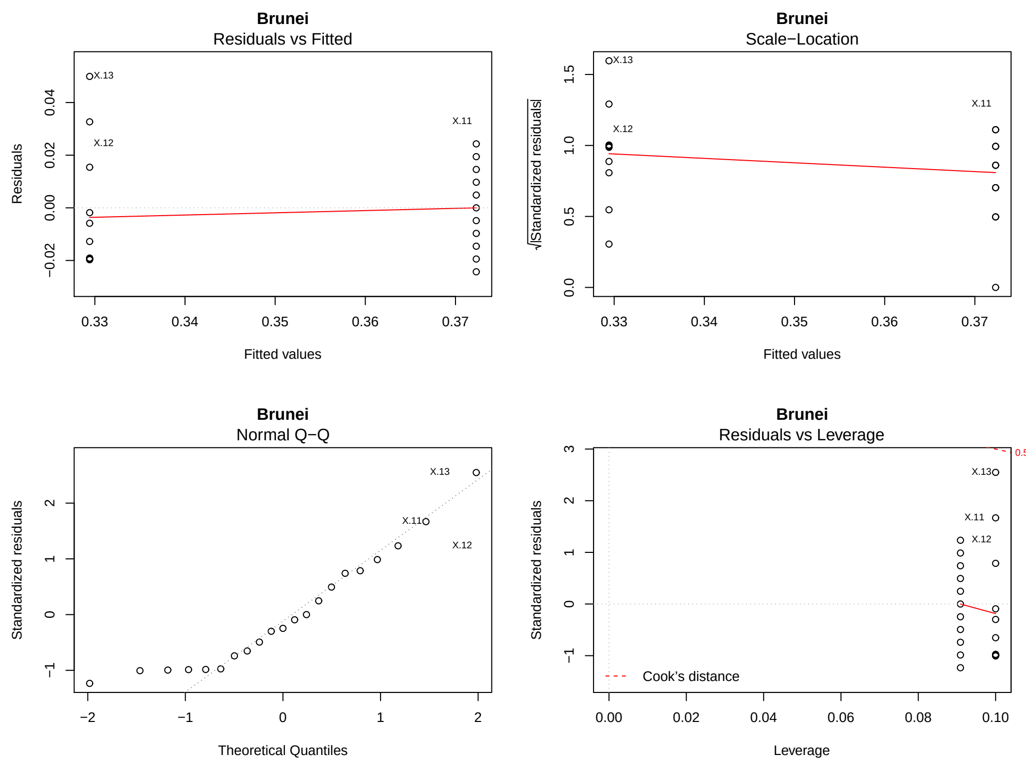
Table 7: Regression results

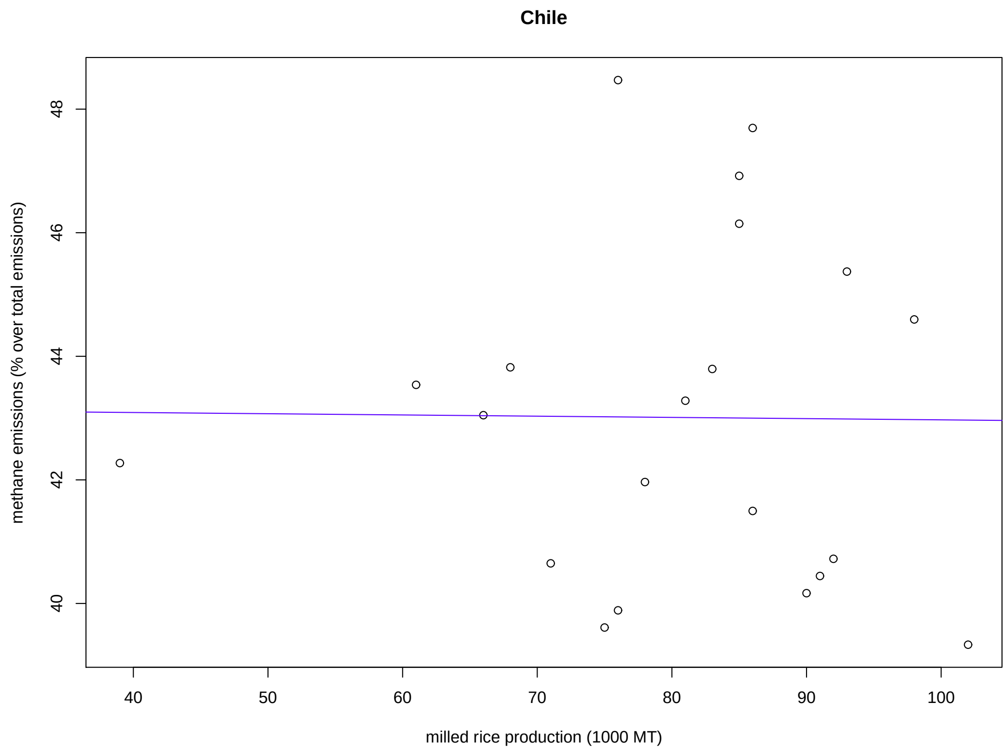

Brazil
Residuals vs Fitted
Residuals
Fitted values
X.18
X.15
X.14
Brazil
Scale−Location
√|Standardized residuals|
Fitted values
X.14
X.15
X.18
Brazil
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.18
X.15
X.14
Brazil
Residuals vs Leverage
Standardized residuals
Leverage
X.20
X.18
X.14
0.5
0.5
1
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.3151	0.0090	35.21	0.0000
h[, j]	0.0143	0.0030	4.75	0.0001

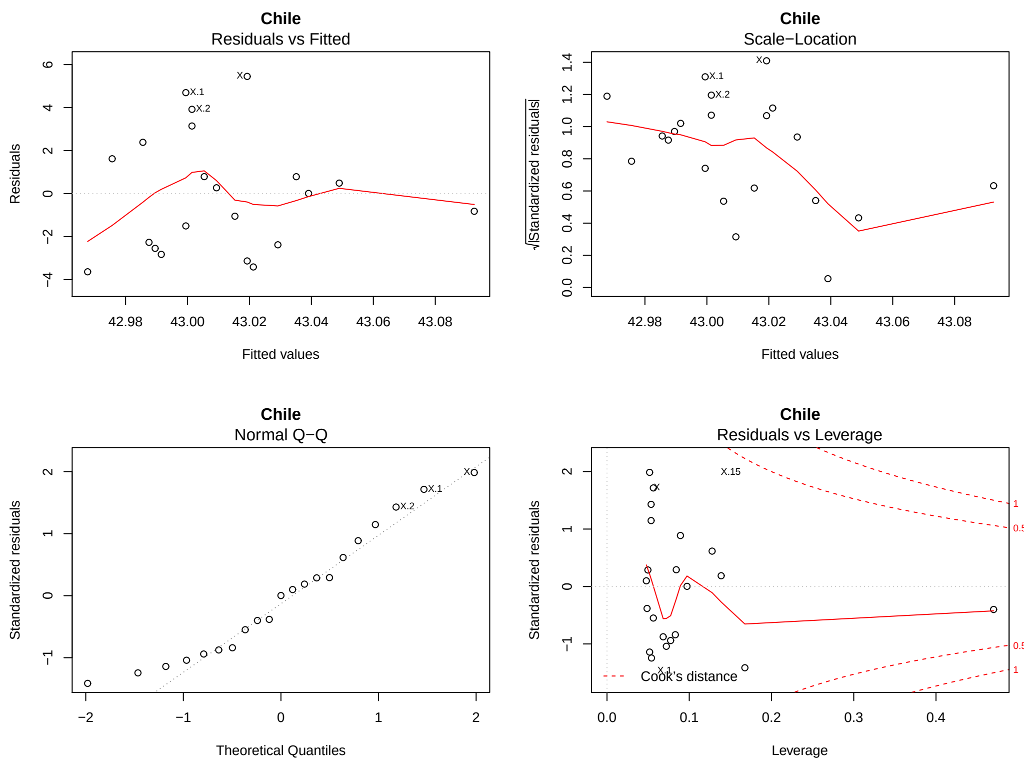
Table 8: Regression results

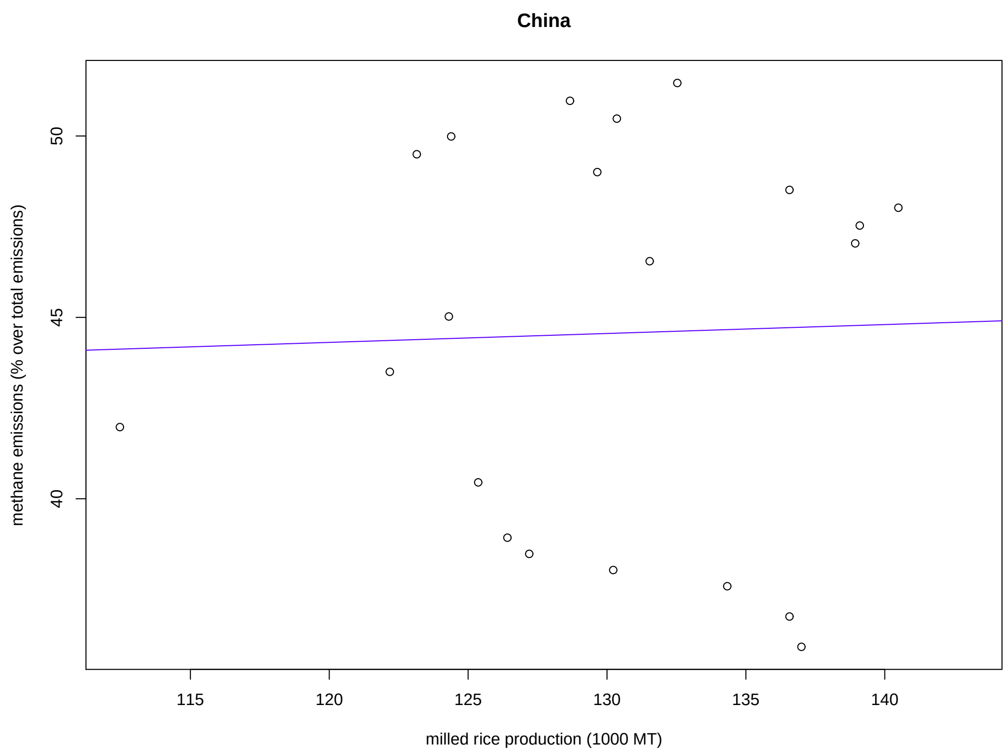

Brunei
Residuals vs Fitted
Residuals
Fitted values
X.13
X.12
X.11
Brunei
Scale−Location
√|Standardized residuals|
Fitted values
X.13
X.12
X.11
Brunei
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.13
X.11
X.12
Brunei
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
X.13
X.11
X.12



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	43.1699	3.6215	11.92	0.0000
h[, j]	-0.0020	0.0446	-0.04	0.9650

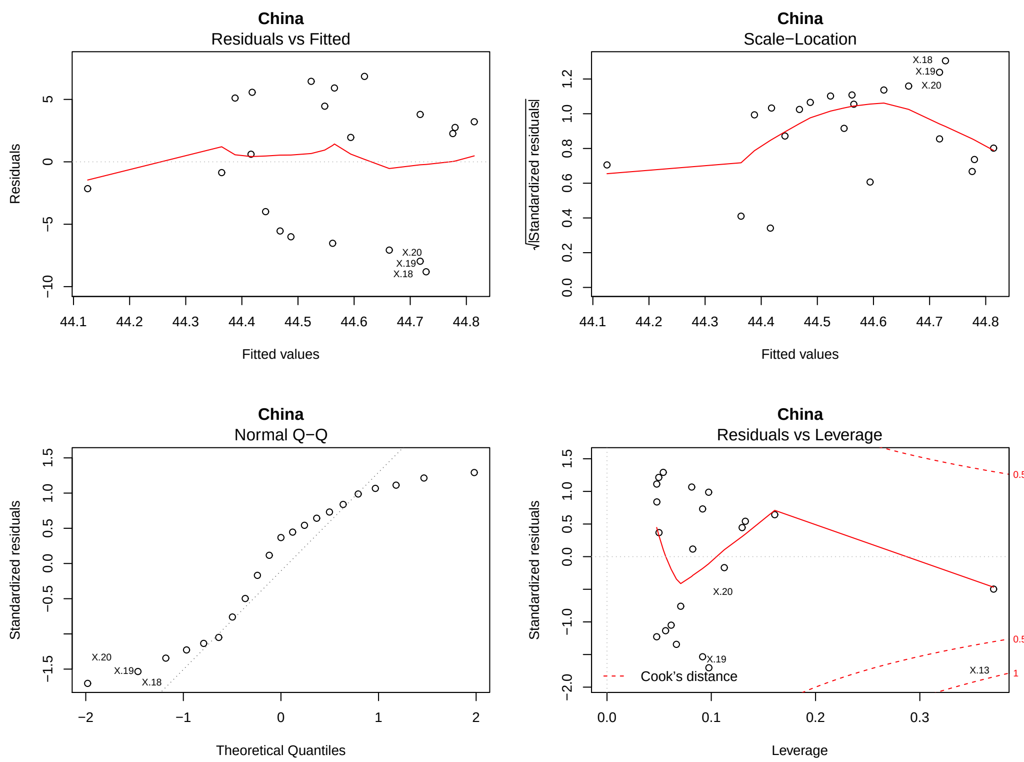
Table 9: Regression results

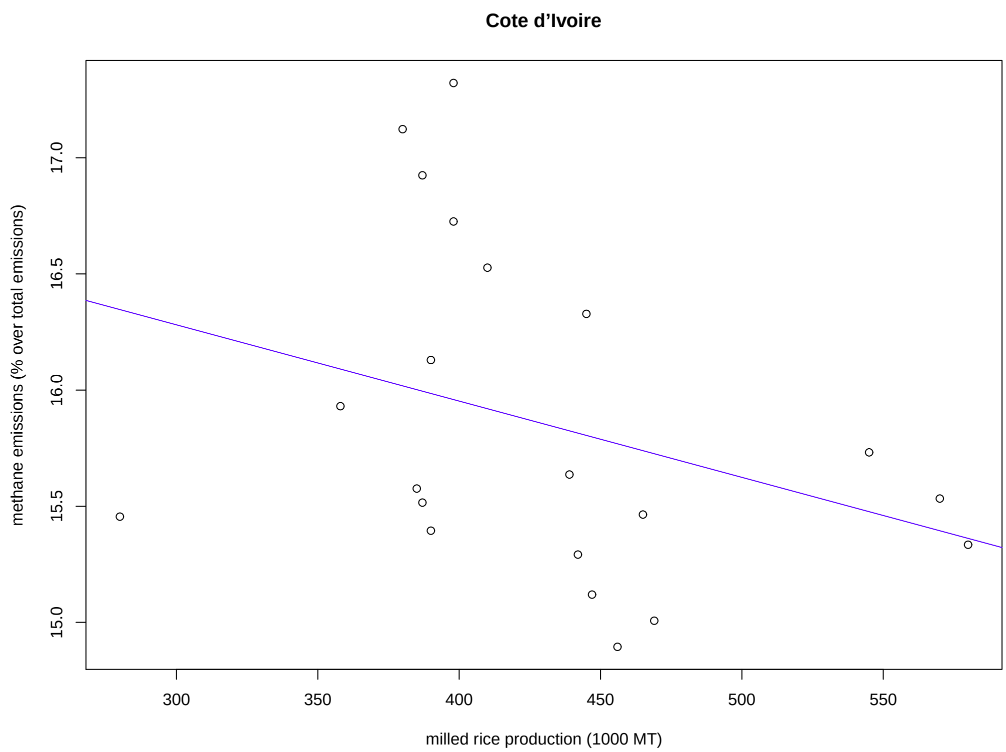

Chile
Residuals vs Fitted
Residuals
Fitted values
X.1
X.2
Chile
Scale−Location
√|Standardized residuals|
Fitted values
X.1
X.2
Chile
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.1
X.2
Chile
Residuals vs Leverage
Standardized residuals
Leverage
X.15
Cook's distance
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	41.3611	22.9057	1.81	0.0868
h[, j]	0.0246	0.1759	0.14	0.8903

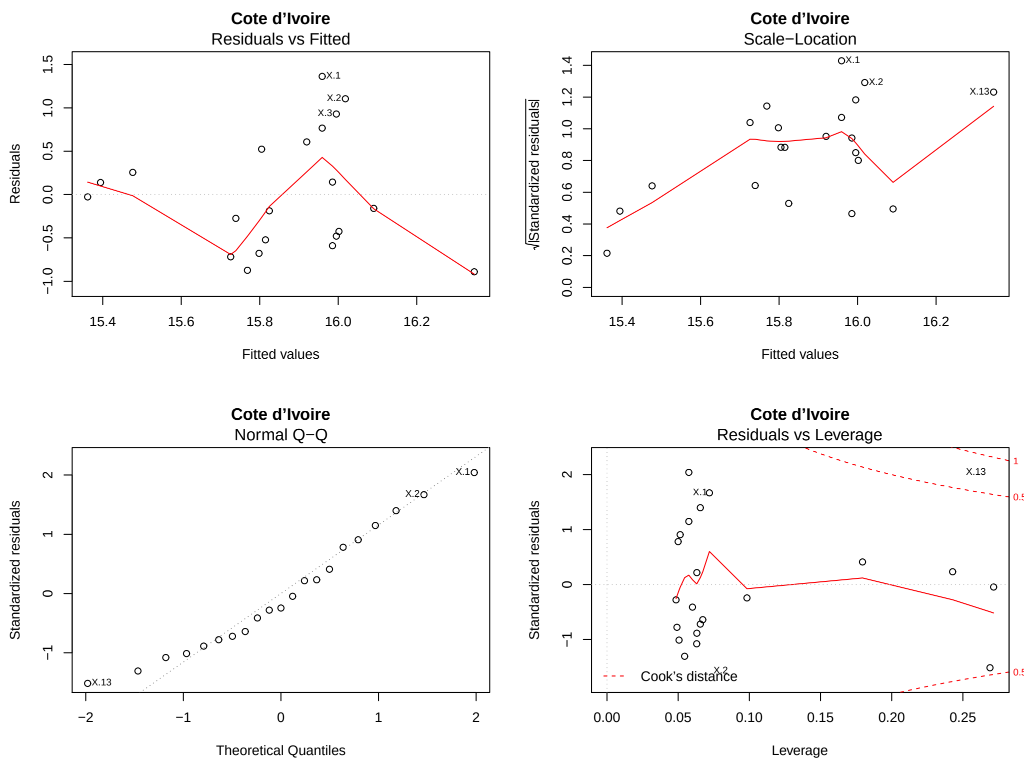
Table 10: Regression results

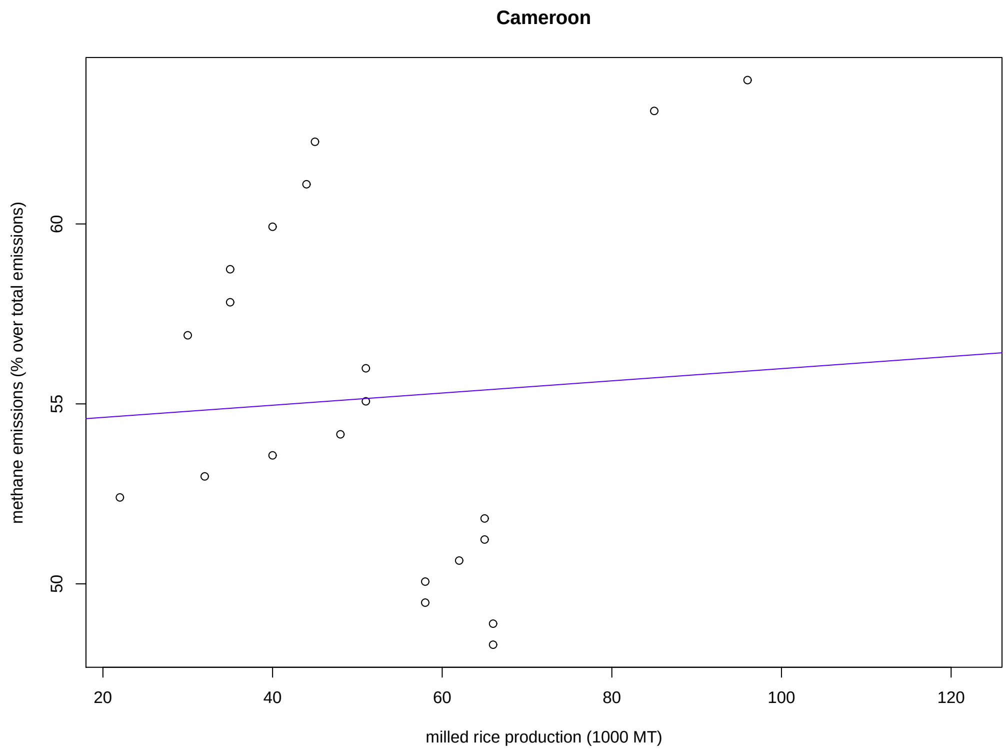

China
Residuals vs Fitted
Residuals
Fitted values
X.20
X.19
X.18
China
Scale−Location
√|Standardized residuals|
Fitted values
X.18
X.19
X.20
China
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20
X.19
X.18
China
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.20
X.19
X.13
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	17.2659	0.9414	18.34	0.0000
h[, j]	-0.0033	0.0022	-1.52	0.1456

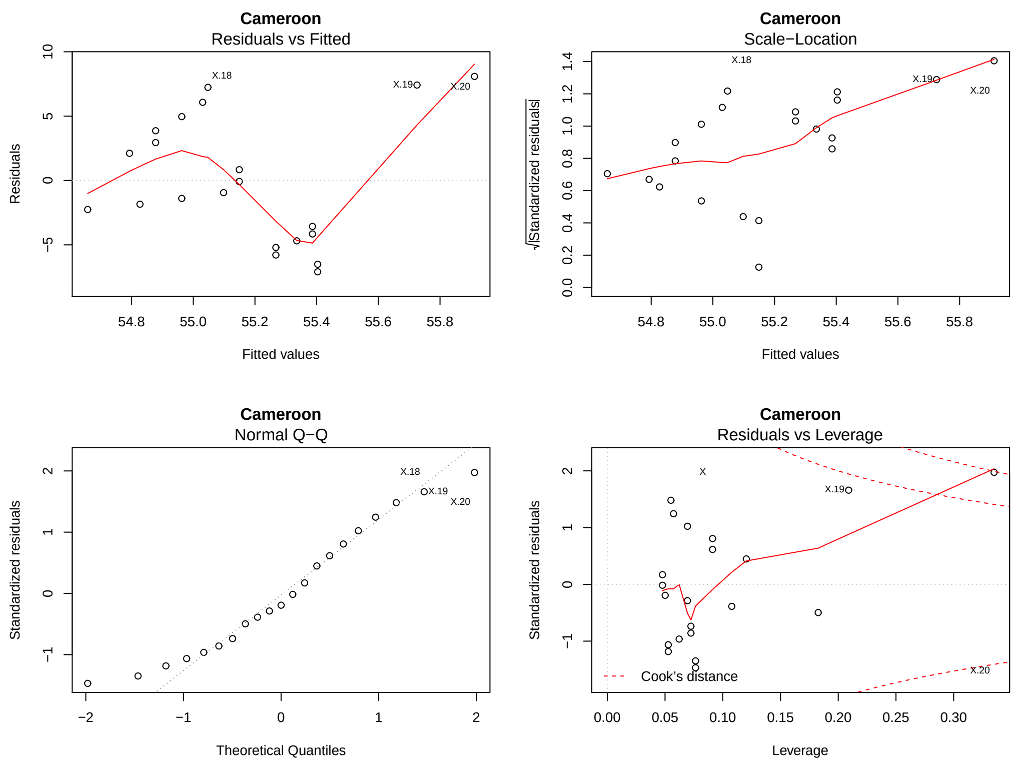
Table 11: Regression results

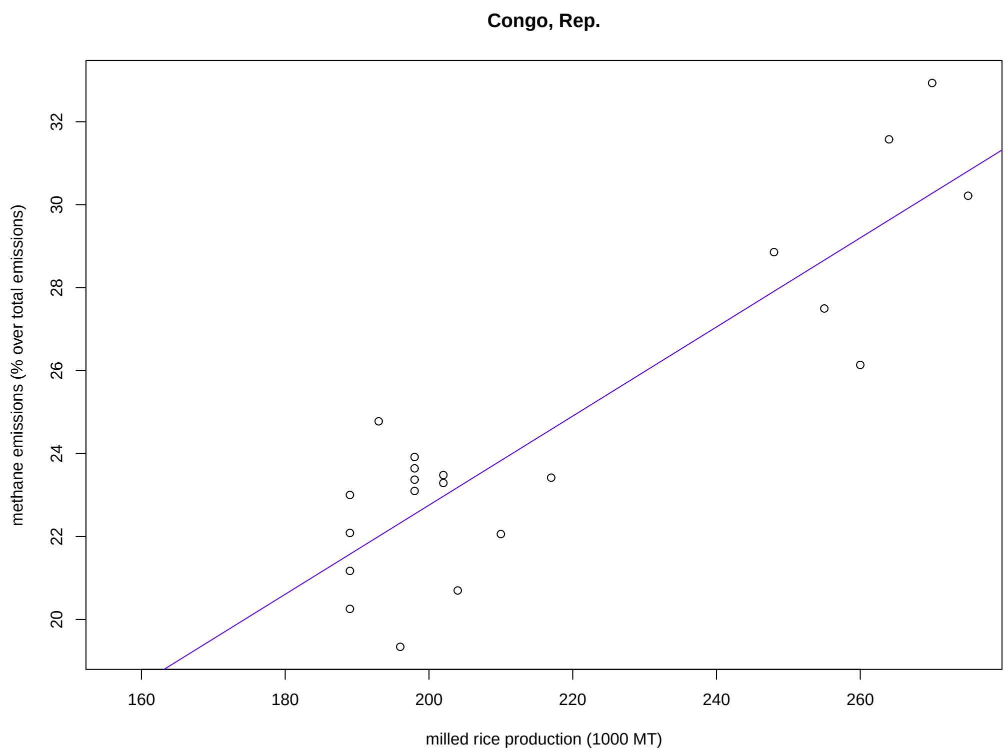

Cote d'Ivoire
Residuals vs Fitted
Residuals
Fitted values
X.1
X.2
X.3
Cote d'Ivoire
Scale−Location
√|Standardized residuals|
Fitted values
X.1
X.2
X.13
Cote d'Ivoire
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.1
X.2
X.13
Cote d'Ivoire
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.13
X.1
X.2
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	54.2849	3.3785	16.07	0.0000
h[, j]	0.0169	0.0613	0.28	0.7853

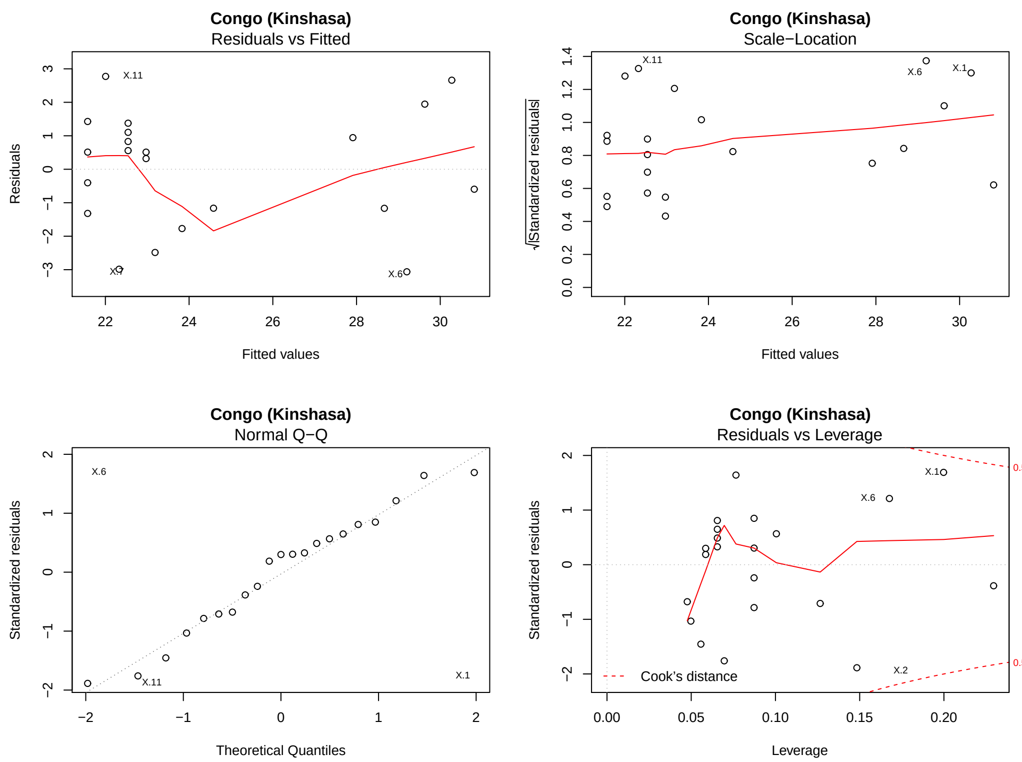
Table 12: Regression results


Cameroon
Residuals vs Fitted
Residuals
Fitted values
X.18
X.19
X.20
Cameroon
Scale−Location
√|Standardized residuals|
Fitted values
Cameroon
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Cameroon
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
1
0.5

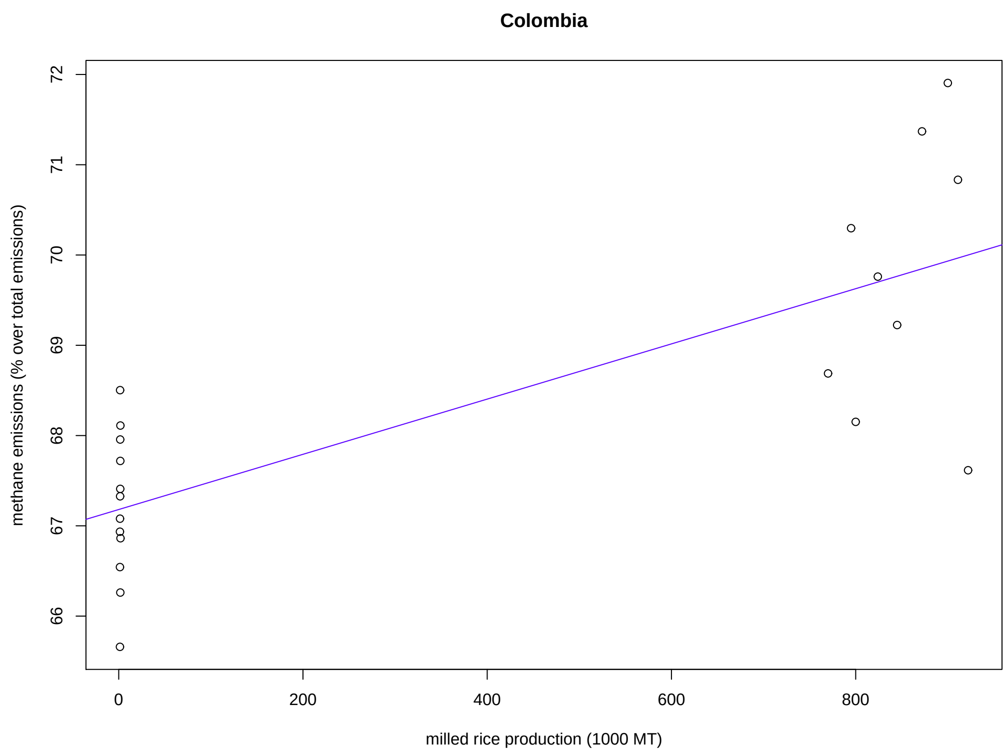


	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.2786	2.7957	0.46	0.6526
h[, j]	0.1074	0.0128	8.39	0.0000

Table 13: Regression results

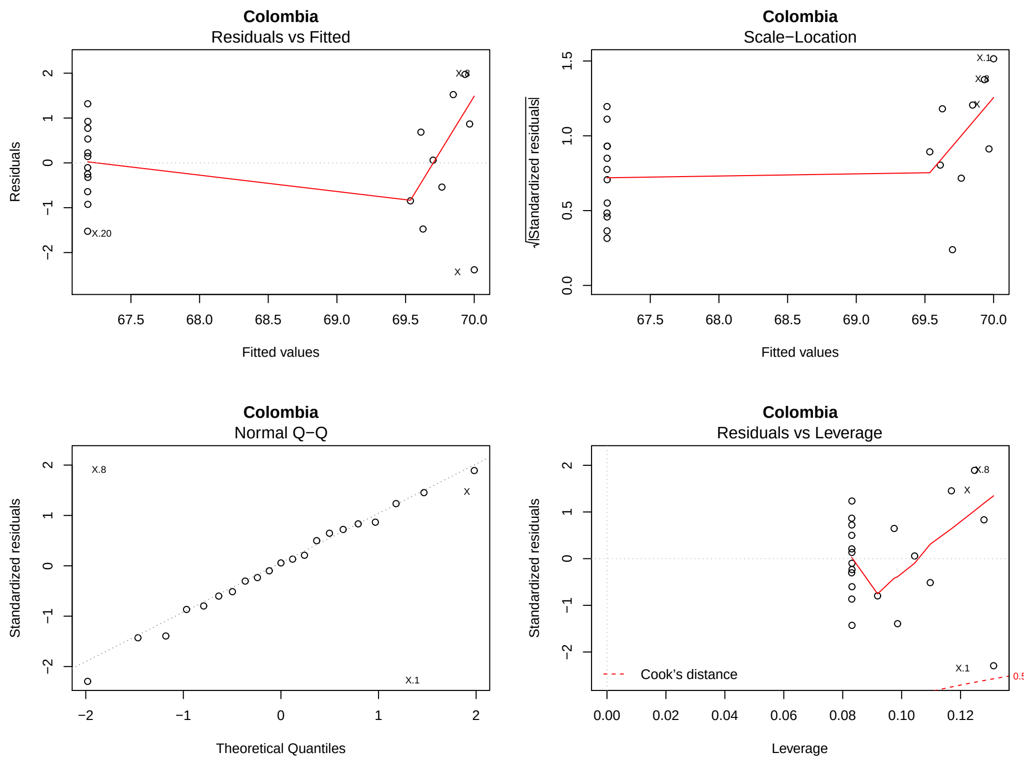


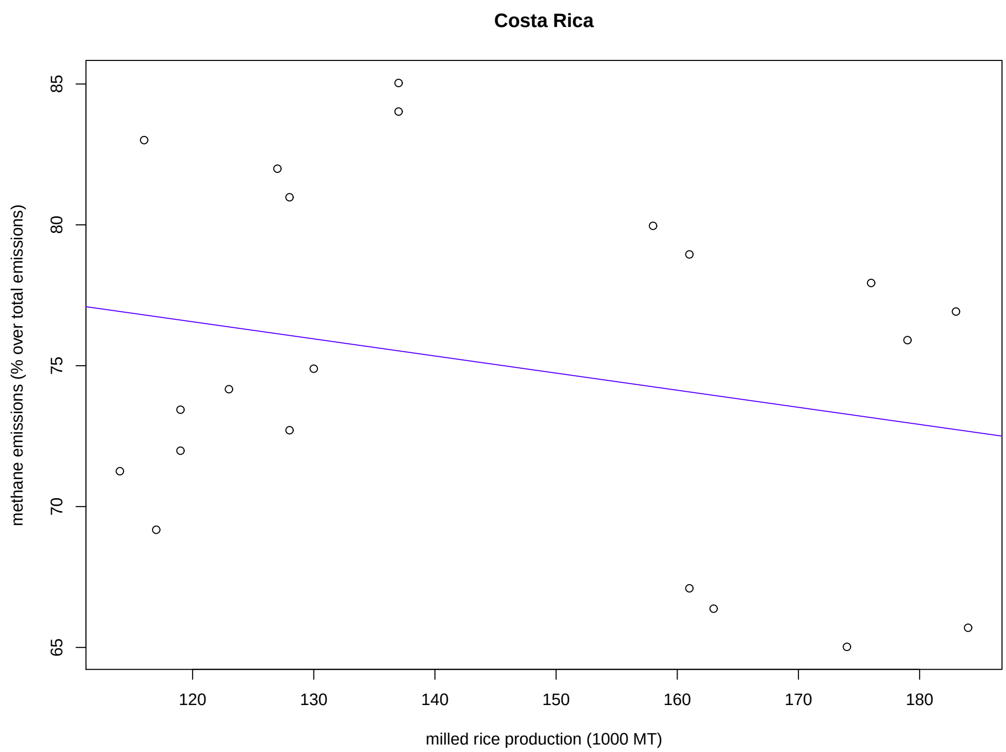
Congo (Kinshasa)
Residuals vs Fitted
Residuals
Fitted values
X.11
X.6
Congo (Kinshasa)
Scale−Location
√|Standardized residuals|
Fitted values
X.11
X.6
X.1
Congo (Kinshasa)
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.6
X.11
X.1
Congo (Kinshasa)
Residuals vs Leverage
Standardized residuals
Leverage
X.1
X.6
X.2
Cook's distance
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	67.1807	0.3220	208.65	0.0000
h[, j]	0.0031	0.0006	5.29	0.0000

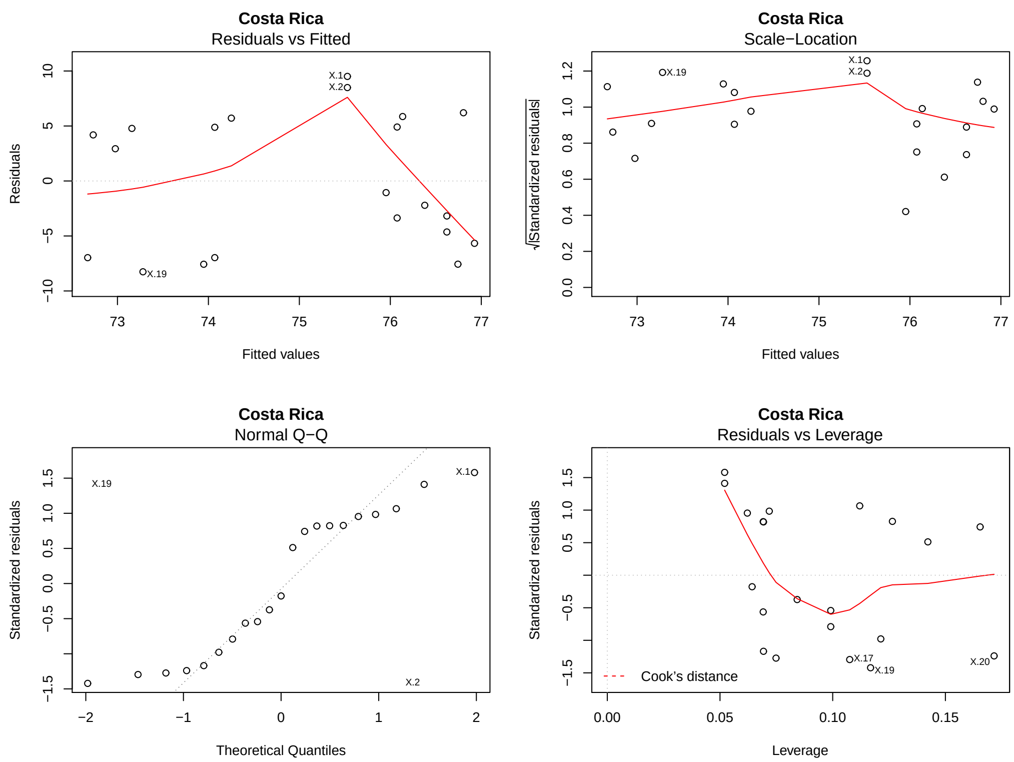
Table 14: Regression results


Colombia
Residuals vs Fitted
Residuals
Fitted values
X.20
Colombia
Scale−Location
√|Standardized residuals|
Fitted values
Colombia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.8
X.1
Colombia
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.8
X.1
0.5

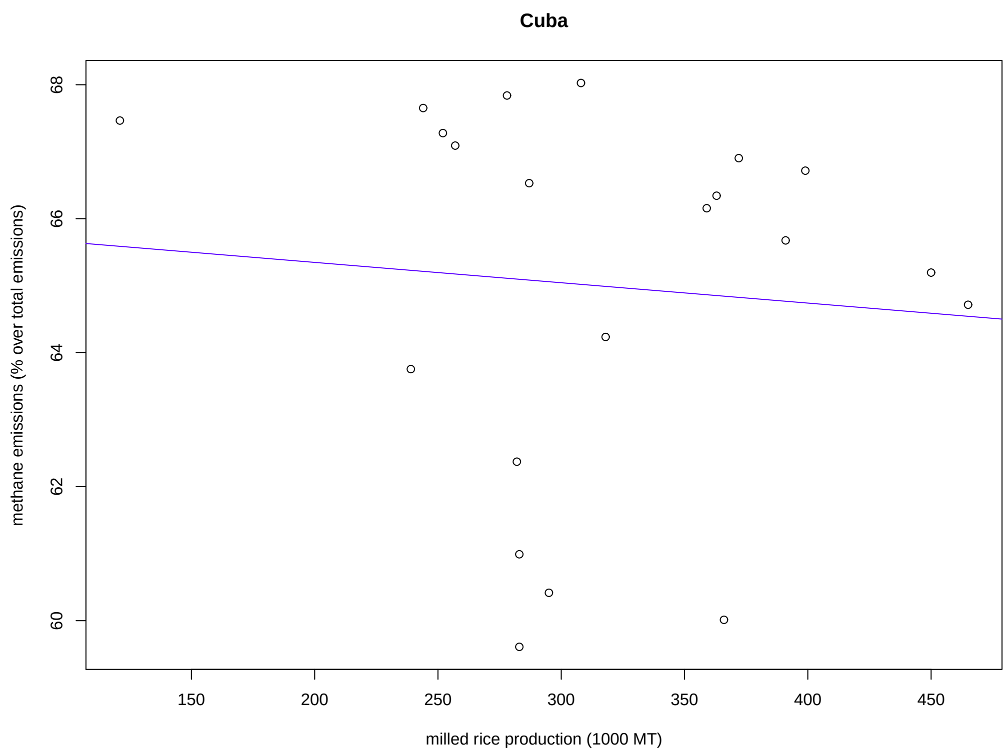


	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	83.8512	8.0700	10.39	0.0000
h[, j]	-0.0608	0.0551	-1.10	0.2837

Table 15: Regression results

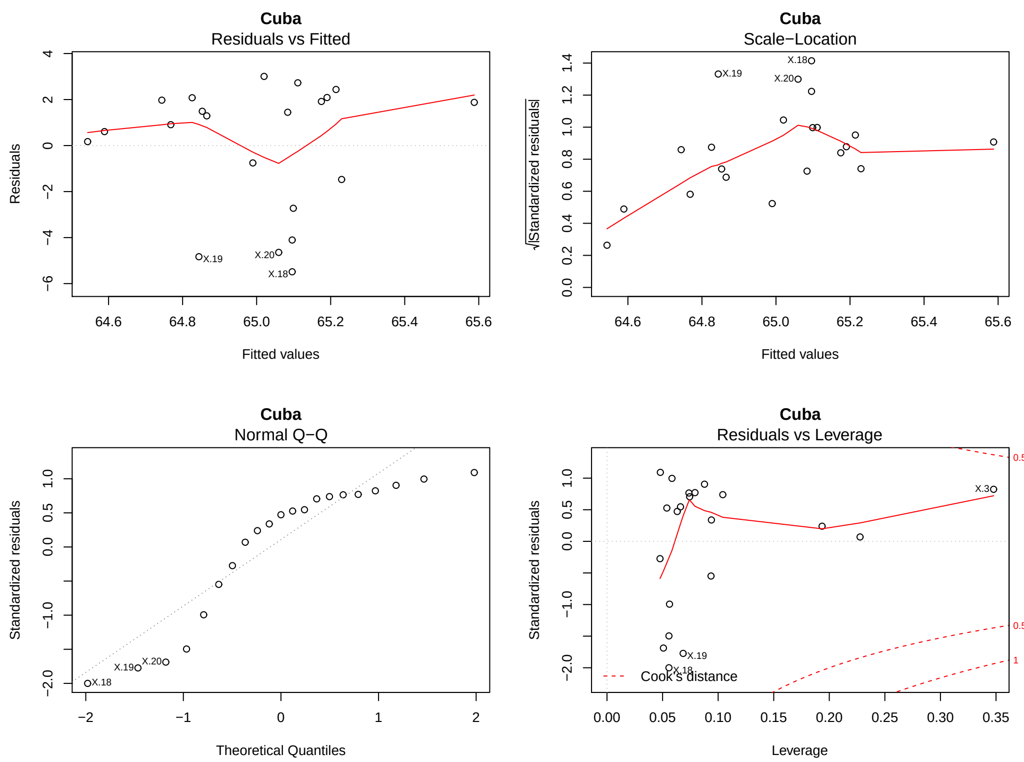


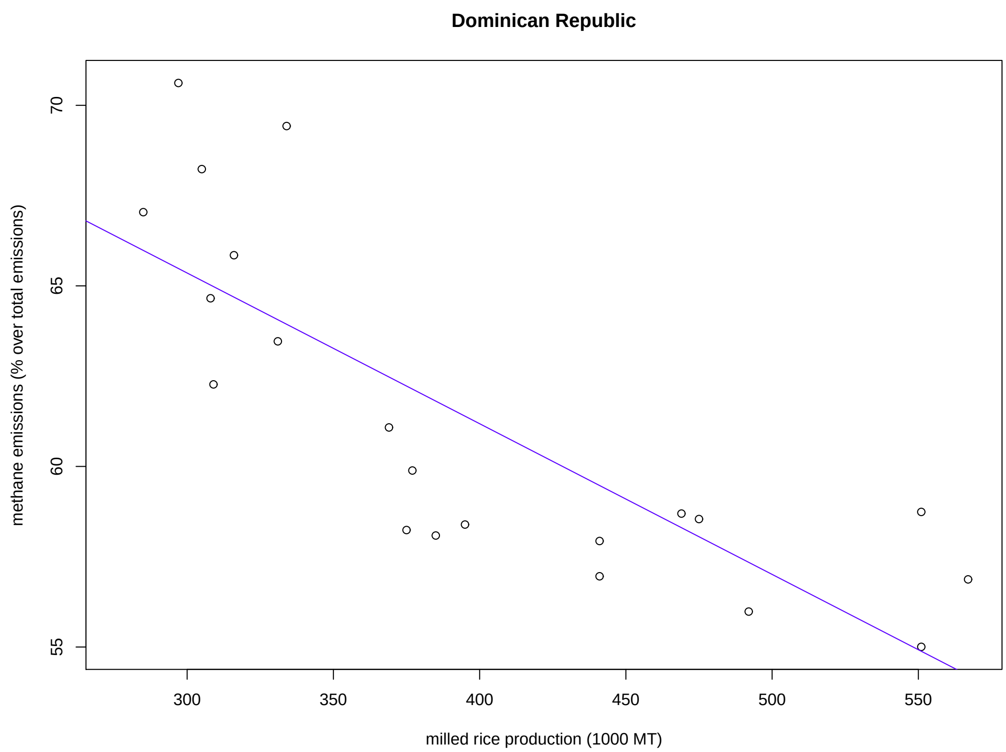
Costa Rica
Residuals vs Fitted
Residuals
Fitted values
X.1
X.2
X.19
Costa Rica
Scale−Location
√|Standardized residuals|
Fitted values
X.1
X.2
X.19
Costa Rica
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.19
X.1
X.2
Costa Rica
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.17
X.19
X.20



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	65.9552	2.5867	25.50	0.0000
h[, j]	-0.0030	0.0080	-0.38	0.7078

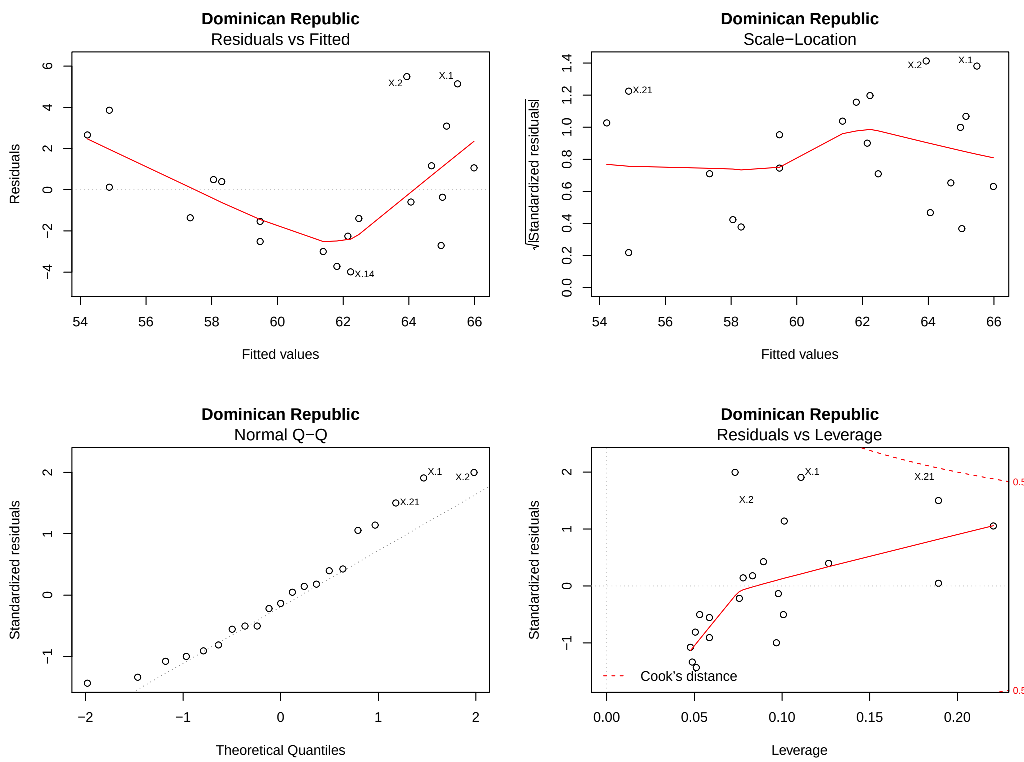
Table 16: Regression results

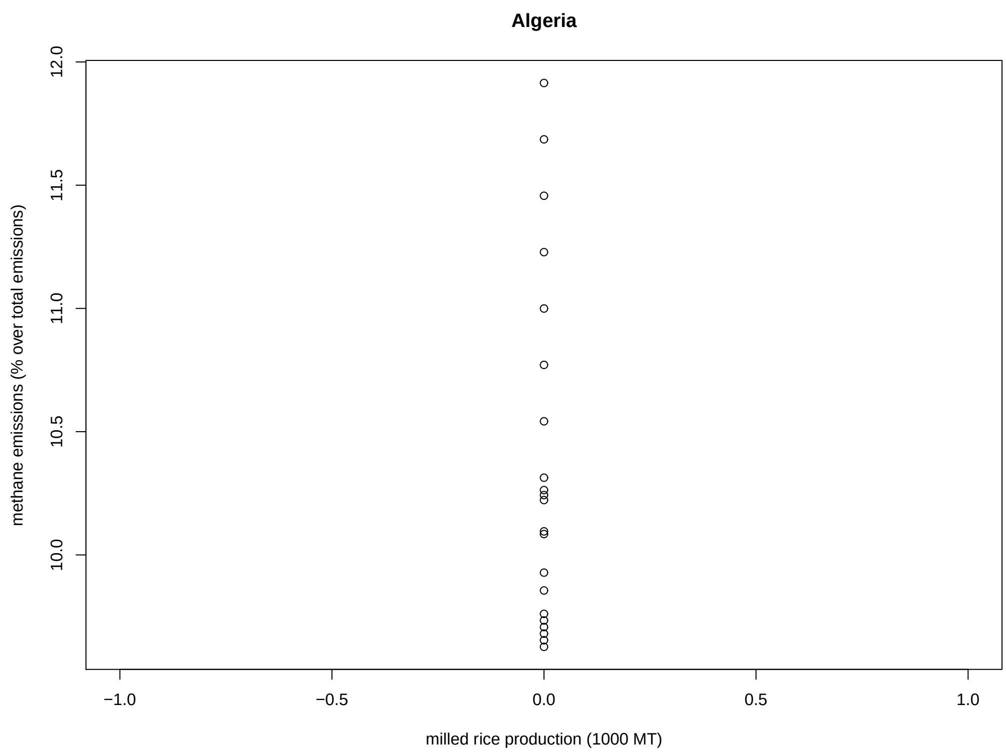

Cuba
Residuals vs Fitted
Residuals
Fitted values
X.19
X.20
X.18
Cuba
Scale−Location
√|Standardized residuals|
Fitted values
X.19
X.18
X.20
Cuba
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.18
X.19
X.20
Cuba
Residuals vs Leverage
Standardized residuals
Leverage
X.3
X.19
X.18
Cook's distance
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	77.8743	2.8823	27.02	0.0000
h[, j]	-0.0417	0.0071	-5.91	0.0000

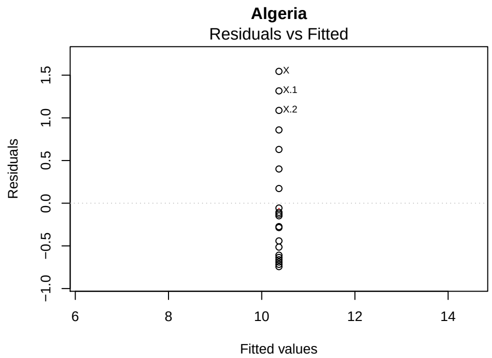
Table 17: Regression results

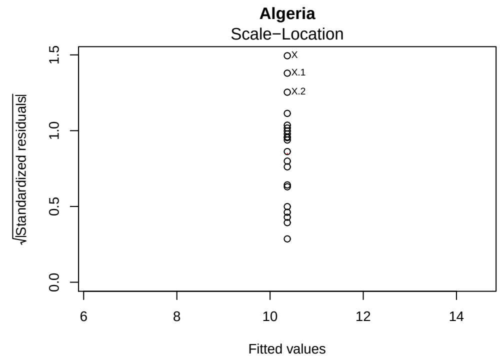

Dominican Republic
Residuals vs Fitted
Residuals
Fitted values
X.2
X.1
X.14
Dominican Republic
Scale−Location
√|Standardized residuals|
Fitted values
X.21
X.2
X.1
Dominican Republic
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.1
X.2
X.21
Dominican Republic
Residuals vs Leverage
Standardized residuals
Leverage
X.1
X.2
X.21
Cook's distance
0.5
0.5

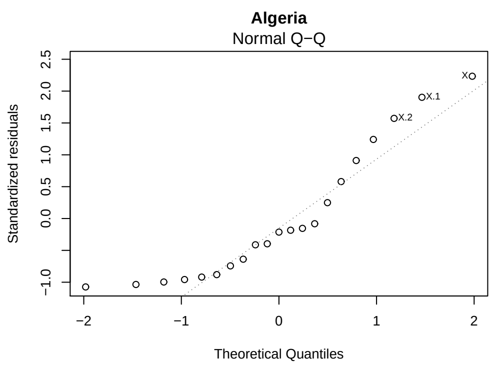


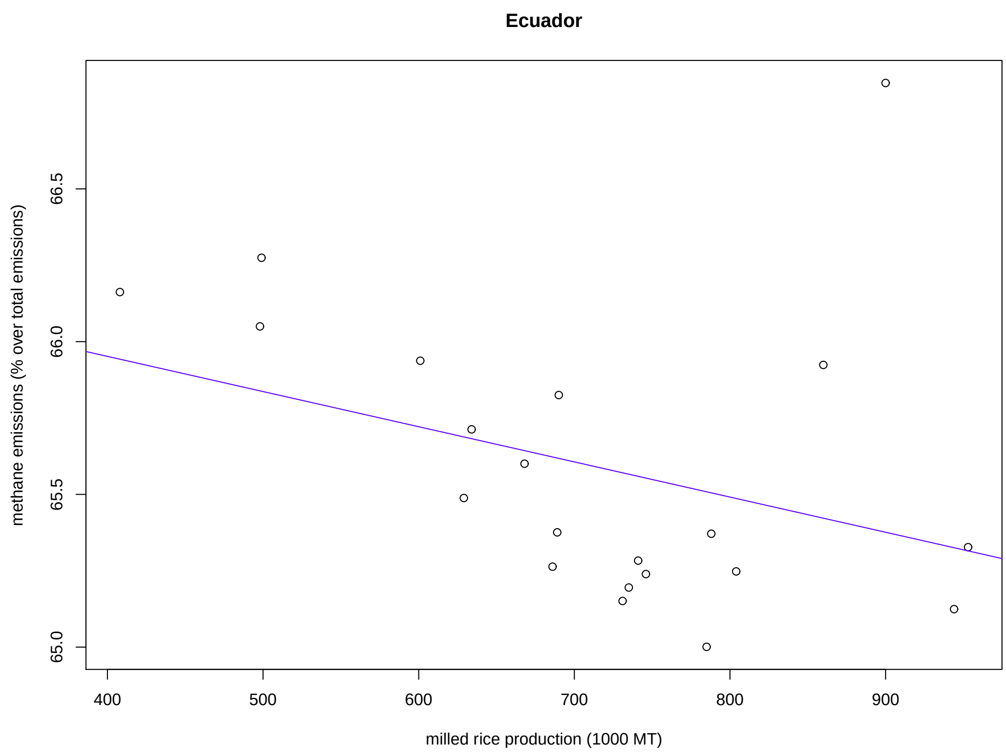
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	10.3699	0.1547	67.04	0.0000

Table 18: Regression results


Algeria
Residuals vs Fitted
Residuals
Fitted values
X
X.1
X.2
−1.0
−0.5
0.0
0.5
1.0
1.5
6
8
10
12
14

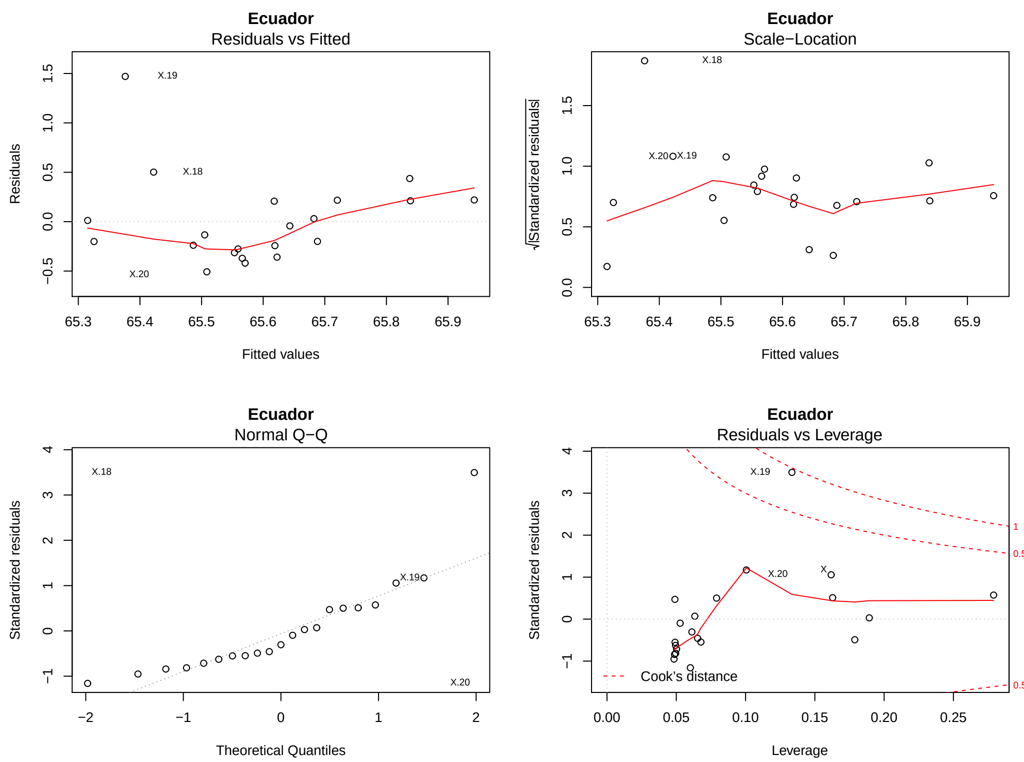

Algeria
Scale−Location
√|Standardized residuals|
Fitted values
X
X.1
X.2
0.0
0.5
1.0
1.5
6
8
10
12
14

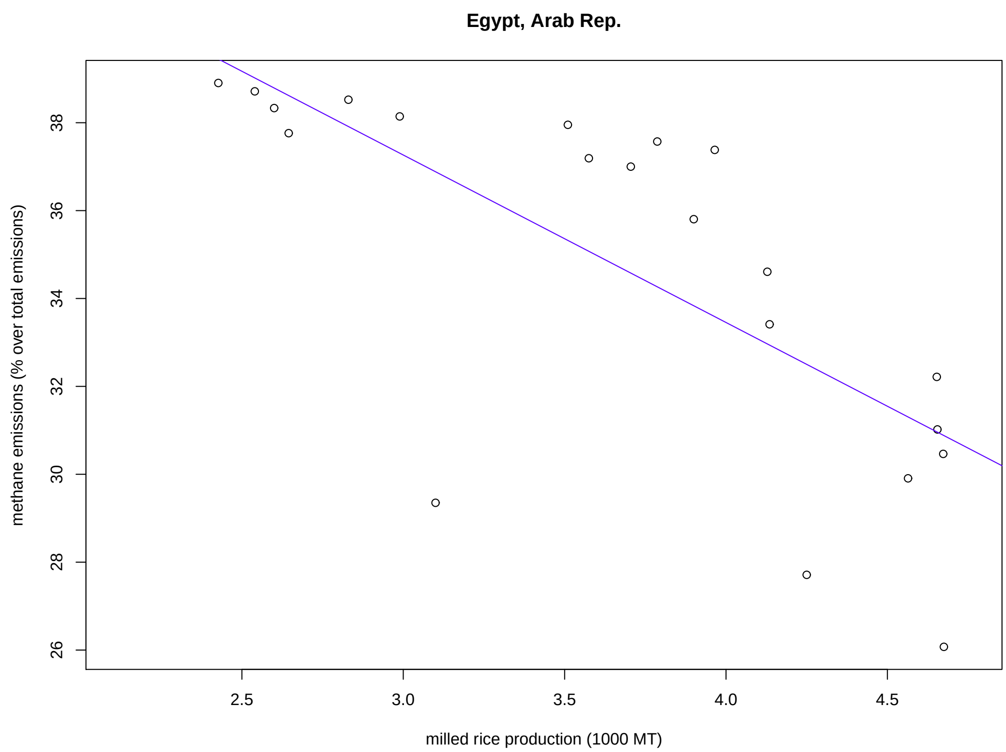

Algeria
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X
X.1
X.2
−1.0
0.0
0.5
1.0
1.5
2.0
2.5
−2
−1
0
1
2



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	66.4123	0.5170	128.46	0.0000
h[, j]	-0.0012	0.0007	-1.62	0.1219

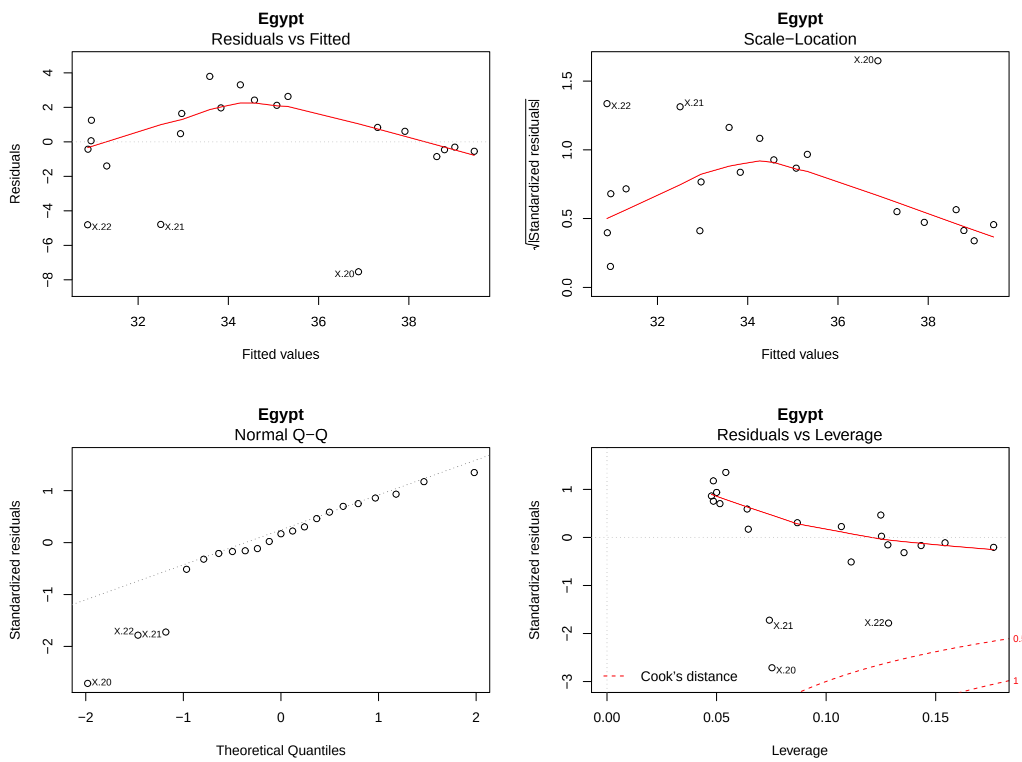
Table 19: Regression results

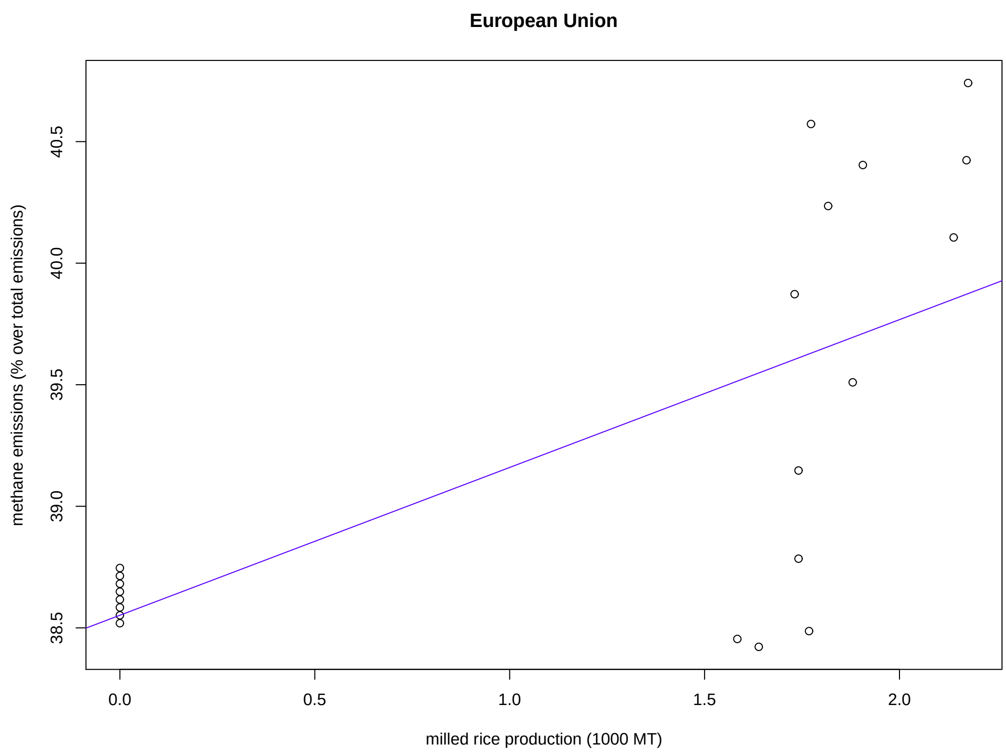

Ecuador
Residuals vs Fitted
Residuals
Fitted values
X.19
X.18
X.20
Ecuador
Scale−Location
√|Standardized residuals|
Fitted values
X.18
X.20
X.19
Ecuador
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.18
X.19
X.20
Ecuador
Residuals vs Leverage
Standardized residuals
Leverage
X.19
X.20
Cook's distance
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	48.6995	3.1052	15.68	0.0000
h[, j]	-3.8114	0.8260	-4.61	0.0002

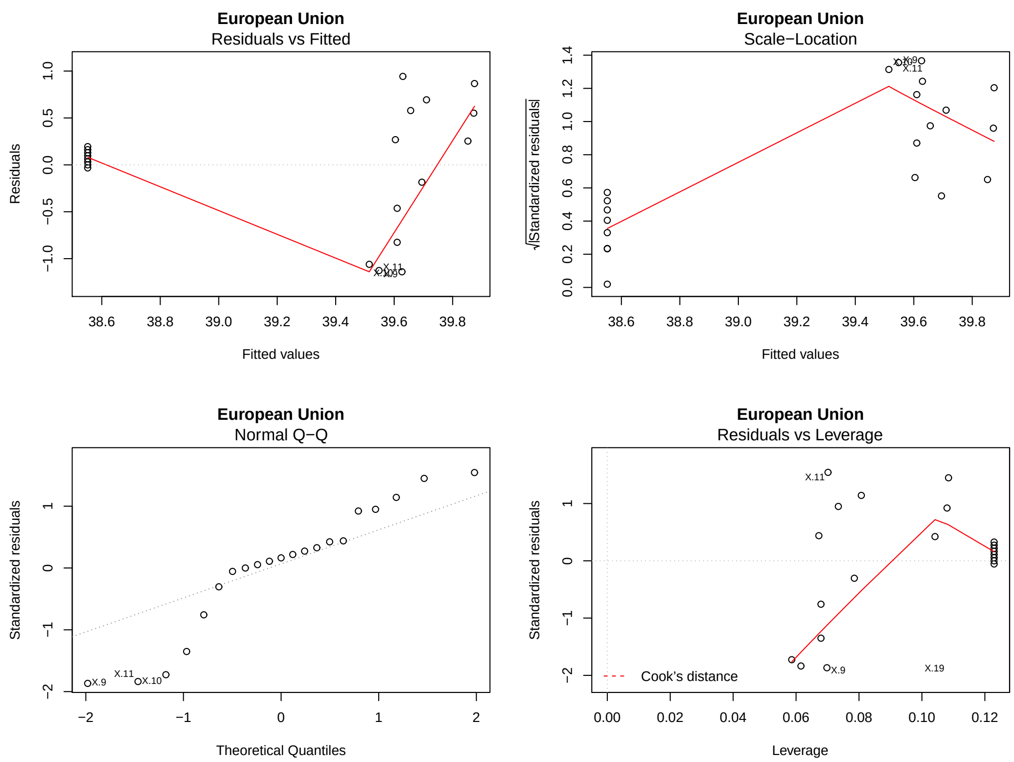
Table 20: Regression results

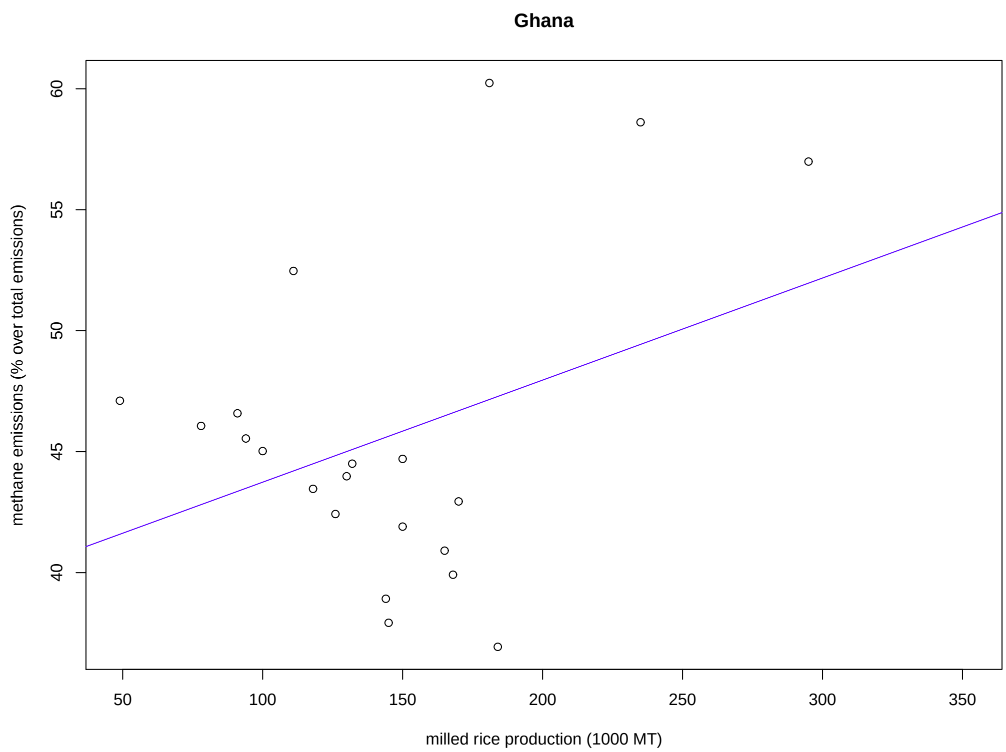

Egypt
Residuals vs Fitted
Residuals
Fitted values
X.22
X.21
X.20
Egypt
Scale−Location
√|Standardized residuals|
Fitted values
Egypt
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Egypt
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	38.5518	0.2220	173.68	0.0000
h[, j]	0.6080	0.1516	4.01	0.0007

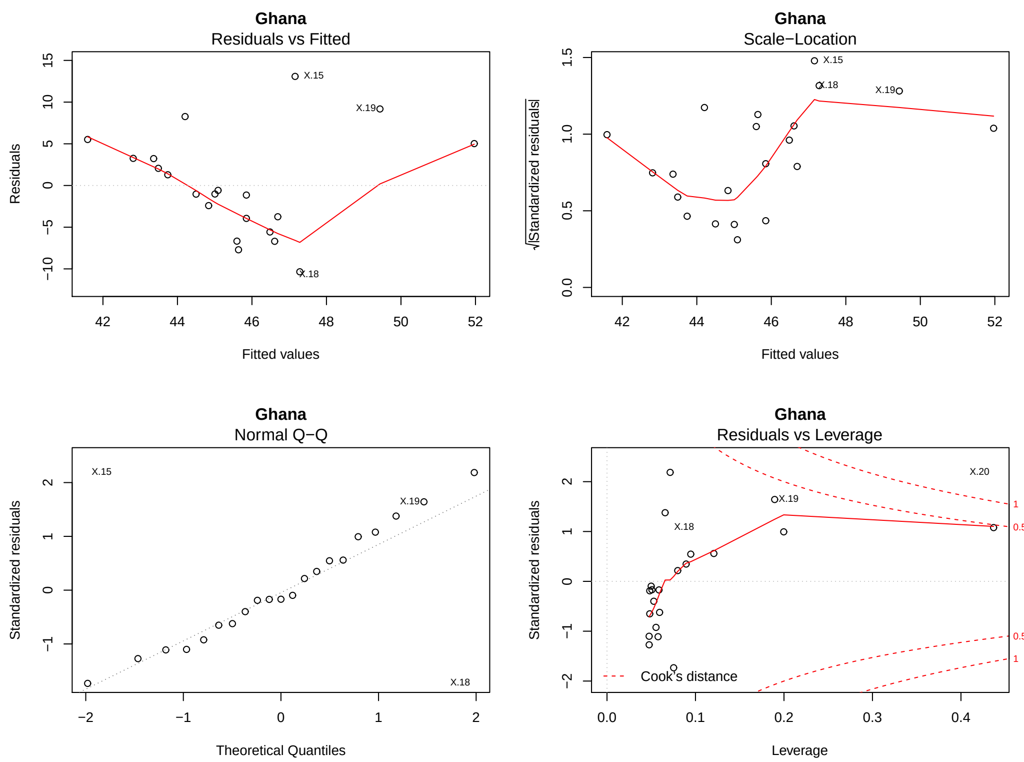
Table 21: Regression results

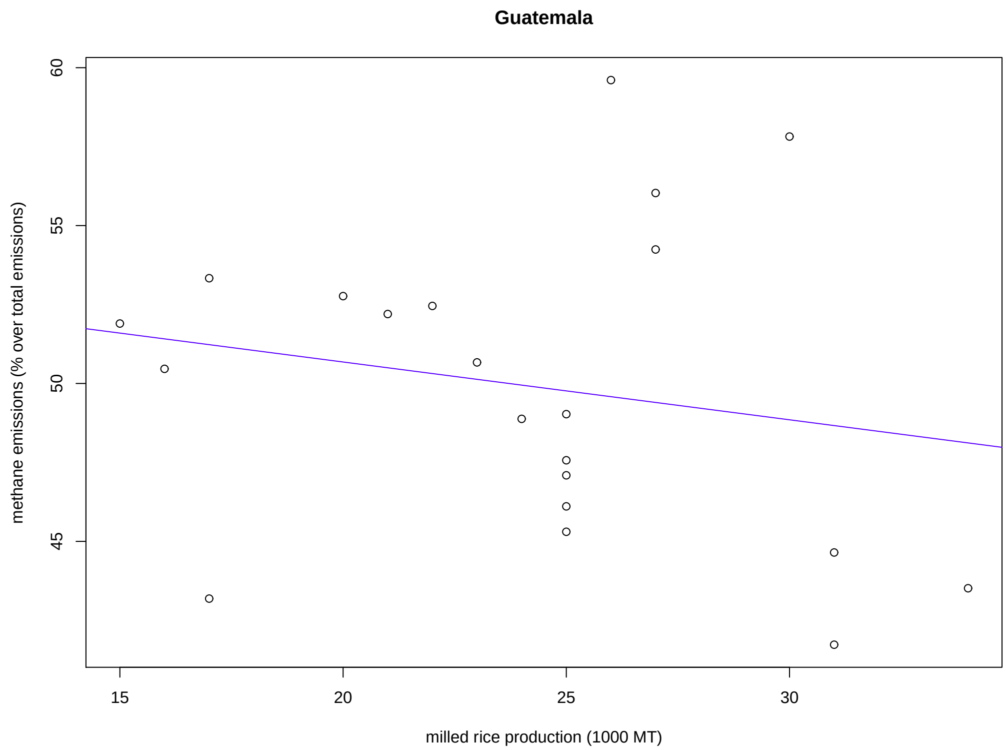

European Union
Residuals vs Fitted
Residuals
Fitted values
European Union
Scale−Location
√|Standardized residuals|
Fitted values
European Union
Normal Q−Q
Standardized residuals
Theoretical Quantiles
European Union
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	39.5221	3.9170	10.09	0.0000
h[, j]	0.0422	0.0256	1.65	0.1157

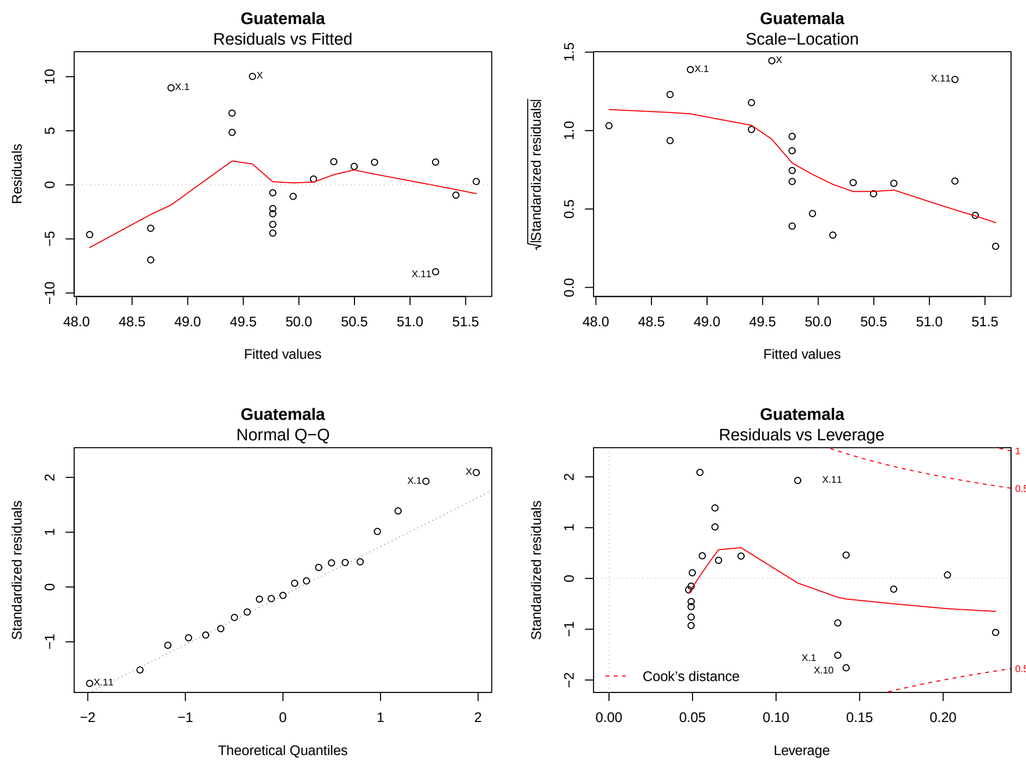
Table 22: Regression results

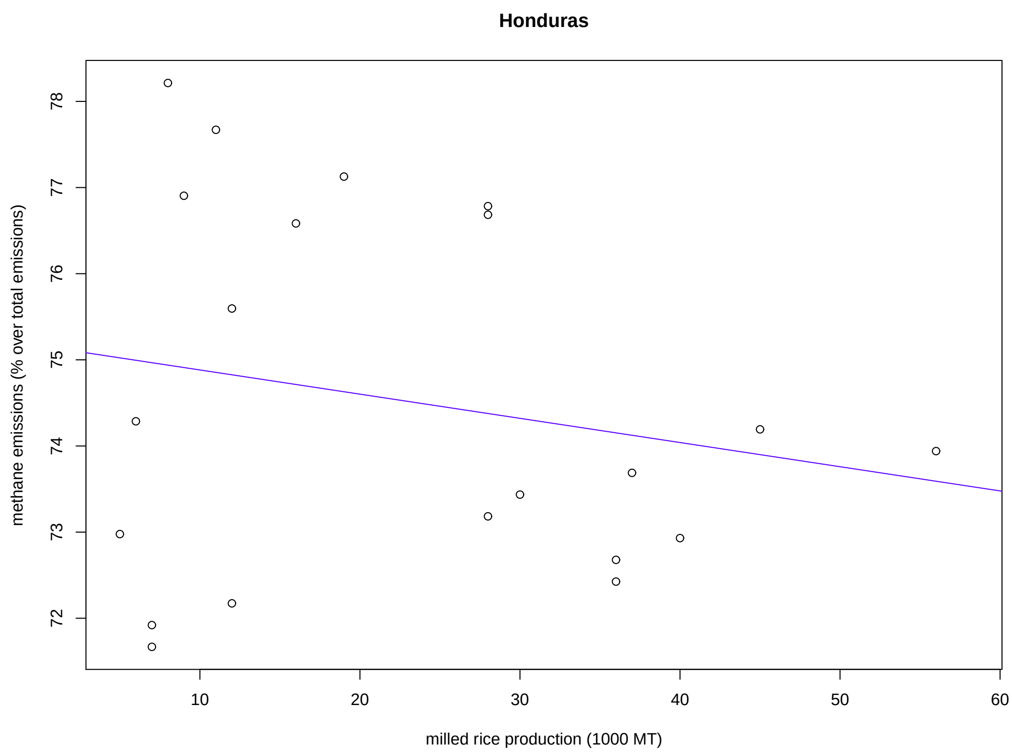

Ghana
Residuals vs Fitted
Residuals
Fitted values
X.15
X.19
X.18
Ghana
Scale−Location
√|Standardized residuals|
Fitted values
X.15
X.18
X.19
Ghana
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.15
X.19
X.18
Ghana
Residuals vs Leverage
Standardized residuals
Leverage
X.20
X.19
X.18
Cook's distance
1
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	54.3410	5.2598	10.33	0.0000
h[, j]	-0.1830	0.2137	-0.86	0.4023

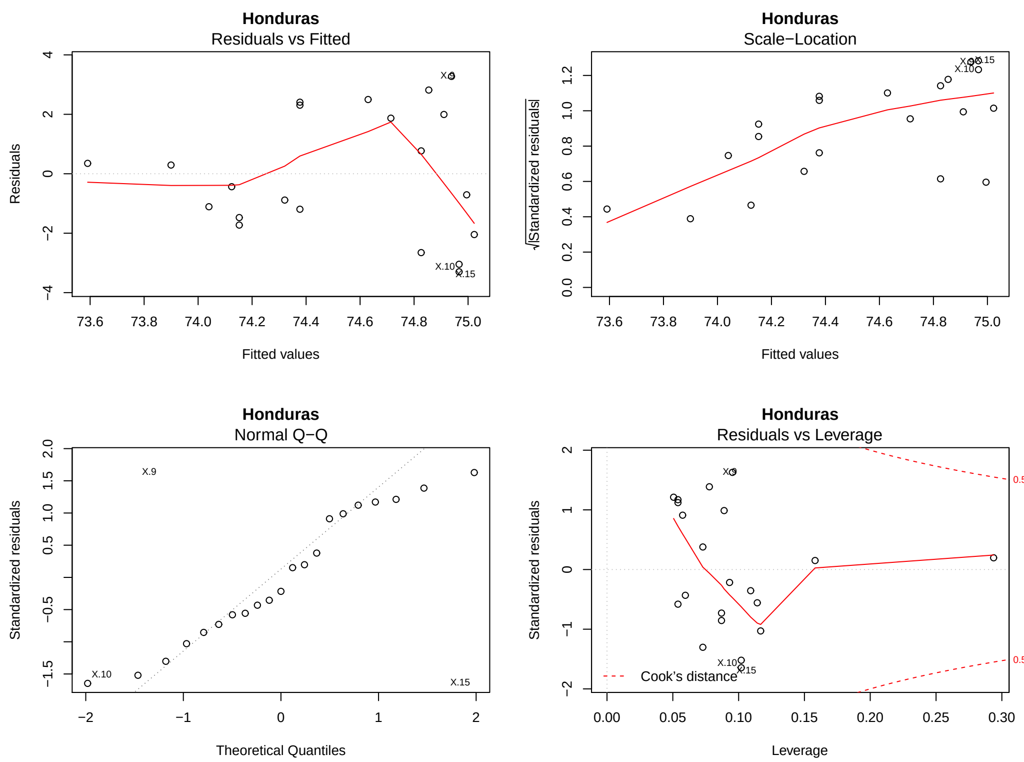
Table 23: Regression results

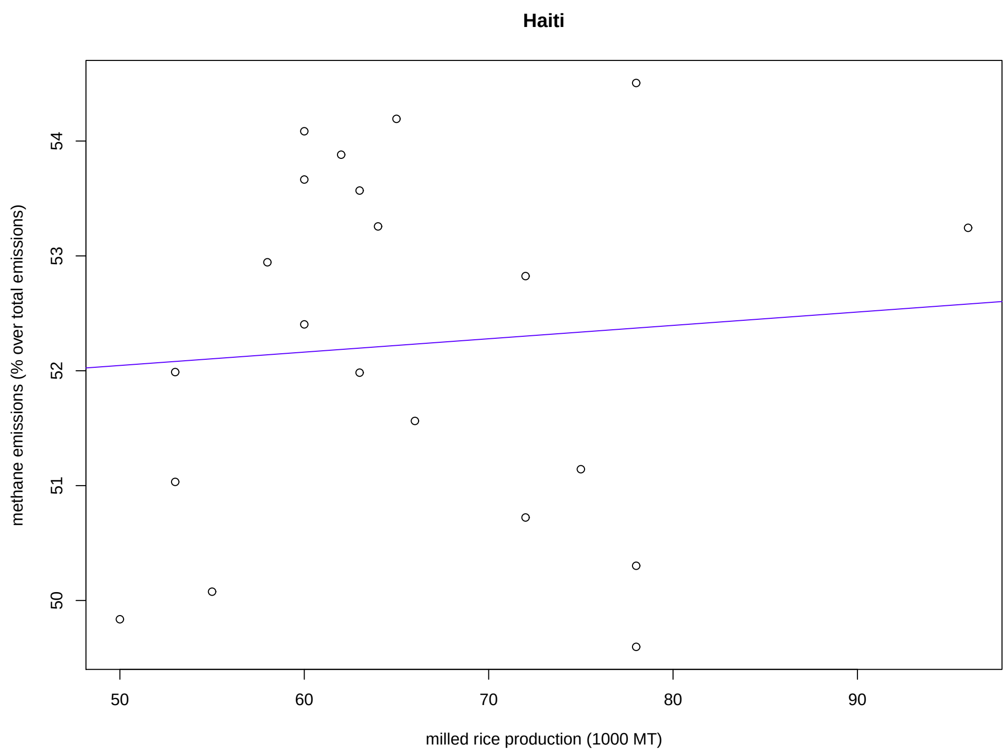

Guatemala
Residuals vs Fitted
Residuals
Fitted values
Guatemala
Scale−Location
√|Standardized residuals|
Fitted values
Guatemala
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Guatemala
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	75.1633	0.8496	88.47	0.0000
h[, j]	-0.0281	0.0315	-0.89	0.3834

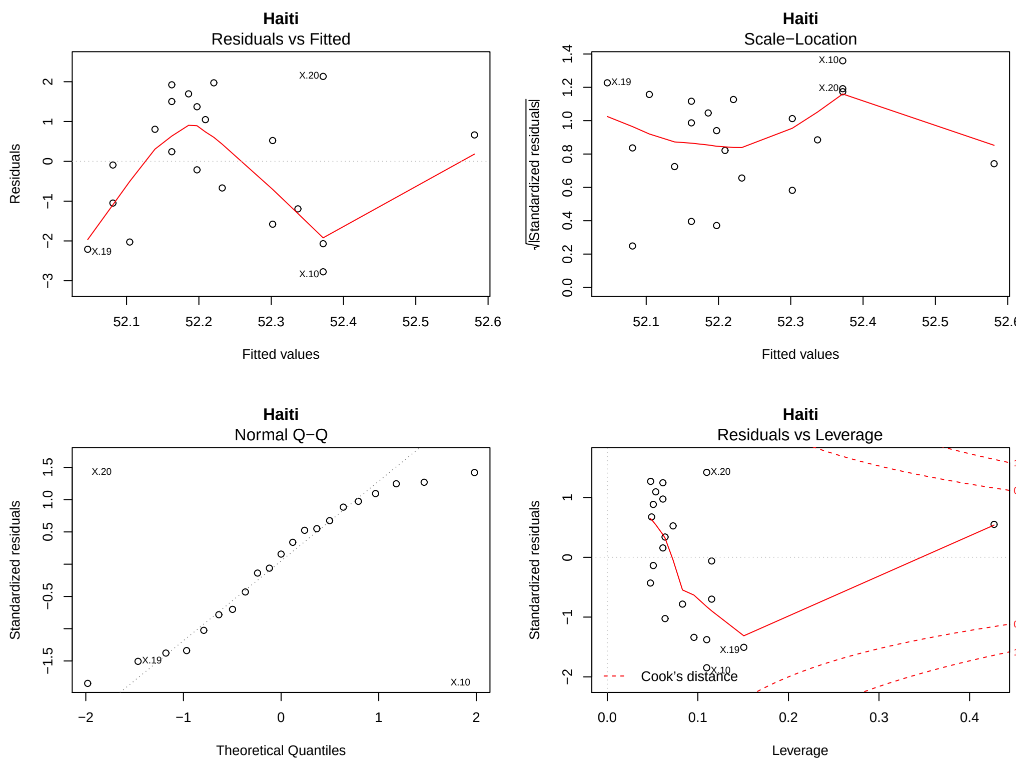
Table 24: Regression results

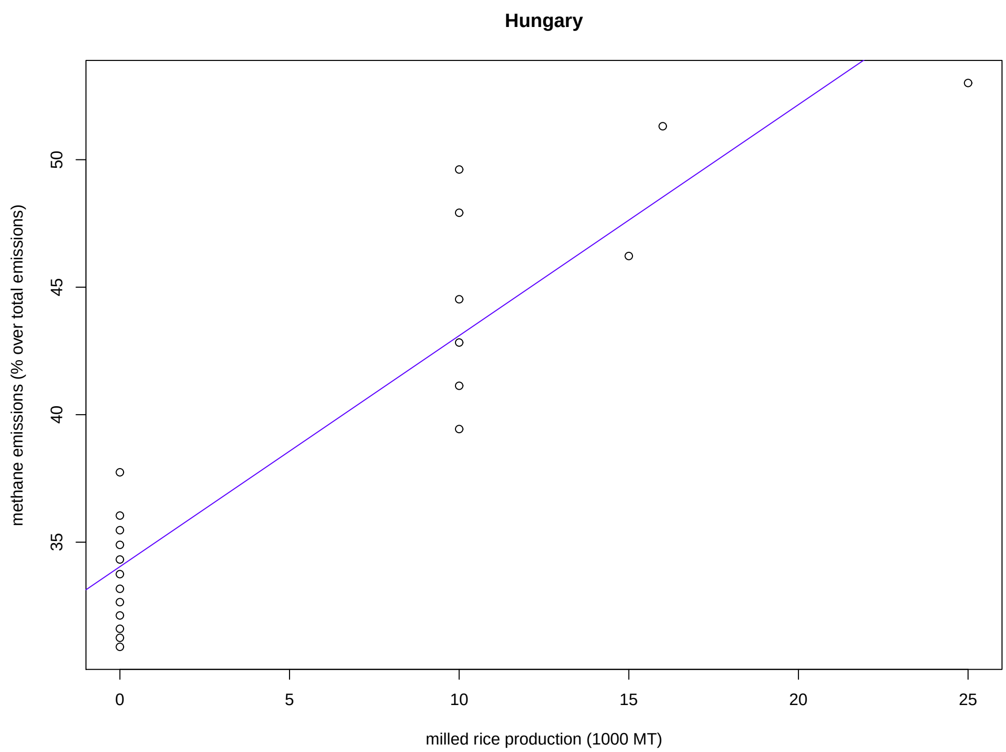

Honduras
Residuals vs Fitted
Residuals
Fitted values
X.9
X.10
X.15
Honduras
Scale−Location
√|Standardized residuals|
Fitted values
Honduras
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.9
X.10
X.15
Honduras
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	51.4646	2.1612	23.81	0.0000
h[, j]	0.0116	0.0324	0.36	0.7239

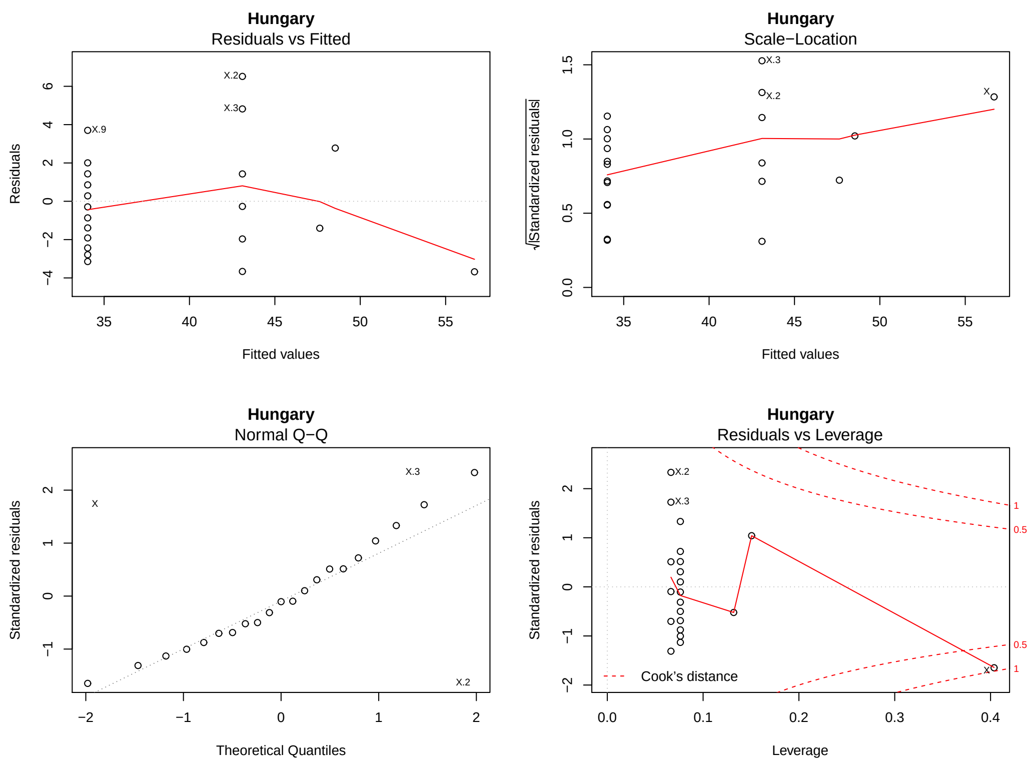
Table 25: Regression results

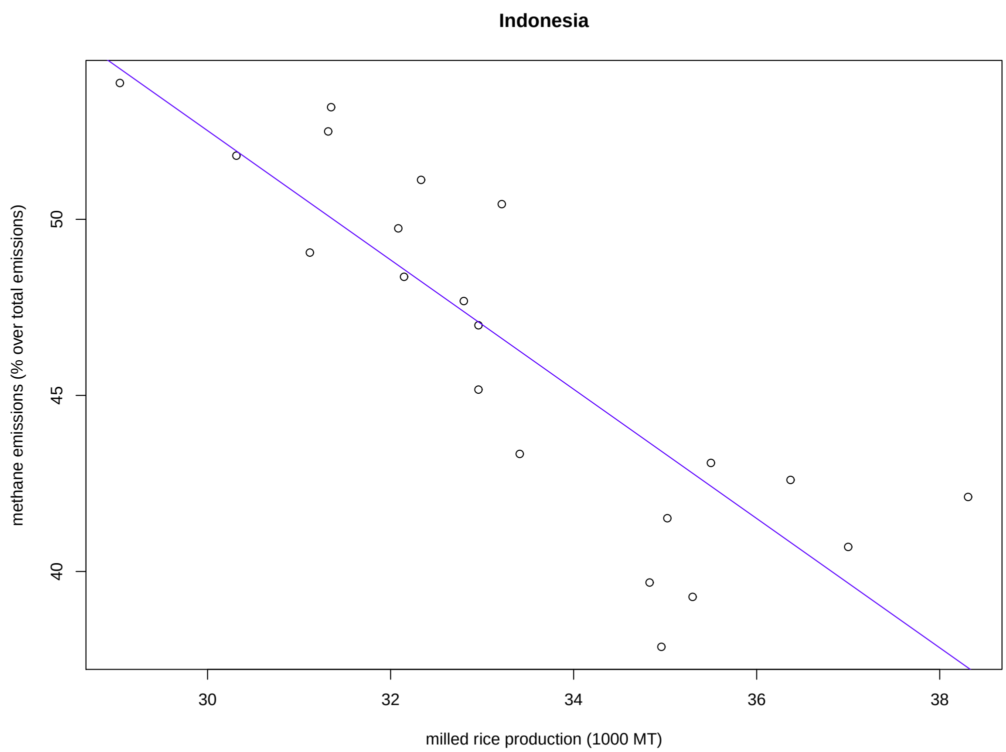

Haiti
Residuals vs Fitted
Residuals
Fitted values
X.20
X.19
X.10
Haiti
Scale−Location
√|Standardized residuals|
Fitted values
X.19
X.10
X.20
Haiti
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20
X.19
X.10
Haiti
Residuals vs Leverage
Standardized residuals
Leverage
X.20
X.19
X.10
Cook's distance
1
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	34.0391	0.7987	42.62	0.0000
h[, j]	0.9060	0.0886	10.22	0.0000

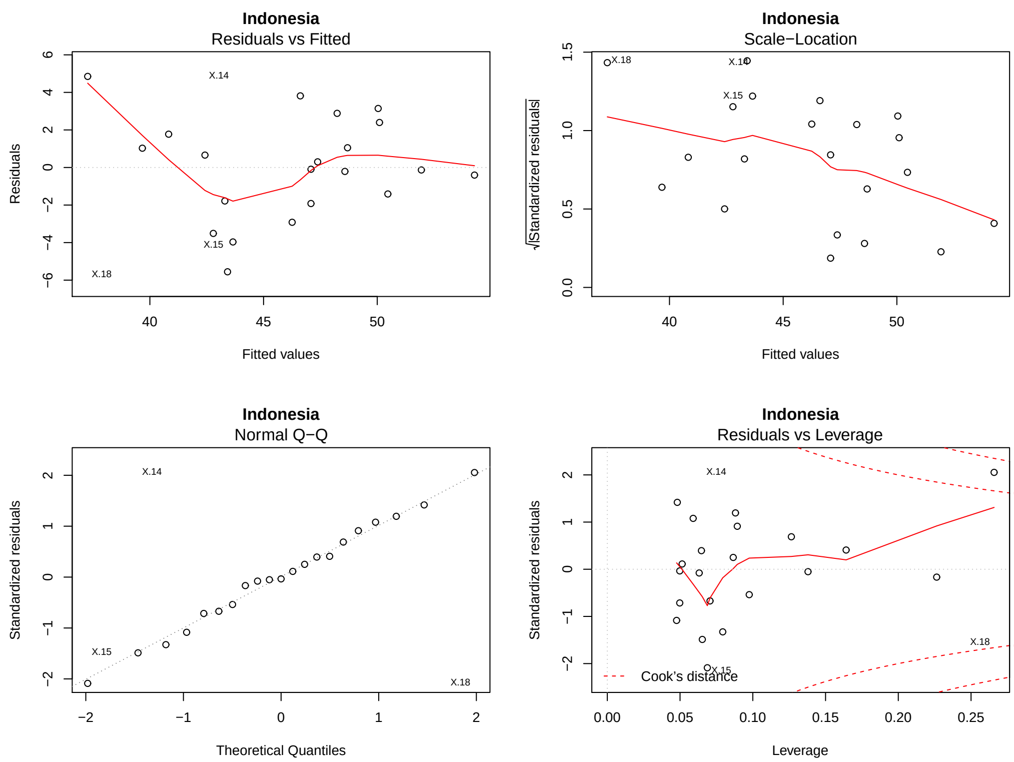
Table 26: Regression results

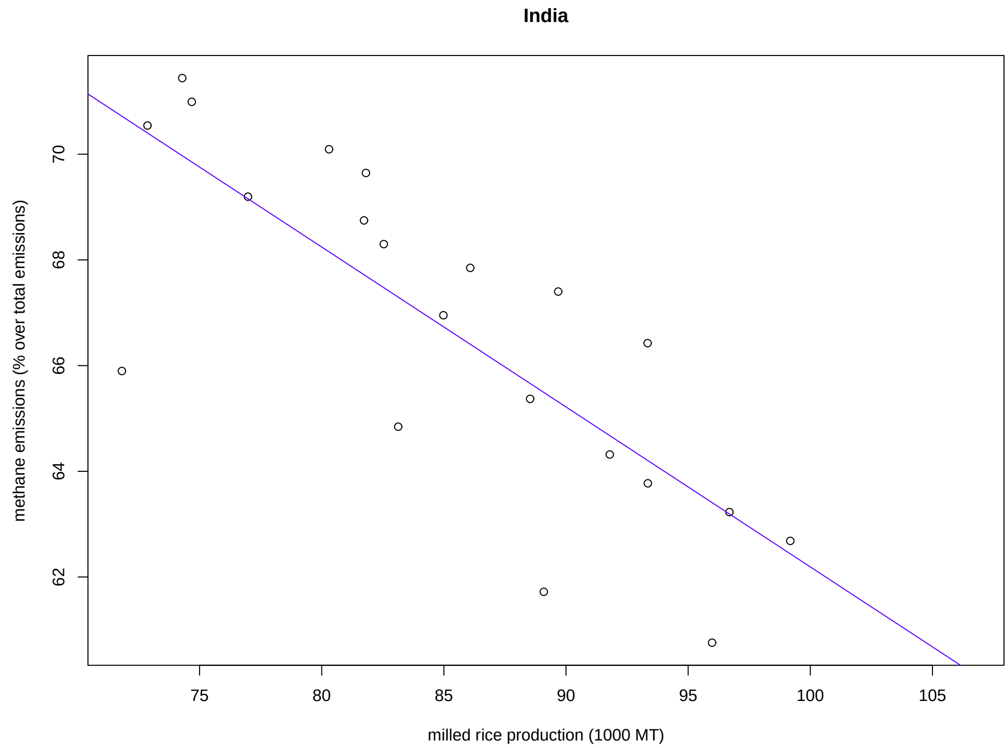

Hungary
Residuals vs Fitted
Residuals
Fitted values
Hungary
Scale−Location
√|Standardized residuals|
Fitted values
Hungary
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Hungary
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	107.5816	8.8736	12.12	0.0000
h[, j]	-1.8355	0.2647	-6.93	0.0000

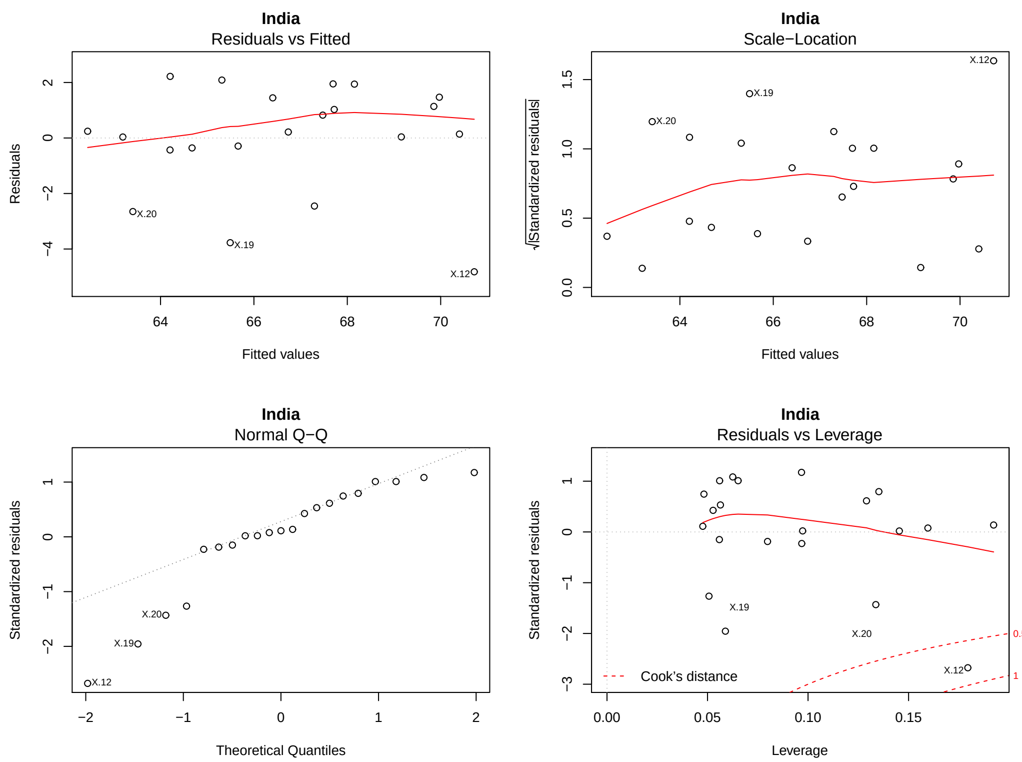
Table 27: Regression results


Indonesia
Residuals vs Fitted
Residuals
Fitted values
X.14
X.15
X.18
Indonesia
Scale−Location
√|Standardized residuals|
Fitted values
X.18
X.14
X.15
Indonesia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.14
X.15
X.18
Indonesia
Residuals vs Leverage
Standardized residuals
Leverage
X.14
X.15
X.18
Cook's distance
1
0.5

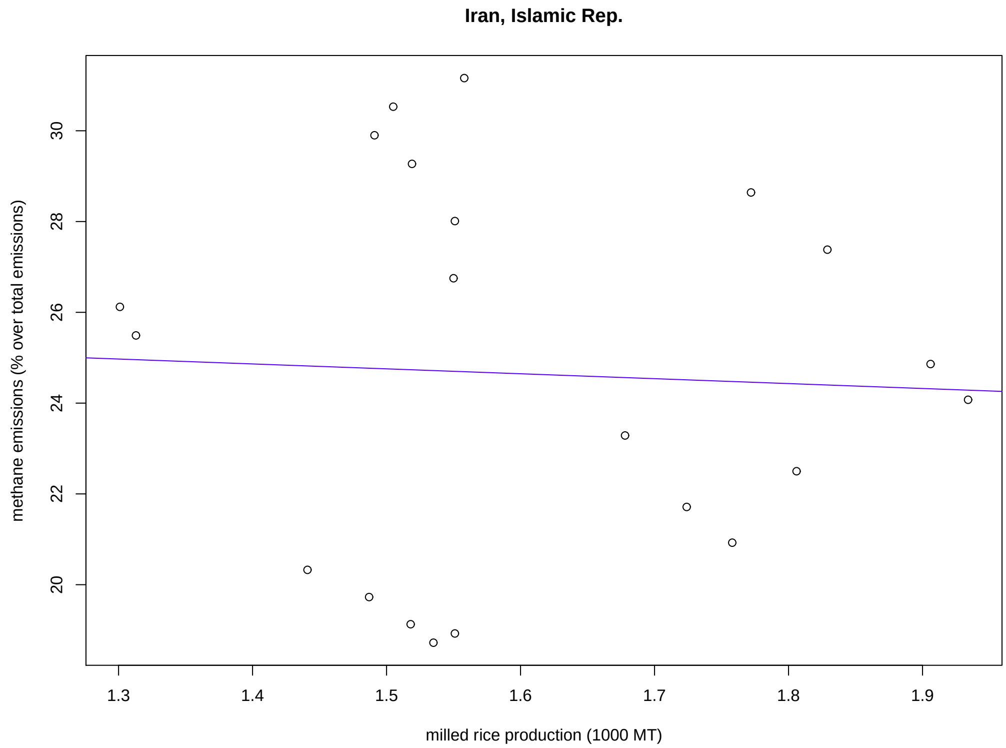


	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	92.4545	4.6248	19.99	0.0000
h[, j]	-0.3026	0.0541	-5.60	0.0000

Table 28: Regression results

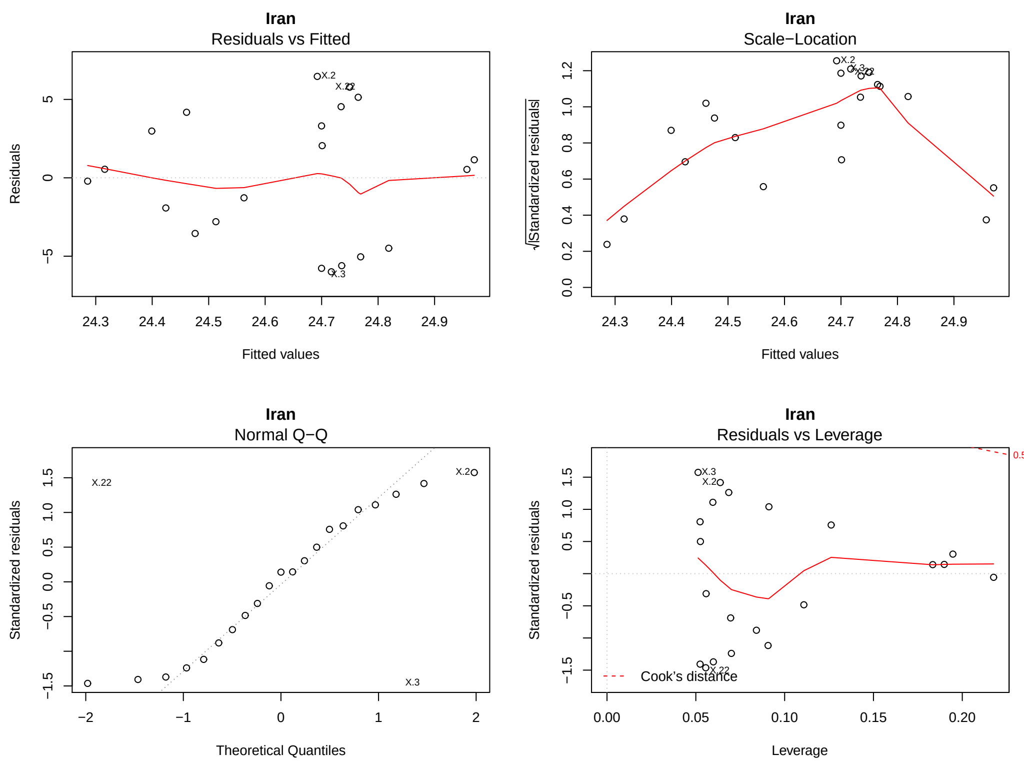


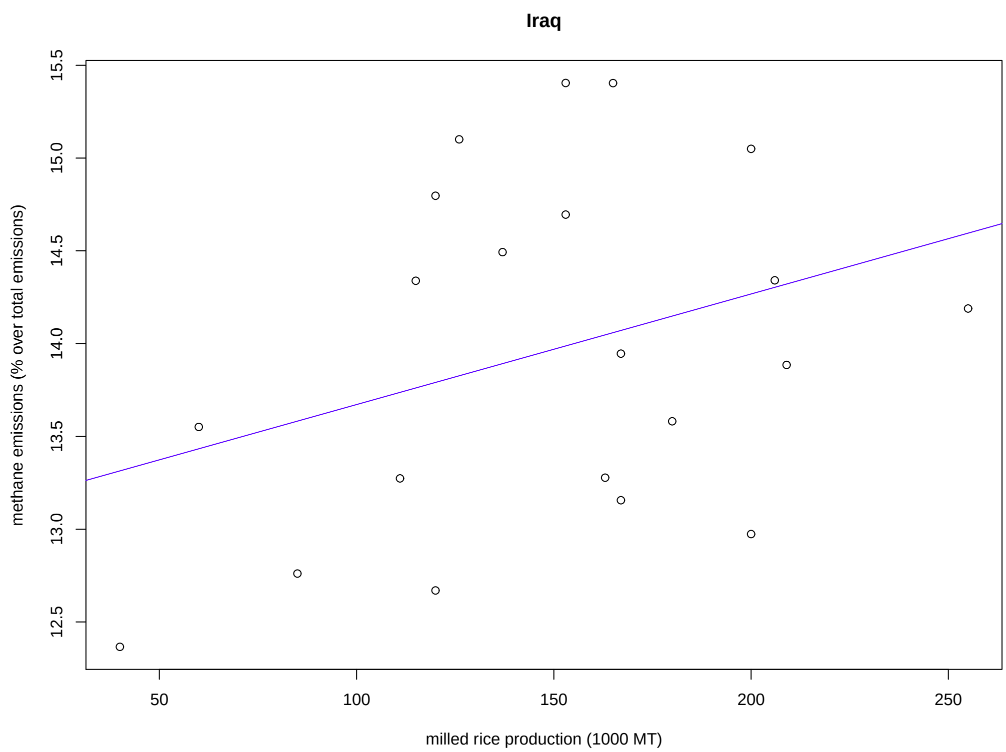
India
Residuals vs Fitted
Residuals
Fitted values
X.20
X.19
X.12
India
Scale−Location
√|Standardized residuals|
Fitted values
X.12
X.19
X.20
India
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20
X.19
X.12
India
Residuals vs Leverage
Standardized residuals
Leverage
X.19
X.20
X.12
Cook's distance
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	26.3773	8.5632	3.08	0.0062
h[, j]	-1.0815	5.3010	-0.20	0.8405

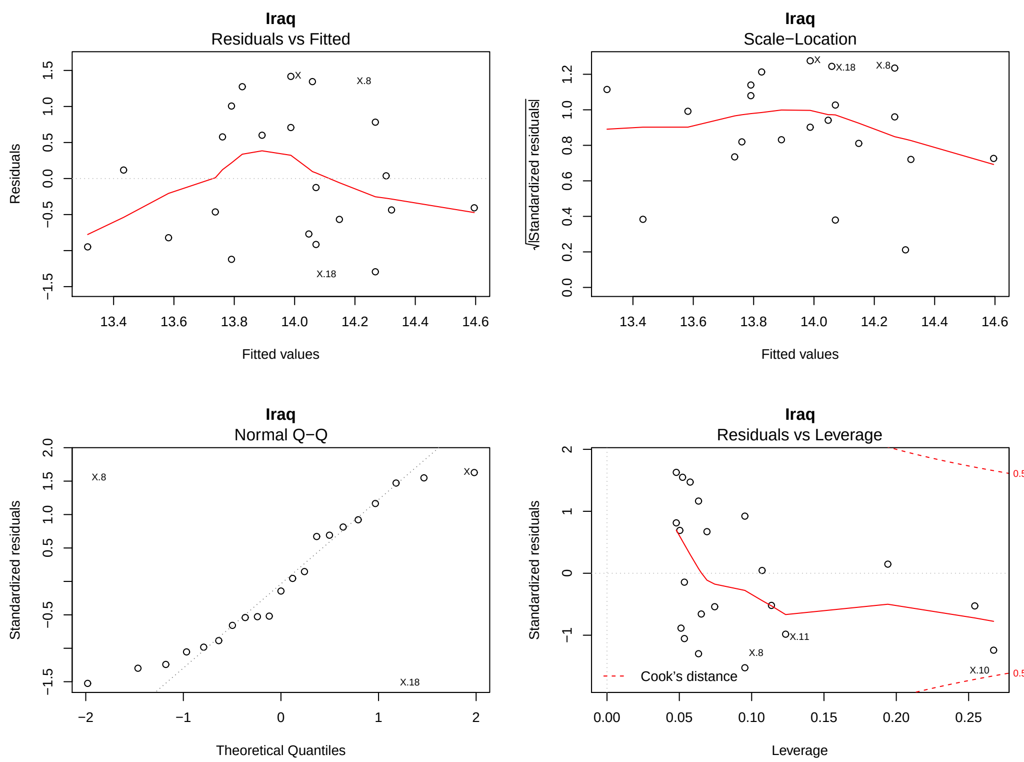
Table 29: Regression results


Iran
Residuals vs Fitted
Residuals
Fitted values
X.2
X.22
X.3
Iran
Scale−Location
√|Standardized residuals|
Fitted values
X.2
X.3
X.22
Iran
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.22
X.2
X.3
Iran
Residuals vs Leverage
Standardized residuals
Leverage
X.3
X.2
X.22
Cook's distance
0.5

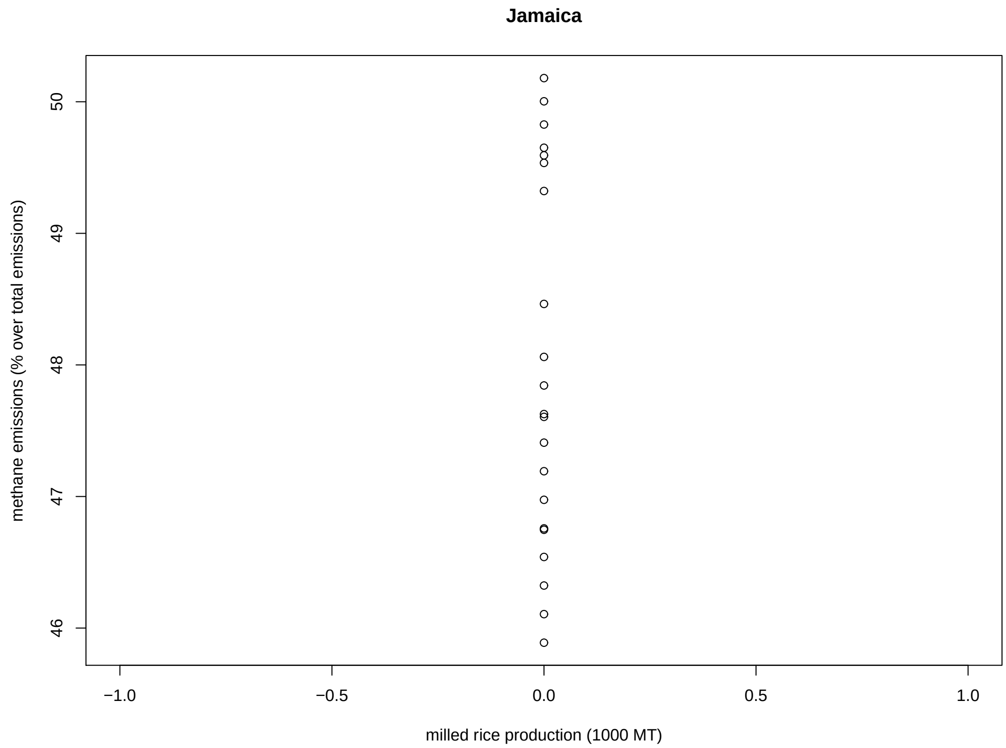


	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	13.0756	0.6036	21.66	0.0000
h[, j]	0.0060	0.0038	1.56	0.1362

Table 30: Regression results

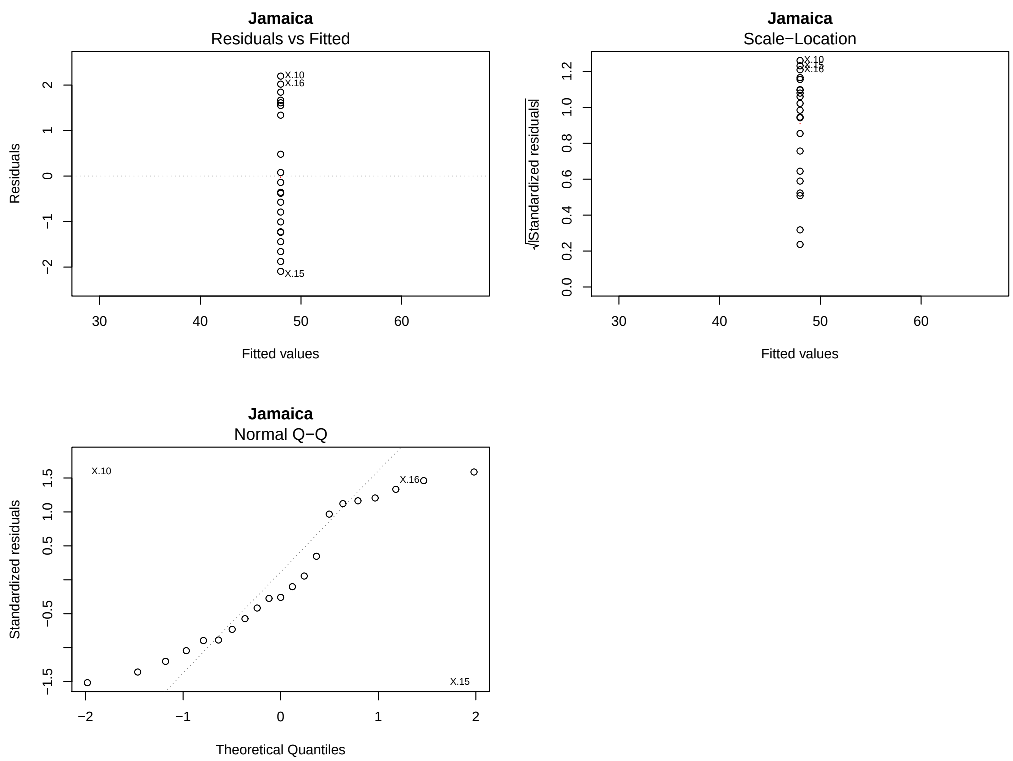


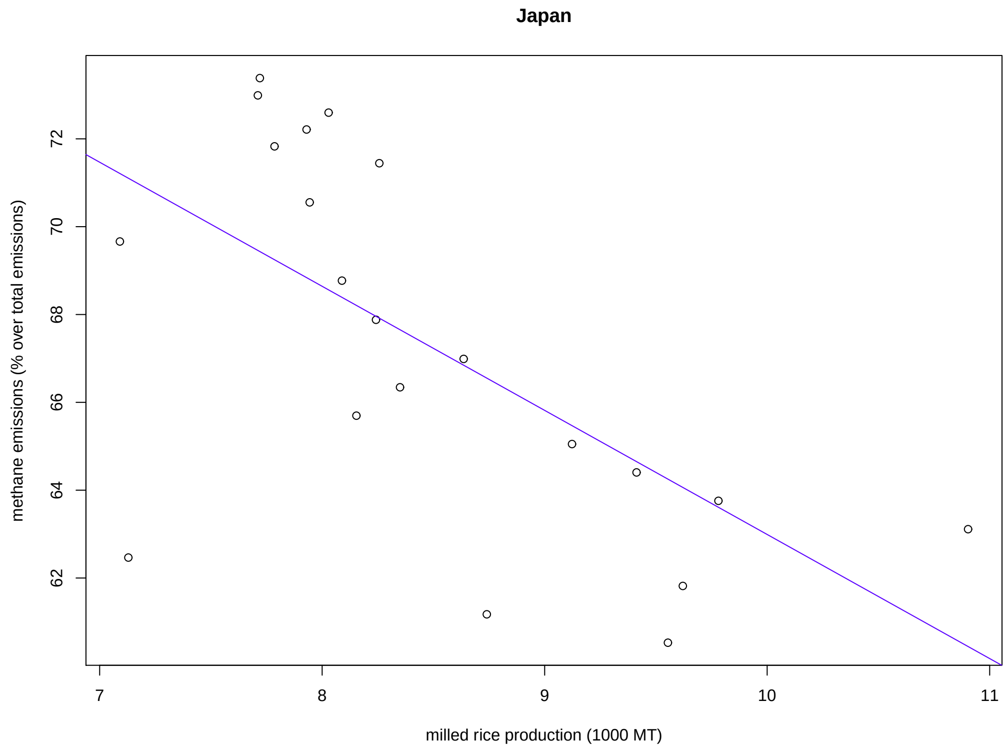
Iraq
Residuals vs Fitted
Residuals
Fitted values
Iraq
Scale−Location
√|Standardized residuals|
Fitted values
Iraq
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Iraq
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	47.9834	0.3092	155.19	0.0000

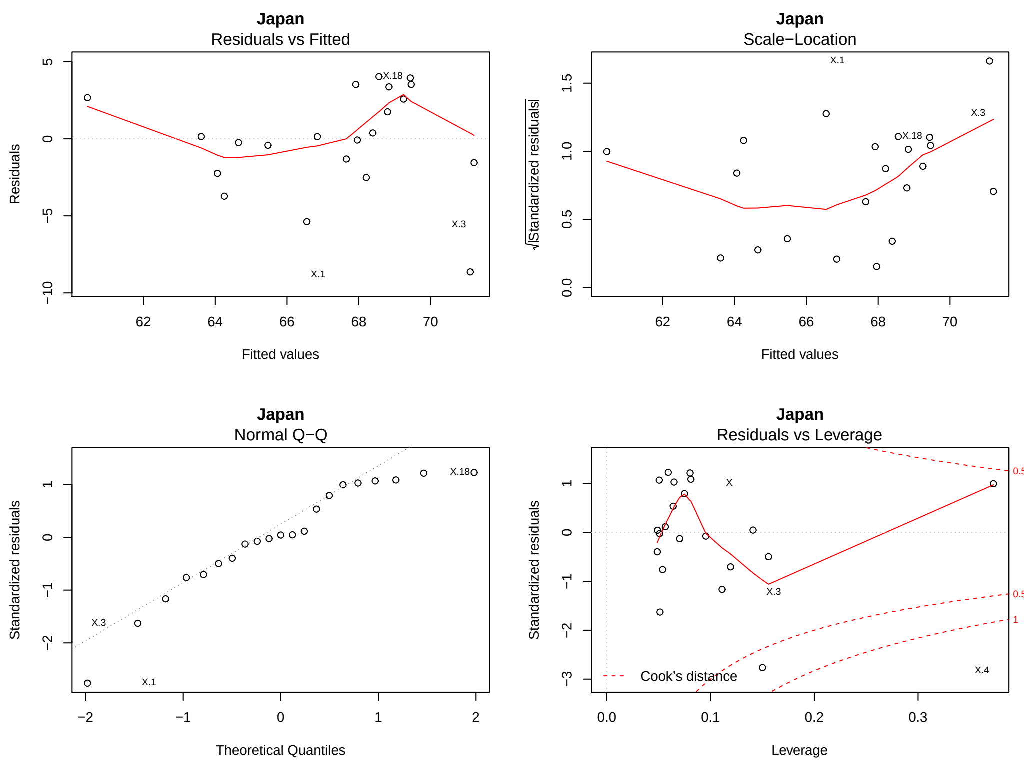
Table 31: Regression results

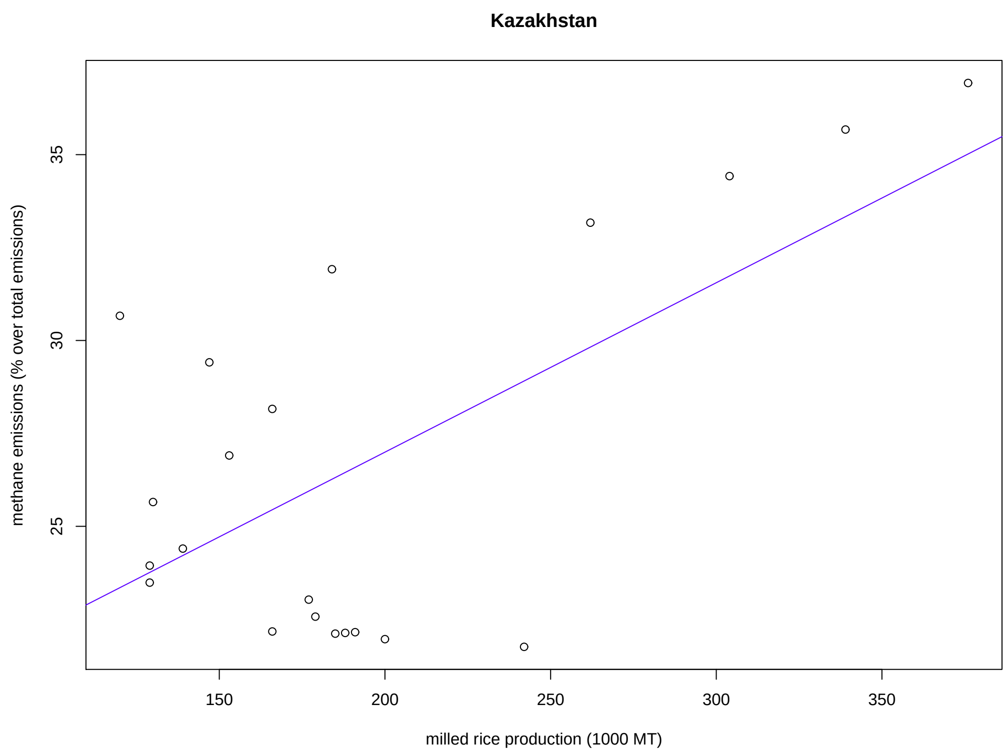

Jamaica
Residuals vs Fitted
Residuals
Fitted values
X.10
X.16
X.15
Jamaica
Scale−Location
√|Standardized residuals|
Fitted values
X.10
X.16
Jamaica
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.10
X.16
X.15



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	91.2456	6.8253	13.37	0.0000
h[, j]	-2.8254	0.7996	-3.53	0.0022

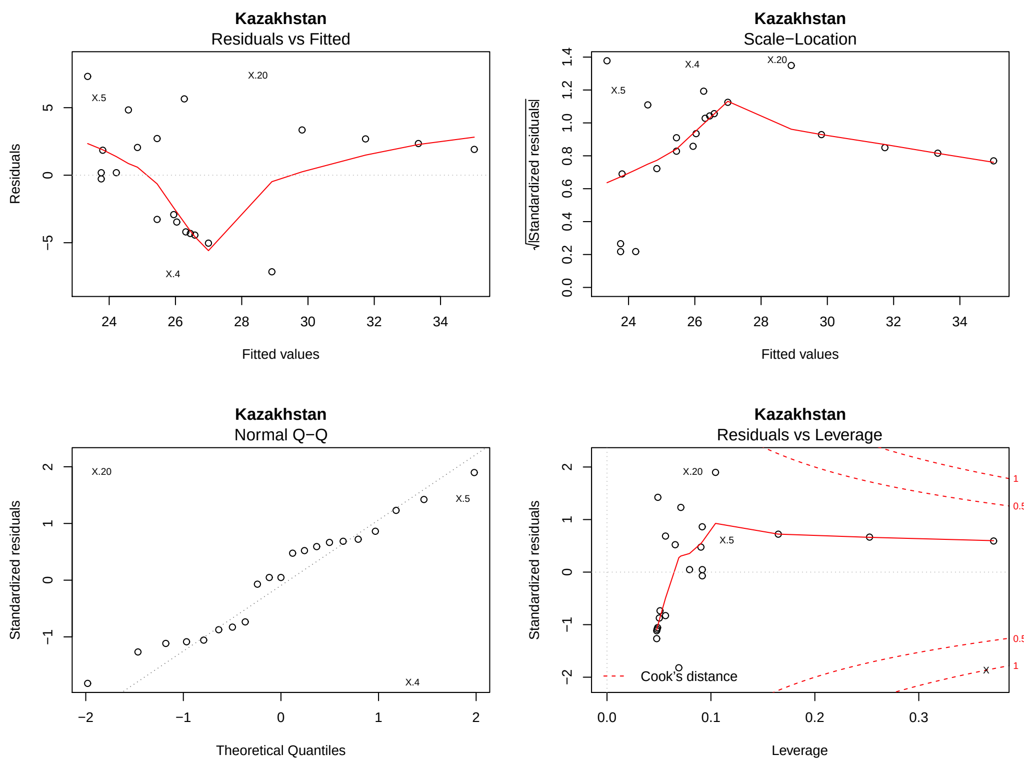
Table 32: Regression results

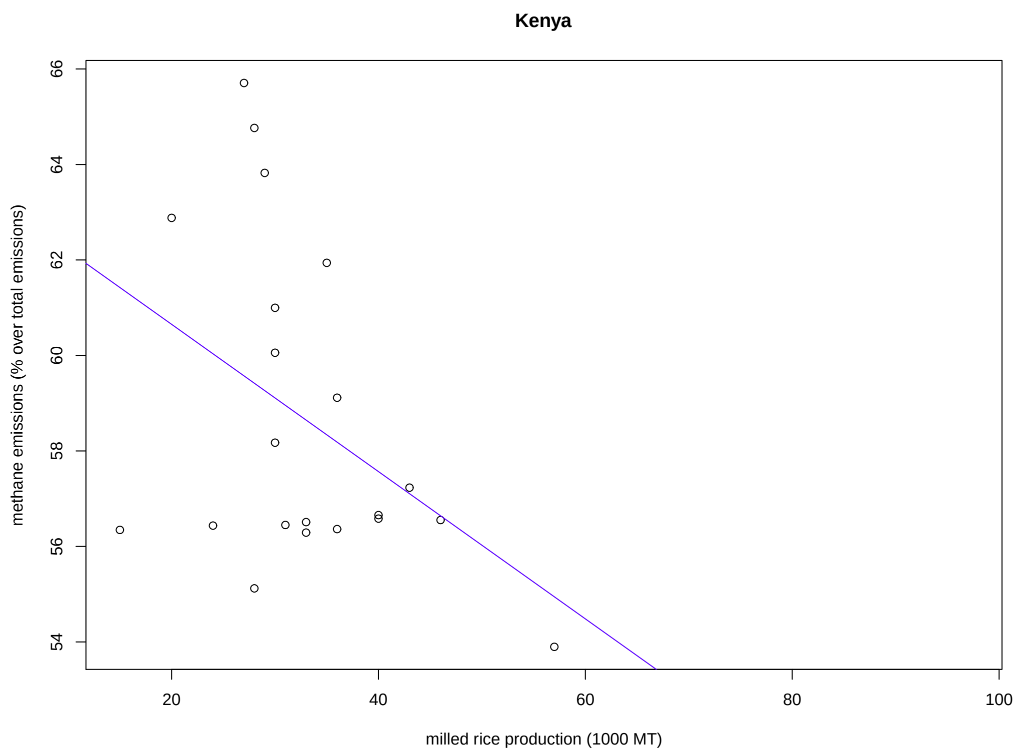

Japan
Residuals vs Fitted
Residuals
Fitted values
X.18
X.3
X.1
Japan
Scale−Location
√|Standardized residuals|
Fitted values
X.1
X.18
X.3
Japan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.18
X.3
X.1
Japan
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X
X.3
X.4
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	17.8800	2.6657	6.71	0.0000
h[, j]	0.0456	0.0129	3.55	0.0022

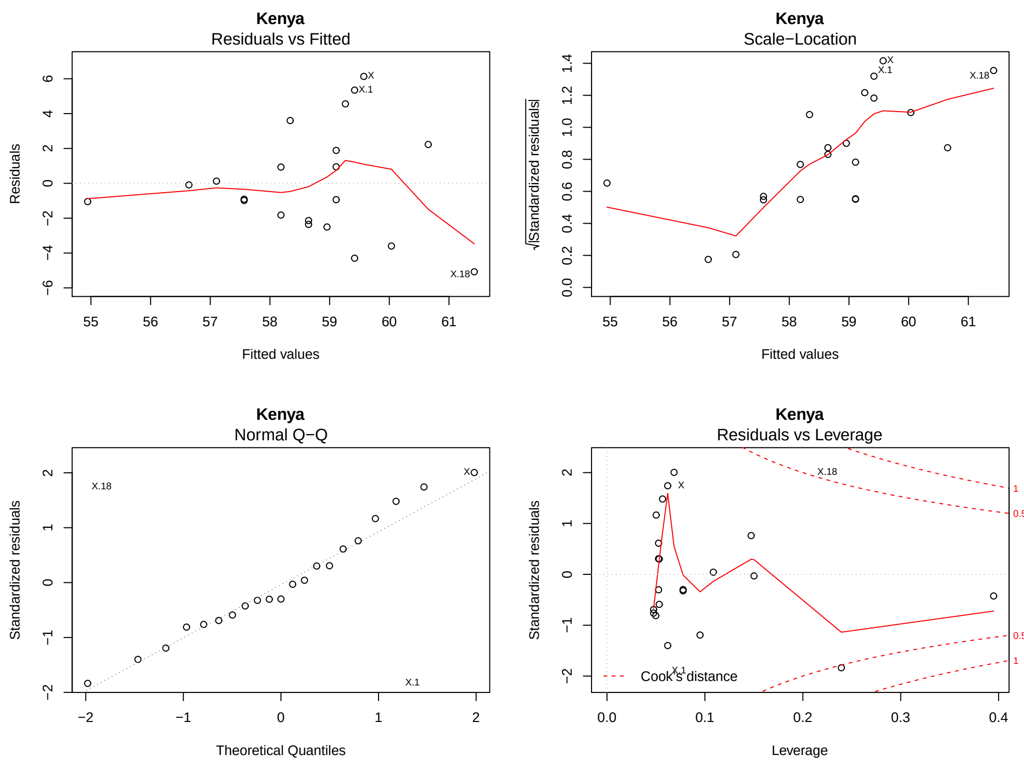
Table 33: Regression results

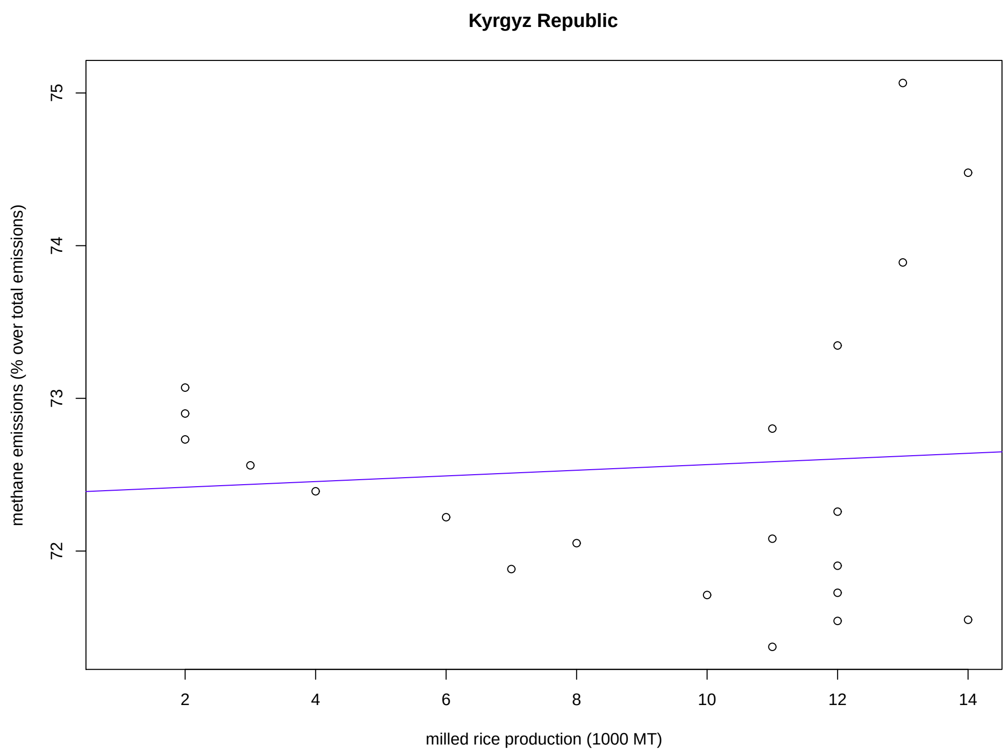

Kazakhstan
Residuals vs Fitted
Residuals
Fitted values
Kazakhstan
Scale−Location
√|Standardized residuals|
Fitted values
Kazakhstan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Kazakhstan
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	63.7366	2.6437	24.11	0.0000
h[, j]	-0.1542	0.0775	-1.99	0.0613

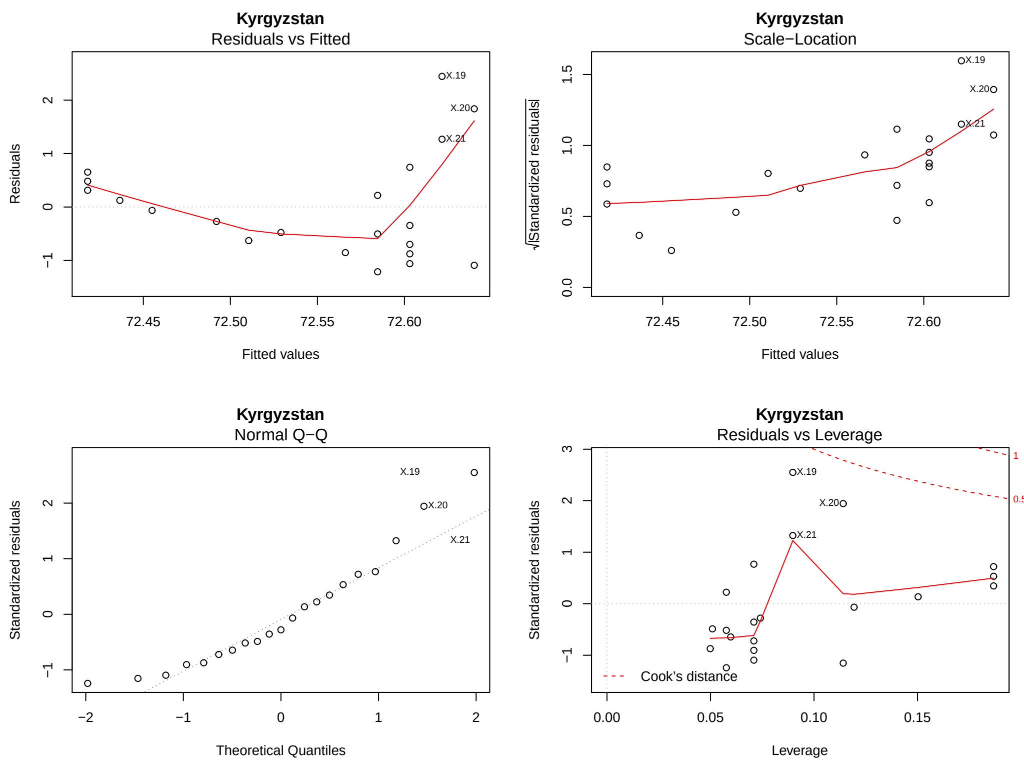
Table 34: Regression results

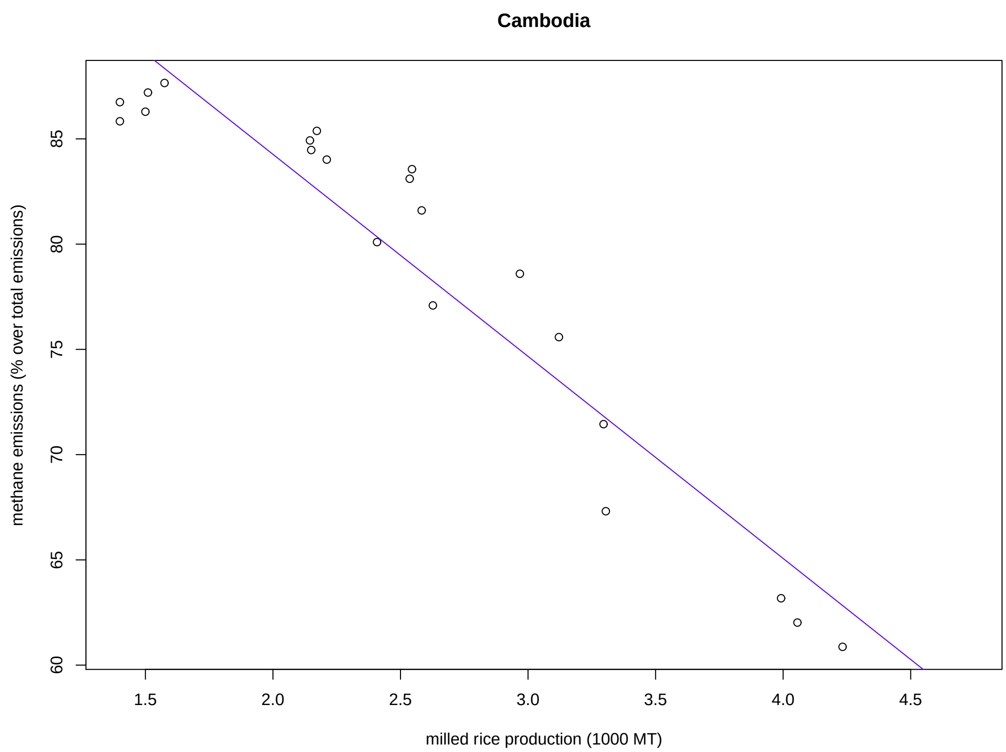

Kenya
Residuals vs Fitted
Residuals
Fitted values
Kenya
Scale−Location
√|Standardized residuals|
Fitted values
Kenya
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Kenya
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	72.3810	0.5280	137.08	0.0000
h[, j]	0.0185	0.0528	0.35	0.7298

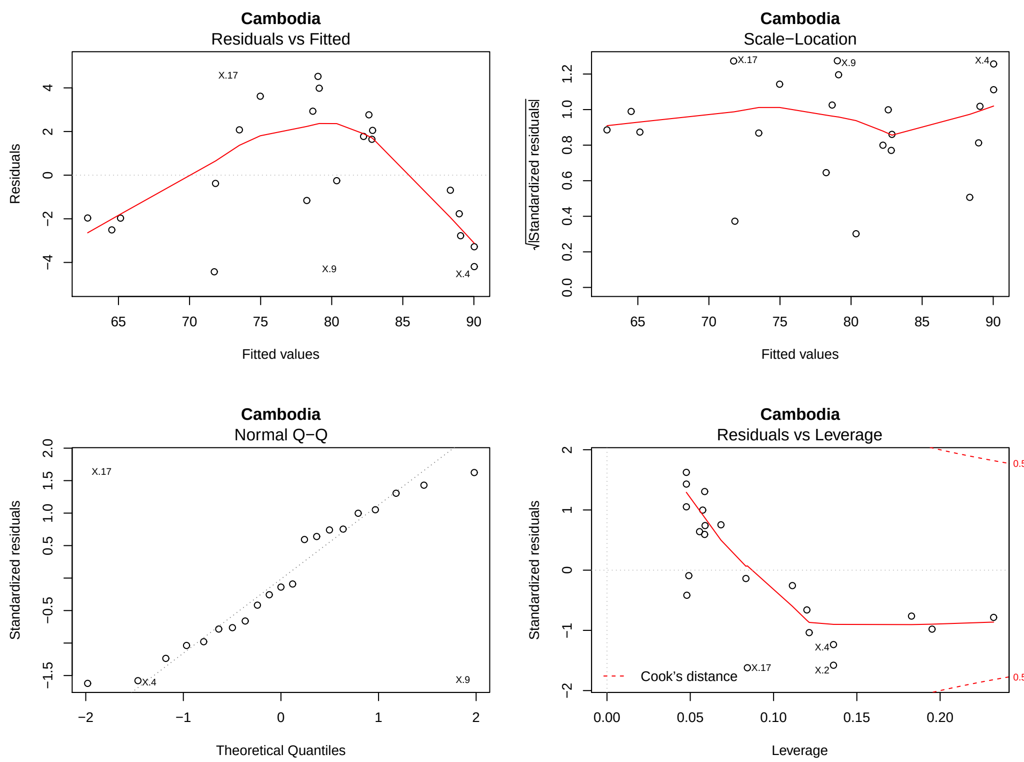
Table 35: Regression results

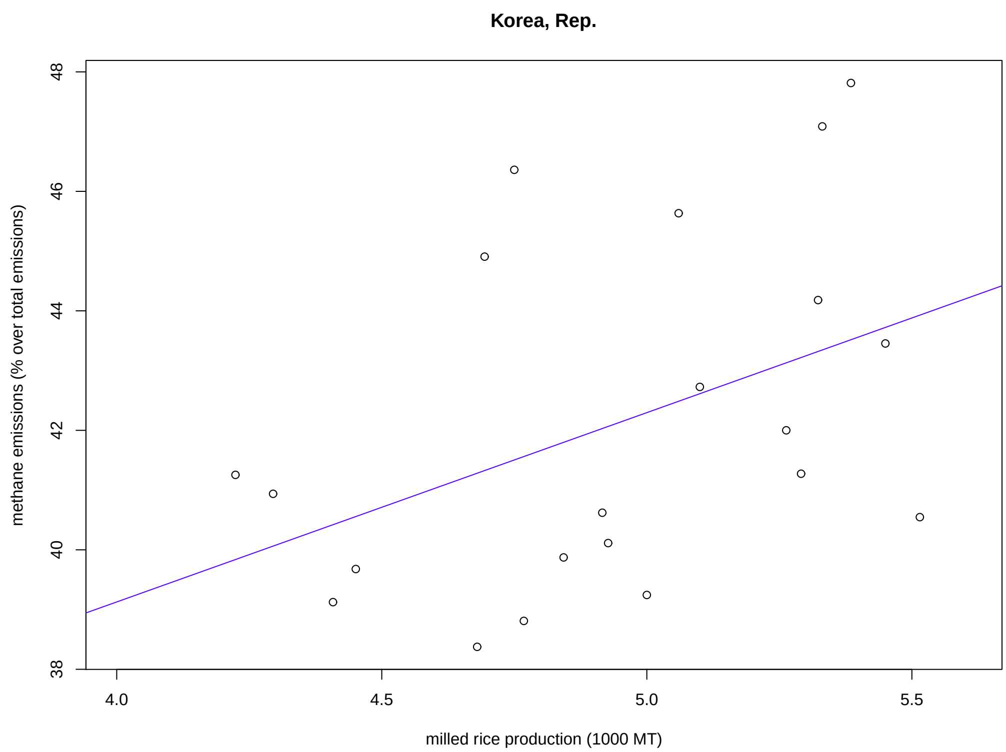

Kyrgyzstan
Residuals vs Fitted
Residuals
Fitted values
X.19
X.20
X.21
Kyrgyzstan
Scale−Location
√|Standardized residuals|
Fitted values
X.19
X.20
X.21
Kyrgyzstan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.19
X.20
X.21
Kyrgyzstan
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.19
X.20
X.21
1
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	103.4652	1.9749	52.39	0.0000
h[, j]	-9.5993	0.7324	-13.11	0.0000

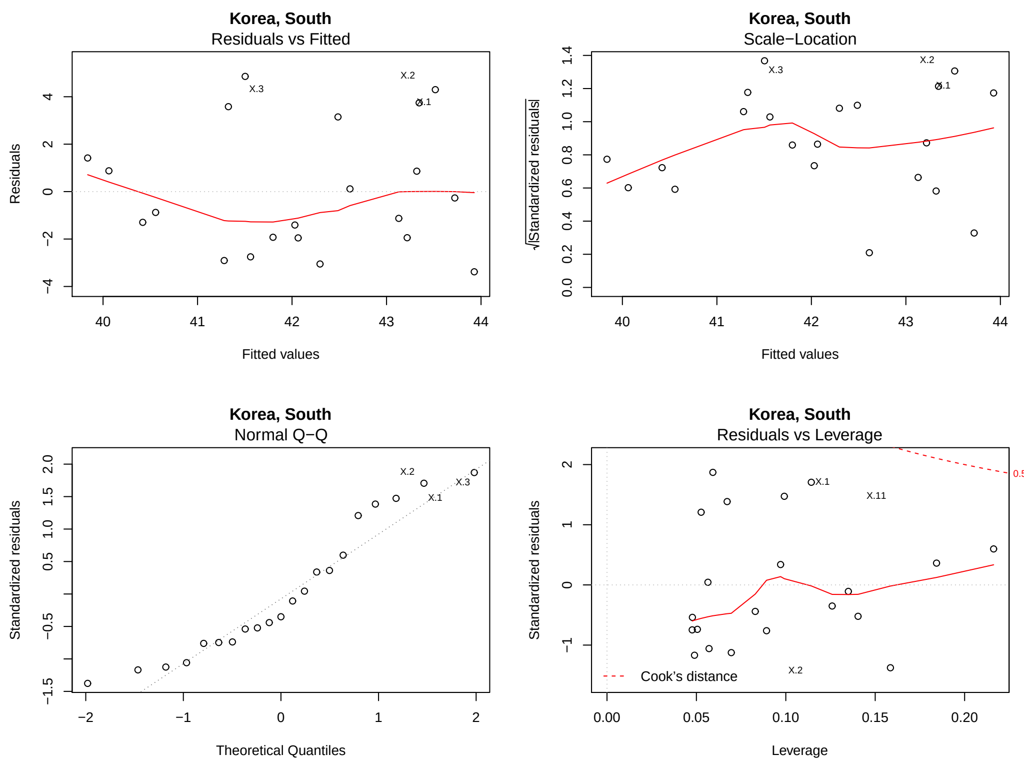
Table 36: Regression results

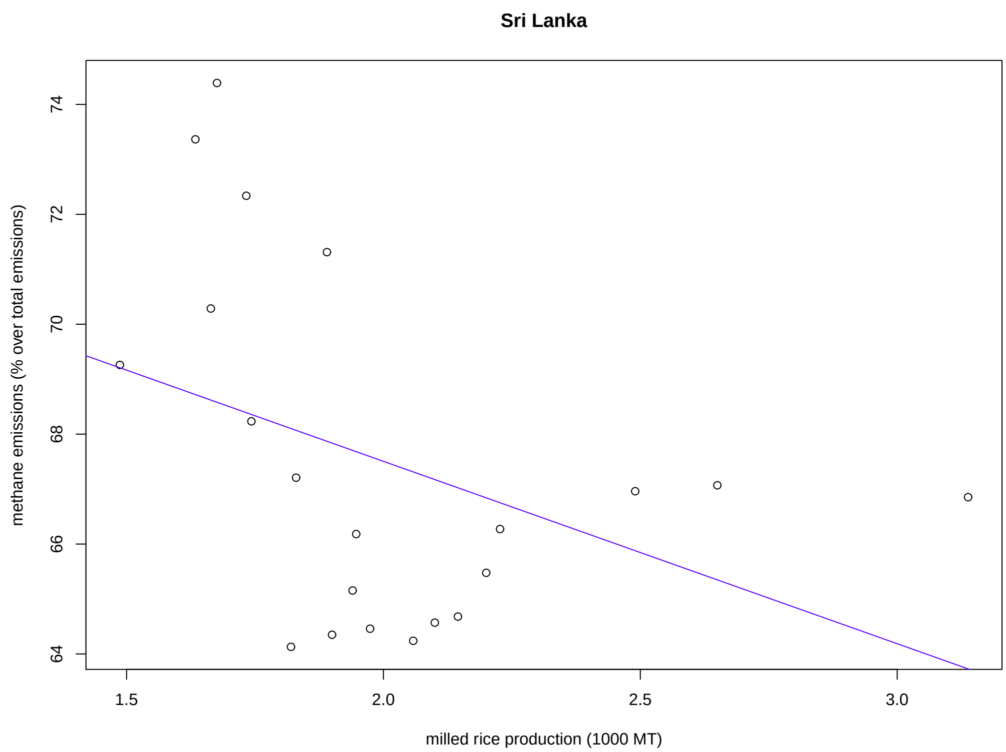

Cambodia
Residuals vs Fitted
Residuals
Fitted values
Cambodia
Scale−Location
√|Standardized residuals|
Fitted values
Cambodia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Cambodia
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	26.4512	7.6351	3.46	0.0026
h[, j]	3.1690	1.5420	2.06	0.0539

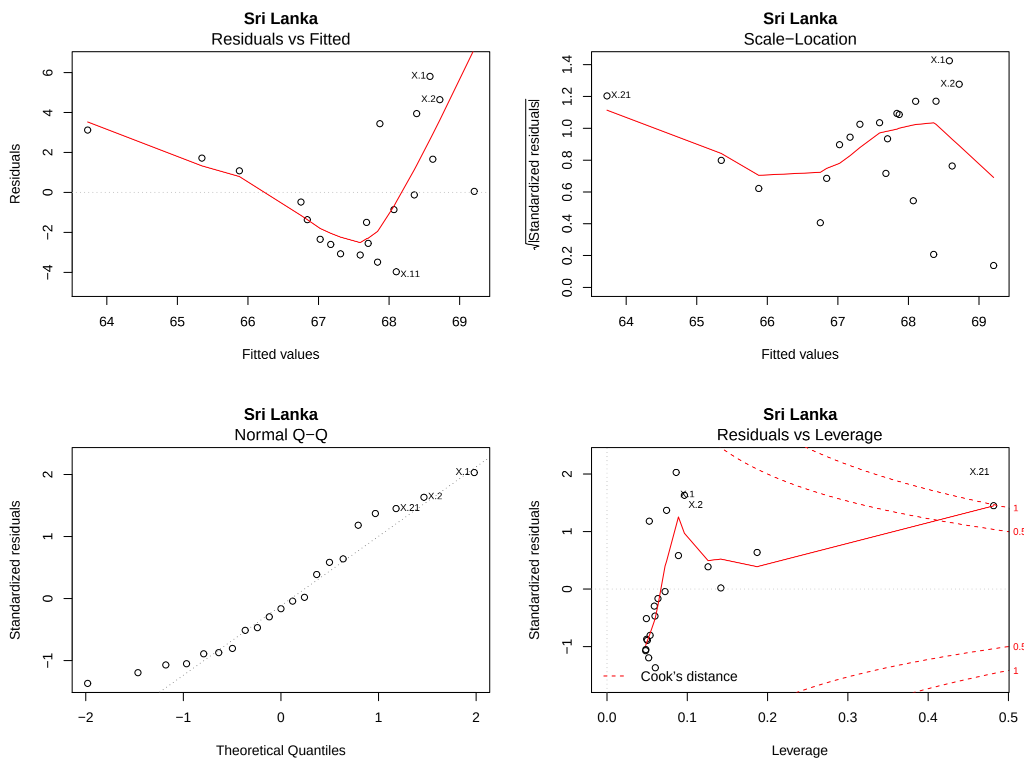
Table 37: Regression results

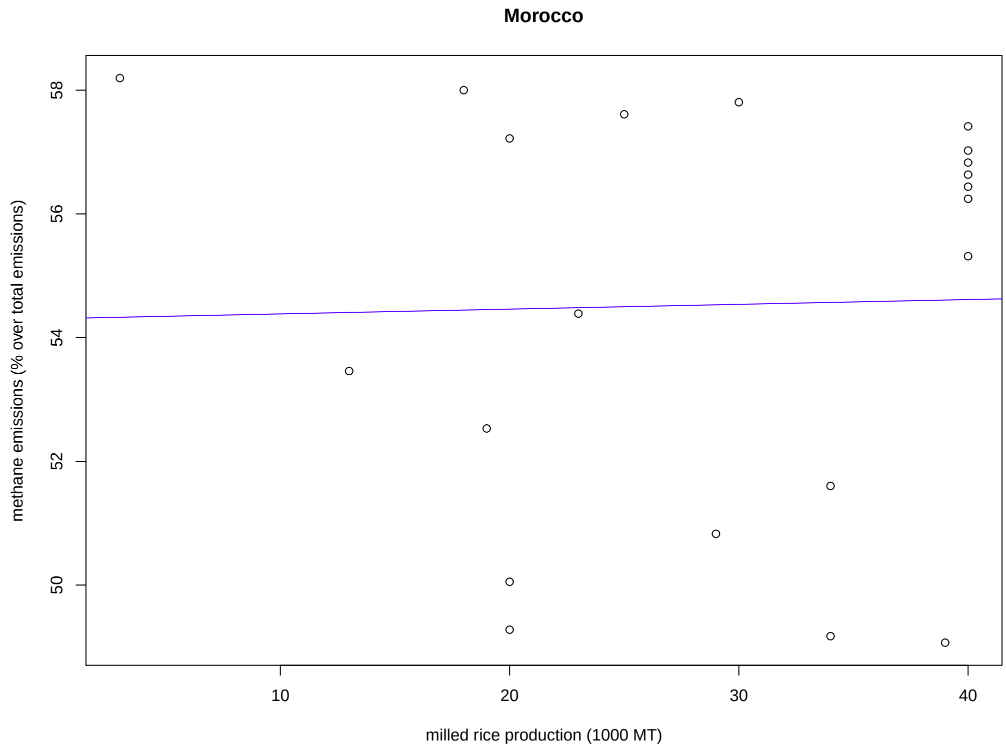

Korea, South
Residuals vs Fitted
Residuals
Fitted values
Korea, South
Scale−Location
√|Standardized residuals|
Fitted values
Korea, South
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Korea, South
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	74.1418	3.5846	20.68	0.0000
h[, j]	-3.3186	1.7520	-1.89	0.0735

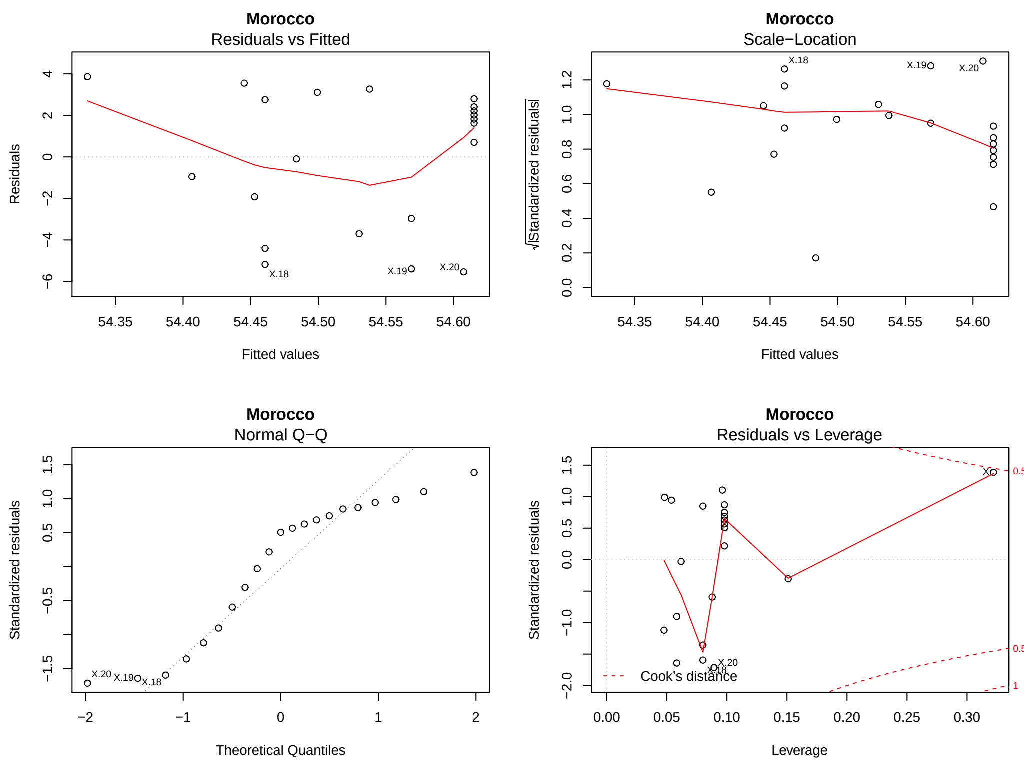
Table 38: Regression results

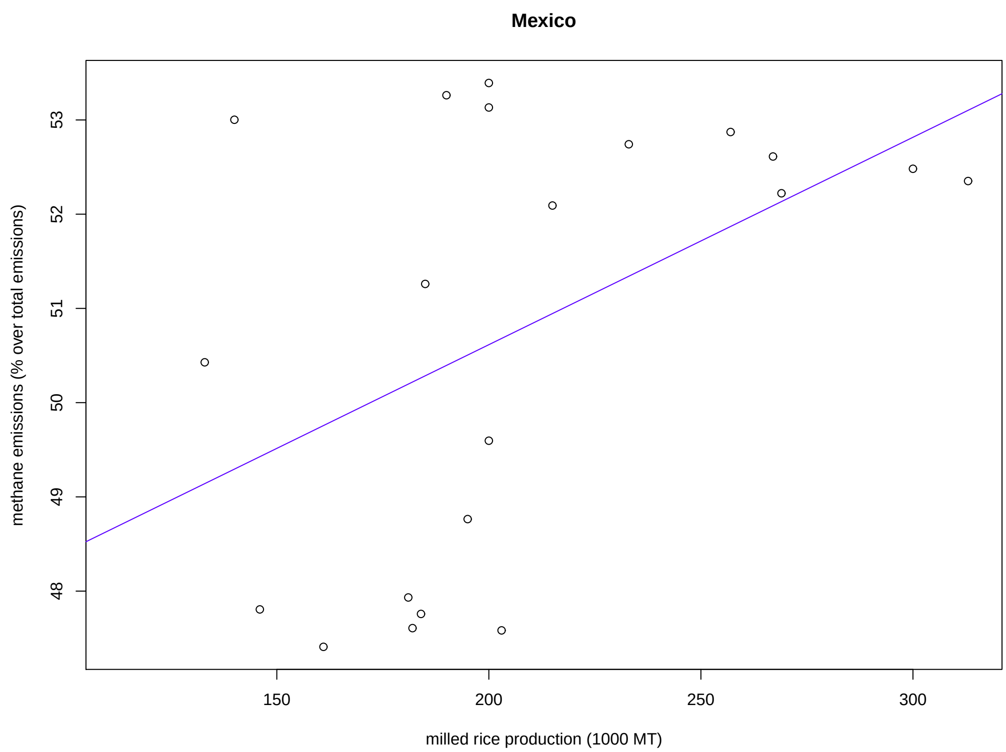

Sri Lanka
Residuals vs Fitted
Residuals
Fitted values
X.1
X.2
X.11
Sri Lanka
Scale−Location
√|Standardized residuals|
Fitted values
X.21
X.1
X.2
Sri Lanka
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.1
X.2
X.21
Sri Lanka
Residuals vs Leverage
Standardized residuals
Leverage
X.21
X.2
Cook's distance
1
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	54.3061	2.1123	25.71	0.0000
h[, j]	0.0077	0.0685	0.11	0.9113

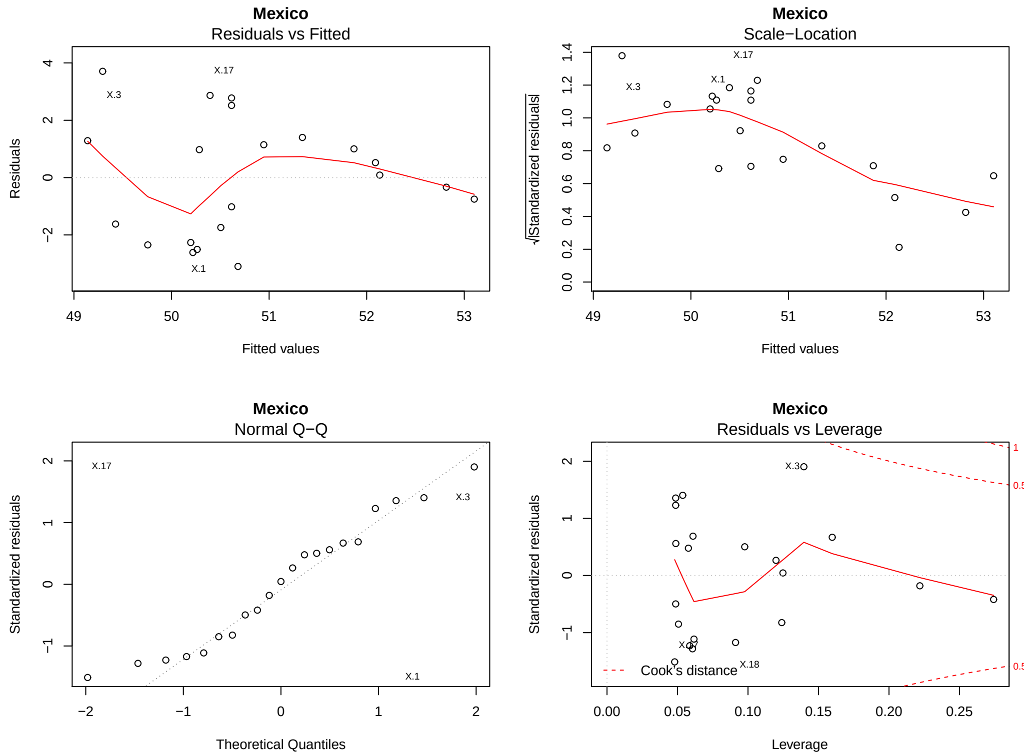
Table 39: Regression results

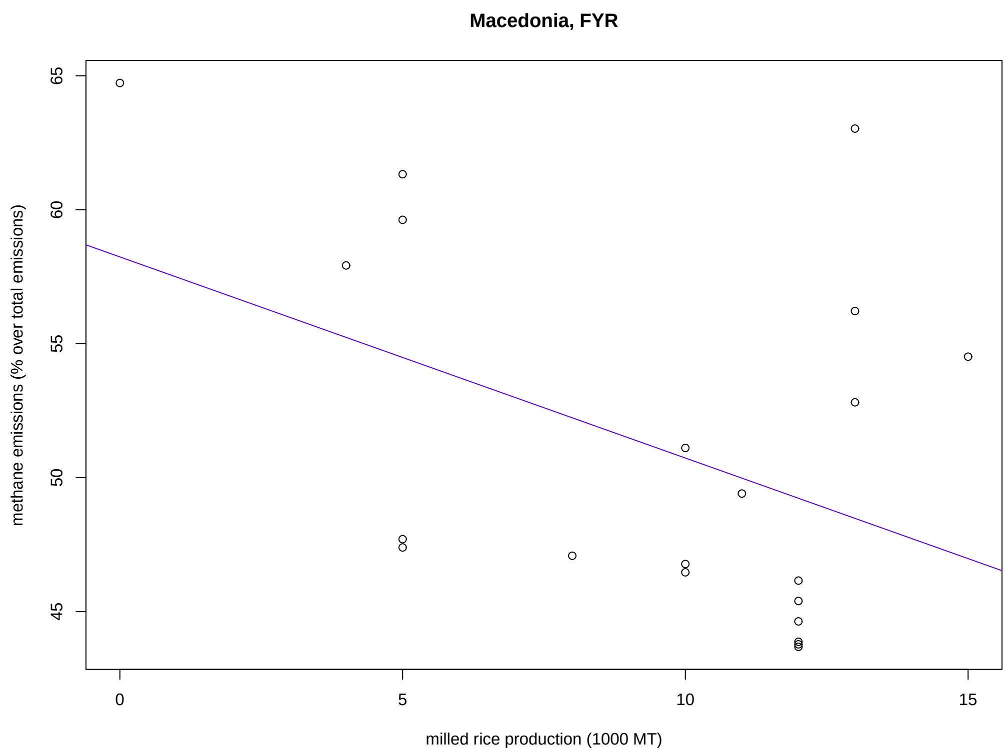

Morocco
Residuals vs Fitted
Residuals
Fitted values
Morocco
Scale−Location
√|Standardized residuals|
Fitted values
Morocco
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Morocco
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	46.2129	2.0155	22.93	0.0000
h[, j]	0.0220	0.0095	2.33	0.0313

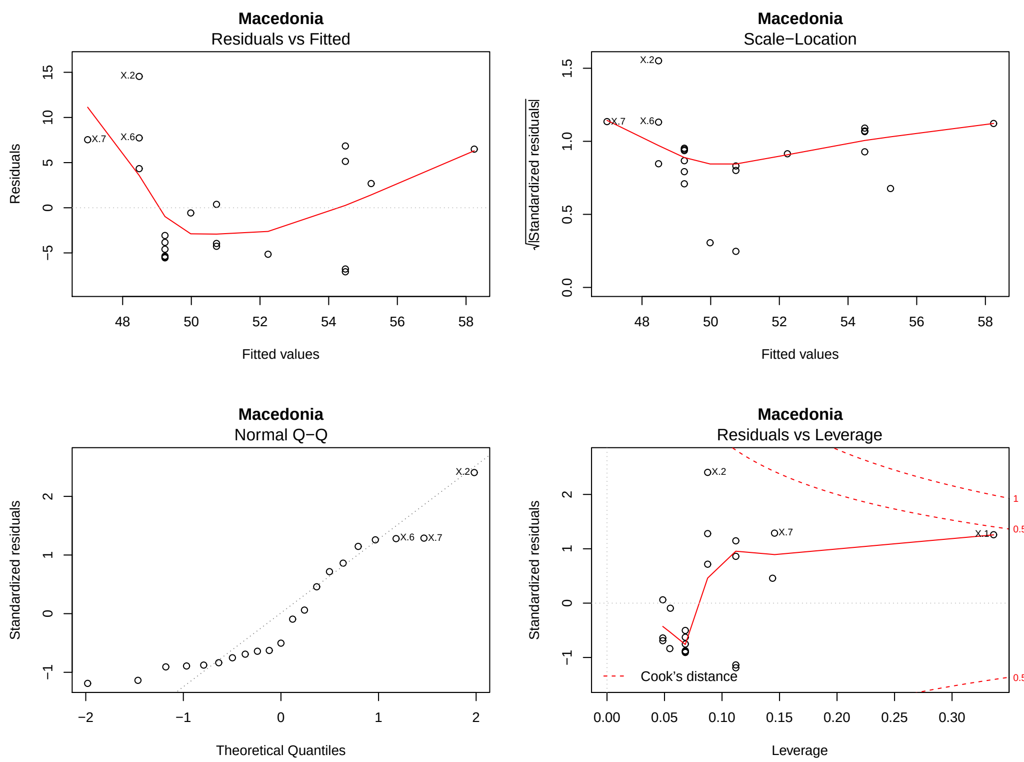
Table 40: Regression results

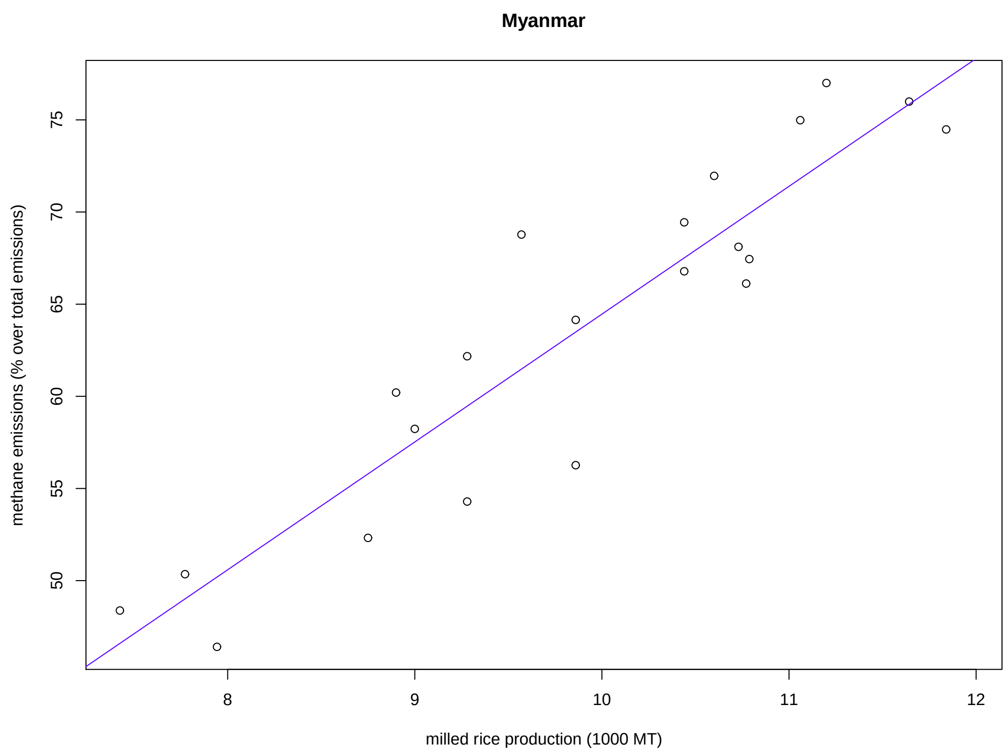

Mexico
Residuals vs Fitted
Residuals
Fitted values
X.17
X.3
X.1
Mexico
Scale−Location
√|Standardized residuals|
Fitted values
X.17
X.3
X.1
Mexico
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.17
X.3
X.1
Mexico
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.3
X.18
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	58.2392	3.6691	15.87	0.0000
h[, j]	-0.7506	0.3587	-2.09	0.0501

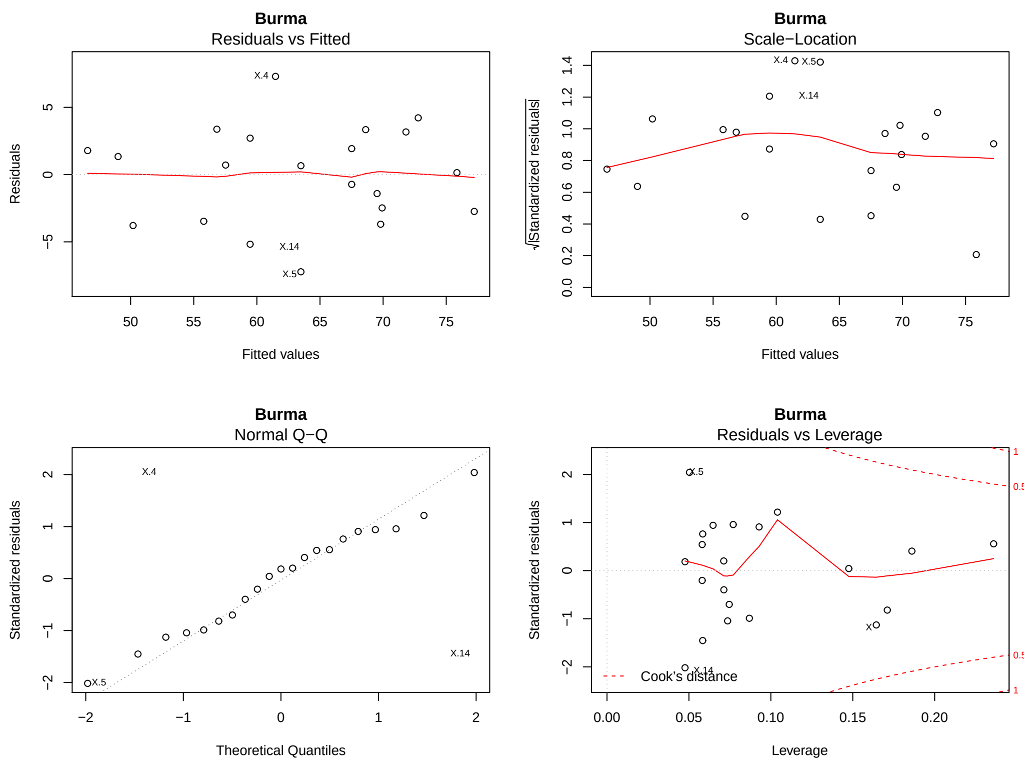
Table 41: Regression results

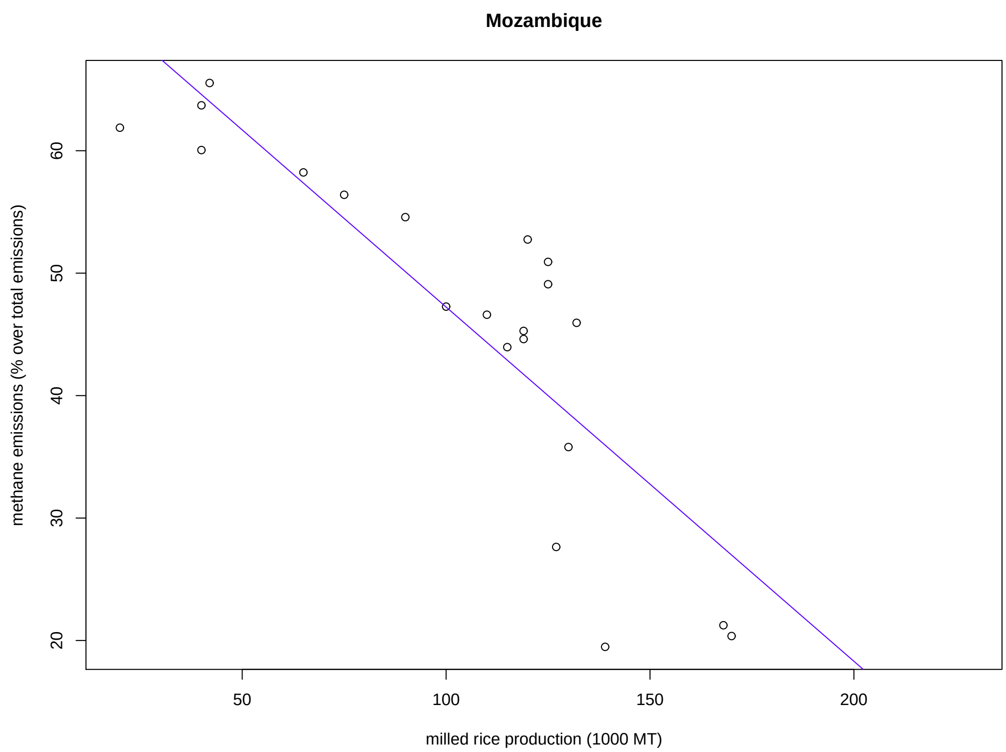

Macedonia
Residuals vs Fitted
Residuals
Fitted values
Macedonia
Scale−Location
√|Standardized residuals|
Fitted values
Macedonia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Macedonia
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-4.8948	6.4866	-0.75	0.4597
h[, j]	6.9354	0.6526	10.63	0.0000

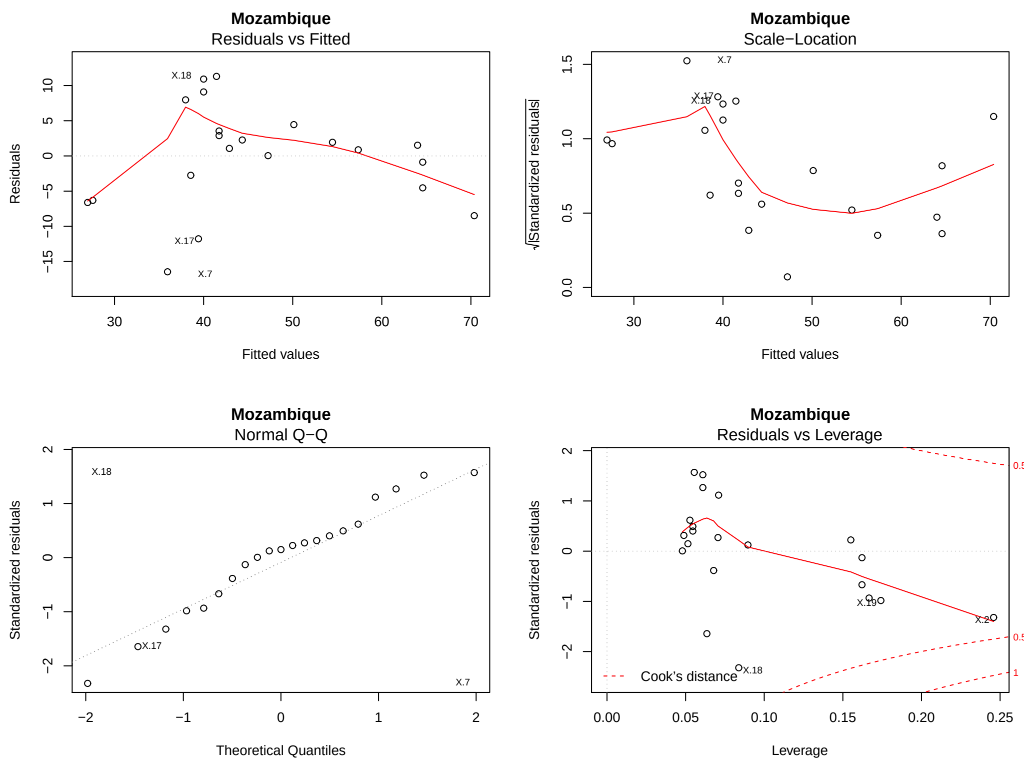
Table 42: Regression results

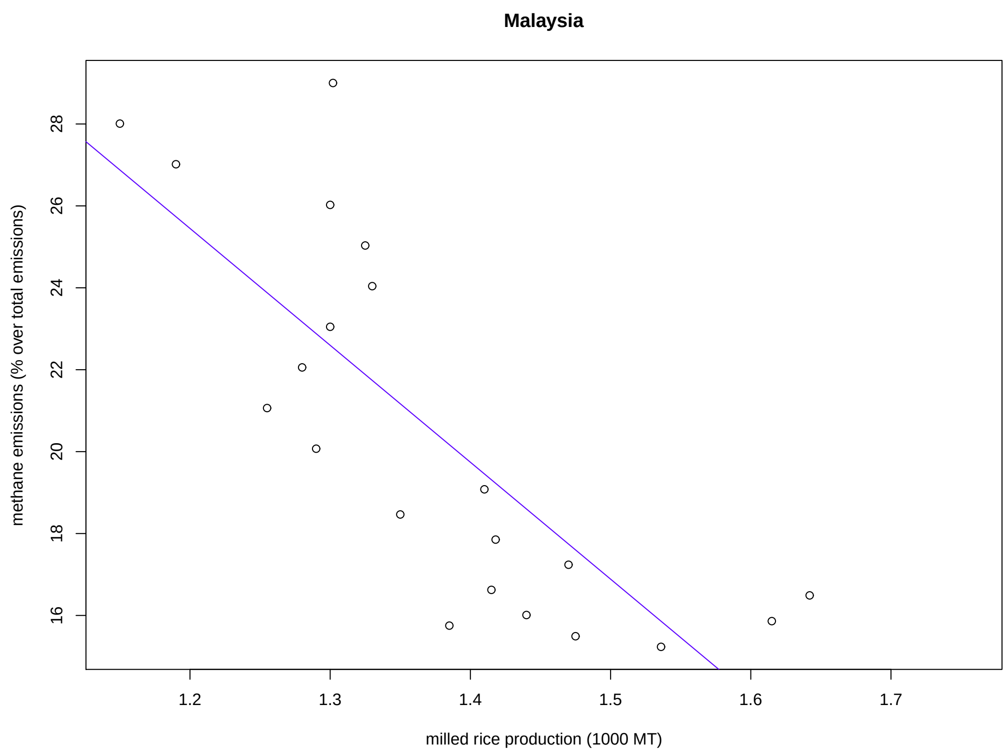

Burma
Residuals vs Fitted
Residuals
Fitted values
X.4
X.14
X.5
Burma
Scale−Location
√|Standardized residuals|
Fitted values
X.4
X.5
X.14
Burma
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.4
X.14
X.5
Burma
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.5
X.14
1
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	76.1617	4.3957	17.33	0.0000
h[, j]	-0.2893	0.0395	-7.32	0.0000

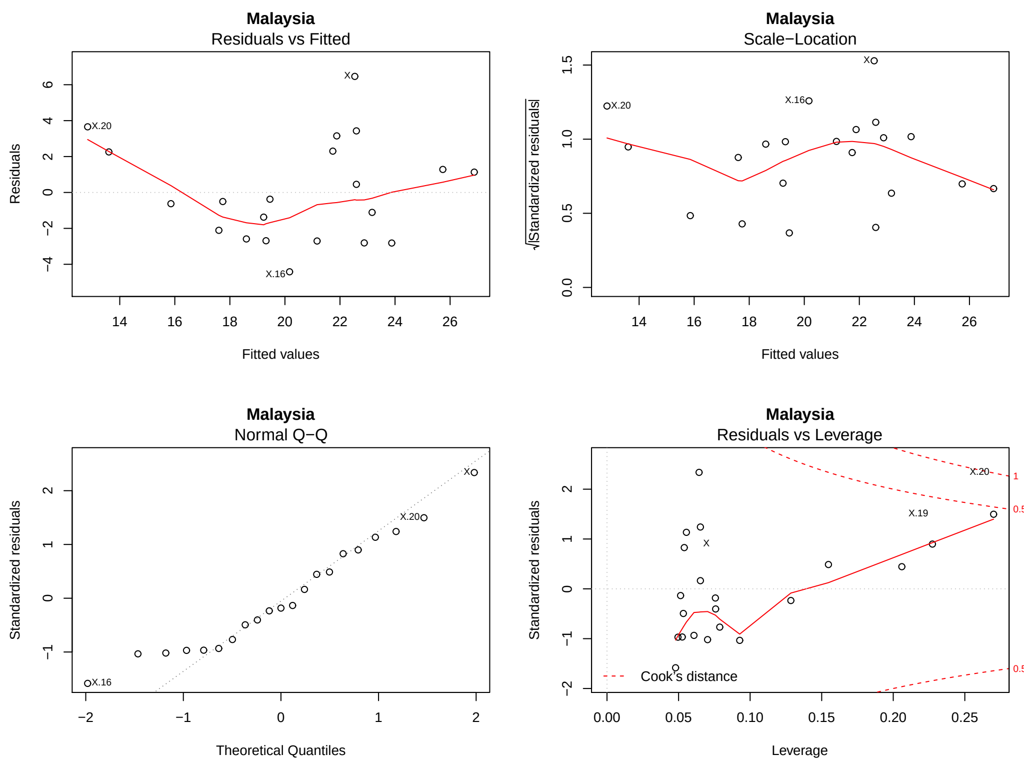
Table 43: Regression results

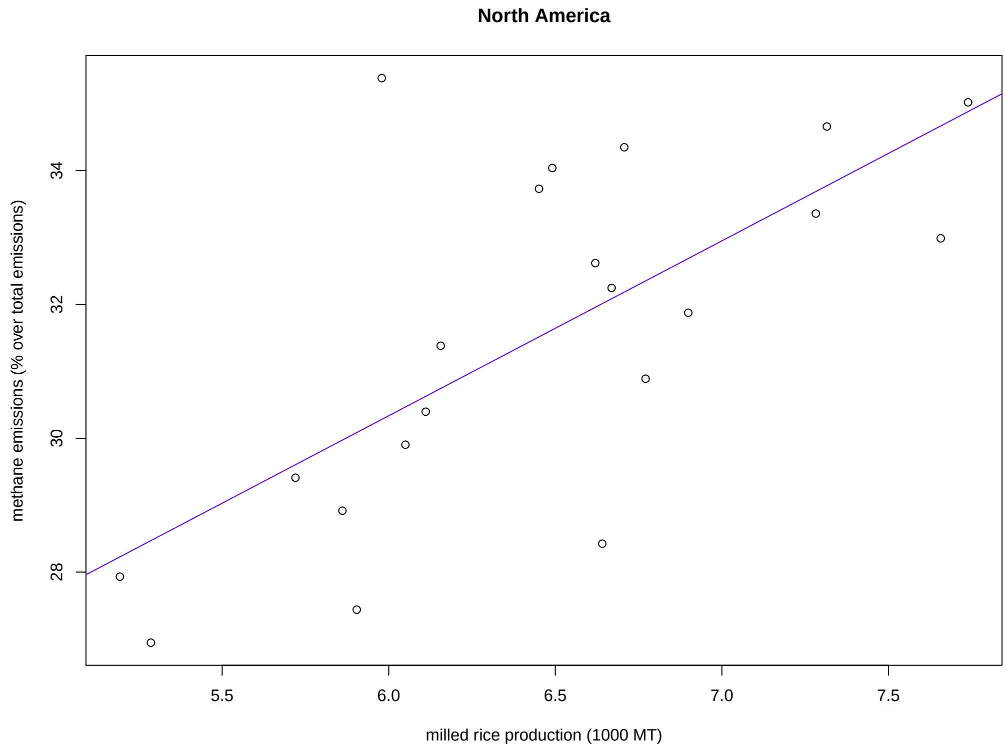

Mozambique
Residuals vs Fitted
Residuals
Fitted values
X.18
X.17
X.7
Mozambique
Scale−Location
√|Standardized residuals|
Fitted values
X.7
X.17
X.18
Mozambique
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.18
X.17
X.7
Mozambique
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.18
X.19
X.2
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	59.7031	6.9766	8.56	0.0000
h[, j]	-28.5441	5.0530	-5.65	0.0000

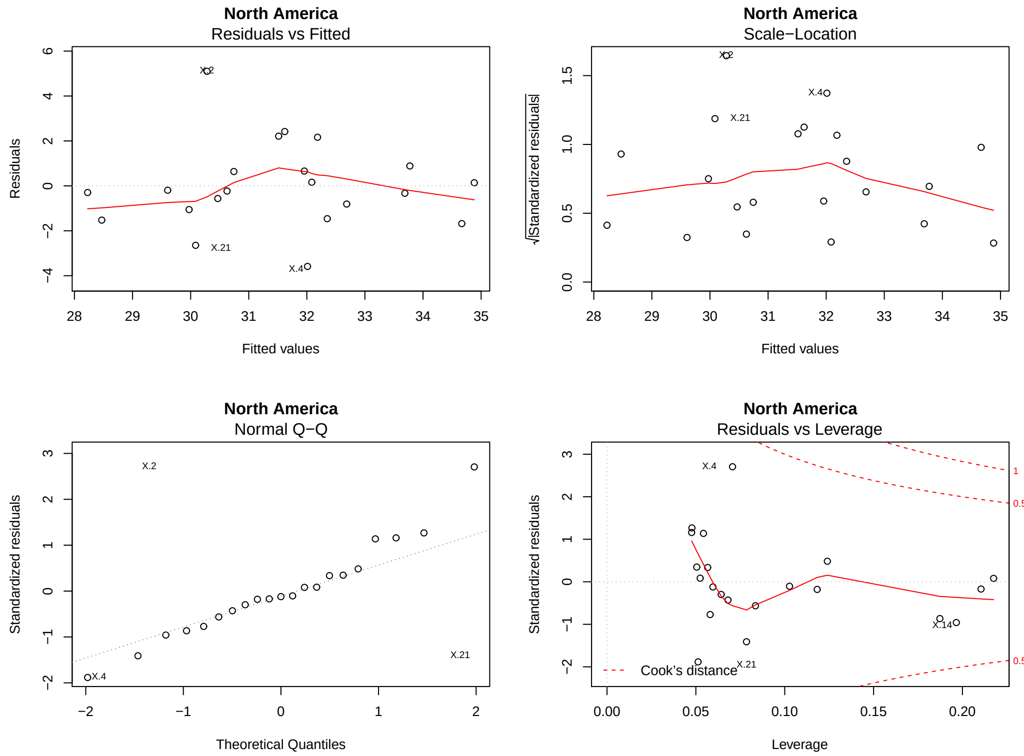
Table 44: Regression results

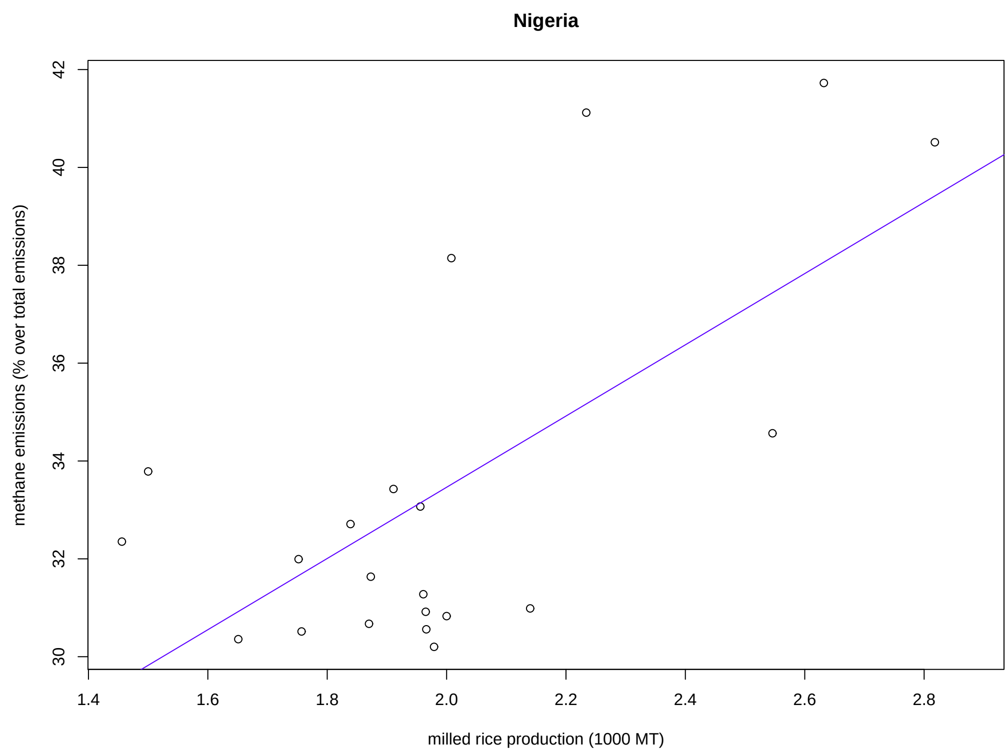

Malaysia
Residuals vs Fitted
Residuals
Fitted values
X.20
X.16
X
Malaysia
Scale−Location
√|Standardized residuals|
Fitted values
X.20
X.16
X
Malaysia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.16
X.20
X
Malaysia
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.20
X.19
X
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	14.6553	4.0654	3.60	0.0019
h[, j]	2.6135	0.6266	4.17	0.0005

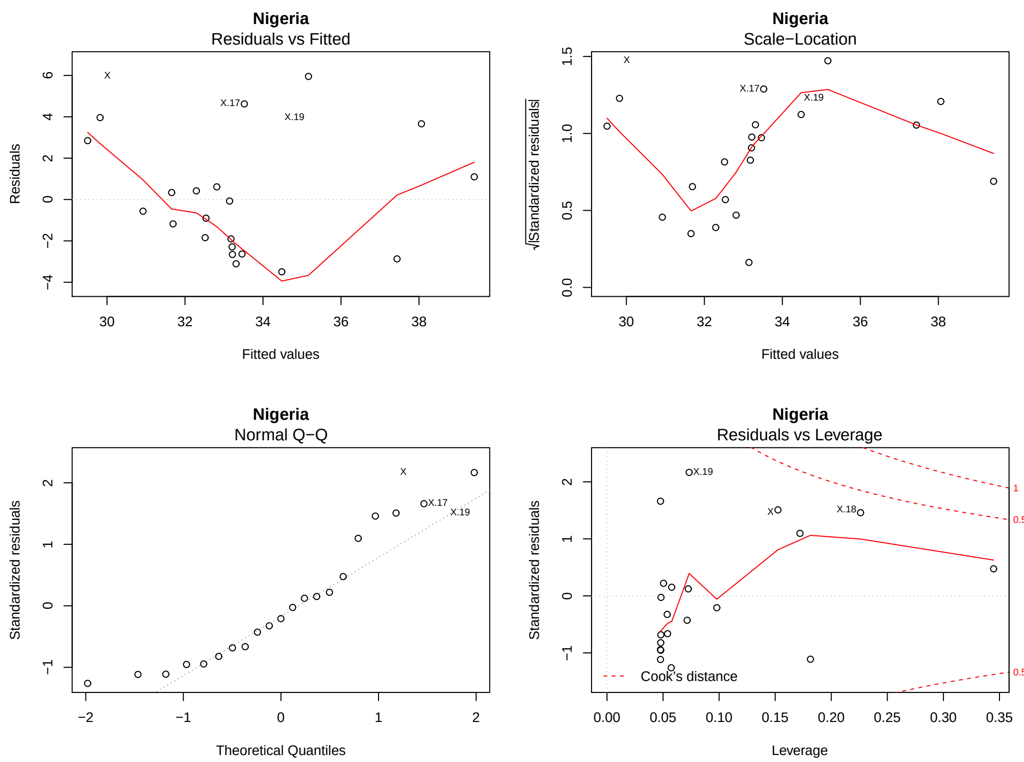
Table 45: Regression results

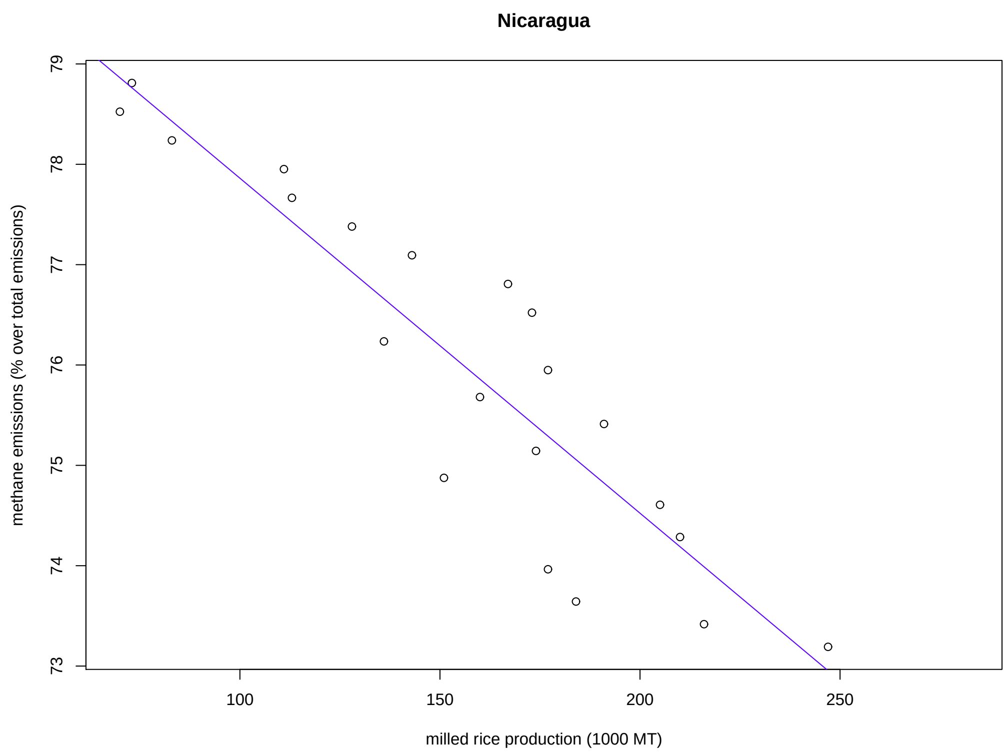

North America
Residuals vs Fitted
Residuals
Fitted values
X.2
X.21
X.4
North America
Scale−Location
√|Standardized residuals|
Fitted values
X.2
X.4
X.21
North America
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.2
X.4
X.21
North America
Residuals vs Leverage
Standardized residuals
Leverage
X.4
X.14
X.21
Cook's distance
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	18.9058	3.7986	4.98	0.0001
h[, j]	7.2785	1.8819	3.87	0.0010

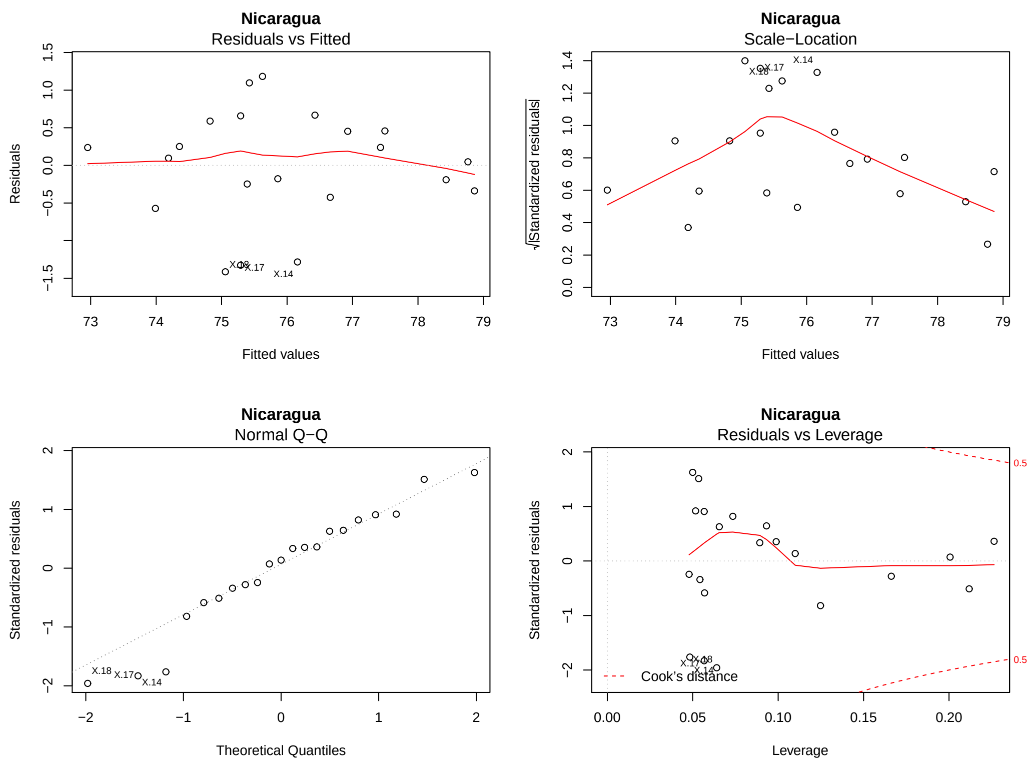
Table 46: Regression results


Nigeria
Residuals vs Fitted
Residuals
Fitted values
Nigeria
Scale−Location
√|Standardized residuals|
Fitted values
Nigeria
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Nigeria
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance

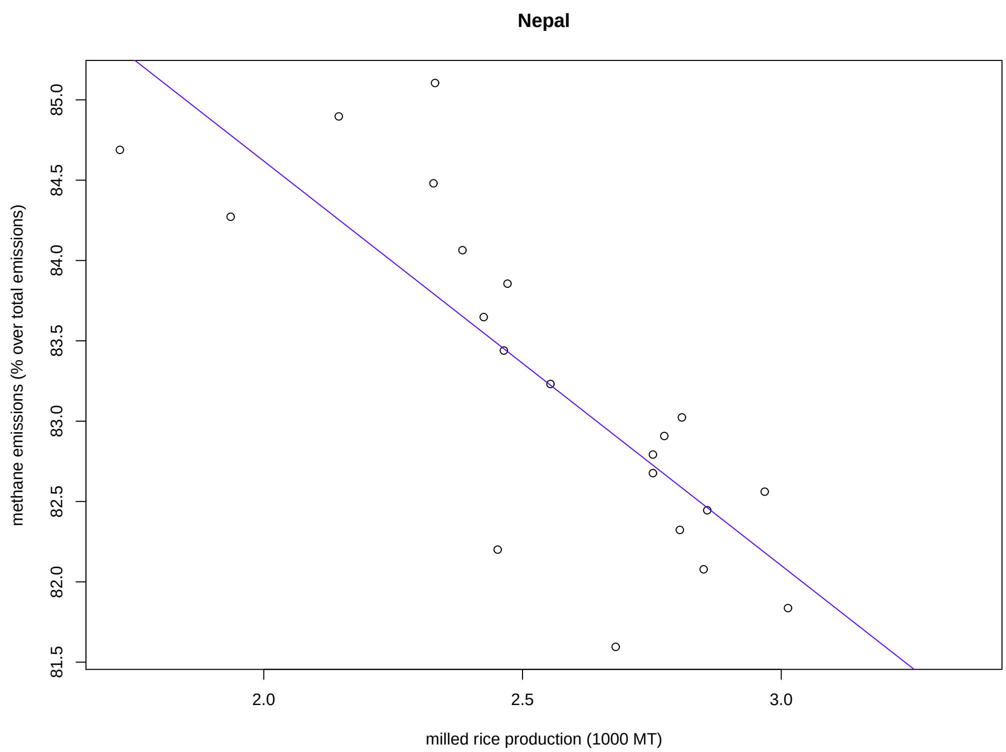


	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	81.1995	0.5707	142.29	0.0000
h[, j]	-0.0334	0.0035	-9.56	0.0000

Table 47: Regression results

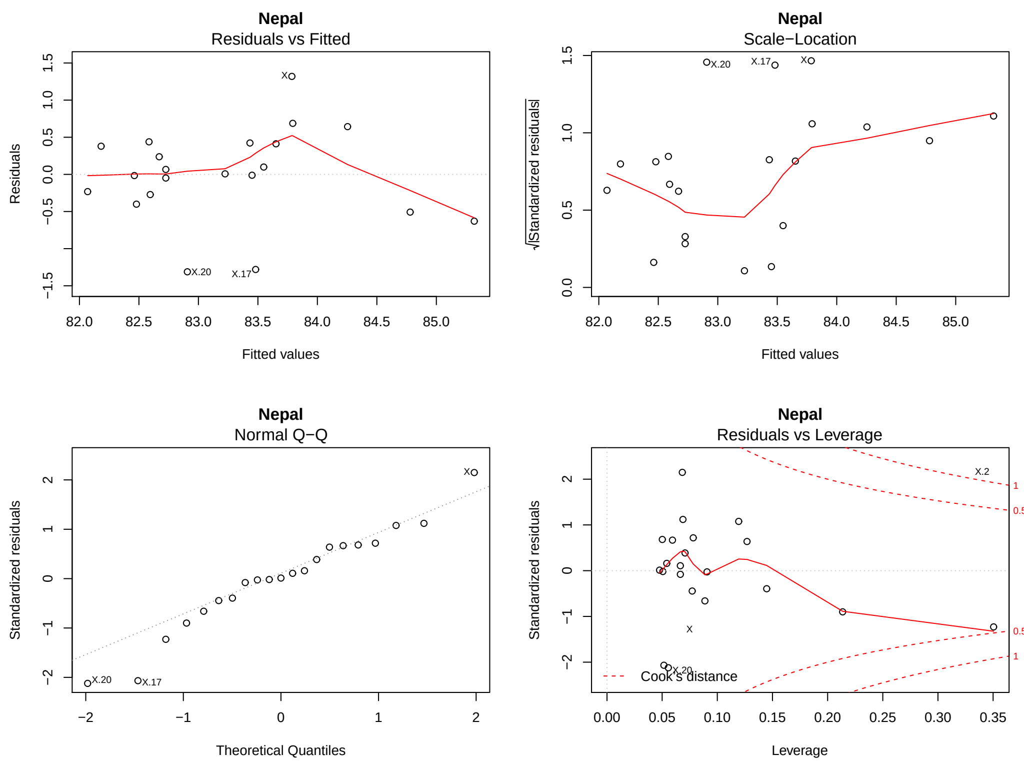


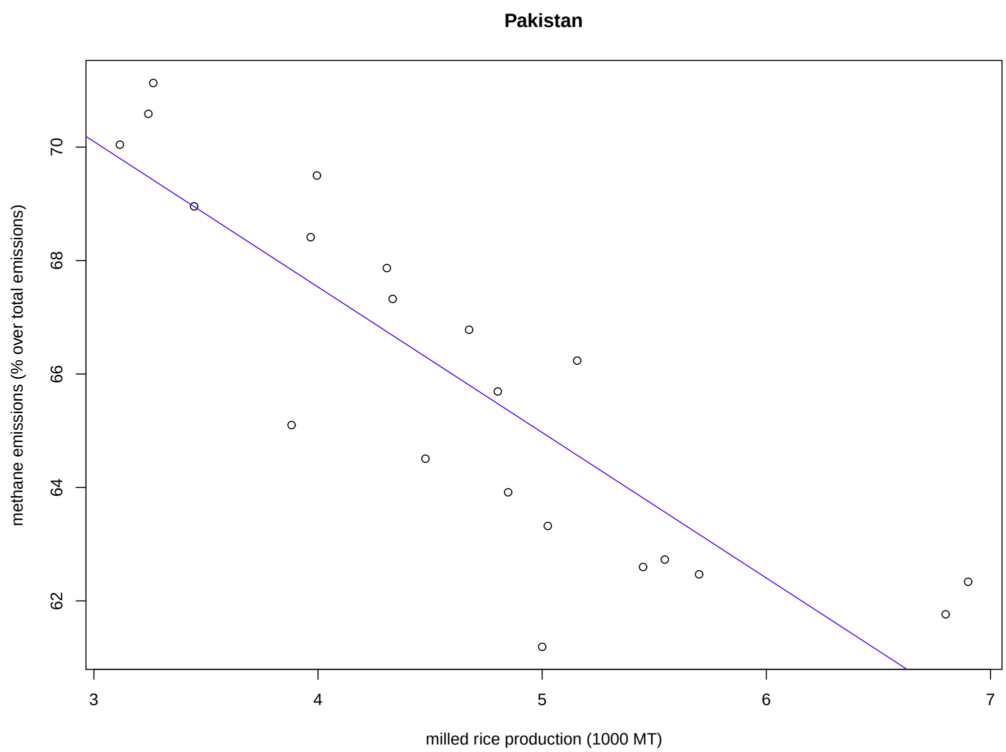
Nicaragua
Residuals vs Fitted
Residuals
Fitted values
X.18
X.17
X.14
Nicaragua
Scale−Location
√|Standardized residuals|
Fitted values
Nicaragua
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Nicaragua
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	89.6535	1.0902	82.23	0.0000
h[, j]	-2.5173	0.4247	-5.93	0.0000

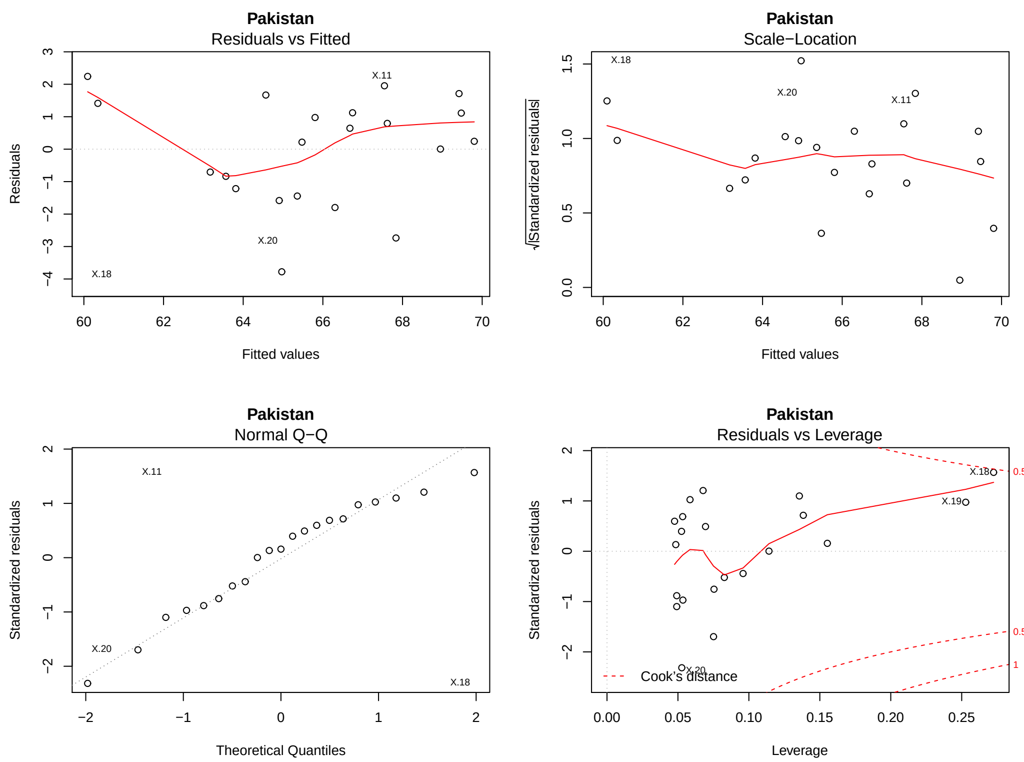
Table 48: Regression results

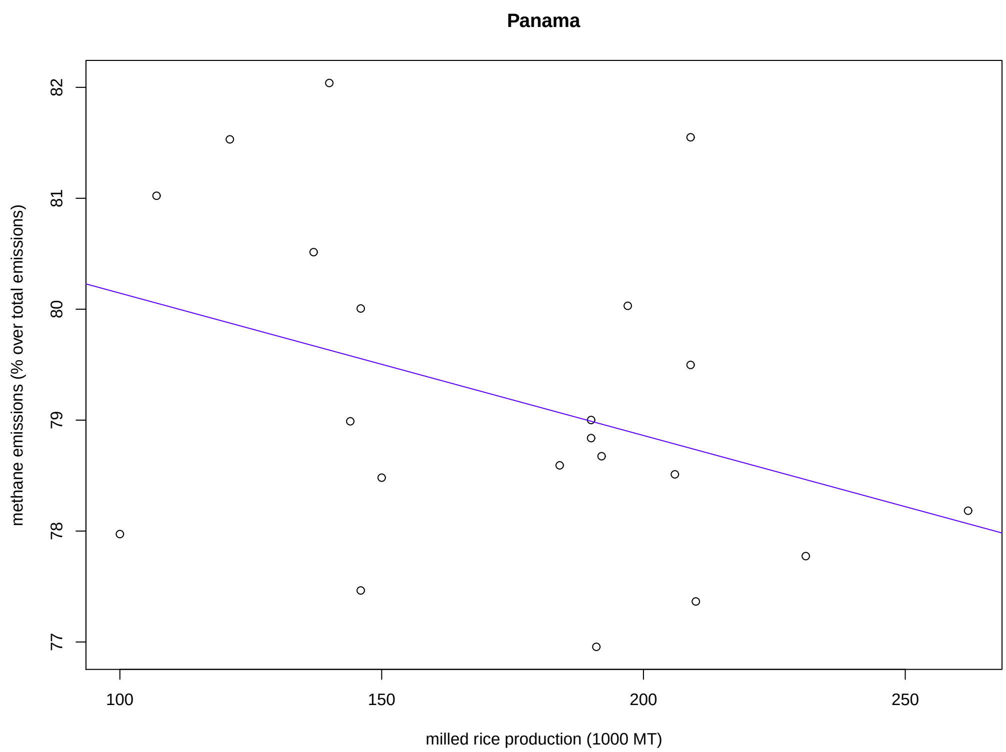

Nepal
Residuals vs Fitted
Residuals
Fitted values
Nepal
Scale−Location
√|Standardized residuals|
Fitted values
Nepal
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Nepal
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	77.7936	1.6980	45.81	0.0000
h[, j]	-2.5651	0.3555	-7.21	0.0000

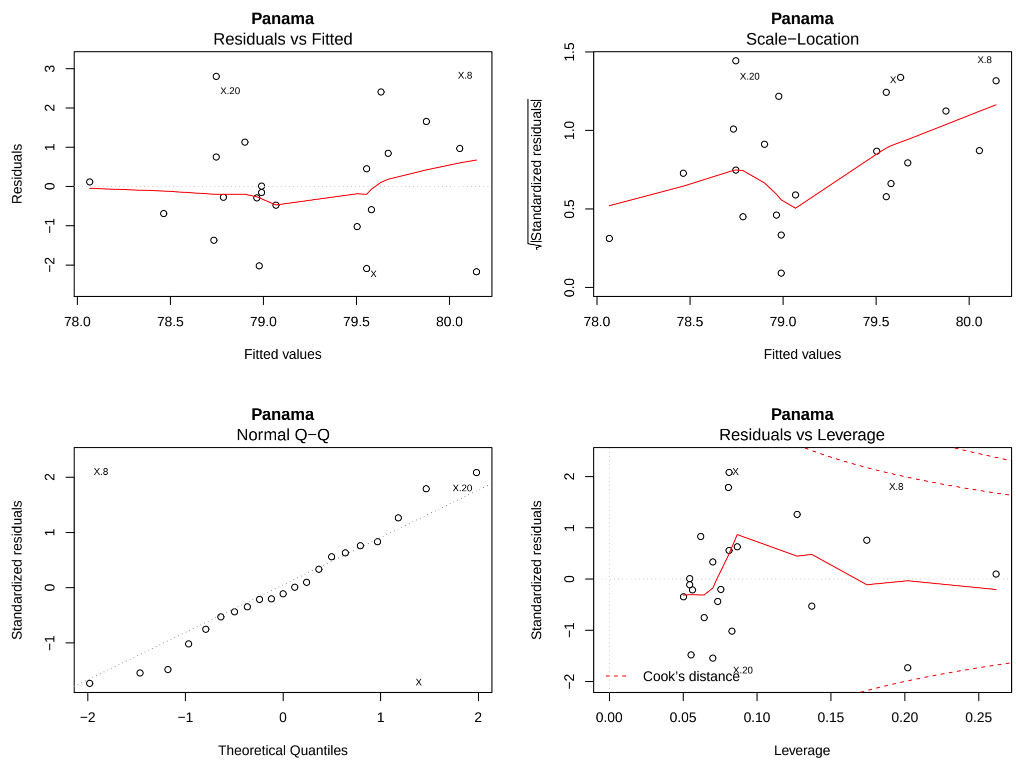
Table 49: Regression results

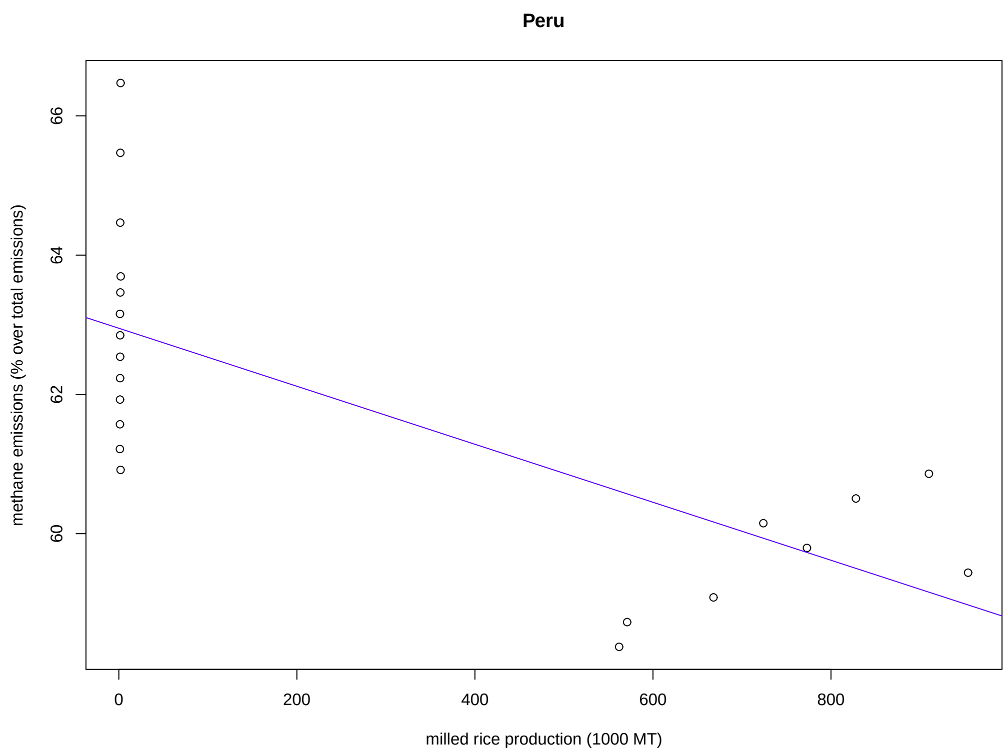

Pakistan
Residuals vs Fitted
Residuals
Fitted values
X.11
X.20
X.18
Pakistan
Scale−Location
√|Standardized residuals|
Fitted values
X.18
X.20
X.11
Pakistan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.11
X.20
X.18
Pakistan
Residuals vs Leverage
Standardized residuals
Leverage
X.18
X.19
X.20
Cook's distance
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	81.4279	1.3283	61.30	0.0000
h[, j]	-0.0128	0.0074	-1.73	0.0996

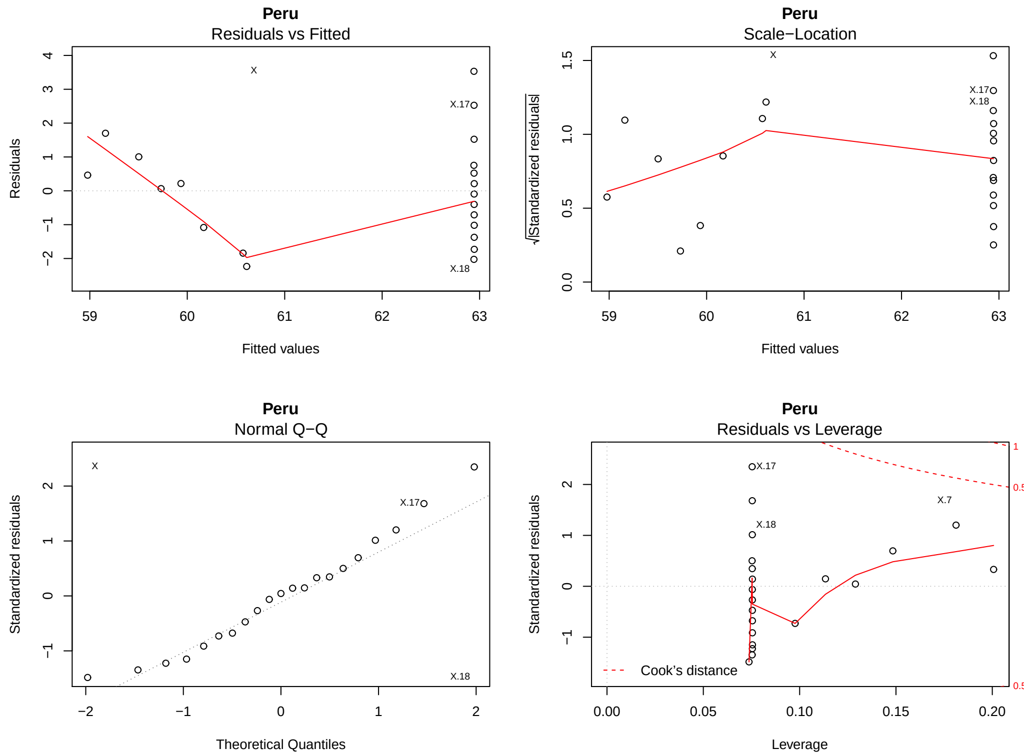
Table 50: Regression results

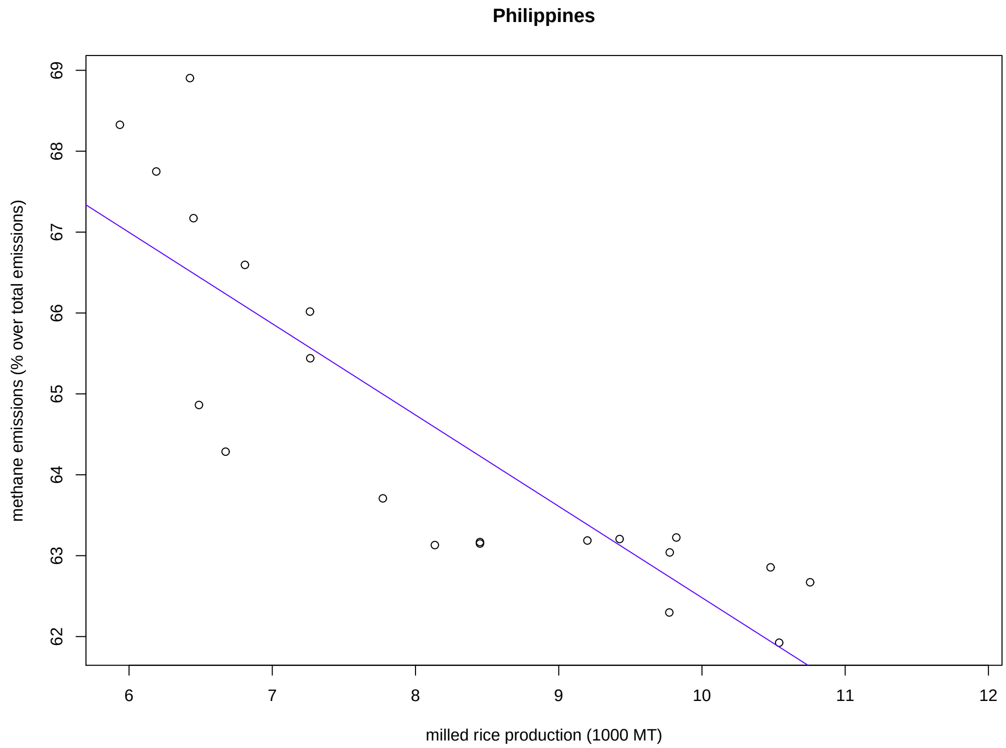

Panama
Residuals vs Fitted
Residuals
Fitted values
Panama
Scale−Location
√|Standardized residuals|
Fitted values
Panama
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Panama
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.8
X.20



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	62.9500	0.4304	146.27	0.0000
h[, j]	-0.0042	0.0009	-4.54	0.0002

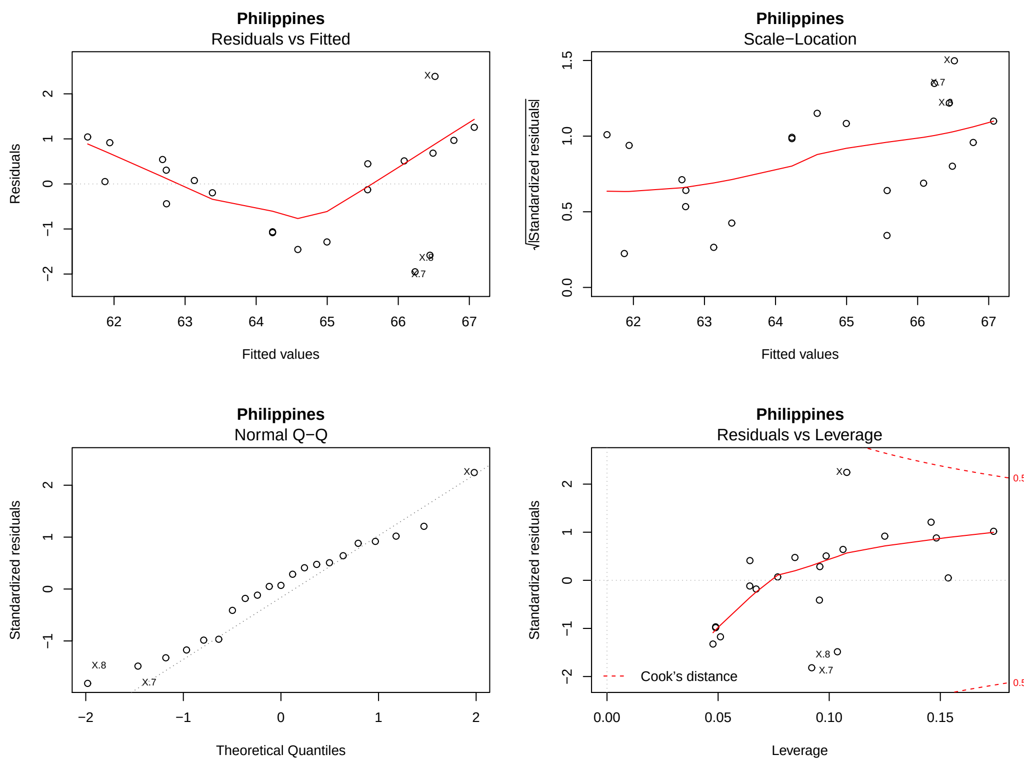
Table 51: Regression results

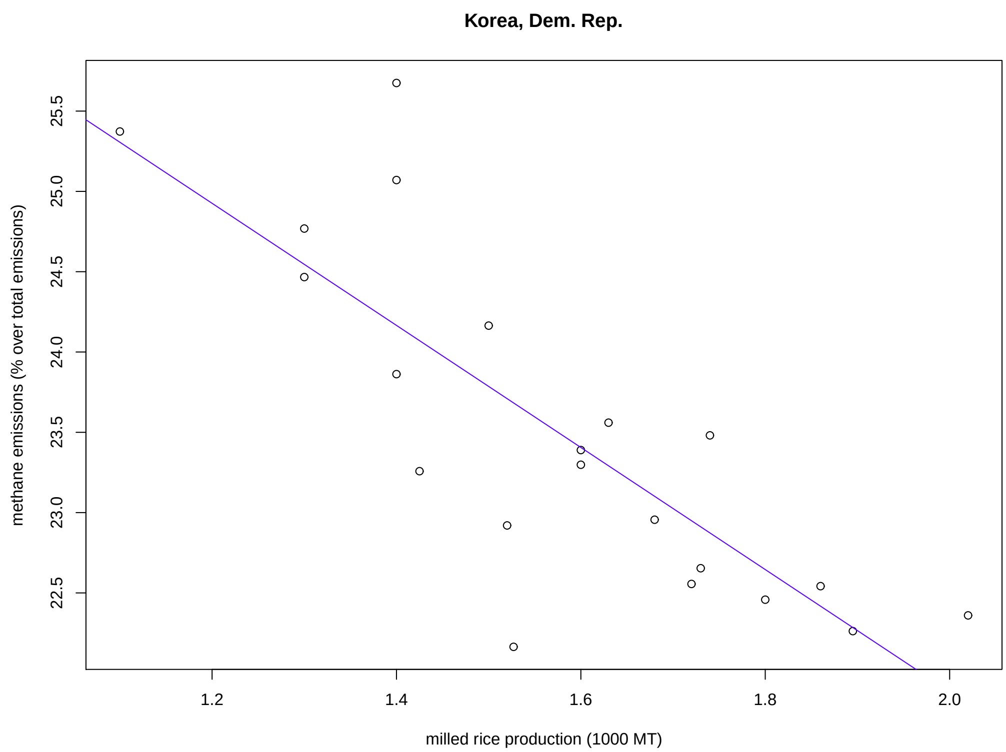

Peru
Residuals vs Fitted
Residuals
Fitted values
X
X.17
X.18
Peru
Scale−Location
√|Standardized residuals|
Fitted values
X
X.17
X.18
Peru
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X
X.17
X.18
Peru
Residuals vs Leverage
Standardized residuals
Leverage
X.17
X.18
X.7
Cook's distance
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	73.7712	1.3041	56.57	0.0000
h[, j]	-1.1291	0.1563	-7.22	0.0000

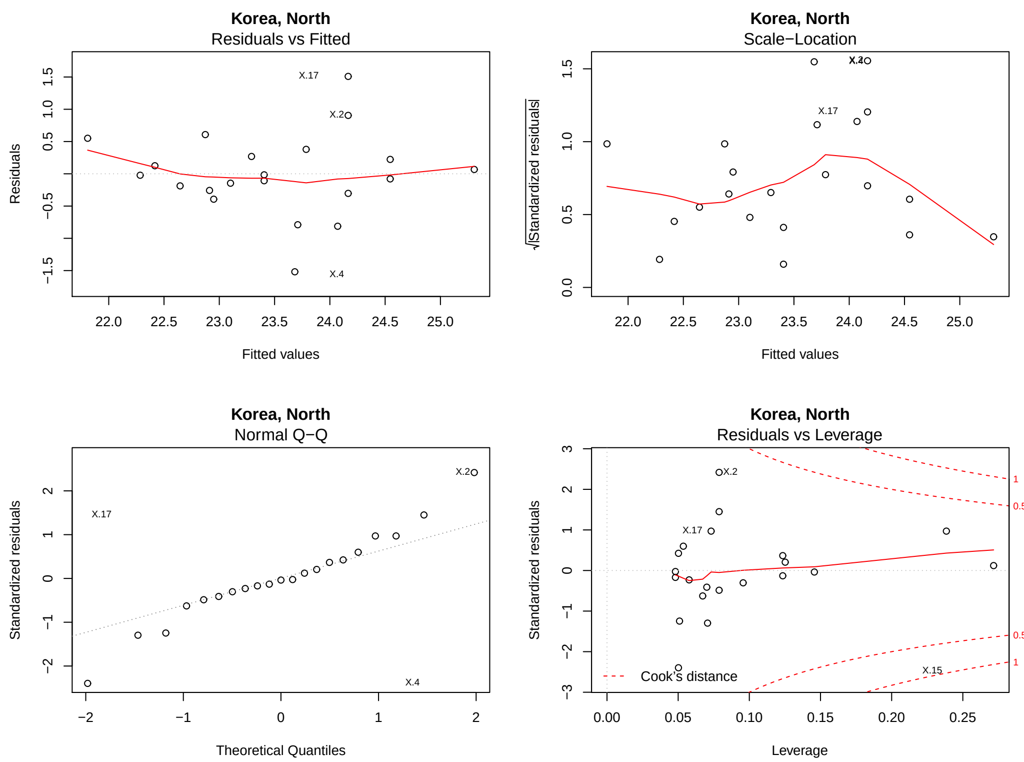
Table 52: Regression results

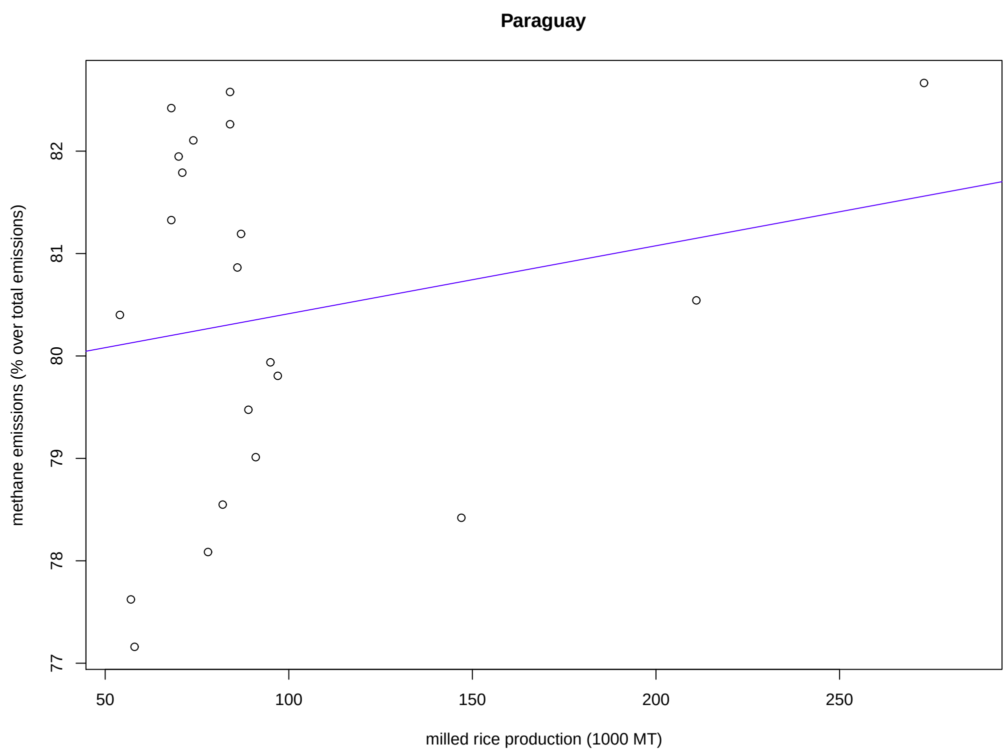

Philippines
Residuals vs Fitted
Residuals
Fitted values
Philippines
Scale−Location
√|Standardized residuals|
Fitted values
Philippines
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Philippines
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage
X.7
X.8
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	29.4866	1.0252	28.76	0.0000
h[, j]	-3.8006	0.6433	-5.91	0.0000

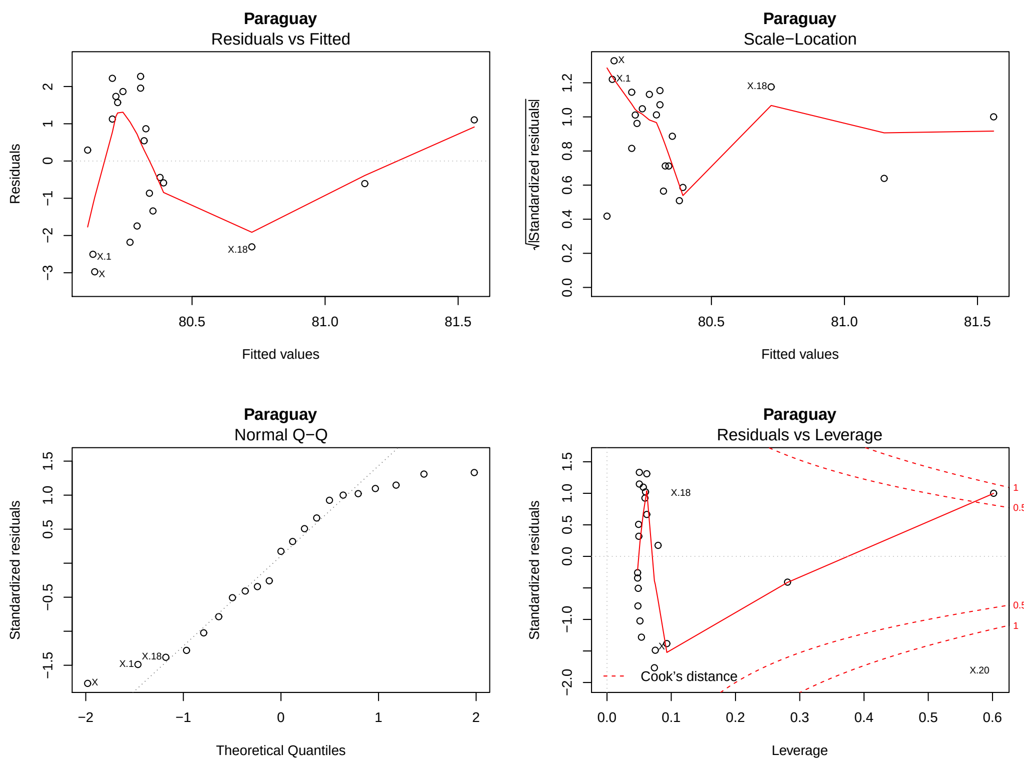
Table 53: Regression results

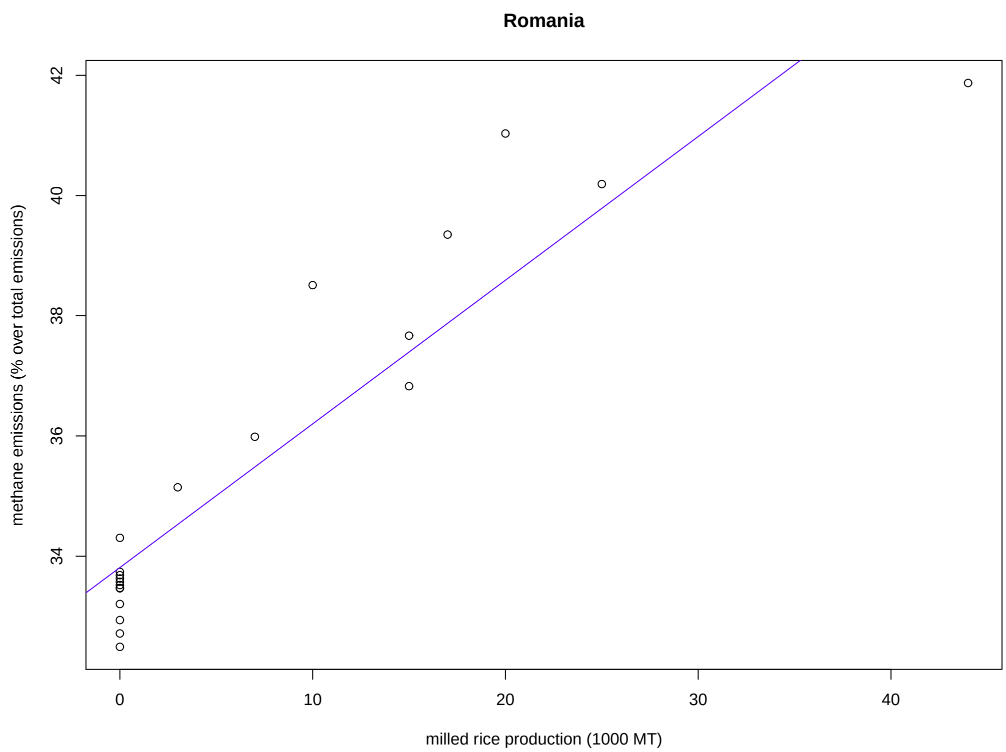

Korea, North
Residuals vs Fitted
Residuals
Fitted values
X.17
X.2
X.4
Korea, North
Scale−Location
√|Standardized residuals|
Fitted values
X.2
X.17
Korea, North
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.17
X.2
X.4
Korea, North
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.2
X.17
X.15
1
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	79.7492	0.8068	98.85	0.0000
h[, j]	0.0066	0.0074	0.90	0.3795

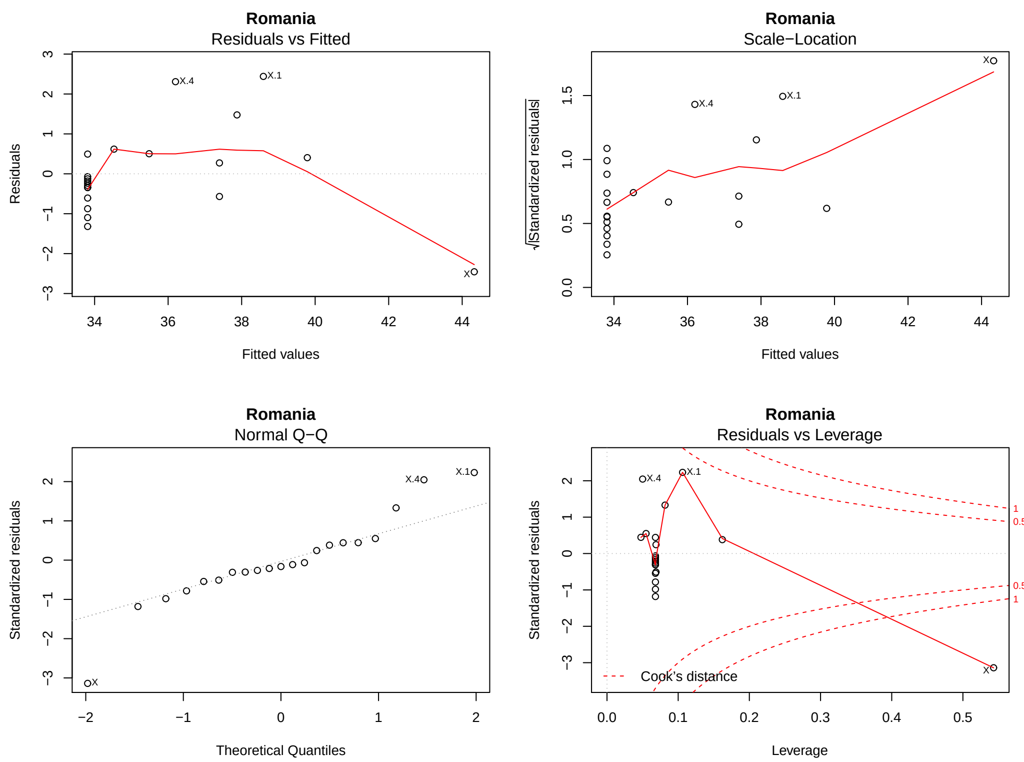
Table 54: Regression results

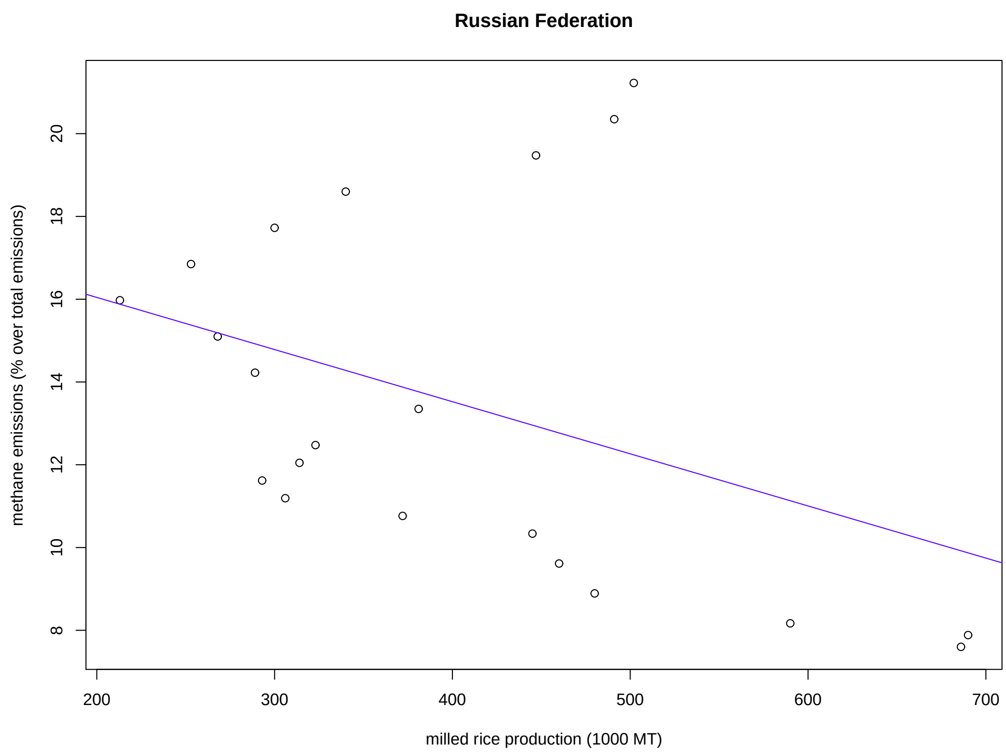

Paraguay
Residuals vs Fitted
Residuals
Fitted values
X.1
X
X.18
Paraguay
Scale−Location
√|Standardized residuals|
Fitted values
X
X.1
X.18
Paraguay
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X
X.1
X.18
Paraguay
Residuals vs Leverage
Standardized residuals
Leverage
X.18
X.20
Cook's distance
1
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	33.8104	0.3019	111.99	0.0000
h[, j]	0.2390	0.0223	10.73	0.0000

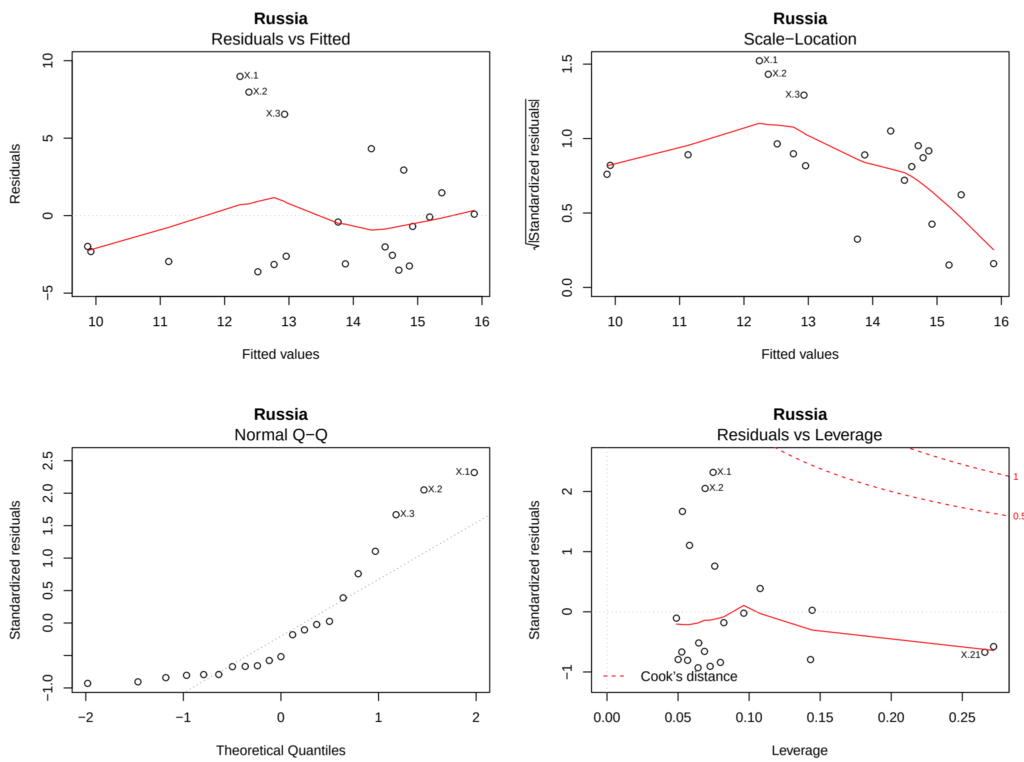
Table 55: Regression results

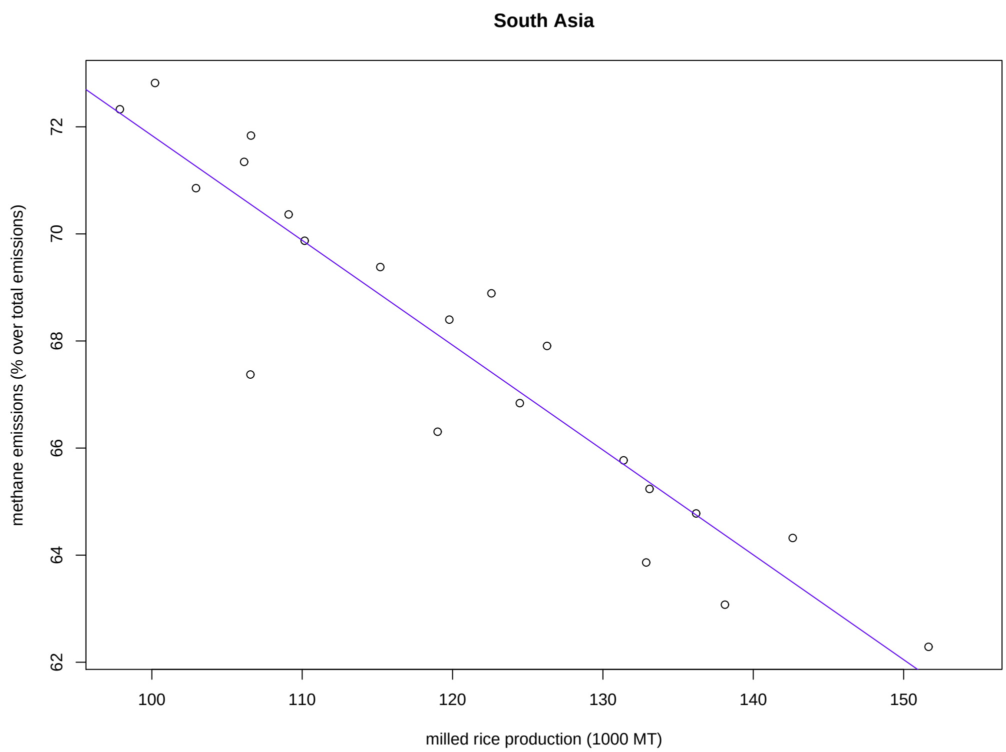

Romania
Residuals vs Fitted
Residuals
Fitted values
X.4
X.1
X
Romania
Scale−Location
√|Standardized residuals|
Fitted values
Romania
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Romania
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	18.5623	2.8067	6.61	0.0000
h[, j]	-0.0126	0.0066	-1.90	0.0727

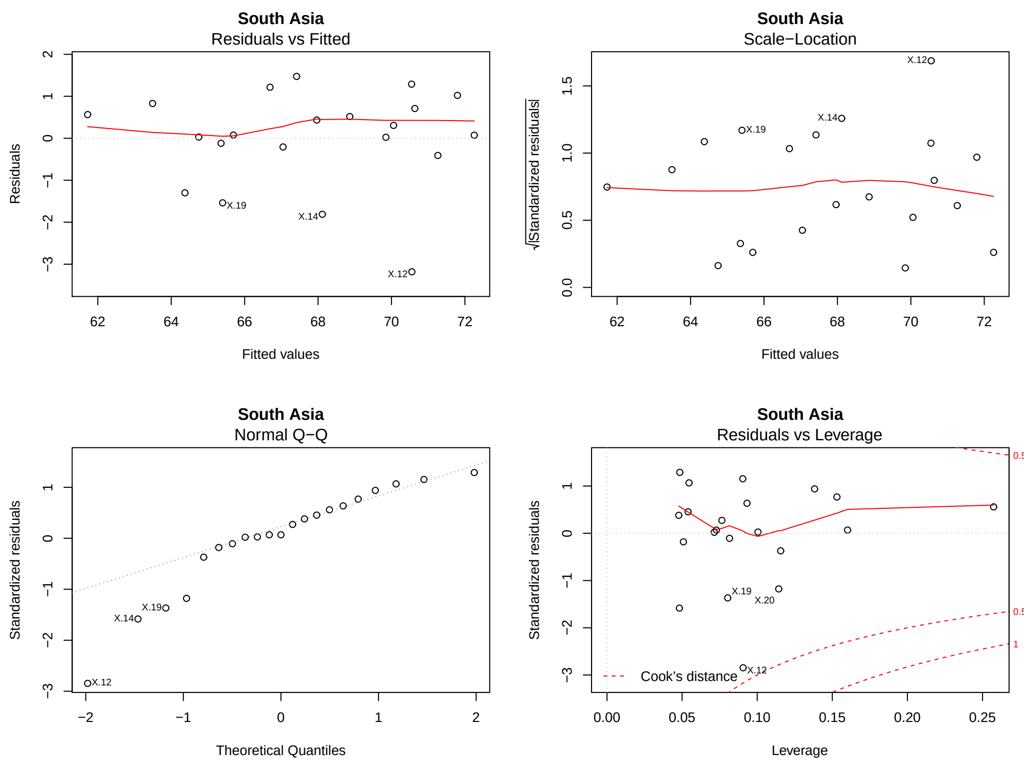
Table 56: Regression results

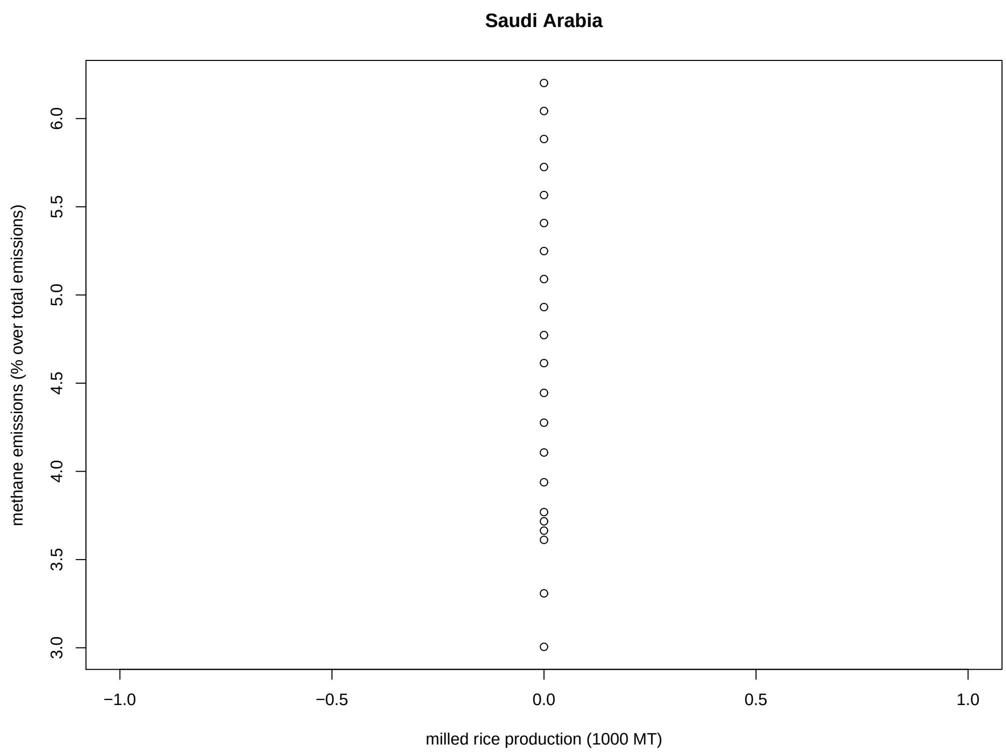

Russia
Residuals vs Fitted
Residuals
Fitted values
X.1
X.2
X.3
Russia
Scale−Location
√|Standardized residuals|
Fitted values
X.1
X.2
X.3
Russia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.1
X.2
X.3
Russia
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.1
X.2
X.21
1
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	91.4201	2.1014	43.51	0.0000
h[, j]	-0.1958	0.0173	-11.32	0.0000

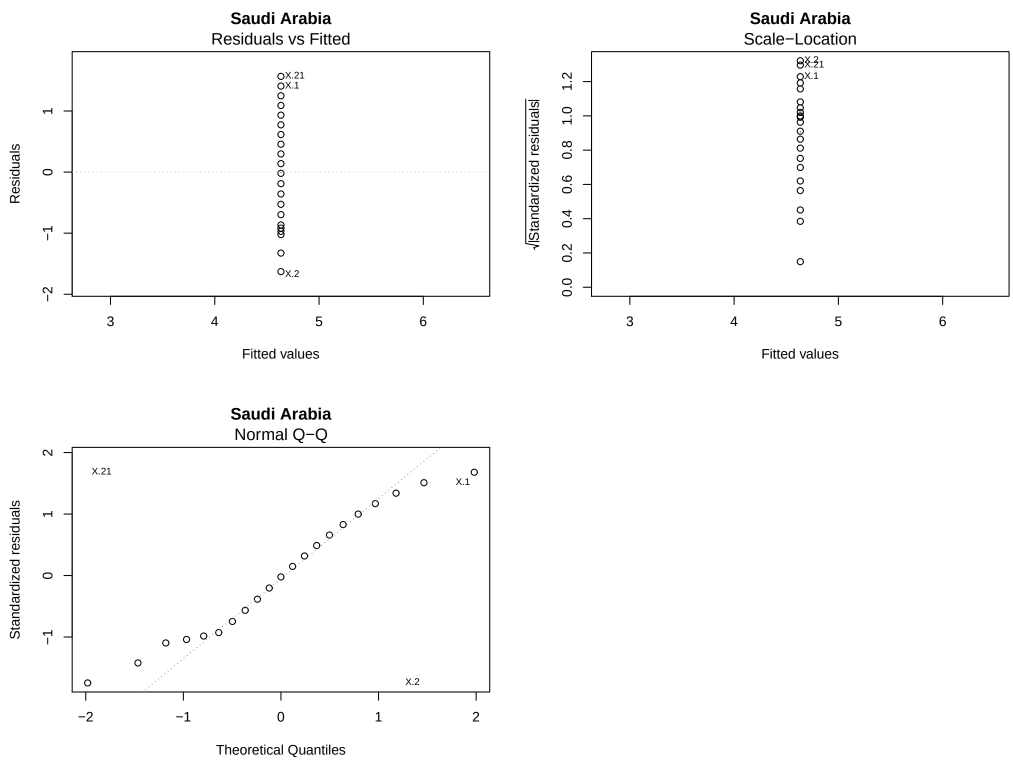
Table 57: Regression results

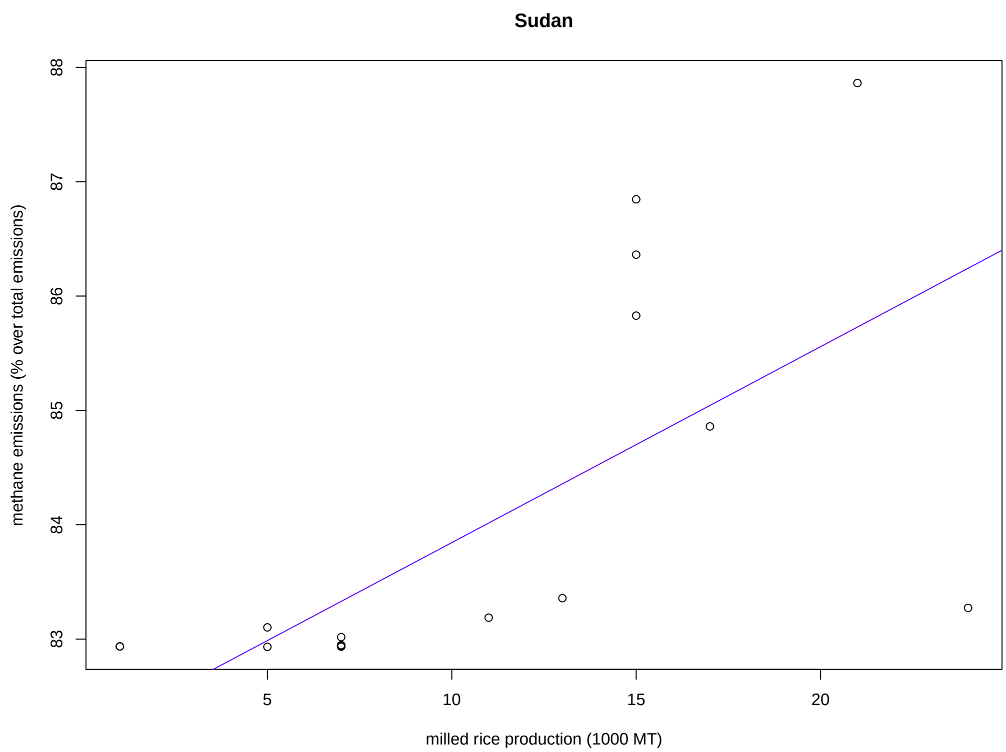

South Asia
Residuals vs Fitted
Residuals
Fitted values
X.19
X.14
X.12
South Asia
Scale−Location
√|Standardized residuals|
Fitted values
X.12
X.19
X.14
South Asia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.12
X.14
X.19
South Asia
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.19
X.20
X.12
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	4.6347	0.2086	22.22	0.0000

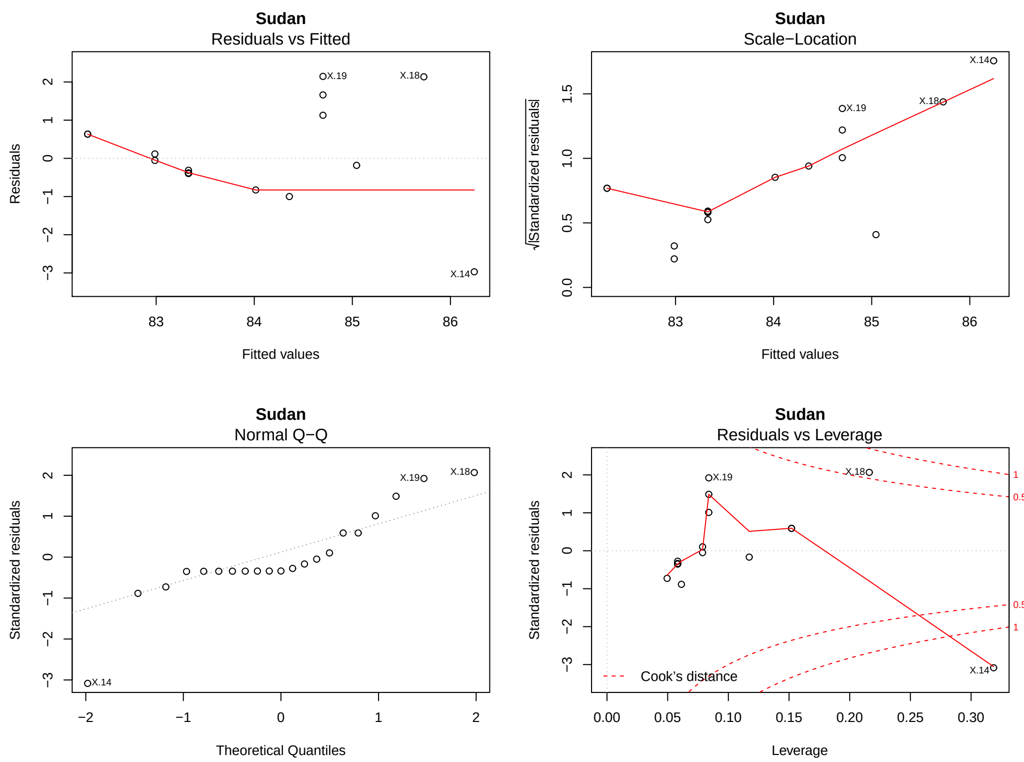
Table 58: Regression results

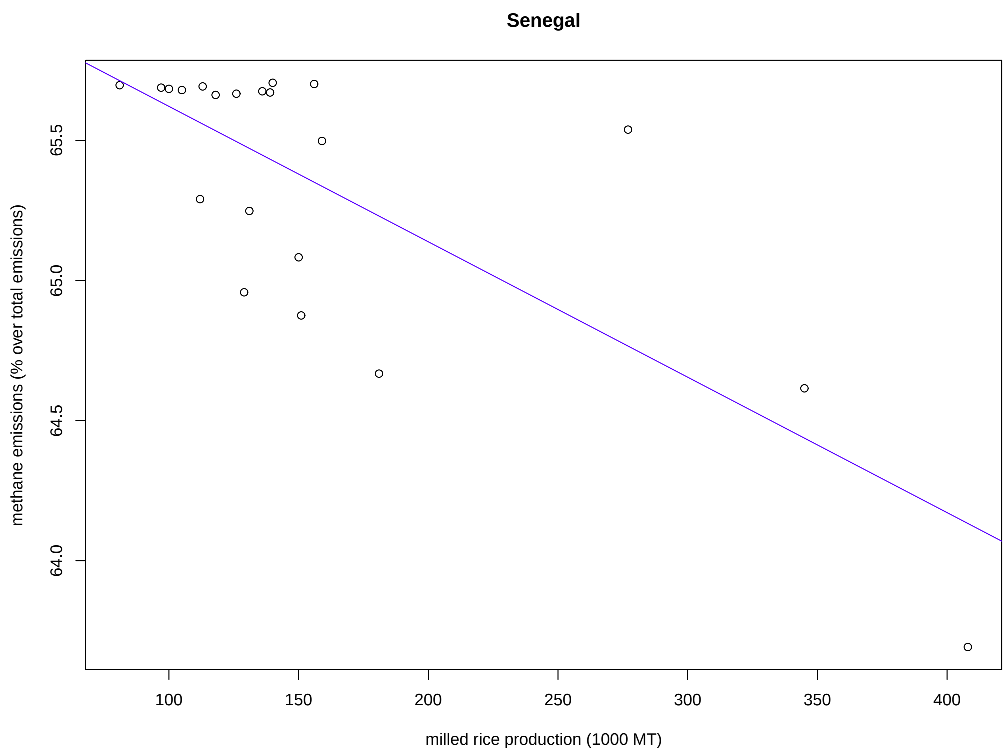

Saudi Arabia
Residuals vs Fitted
Residuals
Fitted values
X.21
X.1
X.2
−2
−1
0
1
3
4
5
6
Saudi Arabia
Scale−Location
√|Standardized residuals|
Fitted values
X.2
X.21
X.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
3
4
5
6
Saudi Arabia
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.21
X.1
X.2
−1
0
1
2
−2
−1
0
1
2



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	82.1300	0.4909	167.29	0.0000
h[, j]	0.1714	0.0428	4.00	0.0008

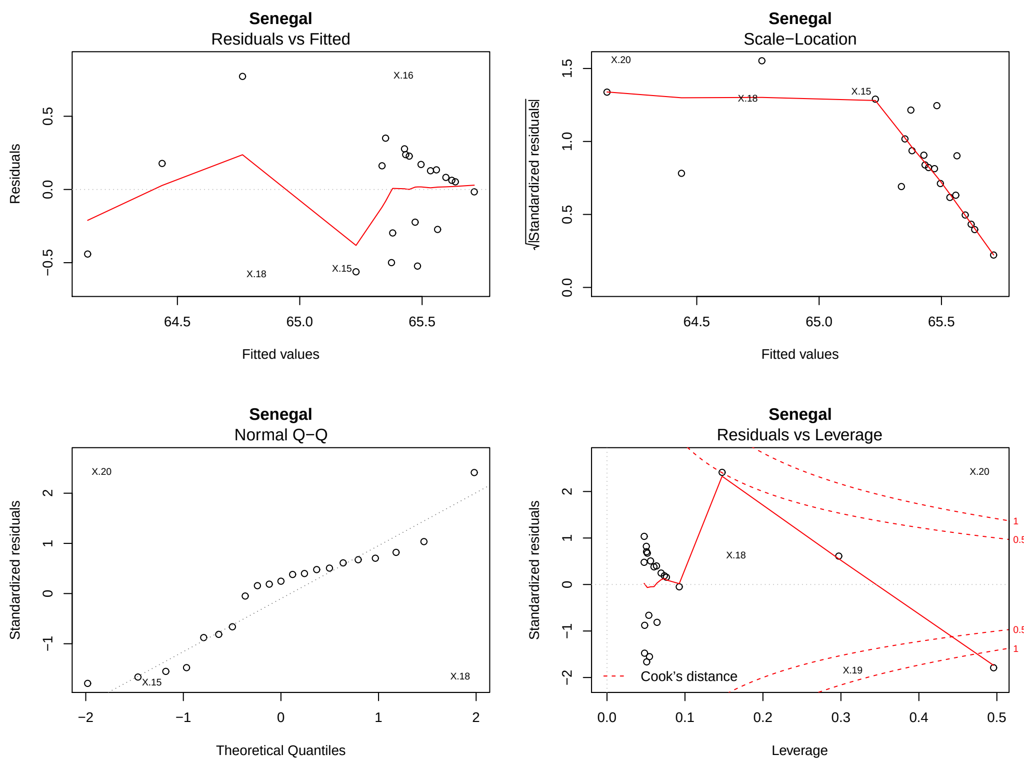
Table 59: Regression results

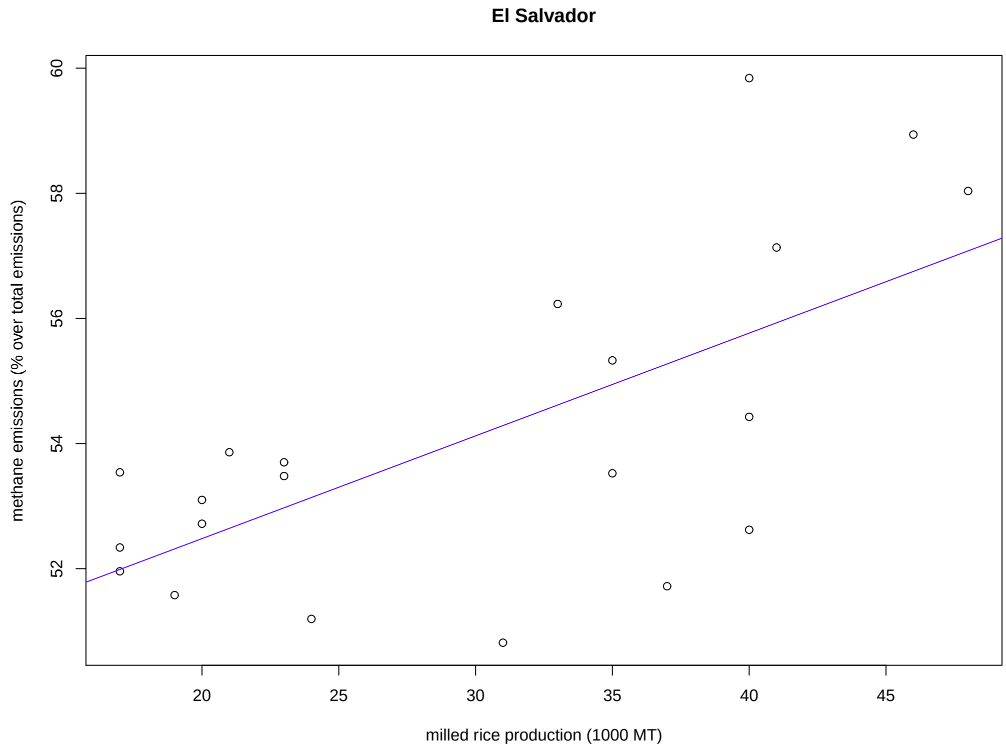

Sudan
Residuals vs Fitted
Residuals
Fitted values
X.19
X.18
X.14
Sudan
Scale−Location
√|Standardized residuals|
Fitted values
X.14
X.19
X.18
Sudan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.19
X.18
X.14
Sudan
Residuals vs Leverage
Standardized residuals
Leverage
X.19
X.18
X.14
Cook's distance
1
0.5
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	66.1045	0.1675	394.74	0.0000
h[, j]	-0.0048	0.0009	-5.17	0.0001

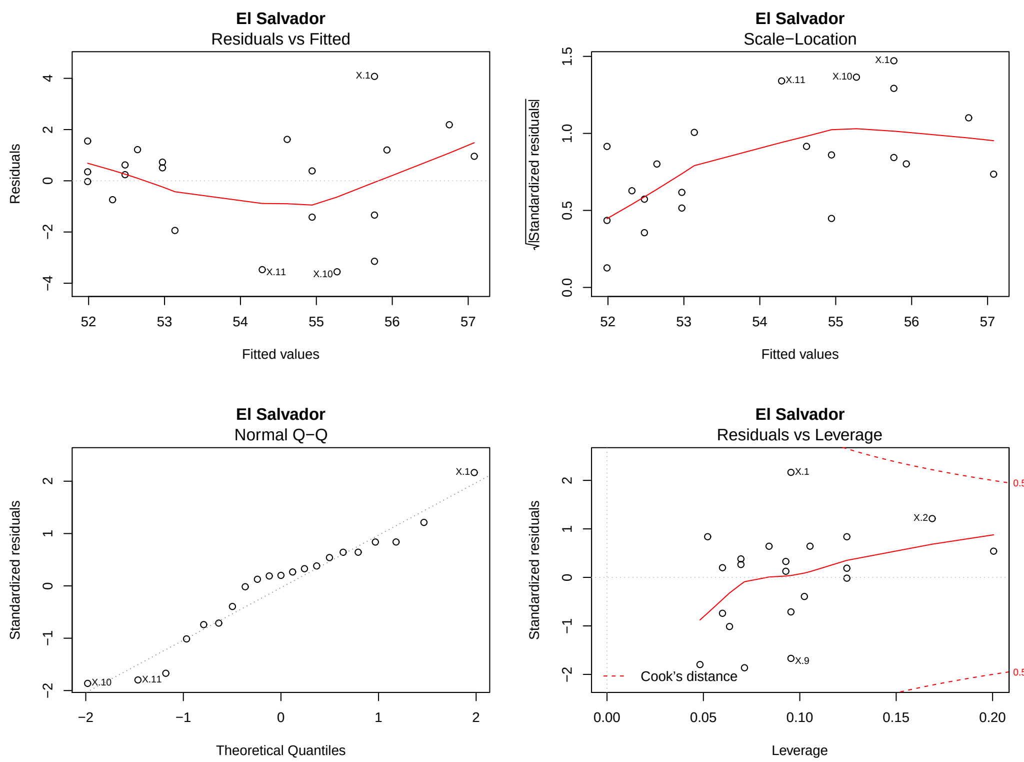
Table 60: Regression results

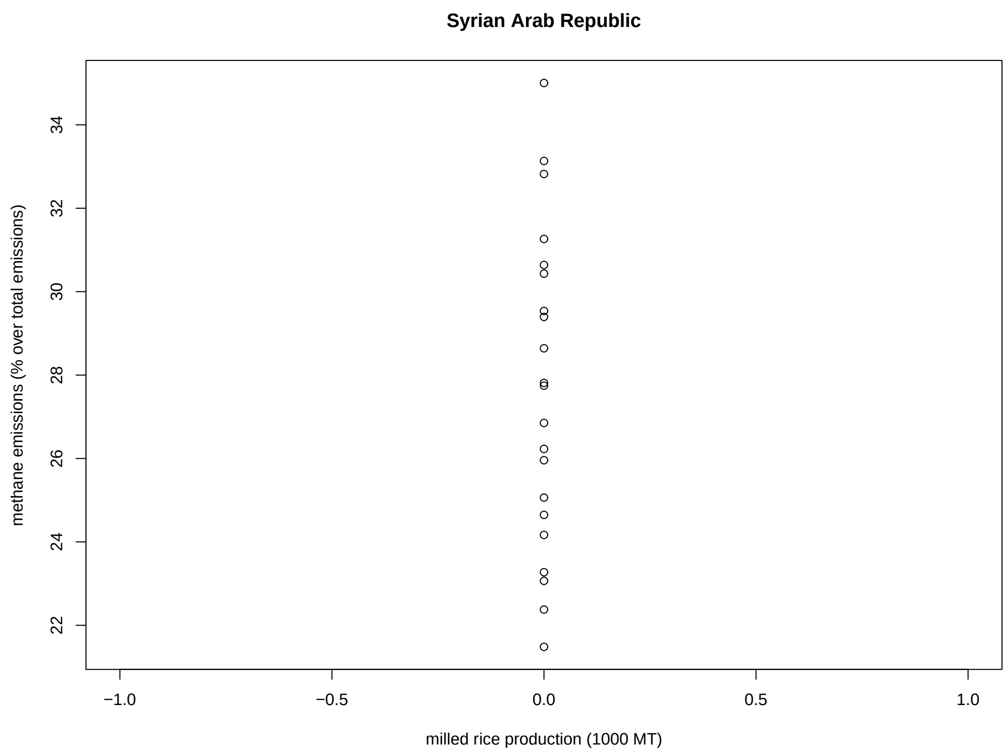

Senegal
Residuals vs Fitted
Residuals
Fitted values
X.16
X.18
X.15
Senegal
Scale−Location
√|Standardized residuals|
Fitted values
X.20
X.18
X.15
Senegal
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20
X.15
X.18
Senegal
Residuals vs Leverage
Standardized residuals
Leverage
X.20
X.18
X.19
Cook's distance



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	49.1948	1.3450	36.58	0.0000
h[, j]	0.1643	0.0427	3.85	0.0011

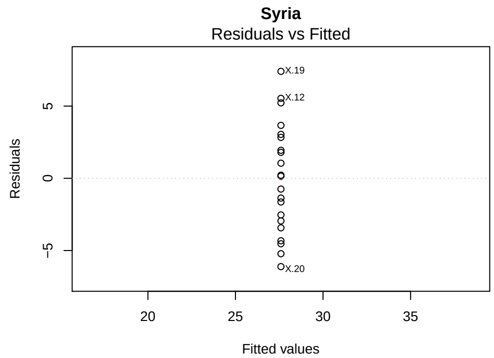
Table 61: Regression results

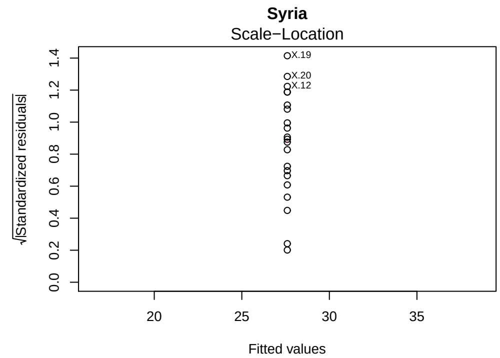

El Salvador
Residuals vs Fitted
Residuals
Fitted values
El Salvador
Scale−Location
√|Standardized residuals|
Fitted values
El Salvador
Normal Q−Q
Standardized residuals
Theoretical Quantiles
El Salvador
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance

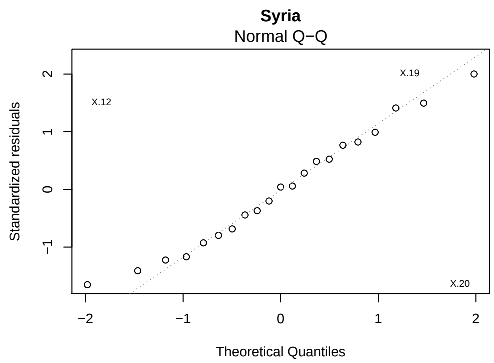


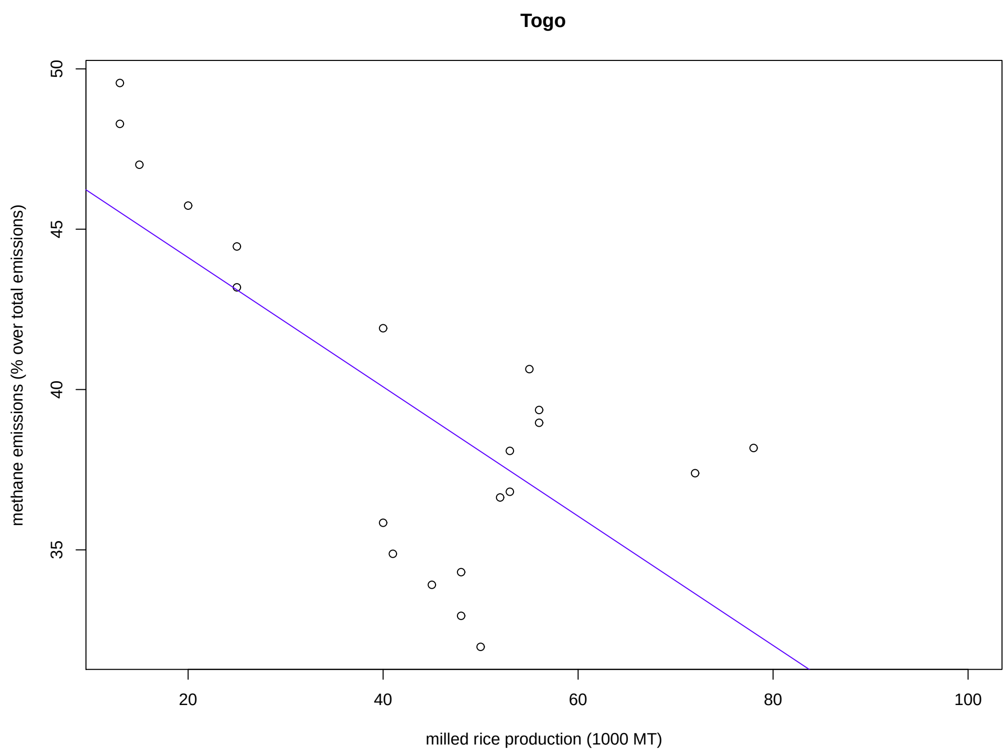
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	27.5976	0.8274	33.35	0.0000

Table 62: Regression results


Syria
Residuals vs Fitted
Residuals
Fitted values
X.19
X.12
X.20
5
0
−5
20
25
30
35

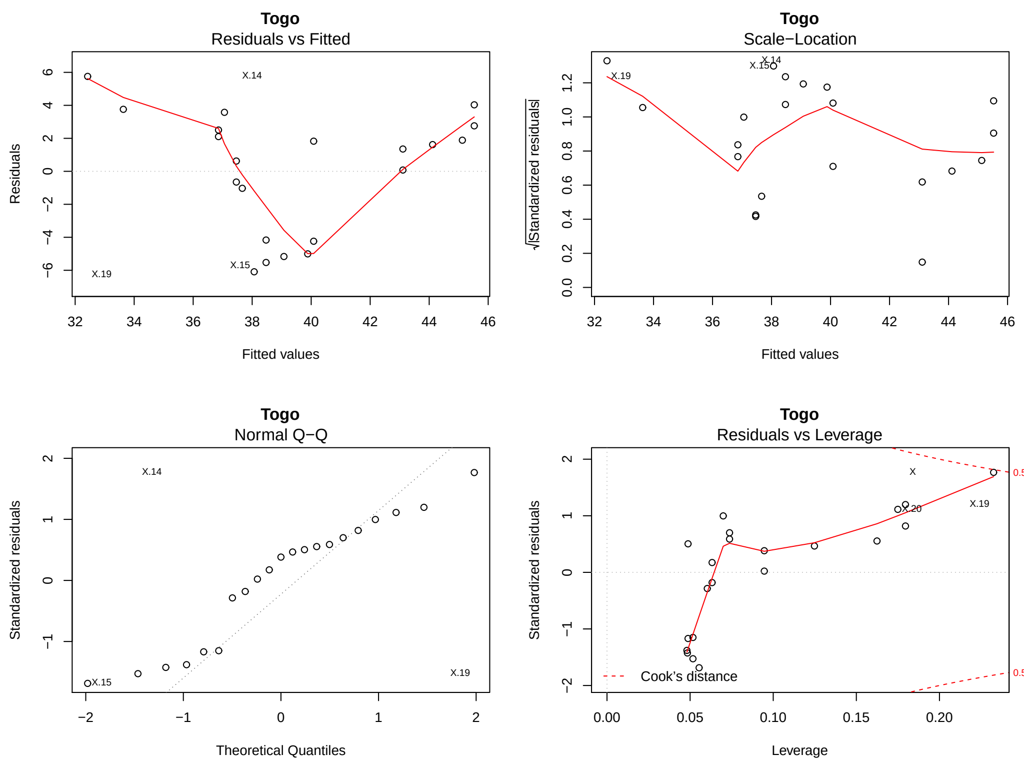

Syria
Scale−Location
√|Standardized residuals|
Fitted values
X.19
X.20
X.12
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
20
25
30
35

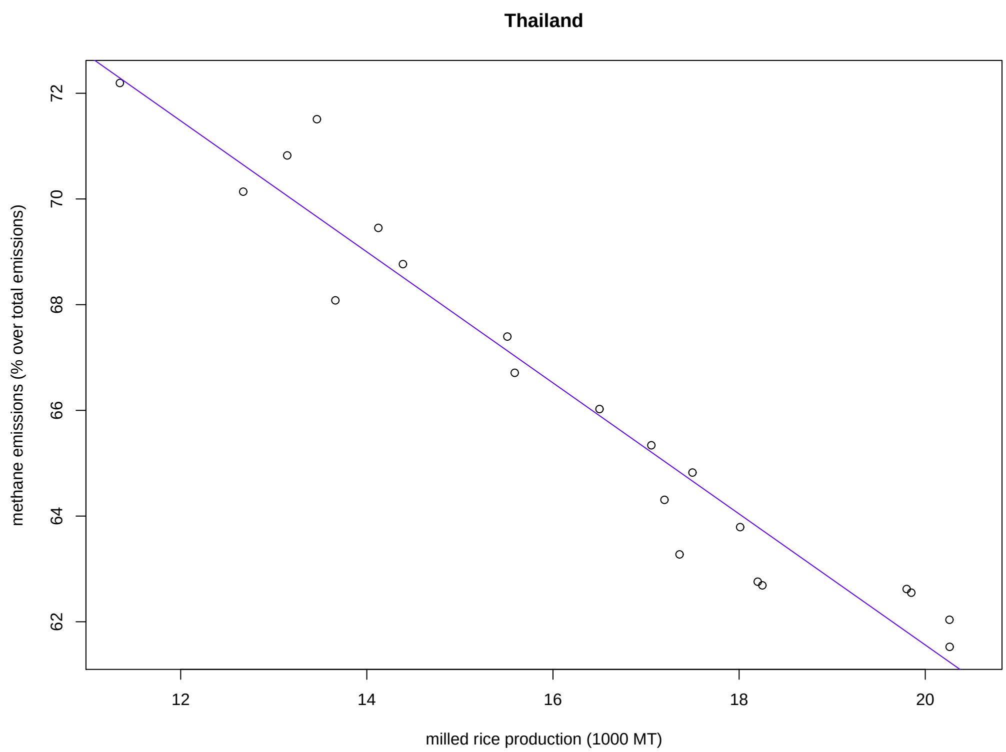

Syria
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.19
X.12
X.20
2
1
0
−1
−2
−1
0
1
2



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	48.1484	2.1028	22.90	0.0000
h[, j]	-0.2016	0.0454	-4.44	0.0003

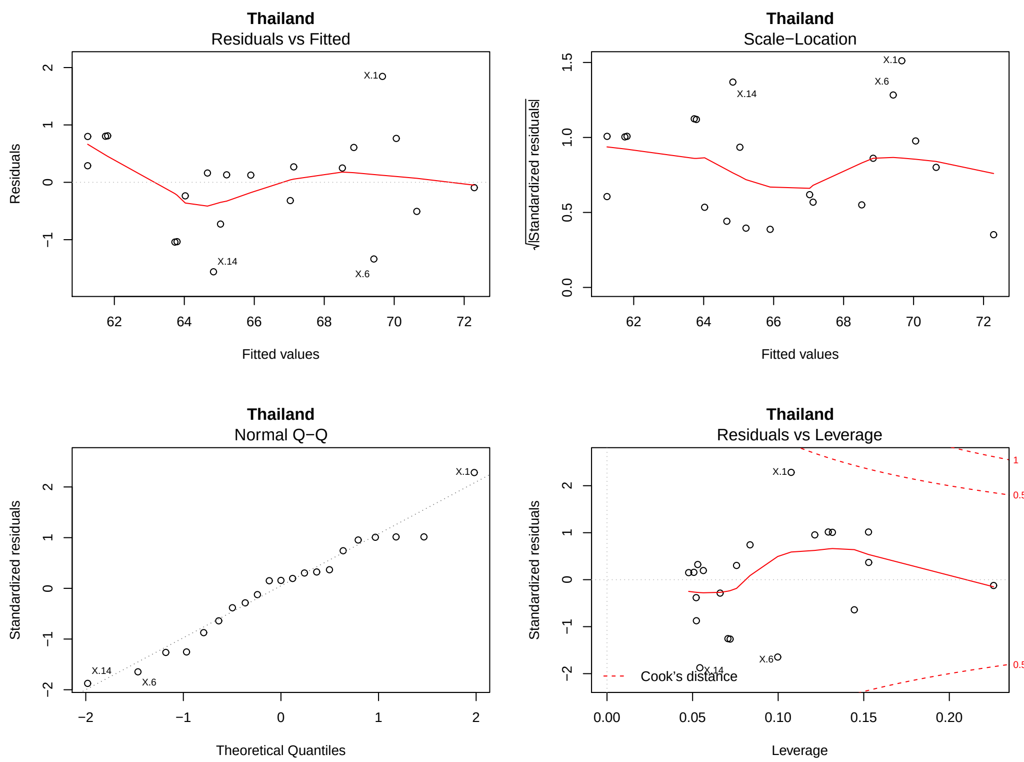
Table 63: Regression results

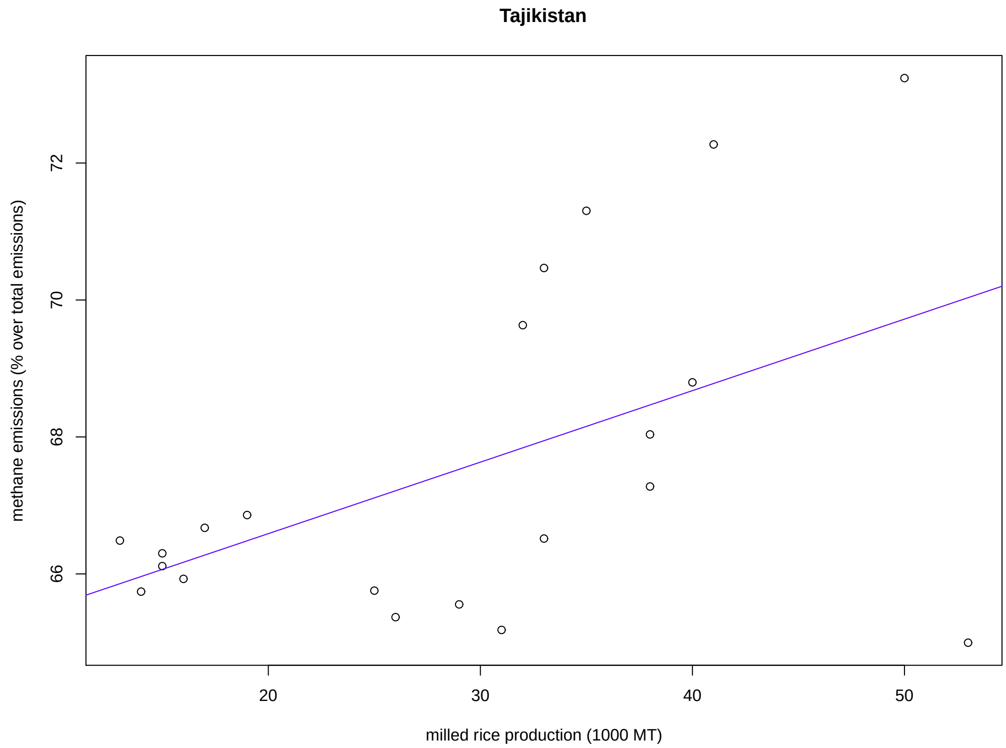

Togo
Residuals vs Fitted
Residuals
Fitted values
X.14
X.15
X.19
Togo
Scale−Location
√|Standardized residuals|
Fitted values
X.14
X.15
X.19
Togo
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.14
X.15
X.19
Togo
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X
X.20
X.19
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	86.3535	1.1888	72.64	0.0000
h[, j]	-1.2396	0.0716	-17.30	0.0000

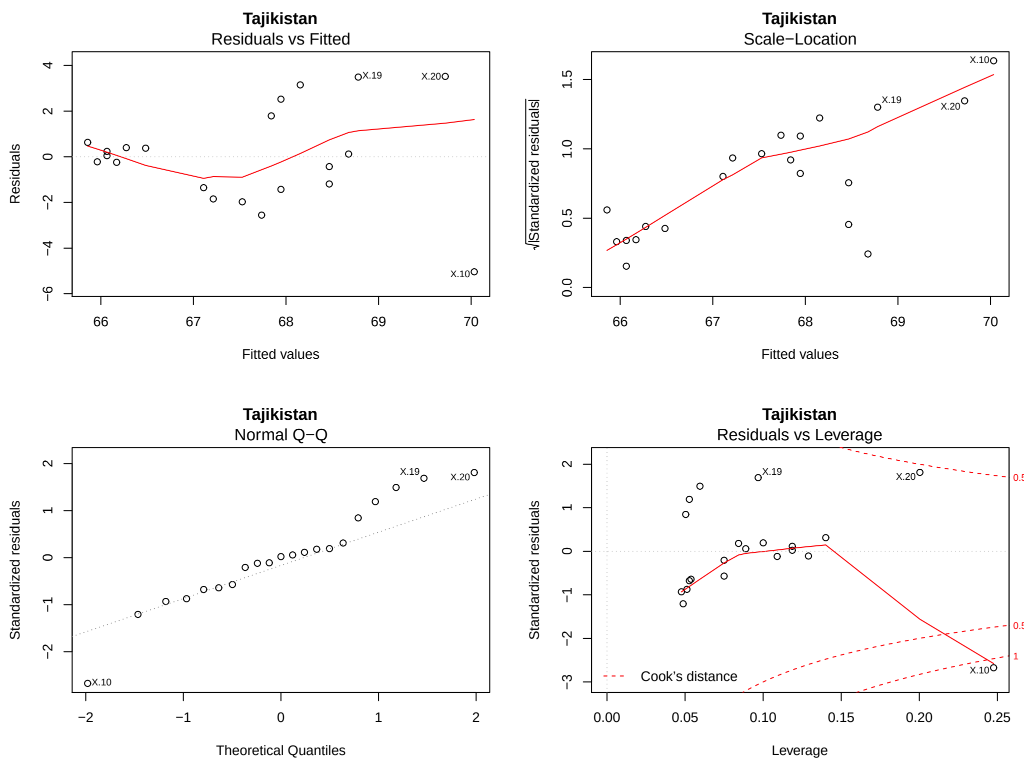
Table 64: Regression results

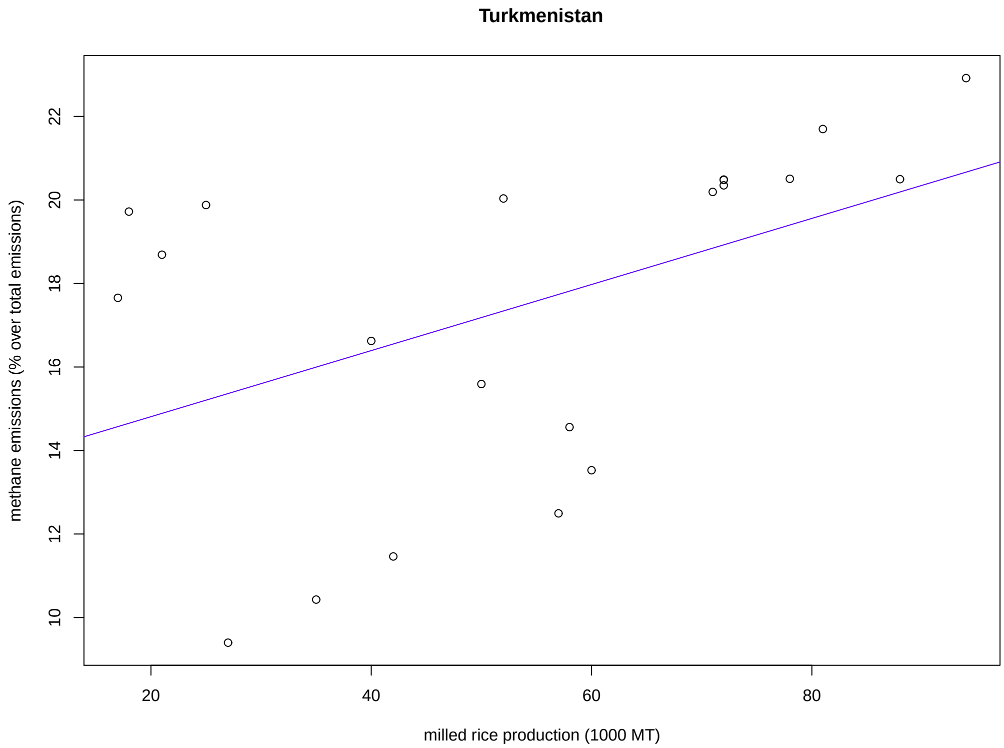

Thailand
Residuals vs Fitted
Residuals
Fitted values
X.1
X.14
X.6
Thailand
Scale−Location
√|Standardized residuals|
Fitted values
Thailand
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Thailand
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	64.5000	1.2814	50.34	0.0000
h[, j]	0.1044	0.0408	2.56	0.0192

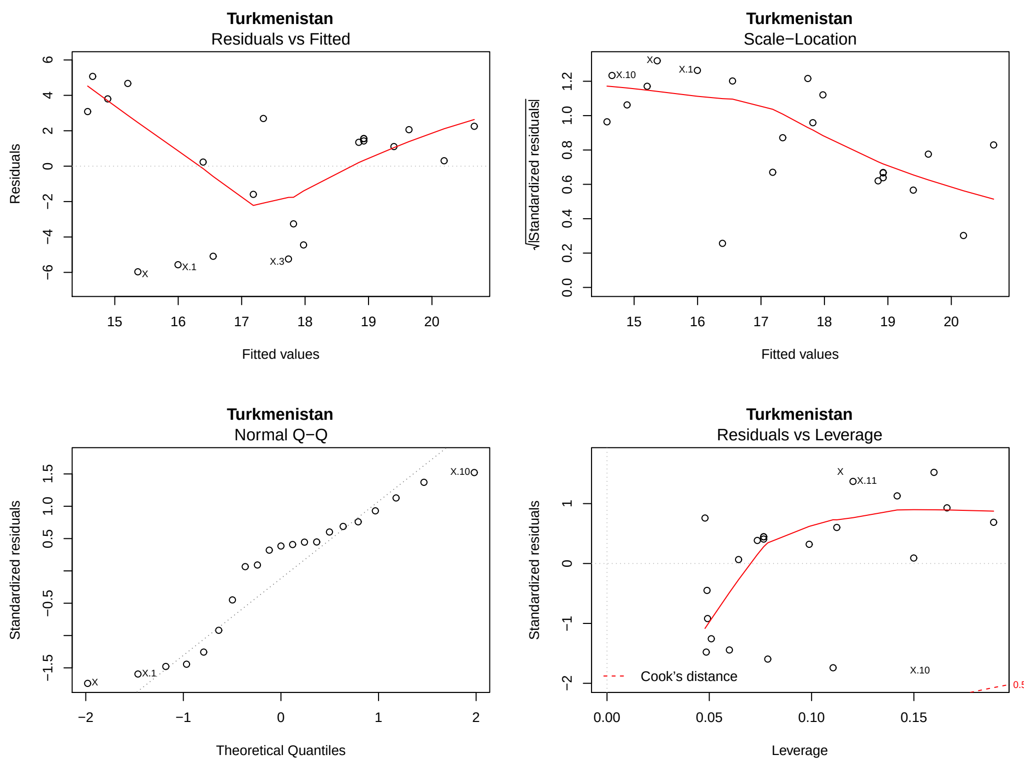
Table 65: Regression results

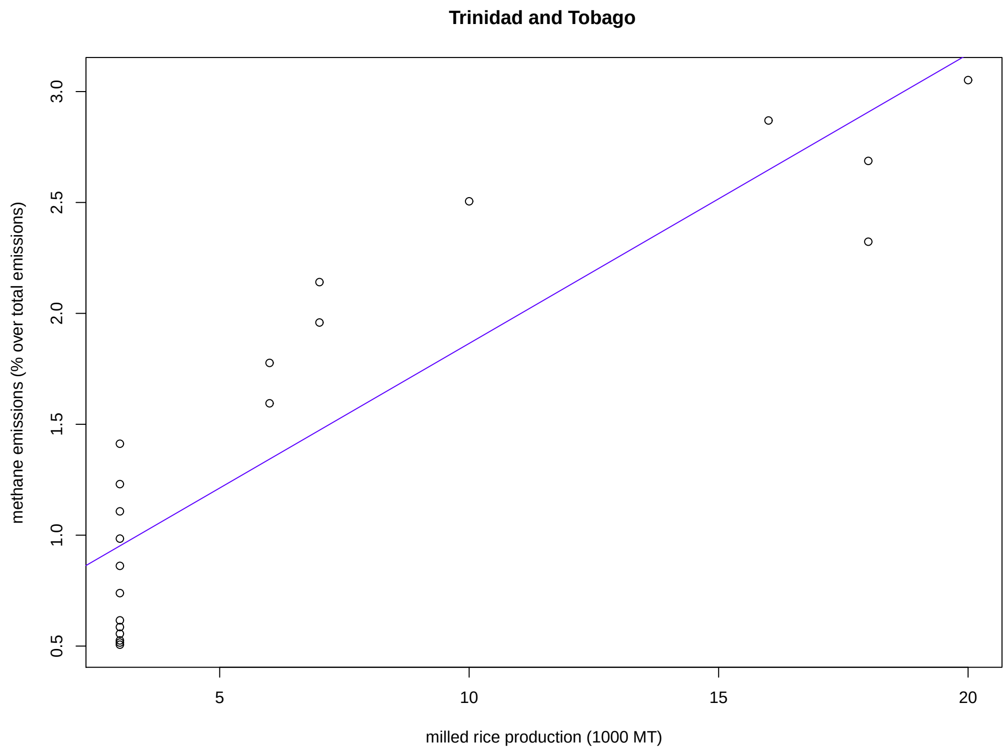

Tajikistan
Residuals vs Fitted
Residuals
Fitted values
X.19
X.20
X.10
Tajikistan
Scale−Location
√|Standardized residuals|
Fitted values
Tajikistan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Tajikistan
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	13.2267	1.9944	6.63	0.0000
h[, j]	0.0791	0.0340	2.33	0.0311

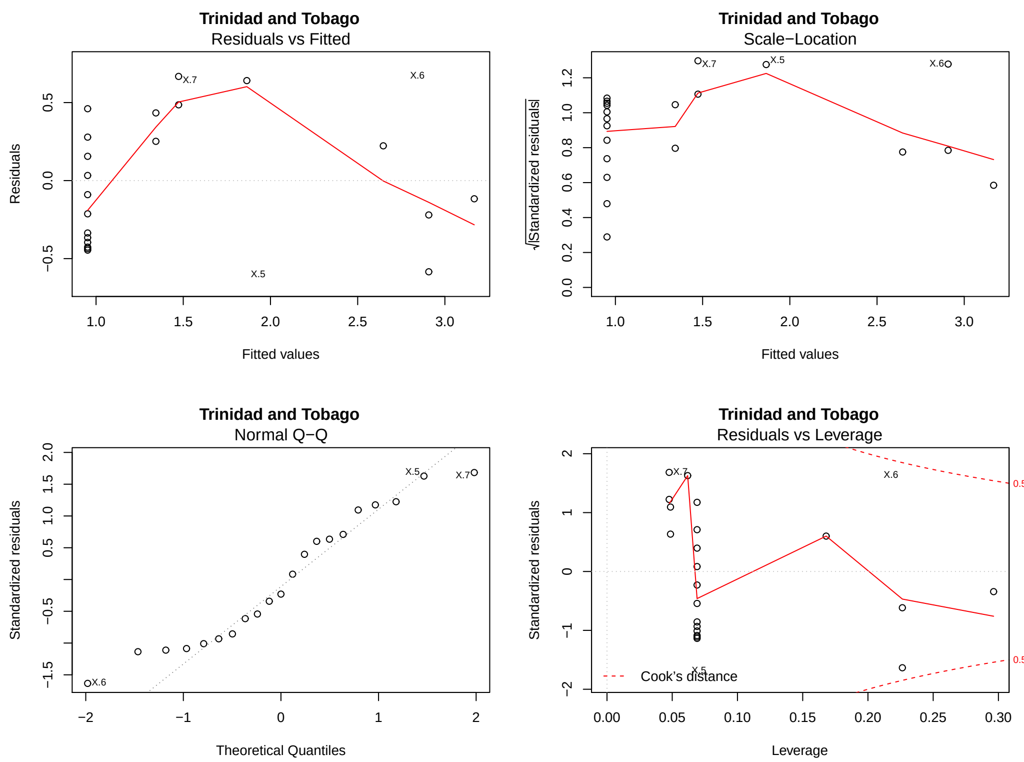
Table 66: Regression results


Turkmenistan
Residuals vs Fitted
Residuals
Fitted values
Turkmenistan
Scale−Location
√|Standardized residuals|
Fitted values
Turkmenistan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Turkmenistan
Residuals vs Leverage
Standardized residuals
Cook's distance
Leverage

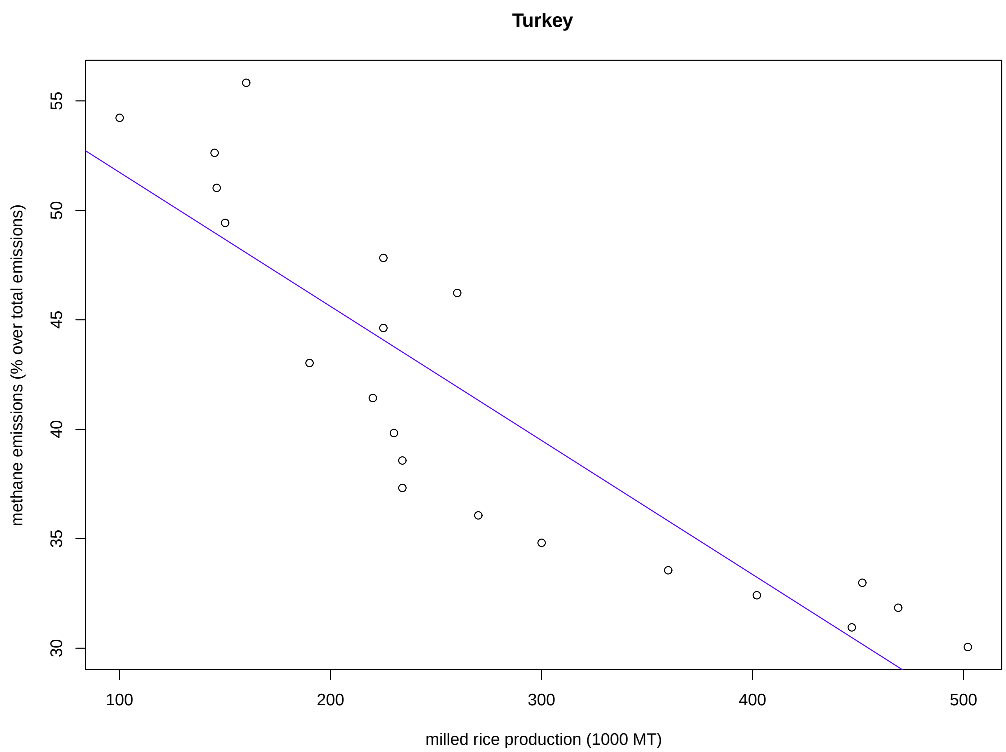


	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.5606	0.1380	4.06	0.0007
h[, j]	0.1304	0.0154	8.45	0.0000

Table 67: Regression results

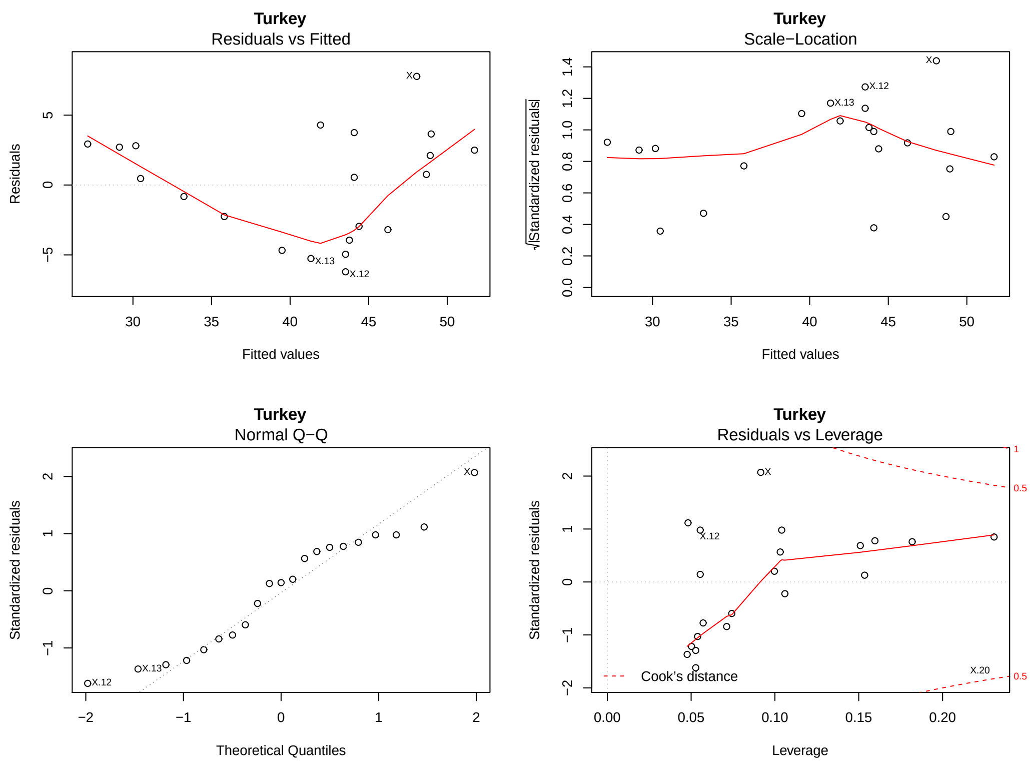


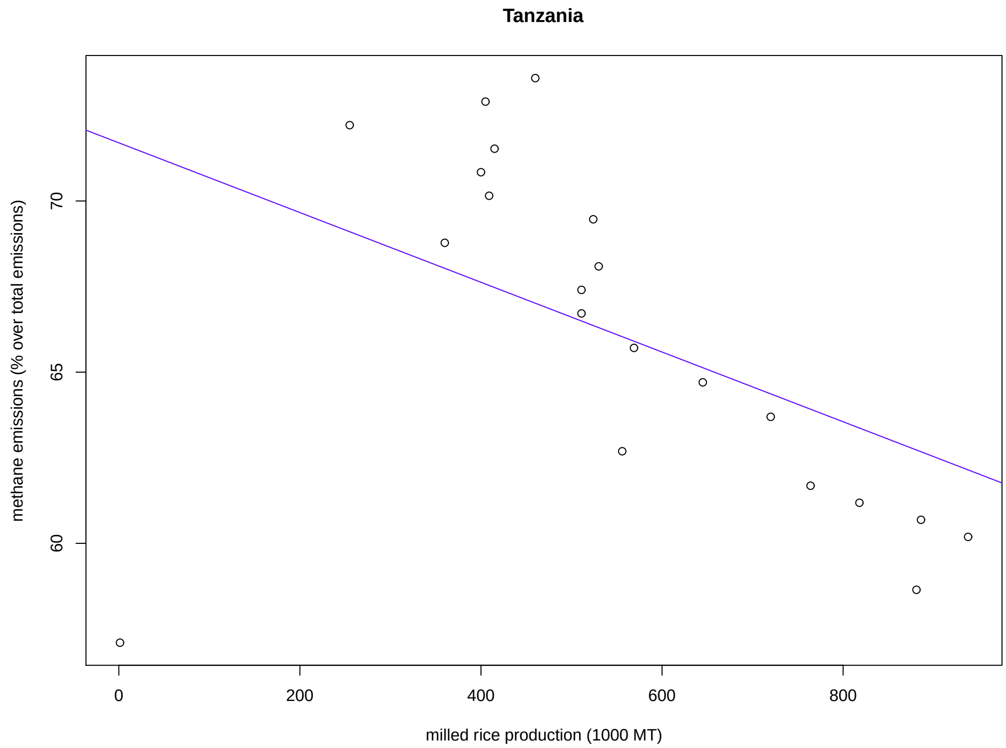
Trinidad and Tobago
Residuals vs Fitted
Residuals
Fitted values
X.7
X.6
X.5
Trinidad and Tobago
Scale−Location
√|Standardized residuals|
Fitted values
X.7
X.5
X.6
Trinidad and Tobago
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.5
X.7
X.6
Trinidad and Tobago
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.7
X.6
X.5
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	57.8550	2.1763	26.58	0.0000
h[, j]	-0.0612	0.0073	-8.34	0.0000

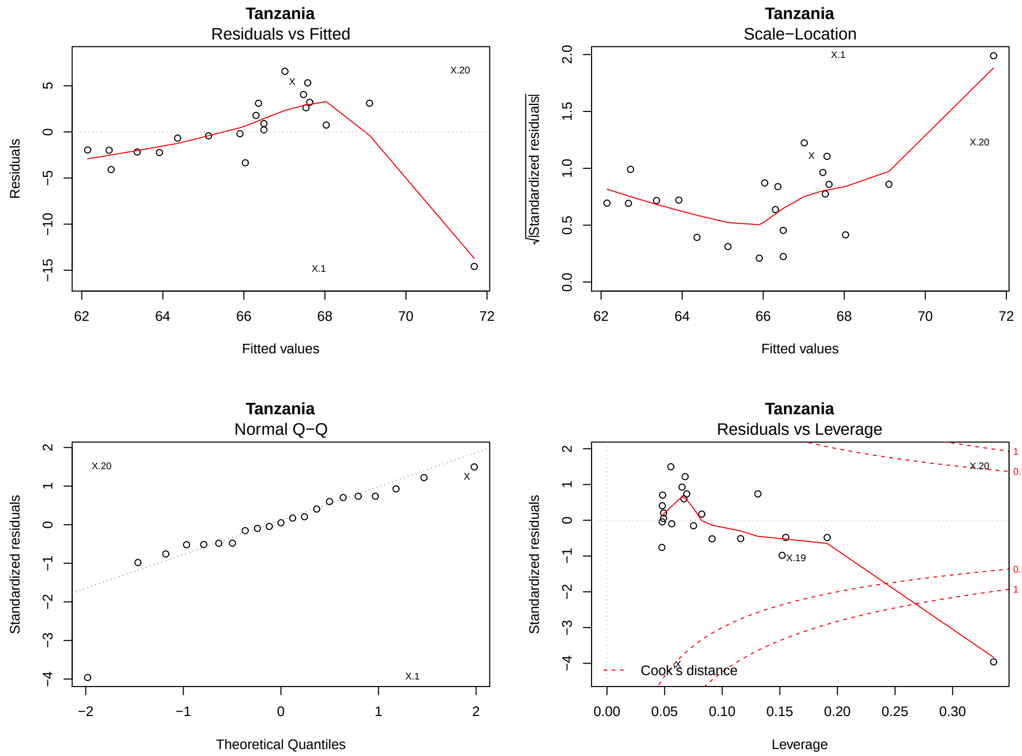
Table 68: Regression results

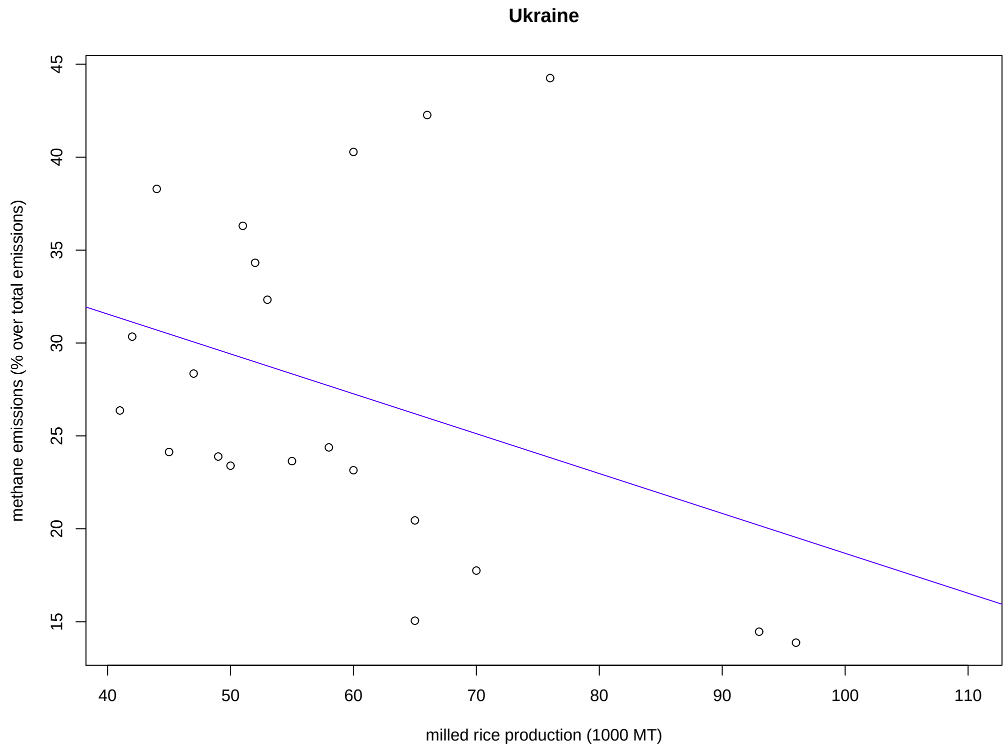

Turkey
Residuals vs Fitted
Residuals
Fitted values
X
X.13
X.12
Turkey
Scale−Location
√|Standardized residuals|
Fitted values
X
X.12
X.13
Turkey
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X
X.13
X.12
Turkey
Residuals vs Leverage
Standardized residuals
Leverage
X
X.12
X.20
Cook's distance
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	71.6986	2.6235	27.33	0.0000
h[, j]	-0.0102	0.0044	-2.31	0.0326

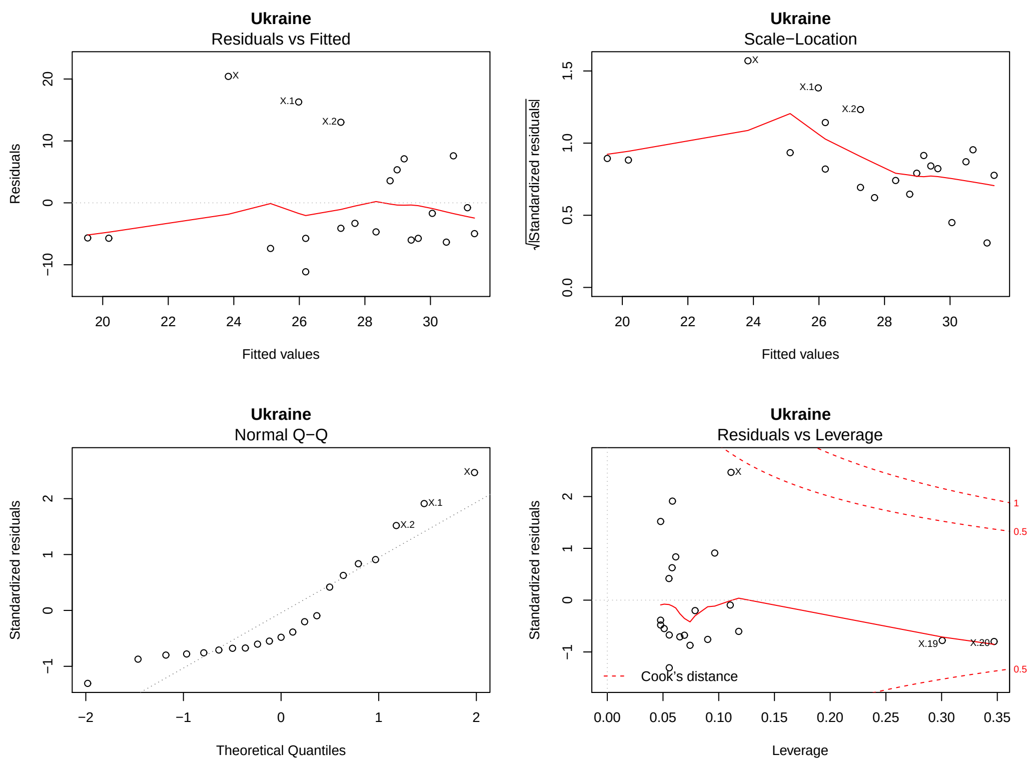
Table 69: Regression results

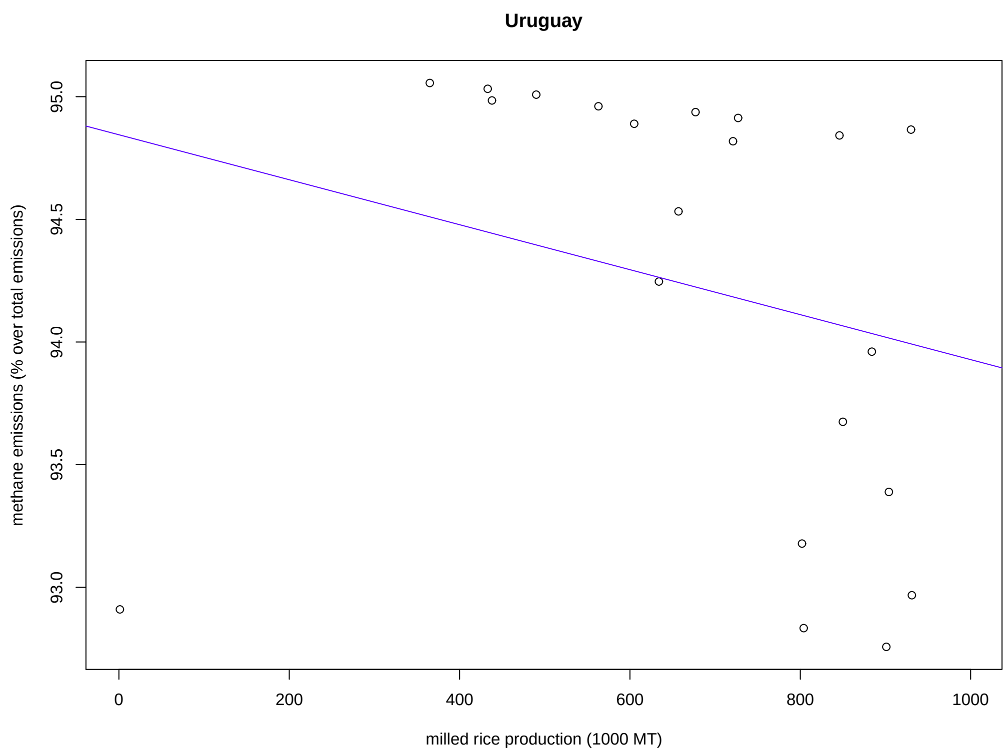

Tanzania
Residuals vs Fitted
Residuals
Fitted values
X.20
X.1
Tanzania
Scale−Location
√|Standardized residuals|
Fitted values
X.1
X.20
Tanzania
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20
X.1
Tanzania
Residuals vs Leverage
Standardized residuals
Leverage
X.20
X.19
Cook's distance
1
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	40.1419	7.8821	5.09	0.0001
h[, j]	-0.2146	0.1297	-1.65	0.1144

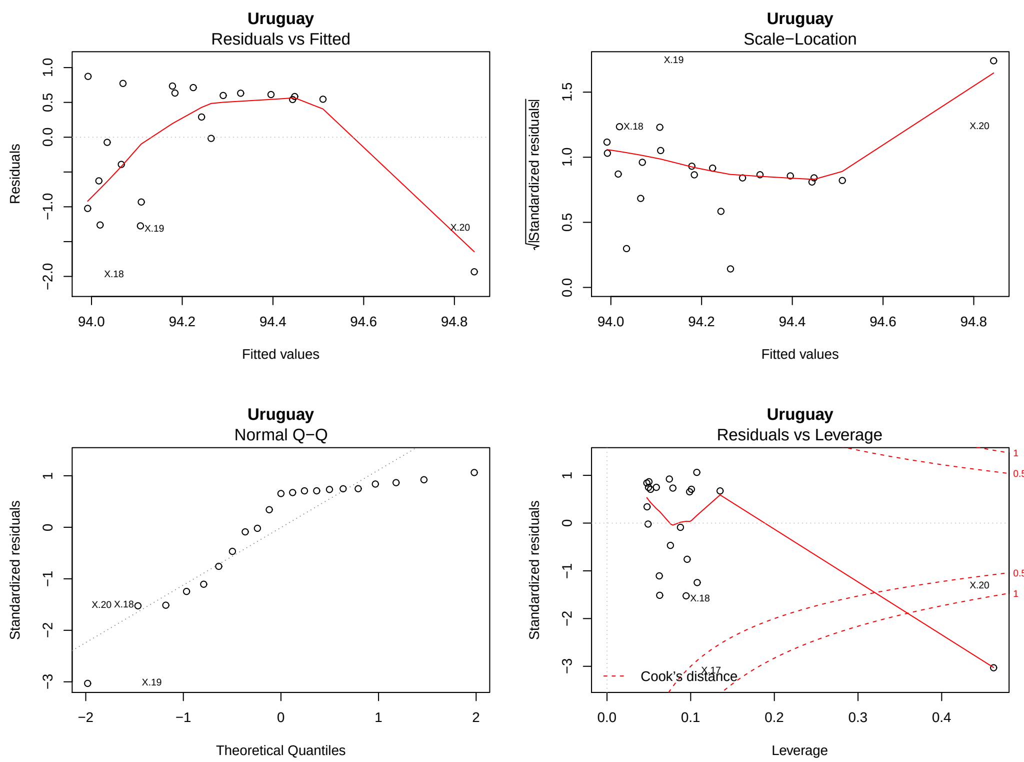
Table 70: Regression results

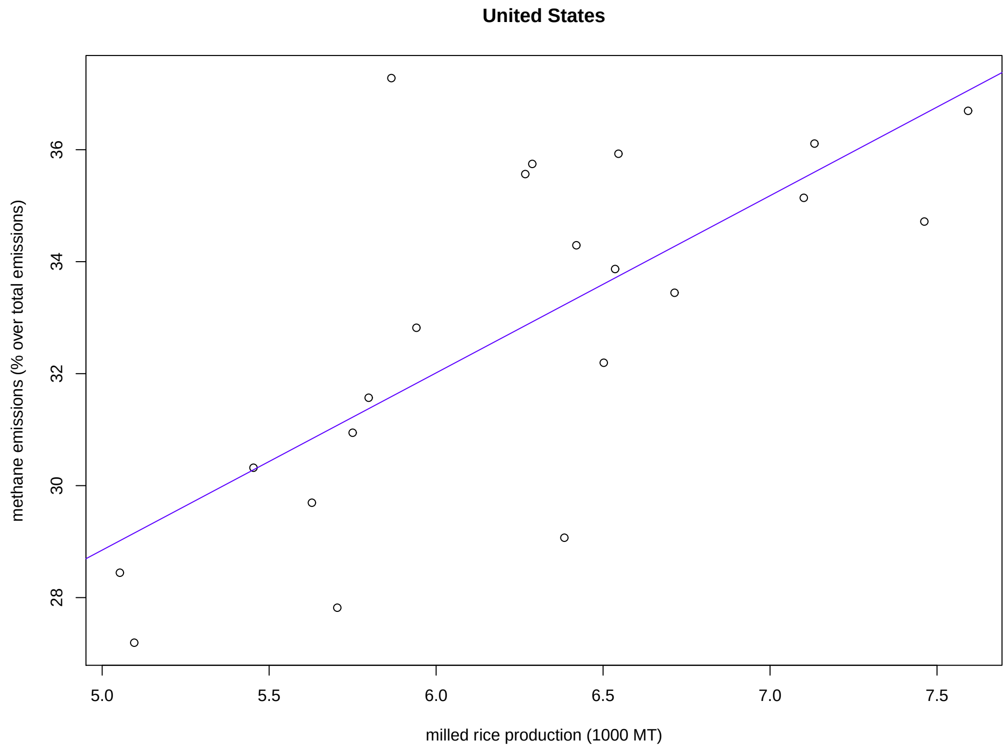

Ukraine
Residuals vs Fitted
Residuals
Fitted values
X
X.1
X.2
Ukraine
Scale−Location
√|Standardized residuals|
Fitted values
X
X.1
X.2
Ukraine
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X
X.1
X.2
Ukraine
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X
X.19
X.20
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	94.8448	0.5923	160.13	0.0000
h[, j]	-0.0009	0.0008	-1.10	0.2843

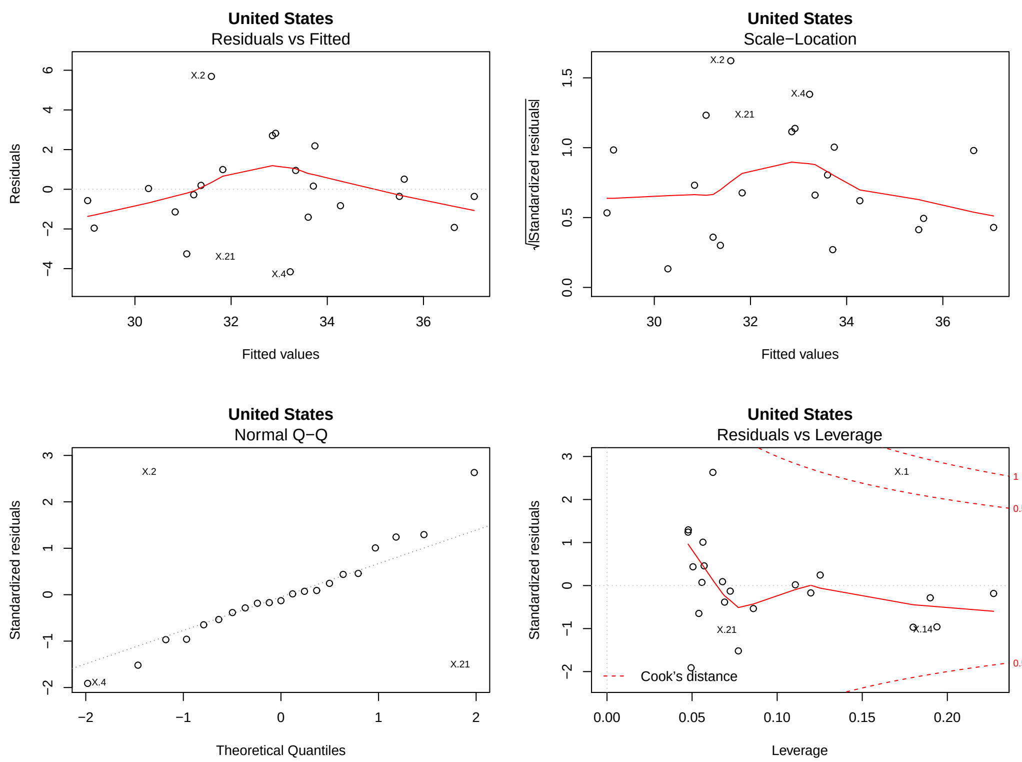
Table 71: Regression results

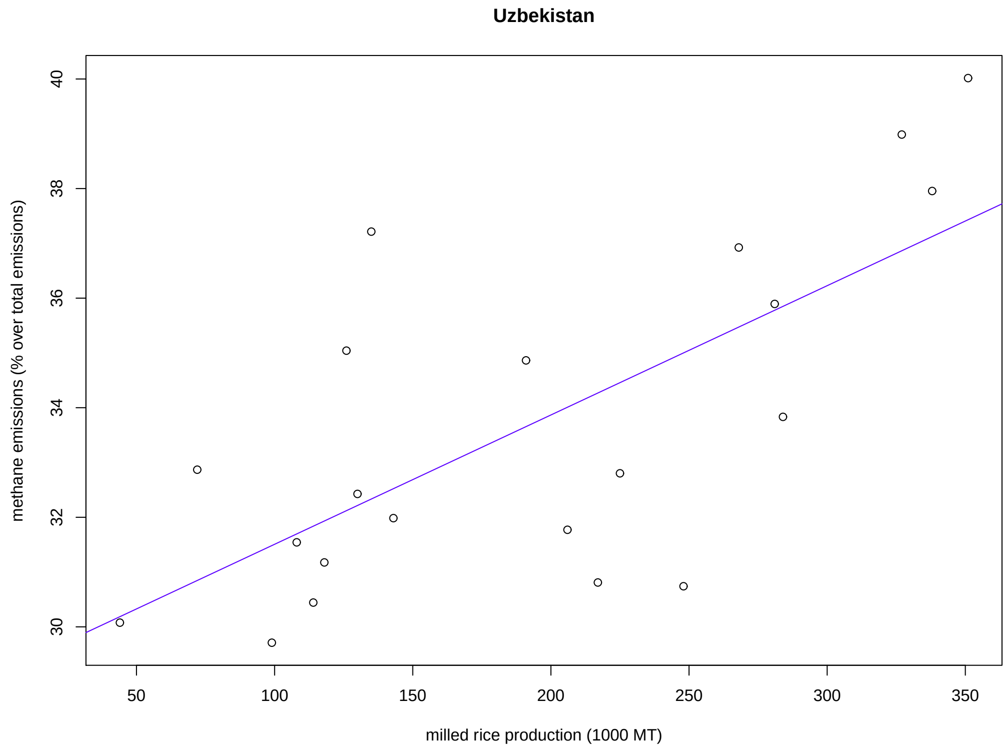

Uruguay
Residuals vs Fitted
Residuals
Fitted values
X.18
X.19
X.20
Uruguay
Scale−Location
√|Standardized residuals|
Fitted values
X.19
X.18
X.20
Uruguay
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.20 X.18
X.19
Uruguay
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.18
X.20
X.17



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	13.0230	4.4273	2.94	0.0084
h[, j]	3.1651	0.7041	4.50	0.0002

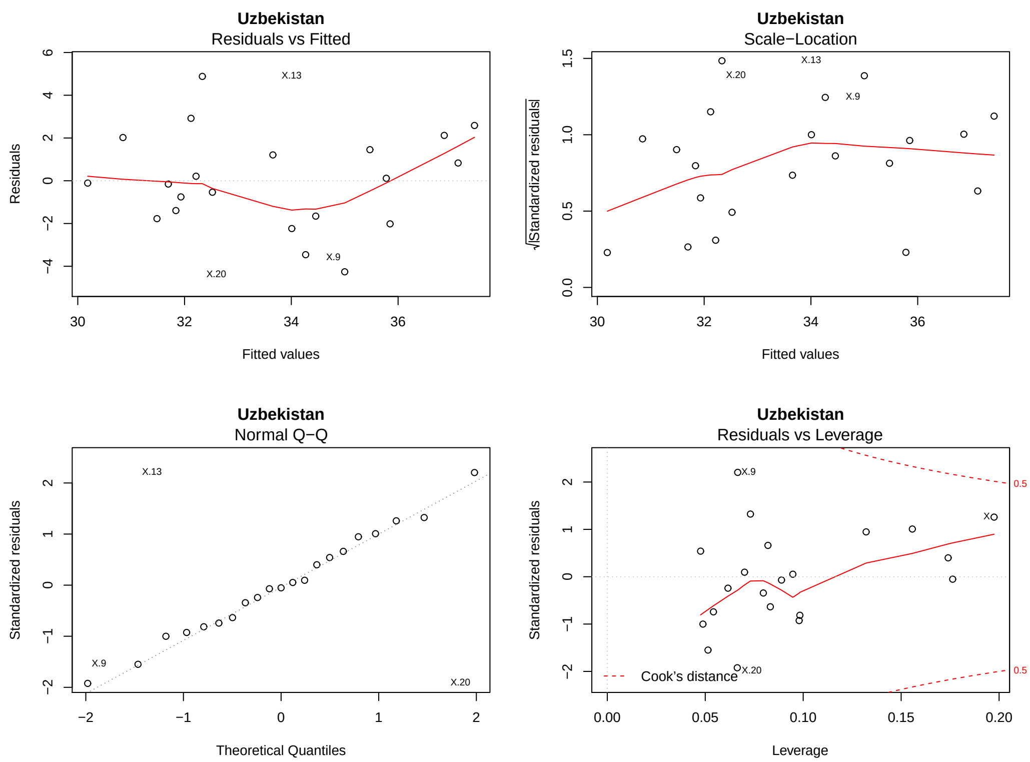
Table 72: Regression results

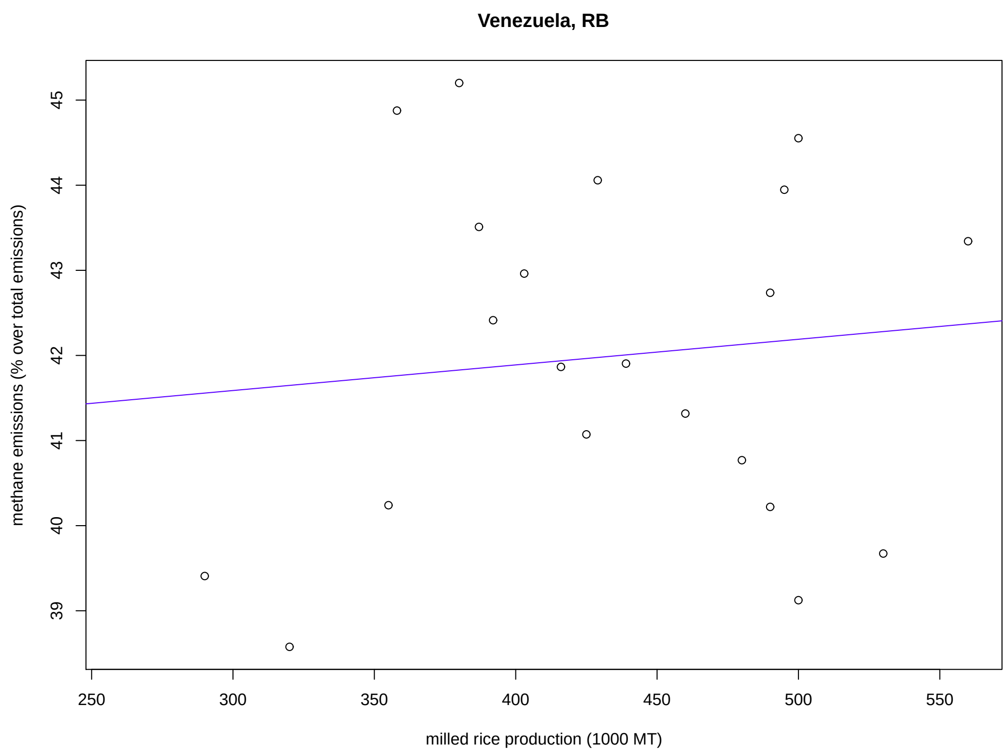

United States
Residuals vs Fitted
Residuals
Fitted values
X.2
X.21
X.4
United States
Scale−Location
√|Standardized residuals|
Fitted values
X.2
X.4
X.21
United States
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.2
X.21
X.4
United States
Residuals vs Leverage
Standardized residuals
Leverage
X.1
X.21
X.14
Cook's distance
1
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	29.1471	1.1788	24.73	0.0000
h[, j]	0.0236	0.0056	4.24	0.0004

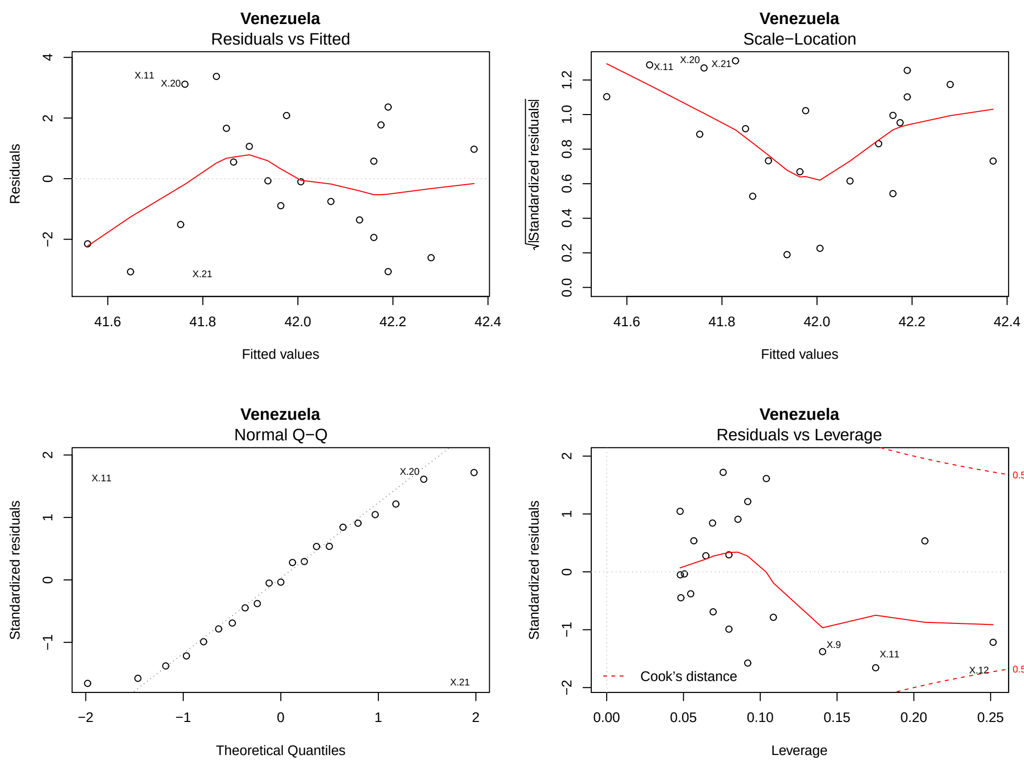
Table 73: Regression results

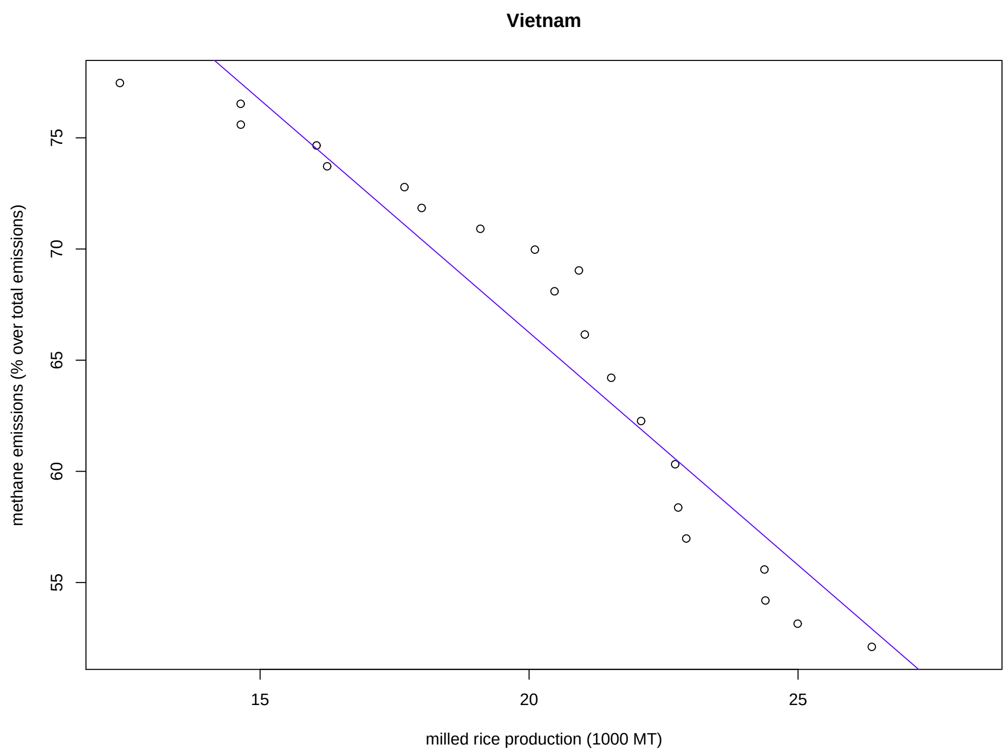

Uzbekistan
Residuals vs Fitted
Residuals
Fitted values
X.13
X.9
X.20
Uzbekistan
Scale−Location
√|Standardized residuals|
Fitted values
Uzbekistan
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Uzbekistan
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	40.6843	2.8228	14.41	0.0000
h[, j]	0.0030	0.0064	0.47	0.6451

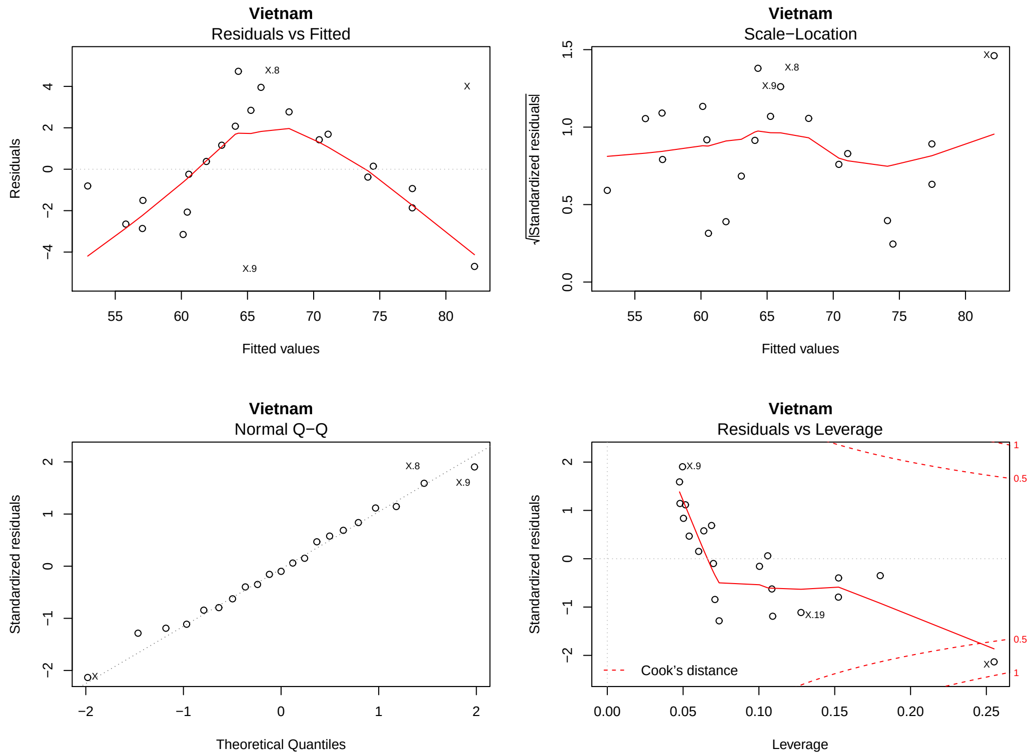
Table 74: Regression results

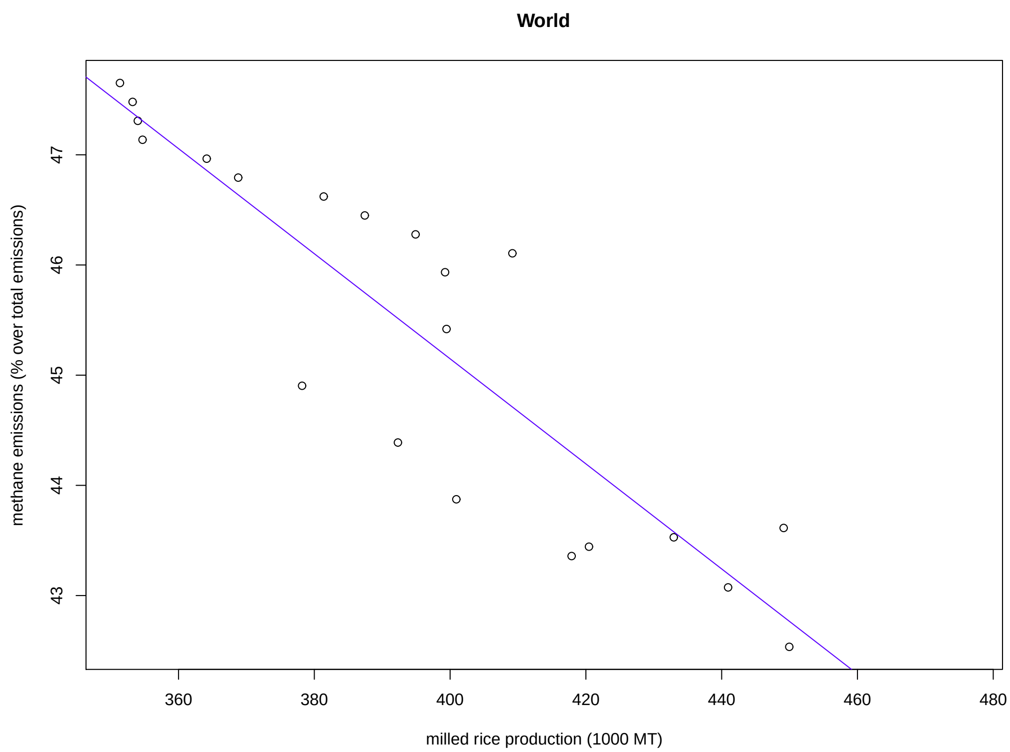

Venezuela
Residuals vs Fitted
Residuals
Fitted values
X.11
X.20
X.21
Venezuela
Scale−Location
√|Standardized residuals|
Fitted values
Venezuela
Normal Q−Q
Standardized residuals
Theoretical Quantiles
Venezuela
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
X.9
X.12



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	108.0904	3.0624	35.30	0.0000
h[, j]	-2.0923	0.1494	-14.01	0.0000

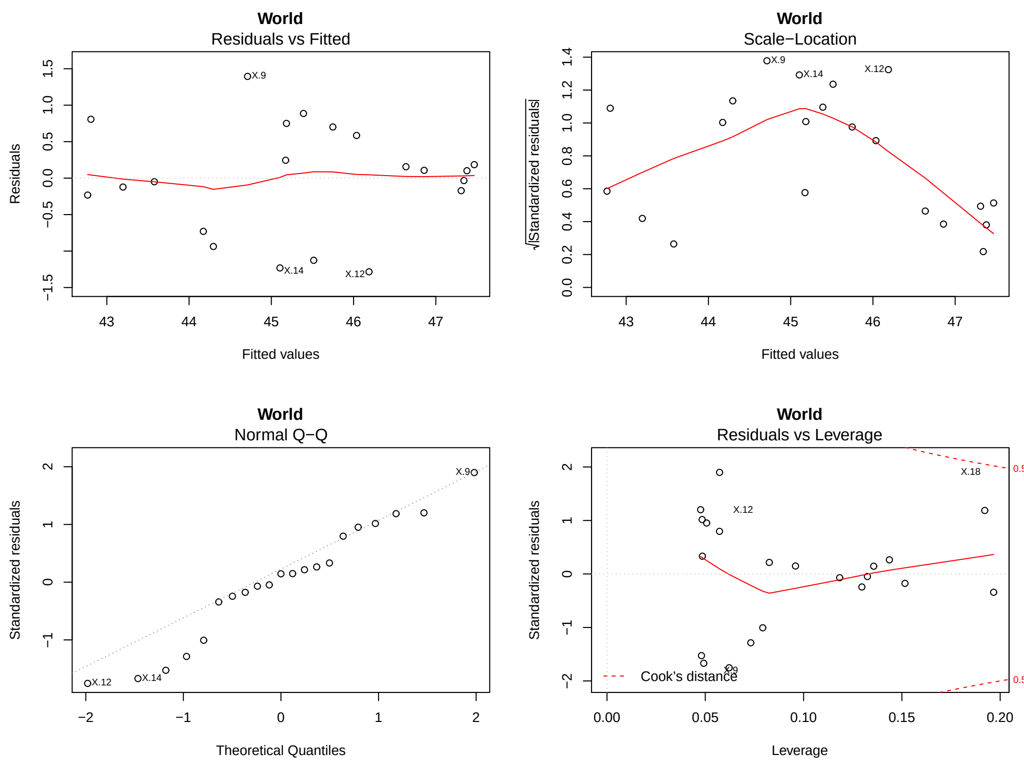
Table 75: Regression results

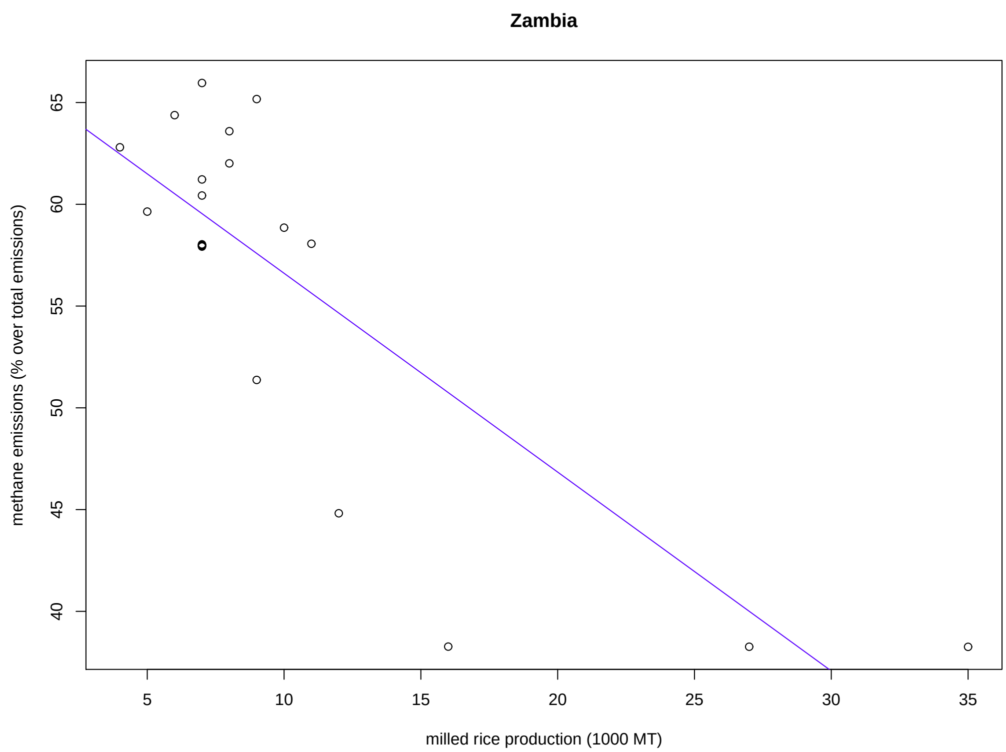

Vietnam
Residuals vs Fitted
Residuals
Fitted values
X.8
X.9
X
Vietnam
Scale−Location
√|Standardized residuals|
Fitted values
X.8
X.9
X
Vietnam
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.8
X.9
X
Vietnam
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.9
X.19
X
0.5
1



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	64.2192	2.1165	30.34	0.0000
h[, j]	-0.0477	0.0053	-8.93	0.0000

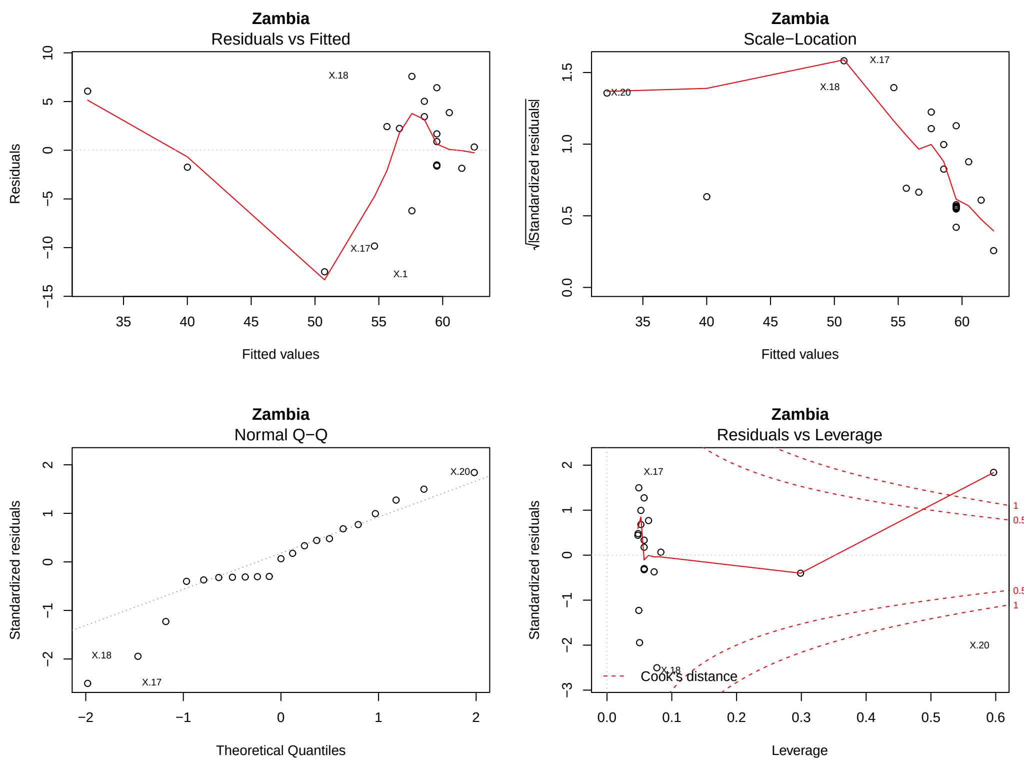
Table 76: Regression results


World
Residuals vs Fitted
Residuals
Fitted values
X.9
X.14
X.12
World
Scale−Location
√|Standardized residuals|
Fitted values
X.9
X.14
X.12
World
Normal Q−Q
Standardized residuals
Theoretical Quantiles
X.9
X.12
X.14
World
Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
X.18
X.12
0.5
0.5



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	66.3801	1.9614	33.84	0.0000
h[, j]	-0.9769	0.1557	-6.28	0.0000

Table 77: Regression results



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