# Saltanat Kondybayeva, PhD

## Al-Farabi Kazakh National University

saltanatkondybayeva@gmail.com

# The theoretical remarks about the shadow economy

# Measuring the shadow economy

# Outline

- *1. A fuzzy-multiple method for assessing the dynamics of the shadow economy*
- *2. Analysis of Shadow Economy degree in Russia by using a fuzzy-multiple method*
- *3. Advantages and disadvantages of the method*
- *4. Estimating informal economy share in Russian regions by cross-section regression model and augmented electricity dynamics approach*

*Goal of this lecture:*

(i) Discussing the definition of the shadow economy and its taxonomy

(ii) Discussing a fuzzy-multiple method of measuring the size of shadow activities of

(iii) Comparing advantages and disadvantages of discussed approaches

*(iv) Estimating informal economy share in Russian regions by cross-section regression model and augmented electricity dynamics approach*

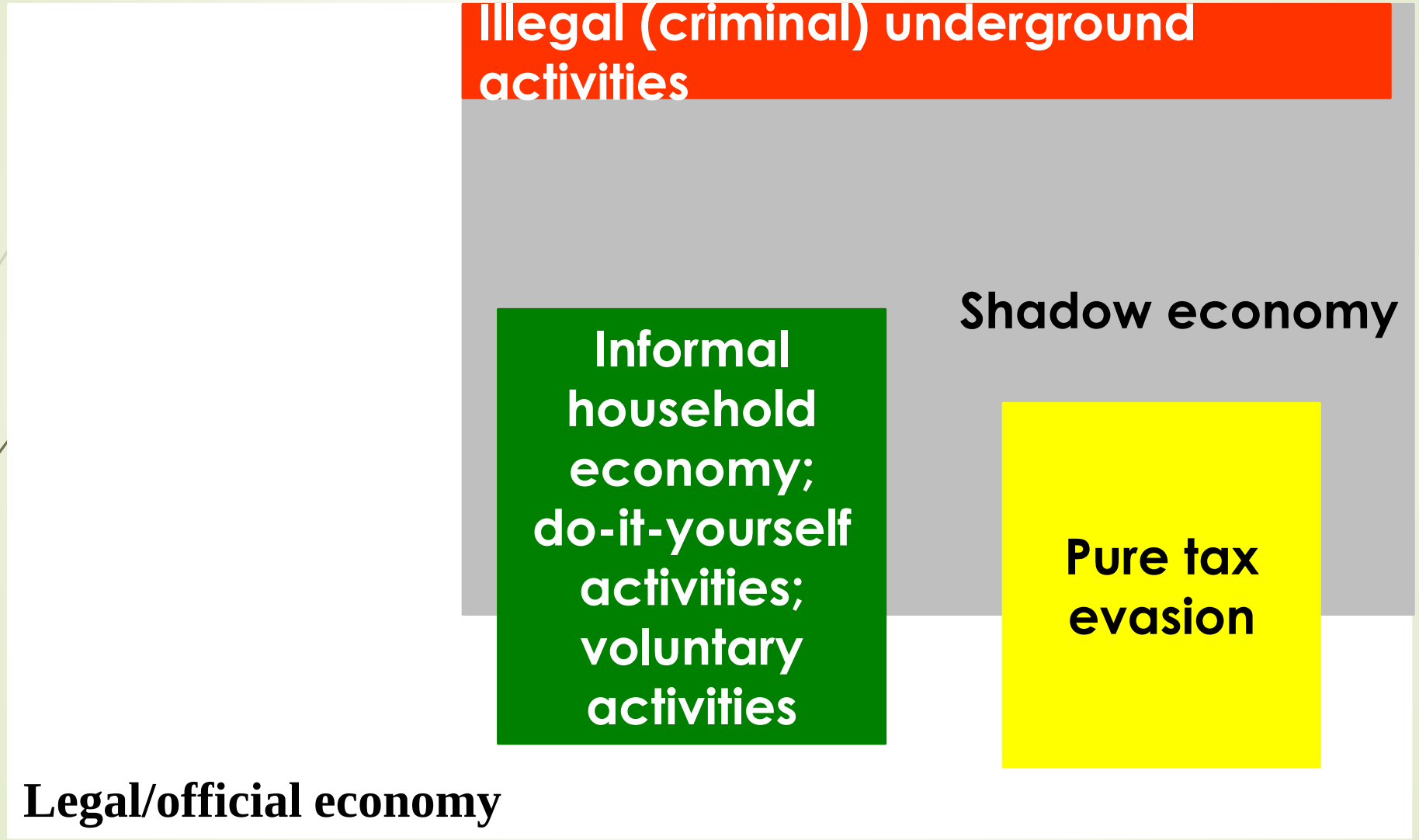
# Introduction - Measuring the shadow economy

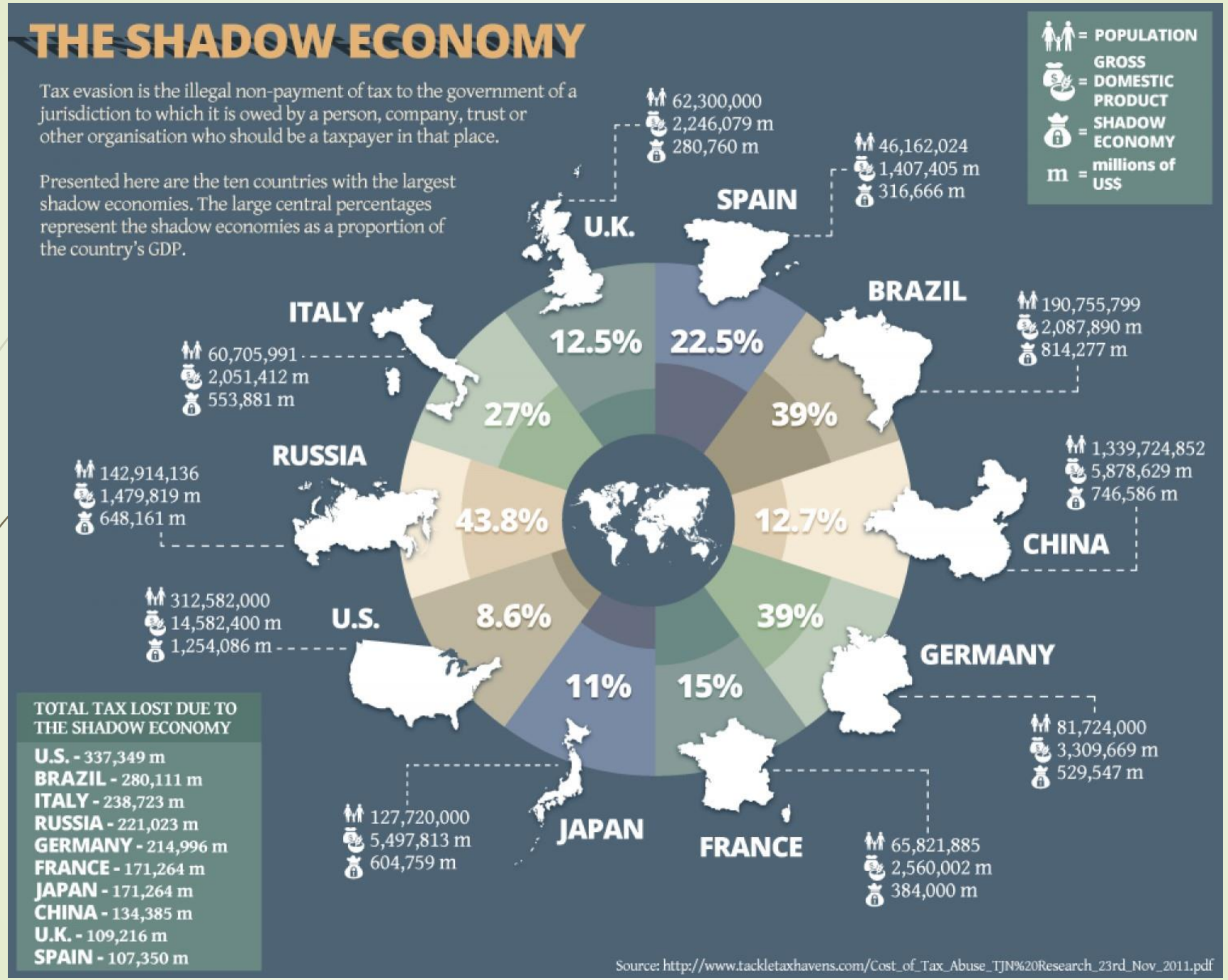
Empirical research about the size and development of the shadow economy all over the world has grown rapidly. Nowadays, there are so many studies, which use different methods in order to estimate the size and development of the shadow economy, that it is quite difficult to judge the reliability of various methods.

**Estimating the size of a shadow economy is a difficult and challenging task.**

# Defining the Shadow Economy

**Figure 1: Legal, shadow, illegal and informal economy and tax evasion**




THE SHADOW ECONOMY
Tax evasion is the illegal non-payment of tax to the government of a jurisdiction to which it is owed by a person, company, trust or other organisation who should be a taxpayer in that place.
Presented here are the ten countries with the largest shadow economies. The large central percentages represent the shadow economies as a proportion of the country's GDP.
= POPULATION
= GROSS DOMESTIC PRODUCT
= SHADOW ECONOMY
m = millions of US$
U.K.
62,300,000
2,246,079 m
280,760 m
12.5%
SPAIN
46,162,024
1,407,405 m
316,666 m
22.5%
BRAZIL
190,755,799
2,087,890 m
814,277 m
39%
ITALY
60,705,991
2,051,412 m
553,881 m
27%
RUSSIA
142,914,136
1,479,819 m
648,161 m
43.8%
CHINA
1,339,724,852
5,878,629 m
746,586 m
12.7%
U.S.
312,582,000
14,582,400 m
1,254,086 m
8.6%
GERMANY
81,724,000
3,309,669 m
529,547 m
39%
JAPAN
127,720,000
5,497,813 m
604,759 m
11%
FRANCE
65,821,885
2,560,002 m
384,000 m
15%
TOTAL TAX LOST DUE TO THE SHADOW ECONOMY
U.S. - 337,349 m
BRAZIL - 280,111 m
ITALY - 238,723 m
RUSSIA - 221,023 m
GERMANY - 214,996 m
FRANCE - 171,264 m
JAPAN - 171,264 m
CHINA - 134,385 m
U.K. - 109,216 m
SPAIN - 107,350 m
Source: http://www.tackletaxhavens.com/Cost_of_Tax_Abuse_TJN%20Research_23rd_Nov_2011.pdf

Three methods of measurement:

1. *Direct procedures* using the micro level and aiming at determining the size of the shadow economy. An example of this method are surveys.
2. *Indirect procedures* that make use of macroeconomic indicators following the development of the shadow economy over time.
3. *Statistical models* that use statistical tools to estimate the shadow economy as an "unobserved" variable.

# *Indirect Approaches*

**These approaches, which are also called "indicator" approaches, are mostly macroeconomic ones and use various (mostly economic) indicators that contain information about the development of the shadow economy (over time).**

## A fuzzy-multiple method for assessing the dynamics of the shadow economy.

Giles and Draeseke [Giles et al., 1999] described a method based on expert assessments that makes it possible to assess the dynamics of the shadow economy using a small statistical base. This method involves the use of two indicators ($I1$ and $I2$), depending on the size of the shadow economy. For example, O. Sokolova [Sokolova, 2003] used data on the total real ($I1$) and regulatory ($I2$) receipts of personal income tax in her work on measuring the share of the shadow economy of the Russian Federation. A. Kostin [Kostin, 2009] used the data on general real ( $I1$) and regulatory ($I2$) receipts of VAT and personal income tax to measure the shadow economy of Russia.

The main assumption of this method is that the two selected indicators adversely affect the share of the shadow economy in GDP.

As an example of indicators, common real ($I1$) and regulatory (I2) receipts of VAT and personal income tax were used. It is assumed that if with increasing tax burden of the population there is a decrease in actually collected taxes, then the shadow economy increases.

To estimate the size of the shadow economy, Giles and Draeseke used fuzzy methods. In their works, the authors convert the two selected indicators into quality indicators: very low, low, normal, high, very high (VL, L, N, H, VH).

There are several ways to determine the boundaries of a fuzzy set. In this case, the non-centered moving average is used. For each factor is taken 12 months a moving average and a forecast is made for one step. Each predicted value is calculated using the formula:

$$F_{t+1} = \left(\frac{1}{N}\right) * \sum_{j=1}^{12} A_{t-j+1},$$

N – the number of preceding periods included in the moving average;
Aj – the actual value at time j;
Fj - the predicted value at time j.

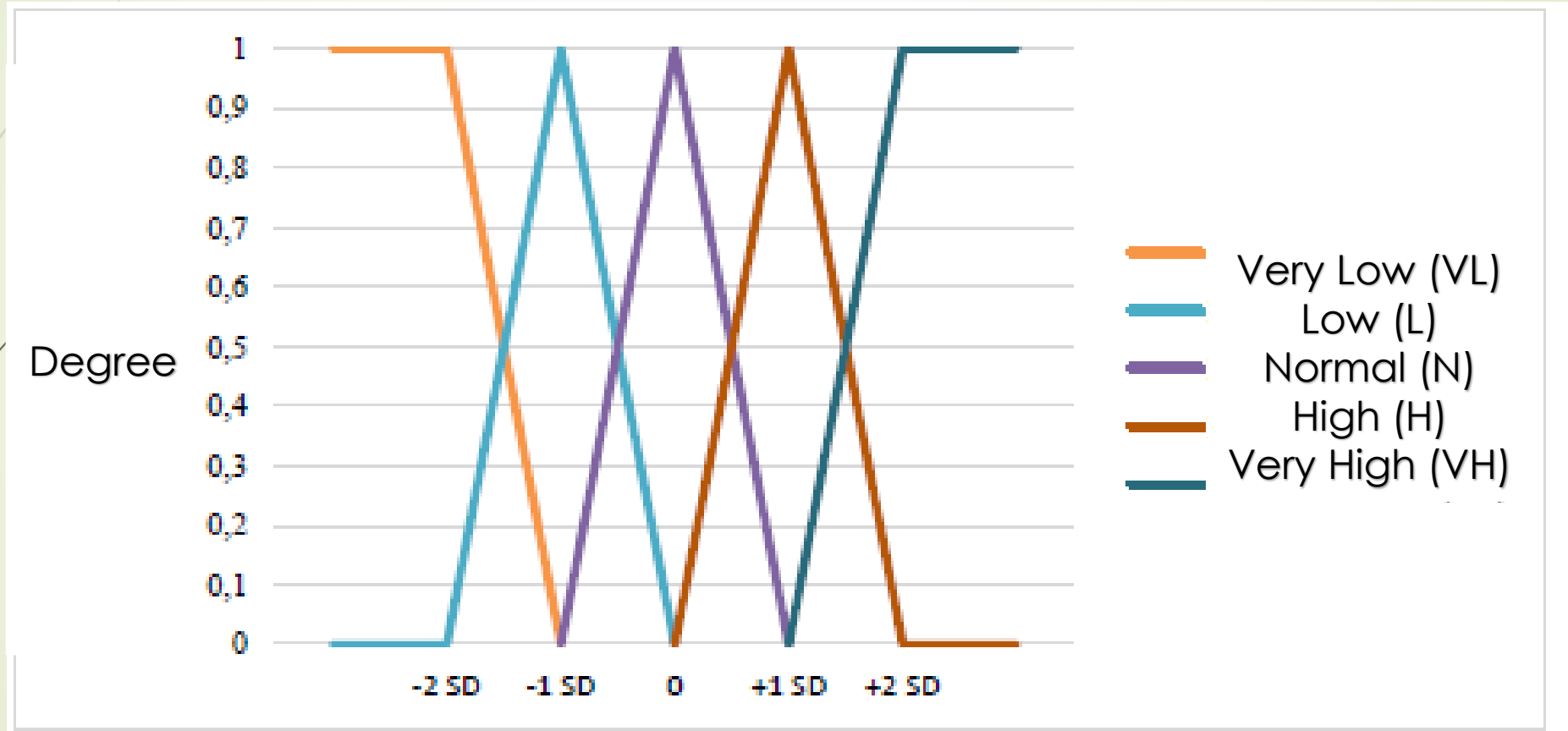
Each forecast value is assigned a value of **"normal" (N)**. To determine other qualitative values, one and **two standard deviations (SD)** are taken around the **"normal"** value for each period. For the description of fuzzy sets **"Low", "Normal"** and **"High"** triangular fuzzy numbers with a single core (the point where the membership function is equal to one) are used. To describe the fuzzy sets **"Very high"** and **"Very low", Z** and **S** are used - linear functions

# Table 1 - Cores fuzzy sets of indicators (I1 and I2)

| Very Low | Low | Normal | High | Very High |
|---|---|---|---|---|
| VL | L | N | H | VH |
| - 2 SD | - 1 SD | F | + 1 SD | + 2 SD |

Source- Robert Draeseke & David E. A. Giles, 1999. "A Fuzzy Logic Approach to Modelling the Underground Economy," Econometrics Working Papers 9909, Department of Economics, University of Victoria.

# Figure 1. Degree of indicators L1 and L2



To estimate the size of the shadow economy, according to the methods of Giles and Draeseke, Table 2 shows the rules of transition from fuzzy indicator values to fuzzy values of the shadow economy.
For example, if regulatory tax revenues are "high" (H), and real tax revenues are "low" (L), then the shadow economy is "big".

Since for each value of actual and nominal factors there are two values of the degree of belonging to different fuzzy values, the shadow economy can have a positive degree of belonging to four fuzzy sets.

Using the "min" and "max" operators for fuzzy sets instead of the usual intersections and unions, we make four possible combinations (Table 3, 4). For September 2005, in Russia actual VAT and personal income tax have a degree of affiliation of 0.83 to a fuzzy set of "High" (H) and 0.17 to a fuzzy set of "Very High" (VH), and the normative VAT and personal income tax have a degree of 0.63 to an unclear set "Low" (L) and 0.37 to the fuzzy set "Very Low" (VL).

Table 2 - Interrelation of fuzzy sets of indicators and fuzzy sets of shadow economy

| | Regulatory tax revenue | Real tax revenues | Shadow Economy |
|---|---|---|---|
| 1 | VH | VH | A |
| 2 | VH | H | B |
| 3 | VH | N | B |
| 4 | VH | L | VB |
| 5 | VH | VL | VB |
| 6 | H | VH | S |
| 7 | H | H | A |
| 8 | H | N | B |
| 9 | H | L | B |
| 10 | H | VL | VB |
| 11 | N | VH | S |
| 12 | N | H | S |
| 13 | N | N | A |
| 14 | N | L | B |
| 15 | N | VL | B |
| 16 | L | VH | VS |
| 17 | L | H | S |
| 18 | L | N | S |
| 19 | L | L | A |
| 20 | L | VL | B |
| 21 | VL | VH | VS |
| 22 | VL | H | VS |
| 23 | VL | N | S |
| 24 | VL | L | S |
| 25 | VL | VL | A |

Source- Robert Draeseke & David E. A. Giles, 1999. "A Fuzzy Logic Approach to Modelling the Underground Economy," Econometrics Working Papers 9909, Department of Economics, University of Victoria.

## Size of the Underground Economy in Russia and the G-7, 1999-2007

(percent of official GDP)

| Country | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| United States | 8.8 | 8.7 | 8.8 | 8.8 | 8.7 | 8.6 | 8.5 | 8.4 | 8.4 | 8.6 |
| Japan | 11.4 | 11.2 | 11.2 | 11.3 | 11.2 | 10.9 | 10.7 | 10.4 | 10.3 | 11.0 |
| United Kingdom | 12.8 | 12.7 | 12.6 | 12.6 | 12.5 | 12.4 | 12.4 | 12.3 | 12.2 | 12.5 |
| France | 15.7 | 15.2 | 15.0 | 15.1 | 15.0 | 14.9 | 14.8 | 14.8 | 14.7 | 15.0 |
| Germany | 16.4 | 16.0 | 15.9 | 16.1 | 16.3 | 16.1 | 16.0 | 15.6 | 15.3 | 16.0 |
| Canada | 16.3 | 16.0 | 15.9 | 15.8 | 15.7 | 15.6 | 15.5 | 15.3 | 15.3 | 15.7 |
| Italy | 27.8 | 27.1 | 26.7 | 26.8 | 27.0 | 27.0 | 27.1 | 26.9 | 26.8 | 27.0 |
| Russian Federation | 47.0 | 46.1 | 45.3 | 44.5 | 43.6 | 43.0 | 42.4 | 41.7 | 40.6 | 43.8 |

Source: Schieder, Friedrich, Andreas Buehn, and Claudio Montenegro. "Shadow Economies All Over the World", World Bank Policy Research Working Paper, 2010.

# Table 3 – The degrees of indicators (Russia, 09.2005)

| **Actual VAT and personal income tax ($I1$)** | **High (H)** | **Very High (VH)** |
|---|---|---|
| | 0,83 | 0,17 |
| Regulatory VAT and personal income tax ($I2$) | Low (L) | Very Low (VL) |
| | 0,63 | 0,37 |

The first combination in this example links the "low" level of regulatory tax revenues and the "very high" level of actual tax revenue. Using the fuzzy operator "MIN", the minimum value is chosen from the degrees of belonging of the indicators (MIN (0.63,0.17)). The value obtained is the degree of belonging of the shadow economy to the fuzzy set "very small". Similarly, other combinations are considered (Table 4).

# Table 4 - Calculation of the degree of the shadow economy (Russia, 09.2005)

| Regulatory / Actual VAT and Personal Income Tax | Rule number | The degree of IE | MIN (Regulatory / Actual VAT and Personal Income Tax) | The connection with the level of the shadow economy | MAX with the level of the shadow economy |
|---|---|---|---|---|---|
| L/VH | 16 | VS | MIN(0.17,0.63) | 0,17 | - |
| L/H | 17 | S | MIN(0.83,0.63) | 0,63 | 0,63 |
| VL/VH | 21 | VS | MIN(0.17,0.37) | 0,17 | - |
| VL/H | 22 | VS | MIN(0.83,0.37) | 0,37 | 0,37 |

As a result, the size of the shadow economy has 0.17, 0.17, 0.37degrees  to the fuzzy set "very small" and 0.63 to the fuzzy set "small". But the size of the shadow economy can not belong to the same fuzzy set with different degrees, therefore the maximum degree is chosen. As a result, we got that the size of the shadow economy to the set "very small" with a degree of affiliation of 0.37 and to the set "small" with a degree of membership of 0.63. Further, the results are normalized so that the sum of the degree of membership is equal to one, but in the example this condition has already been done.

As a result, we have the size of a shadow economy in a fuzzy-multiple dimension. To obtain a numerical range of the share of the shadow economy in GDP, it is necessary to convert the fuzzy set to an ordinary number.

To solve this issue Giles and Draeseke offer each fuzzy set the value of the size of the shadow economy to be compared with the values 0, 0.25, 0.5, 0.75, 1 (for "very small", "small", “normal", “high", "very high", respectively). The degrees of belonging to these fuzzy sets are multiplied by these values and added (in our example: 0.63 * 0.25 + 0.37 * 0 = 0.16). Giles and Draeseke [Giles et al., 1999] write that if the value of this indicator is less than 0.5, then economic agents begin to emerge from the shadow, and vice versa.

Table 5 - Rules for the transition from fuzzy values of the size of the shadow economy to the deviation of the size of the shadow economy from the expected

| Very Small | Small | Normall | High | Very high |
|---|---|---|---|---|
| **VS** | S | A | B | VB |
| **F - 2 SD** | F - 1 SD | Mean F | F + 1 SD | F + 2 SD |

**Source- Robert Draeseke & David E. A. Giles, 1999. "A Fuzzy Logic Approach to Modelling the Underground Economy," Econometrics Working Papers 9909, Department of Economics, University of Victoria.**

## Rules for the transition from fuzzy values of the size of the shadow economy to the deviation of the size of the shadow economy from the expected

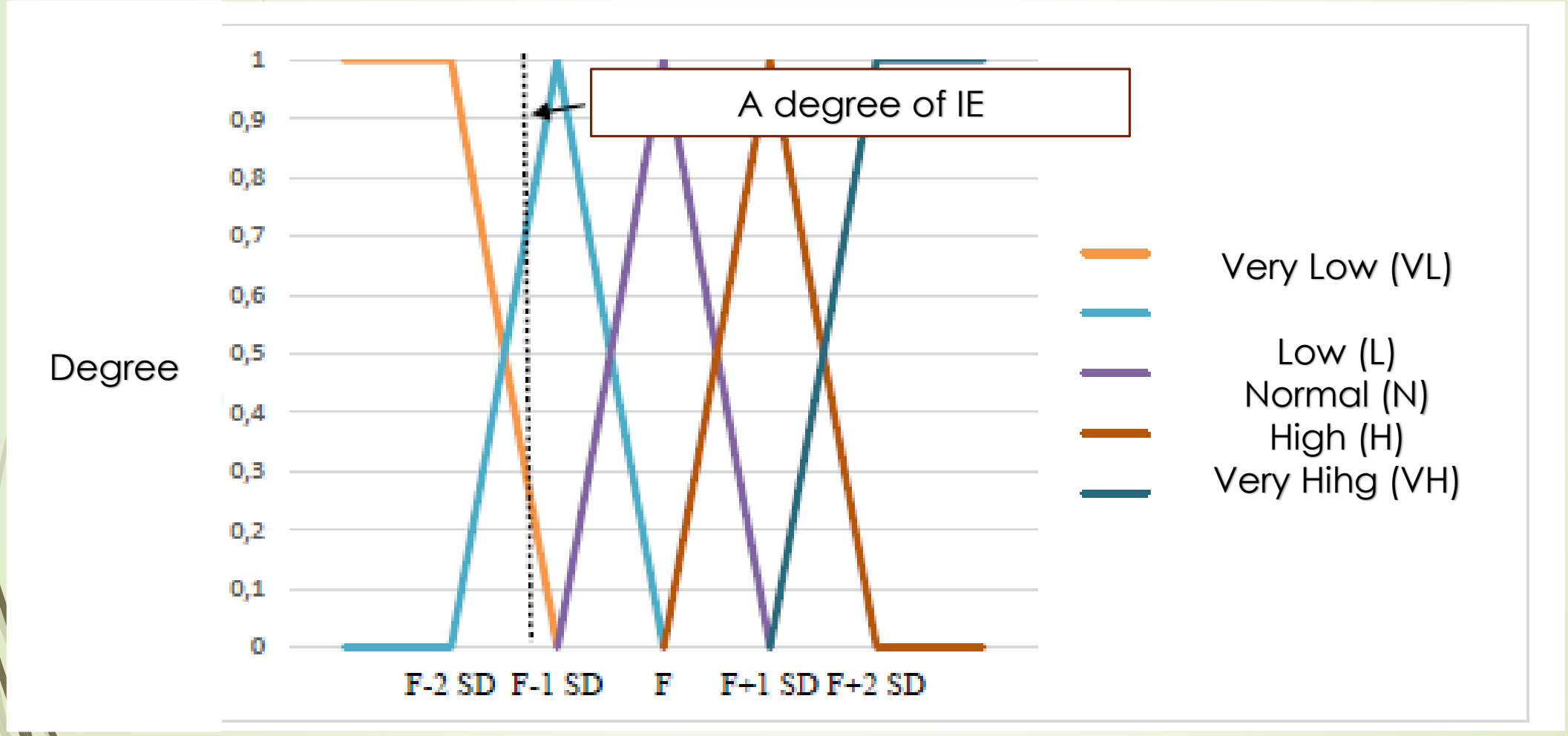
First, the expected size of the shadow economy (for the selected period) and the standard deviation from it are exogenously given.

Second, the obtained values of the shadow economy's belonging to different fuzzy sets are the indices of the deviation of the shadow economy by a certain number of standard deviations relative to the mathematical expectation for the selected period (at a time of 12 months). This approach allows us to find a point at which the conditions for belonging to the size of the shadow economy are simultaneously fulfilled for two fuzzy sets, thereby obtaining a direct mapping (each single size of the shadow economy that is described by fuzzy sets corresponds to a single clear number).

## Rules for the transition from fuzzy values of the size of the shadow economy to the deviation of the size of the shadow economy from the expected

Third, knowing the given expected size of the shadow economy, a given standard deviation and the estimated deviation of the size of the dynamics of the shadow economy from the average, it is possible to estimate the size of the shadow economy. As a result, the obtained rule of transition from fuzzy values of the size of the shadow economy to clear ones is set forth in the Table 5 and in the Figure 2.

Figure 2 - Functions of the size of the shadow economy (Russia, 09.2005)



For example, for September 2005, the mathematical expectation of the size of the shadow economy is 0.51 (F), the standard deviation is 0.022 (SD). The fuzzy size of the shadow economy: S with a degree of membership of 0.63 and VS with a degree of membership of 0.37 (Figure 2). The size of the shadow economy was equal to:

$$0.63*(0.51-(1*0.022))+0.37*(0.51-(2*0.022))=0.48.$$

The share of the shadow economy in GDP was 48%

**Advantages of this method:**

- the use of logic;
- easy to use;
- small size of the required statistical base.

# Disadvantages of this method:

1. Only two factors considered;

2. Despite the fact that logical relationships seem plausible, the very process of their transformation is controversial;

3. the results of this method depend on the selected indicators, the specified values of mathematical expectation and the standard deviation of the size of the shadow economy, which introduces uncertainty into the final results;

4. The process of transition from a fuzzy set of the size of the shadow economy to a clear equivalent is complicated by the definition of fuzzy sets. The proposed algorithm has limitations on measuring the shadow economy by a maximum of ± 2 standard deviations from the mathematical expectation.

# The offers to improve the approach

- 1) increase in the number of indicators;
- 2) statistical justification of the methodology for transferring fuzzy sets of indicators into fuzzy sets of the shadow economy;
- 3) developing a more valid method of transition from fuzzy sets to clear equivalents.

# Estimating informal economy share in Russian regions

**Informal economy in Russian regions is measured using two approaches:**

1) **cross-section regression model for electricity consumption in Russian regions;**
2) **augmented electricity dynamics approach.**

1) Regression model is applied for electricity consumption in production of goods and services (total electricity consumption less losses, less households' consumption). Model was estimated on the basis of regional data in 2011. It allowed estimating informal economy share in 67 Russian regions in 2011. The average informal economy share is estimated at 40% with standard deviation 18 percentage points. These results show high positive correlation with usual proxies for informal economy such as corruption, unemployment, and especially dependency of regional budget from Federal transfers.

2) Augmented electricity dynamics approach is developed to estimate dynamics of informal economy share in regions over 2004-2011. Comparing to traditional method in the literature, it takes into account changes in regional industrial structure and electricity intensity of GRP. It leads to more accurate estimates. It has been shown that the share of informal economy in Russia diminished from 55% in 2004 to 40% in 2011 due to the growth of formal sector. Only 16 from 65 regions witnessed an increase in informal economy share over the period.

## 1) cross-section regression model for electricity consumption in Russian regions

Electricity consumption method is considered as the most prospective for the measurement of informal activity. Electricity is the most important energy source in the Russian economy. In 2012 electricity consumption for final use in Russia was 47% of the total use of energy sources. All economic activities require energy for equipment, lightening, heating. Electricity consumption data is available from Rosstat with high level of details (regional, industrial dimensions).

The simplest modification of electricity approach is called “Electricity consumption model” (ECM). It implies that total electricity consumption has a constant elasticity (usually unitary) to the total economic activity. Thus, percentage point change of informal economy share is calculated as a difference between growth rate in electricity consumption and growth rate of officially-recorded GDP

# “Modified electricity consumption model” (MEC)

Eilat and Zinnes (2002) introduced approach based on regression with factors of electricity consumption: changes in electricity prices, share of industrial production in GDP and efficiency of energy use. This approach was called “Modified electricity consumption model” (MEC).
The basic idea of MEC is to filter out the influence of other factors of electricity consumption besides total economic activity.

The regression function. The percentage change in electricity consumption was in the left-hand side of equation. The right-hand side was constituted by 1) the percentage change of electricity prices, 2) the percentage point change of industry share in GDP, 3) and the percentage point change in the share of private sector in GDP (which is assumed to be a proxy for energy efficiency improvements).

# The Lacko method

- Lacko (1998, 1999, 2000a,b) assumes that a certain part of the shadow economy is associated with the household consumption of electricity. This part comprises so-called household production, do-it-yourself activities, and other non-registered production and services. Lacko further assumes that in countries where the portion of the shadow economy associated with household electricity consumption is high, the rest of the hidden economy (or the part Lacko cannot measure) will also be high. Lacko (1996, pp. 19 ff.) assumes that in each country a part of the household consumption of electricity is used in the shadow economy.

Lacko's approach (1998, p. 133) can be described by the following two equations:

$$\ln E_i = \alpha_1 \ln C_i + \alpha_2 \ln PR_i + \alpha_3 G_i + \alpha_4 Q_i + \alpha_5 H_i + u_i \text{ , with } \alpha_1 > 0, \alpha_2 < 0, \alpha_3 > 0, \alpha_4 < 0, \alpha_5 > 0$$

and

$$H_i = \beta_1 T_i + \beta_2 (S_i - T_i) + \beta_3 D_i \text{ with } \beta_1 > 0, \beta_2 < 0, \beta_3 > 0$$

where $i$ indicates the number assigned to the country,
$E_i$ is per capita household electricity consumption in country $i$,
$C_i$ is per capita real consumption of households without the consumption of electricity in country $i$ in US dollars (at purchasing power parity),
$PR_i$ is the real price of consumption of 1 kWh of residential electricity in US dollars (at purchasing power parity),
$G_i$ is the relative frequency of months requiring heating in houses in country $i$,
$Q_i$ is the ratio of energy sources other than electricity energy to all energy sources in household energy consumption,
$H_i$ is the per capita output of the hidden economy,
$T_i$ is the ratio of the sum of paid personal income, corporate profit and taxes on goods and services to GDP,
$S_i$ is the ratio of public social welfare expenditures to GDP, and
$D_i$ is the sum of the number of dependents over 14 years of age and inactive earners, both per 100 active earners.

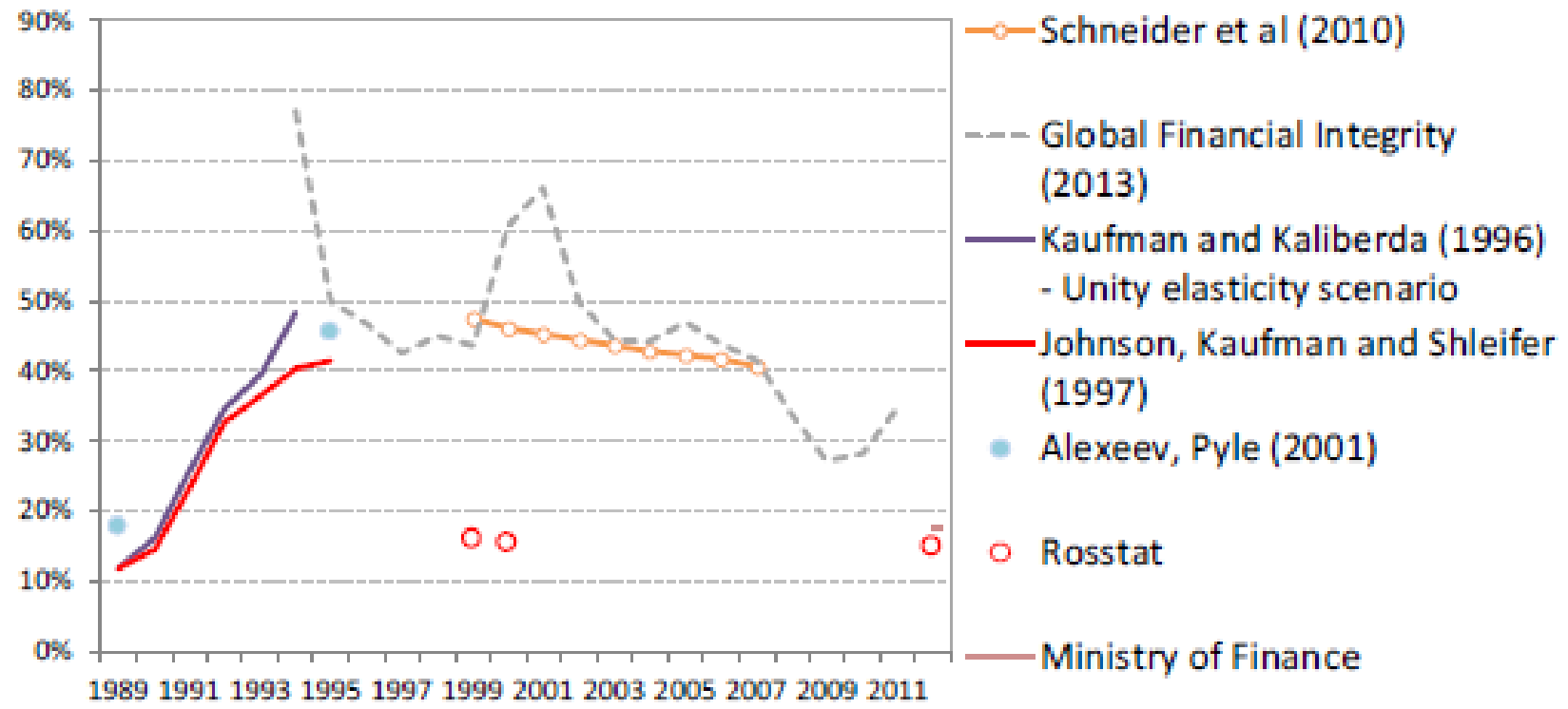
The main **advancement** in Lacko's method was using factors of cross-country variance in the level of informal economy (tax burden, social expenditures, number of dependents). It allows separating informal economy and other factors which influence electricity consumption and present in the residual of regression 1. However the list of informal economy determinants might be incomplete. Thus, Lacko's method estimates only a part of informal economy which is attributable directly to a chosen set of factors.

*The research implement regression analysis of cross-section electricity consumption data. However, there are 3 differences to Lacko:*

1) the use cross-section of regions instead of countries;
2) analysis of electricity consumption in production of goods and services, while Lacko was focused on households;
3) we do not model factors which affect informal output, we treat informal economy as a residual of regression for electricity consumption.

# Empirical estimates of unofficial economy in Russia

Figure 3 **Comparison of the estimates of informal economy share in Russia, % of GDP**




Unofficial economy in the Soviet Union was estimated at 12% of GDP. During transition period of 1990-s its share substantially increased according to the majority of studies. In 1995 unofficial economy was estimated at 41.6% of GDP.

# Empirical estimates of unofficial economy in Russia

Estimated share of unofficial sector in Russia in 2000-s is sizeable. Schneider (2006) reported 48.7% in 2002/2003 on the basis of DYMIMIC model and currency demand approach. Relatively recent study by Worldbank published the same result – 43.6% during 1999-2007 (Schneider et all, 2010).

According to Rosstat about 19% of Russian workers were engaged in informal activities in 2012. Only 4% of workers were employed in informal sector in Moscow and 9% in Moscow region. Informal workers are concentrated in several sectors: trade (34%), agriculture (26%), construction (10%), manufacturing (9%) and transport & communications (8%).

# Regression model for regional electricity consumption

The model of electricity consumption in industry j in the region i consisting of variable and fixed parts:

$$E_{i,j,t} = \gamma_{i,j,t} Q_{i,j,t} + \mu_{i,j,t} Cap_{i,j,t}$$

Where $E_{i,j,t}$ – electricity consumption in region i in sector j in year t;

$\gamma_{i,j,t}$ – electricity consumption in region i in sector j in year t per unit of output in this sector $Q_{i,j,t}$; $\mu_{i,j,t}$ – electricity consumption in region i in sector j in year t per unit of capacities in this sector $Cap_{i,j,t}$.

# Regression model for regional electricity consumption

Total electricity consumption in a region is a sum of formal sector (with index f) and informal (index u):

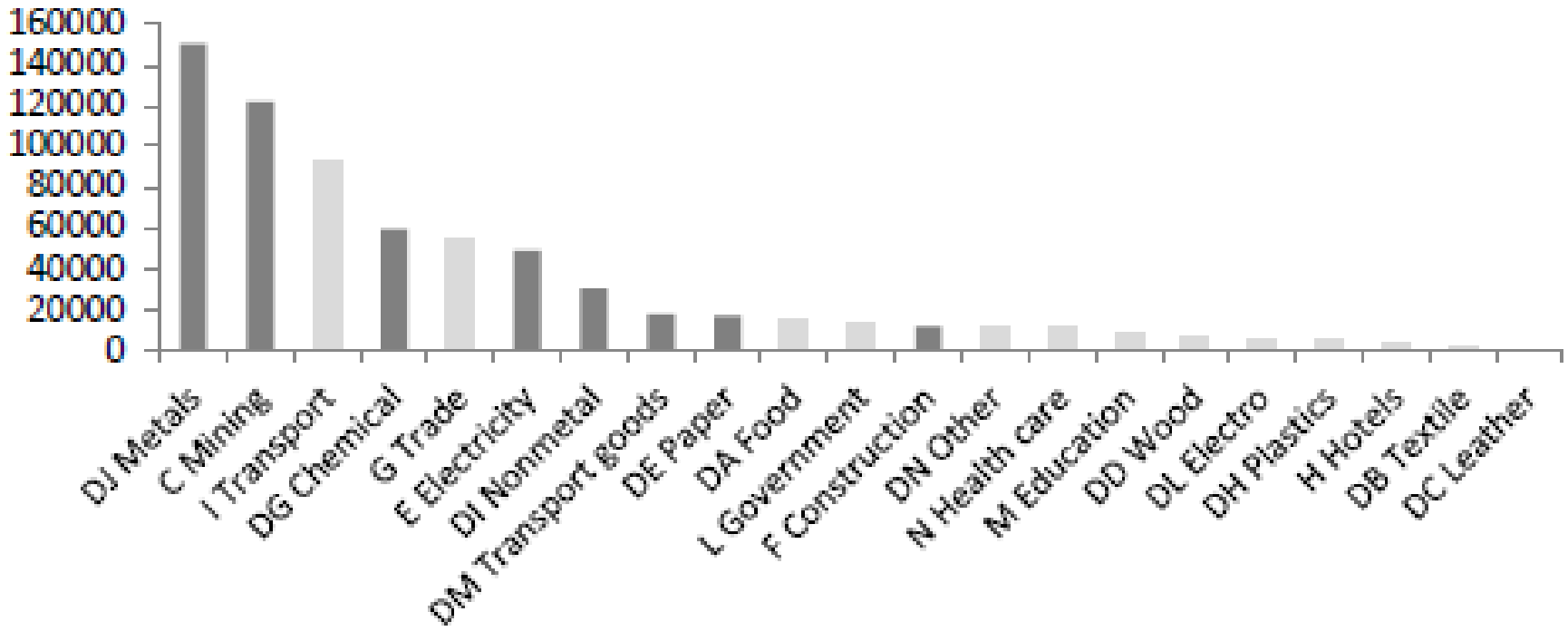
$$E_{i,j,t} = \gamma_{i,j,t} Q^{f}_{i,j,t} + \mu_{i,j,t} Cap^{f}_{i,j,t} + \gamma_{i,j,t} Q^{u}_{i,j,t} + \mu_{i,j,t} Cap^{u}_{i,j,t}$$

Total electricity consumption in the region is given by:

$$E_{i,t} = \sum_j \gamma_{i,j,t} Q^{f}_{i,j,t} + \sum_j \mu_{i,j,t} Cap^{f}_{i,j,t} + \sum_j \gamma_{i,j,t} Q^{u}_{i,j,t} + \sum_j \mu_{i,j,t} Cap^{u}_{i,j,t}$$

Electricity consumption by industries is presented in the figure 3. Significant industries used in a regression are marked with a dark color. They are 1) production of metals; 2) mining industry; 3) chemical industries; 4) electricity generation, gas and water distribution; 5) production of non-metal mineral commodities (cements, bricks, etc.); 6) production of transport goods (passenger cars, trucks, etc.); 7) paper production; 8) construction.

Figure 3 **Electricity consumption by industries in Russia in 2011, GWt*h**



# Regression model for regional electricity consumption

Subdividing industries into significant and insignificant we can use the following representation of electricity consumption in the region:

$$\frac{E_i}{Q_i^f} = \frac{E_i^{insign}}{Q_i^f} + \sum_{j \in sign} \frac{\beta_j Q_{i,j}^f}{Q_i^f}$$

Where $\frac{E_i^{insign}}{Q_i^f} = \frac{\sum_{j \in insign} \gamma_{i,j} Q_{i,j}^f}{Q_{i,t}^f}$ represents electricity consumption by insignificant industries.

Besides industrial structure of economy regional electricity consumption is subject to the following factors which could differ across regions.

**Capacity utilization**. The higher capacity utilization, the lower electricity intensity due to the existence of fixed costs. In a regression we suppose that all regions have similar capacity utilization for a particular industry. It allows us not include this factor into the regression.

- **Electricity prices** which could stimulate more efficient use of electricity.
- **Availability and prices of substitutes for electricity.** If natural gas is very expensive or there is no sufficient natural gas infrastructure, then region will rely more on electricity.

**Weather condition**s: cold winter or hot summer could increase electricity consumption for heating or air-conditioning.

# Regression model for regional electricity consumption

Taking into account additional factors, we use the following regression specification:

$$\frac{E_i}{Q_i^f} = \beta_1 \frac{E_i^{insign}}{Q_i^f} + \sum_{j=sign} \frac{\beta_j Q_{i,j}^f}{Q_i^f} + \beta_2\ temper_i + \beta_3\ P_i^e + \beta_4\ P_i^G + \beta_0 + \varepsilon_i$$

Coefficient $\beta\beta_1$ is assumed to be 1 because we subtract insignificant industries from the total electricity consumption. However, calculating electricity consumption by insignificant industries $E$-insign we use Russian average electricity intensities. It does not guarantee that it will be accurate for a particular region. We need to estimate in regression whether coefficient $\beta\beta_1$ equals 1 in order to check appropriateness of our approach.

Electricity consumption in informal sector is assumed to be equal to the intercept plus the residual:

$$\frac{\sum_j\ r_{i,j} Q_{i,j}^u}{Q_i^f} = \beta_0 + \varepsilon_i$$

This regression equation is estimated on the basis of cross-section data for Russian regions in 2011.

# Estimates of informal activity in Russian regions in 2011

The data on 67 Russian regions and 28 industries: 14 aggregated economic sectors (agriculture, mining, transport, educations, etc.) and 14 individual manufacturing sub-sectors (food, metallurgy, machinery, etc.).

Official economic activity was measured by the gross regional product (GRP) and value added in aggregated sectors.

Electricity consumption by production sectors is calculated as the total electricity consumption in the region less losses in electricity grids and consumption by households.

# Estimates of informal activity in Russian regions in 2011

**Table 1. Descriptive statistics of the estimation sample (67 Russian regions in 2011)**

| Variable | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|
| Electricity consumption in production of goods and services per official GRP, KWt*h per ths rubles | 13.4 | 8.76 | 1.15 | 46.1 |
| Electricity consumption by insignificant industries per official GRP, KWt*h per ths rubles | 6.171 | 2.525 | 0.87 | 13.47 |
| Electricity price | 252.8 | 42.56 | 151.72 | 380.000 |
| Paper industry share in GRP | 0.6% | 1.0% | 0.0% | 6.3% |
| Chemical industry share in GRP | 1.4% | 1.9% | 0.0% | 9.7% |
| Non-metal minerals share in GRP | 0.8% | 0.7% | 0.1% | 4.0% |
| Metals industry share in GRP | 3.0% | 5.4% | 0.0% | 26.5% |
| Transport machinery share in GRP | 1.6% | 1.8% | 0.0% | 9.0% |
| Mining industry share in GRP | 5.1% | 9.4% | 0.0% | 49.5% |
| Electricity, gas, water supply share in GRP | 2.9% | 1.4% | 0.4% | 7.8% |
| Construction share in GRP | 5.2% | 2.8% | 1.3% | 19.1% |

# Estimates of informal activity in Russian regions in 2011

**Table 2. Results of regression for electricity consumption in production sectors per Gross regional product, cross-section of Russian regions, 2011 year**

| Regressor | Coef. | Std. error | t-statistics | P>t |
|---|---|---|---|---|
| Electricity consumption by insignificant industries per GRP | 1.06 | 0.23 | 4.7 | 0.000 |
| Electricity price | -0.029 | 0.012 | -2.5 | 0.015 |
| Paper industry share in GRP | 238.5 | 43.99 | 5.42 | 0.000 |
| Chemical industry share in GRP | 5.6 | 21.73 | 0.26 | 0.797 |
| Non-metal minerals share in GRP | 65.4 | 62.62 | 1.04 | 0.301 |
| Metals industry share in GRP | 87.1 | 8.11 | 10.73 | 0.000 |
| Transport machinery share in GRP | -15.1 | 22.01 | -0.69 | 0.496 |
| Mining industry share in GRP | 24.7 | 5.05 | 4.89 | 0.000 |
| Electricity, gas, water supply share in GRP | 77.6 | 34.73 | 2.23 | 0.030 |
| Construction share in GRP | -22.4 | 16.22 | -1.38 | 0.174 |
| Constant | 7.46 | 4.00 | 1.87 | 0.067 |

Number of observations (regions): 67. R-squared: 89%. Adj. R-squared: 87%.

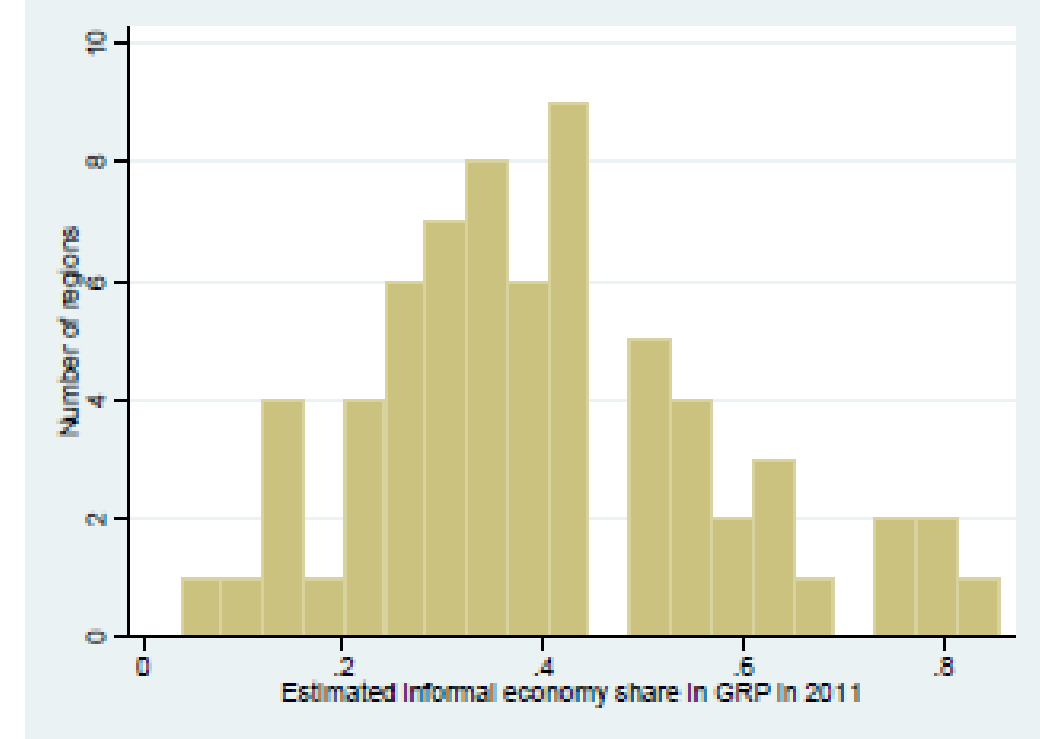
# Estimates of informal activity in Russian regions in 2011

Adjusted $R_2$ of regression is 87%. It is very important indicator of regression for us because we are going to use a residual for calculation of informal economy share. If $R_2$ were low like 20%-40%, it would mean either a) there is a huge informal economy variation or b) there are other factors which were not captured in the regression, they exist in residual term. In this case, due to high impact of other factors we cannot use residual term for calculation of informal economy share. When $R_2$ is high then influence of other factors on regression residual is as low as possible. It allows us to use residual for estimation of informal economy.

According to regression results, electricity prices affect electricity consumption negatively (in line with our hypothesis). Temperature and natural gas prices are not presented in the final regression as they are insignificant. Industrial structure of the region has significant effect on electricity intensity of GRP. Industries which influence positively electricity intensity are paper, chemical industry, metals industry, mining industry, electricity production and water & natural gas supply. The higher their share in the regional output, the higher electricity consumption per unit of GRP. Transport machinery and construction sectors are insignificant factors for electricity consumption intensity in the region.

# Estimates of informal activity in Russian regions in 2011

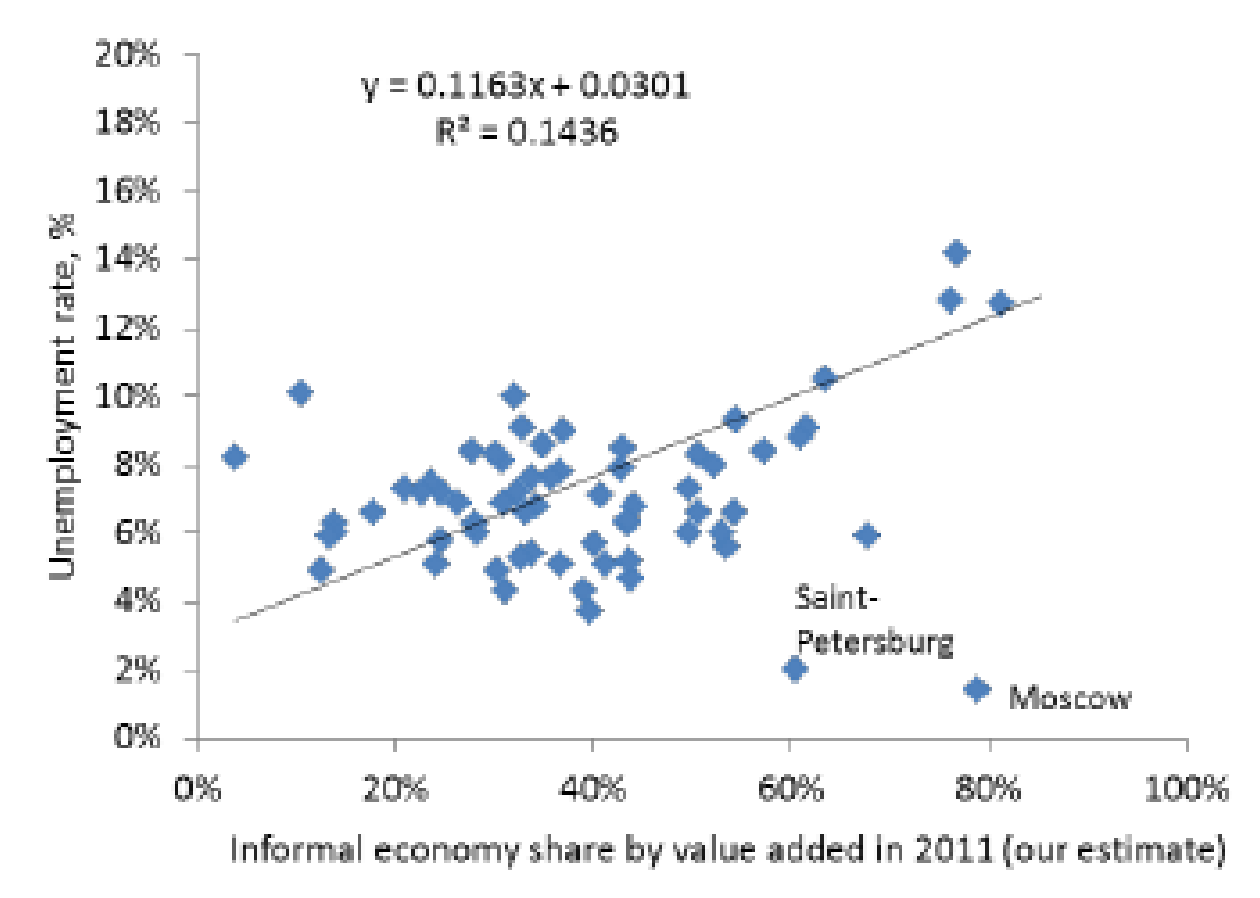
**Figure 4. Distribution of Russian regions by estimated informal economy share in 2011**




Calculated informal economy share ranges from 3.8% to 85% with the average level of 40%. 85% seems unrealistically high. The histogram, table and the map with informal economy share by regions in 2011 are presented below. There are 10 regions with informal economy share above 60%: Ingushetia, Moscow, Dagestan, Kalmykia, Altay Republic, Krasnodar region, Kabardino Balkaria, Kaliningrad, Astrakhan, and Saint-Petersburg. Southern small regions are likely to have high informal economy share because they have a large share of small business and low government control over economic activity. Informal economy share in Moscow (79%) is likely to be overestimated.

# Informal economy and economic conditions in Russian regions

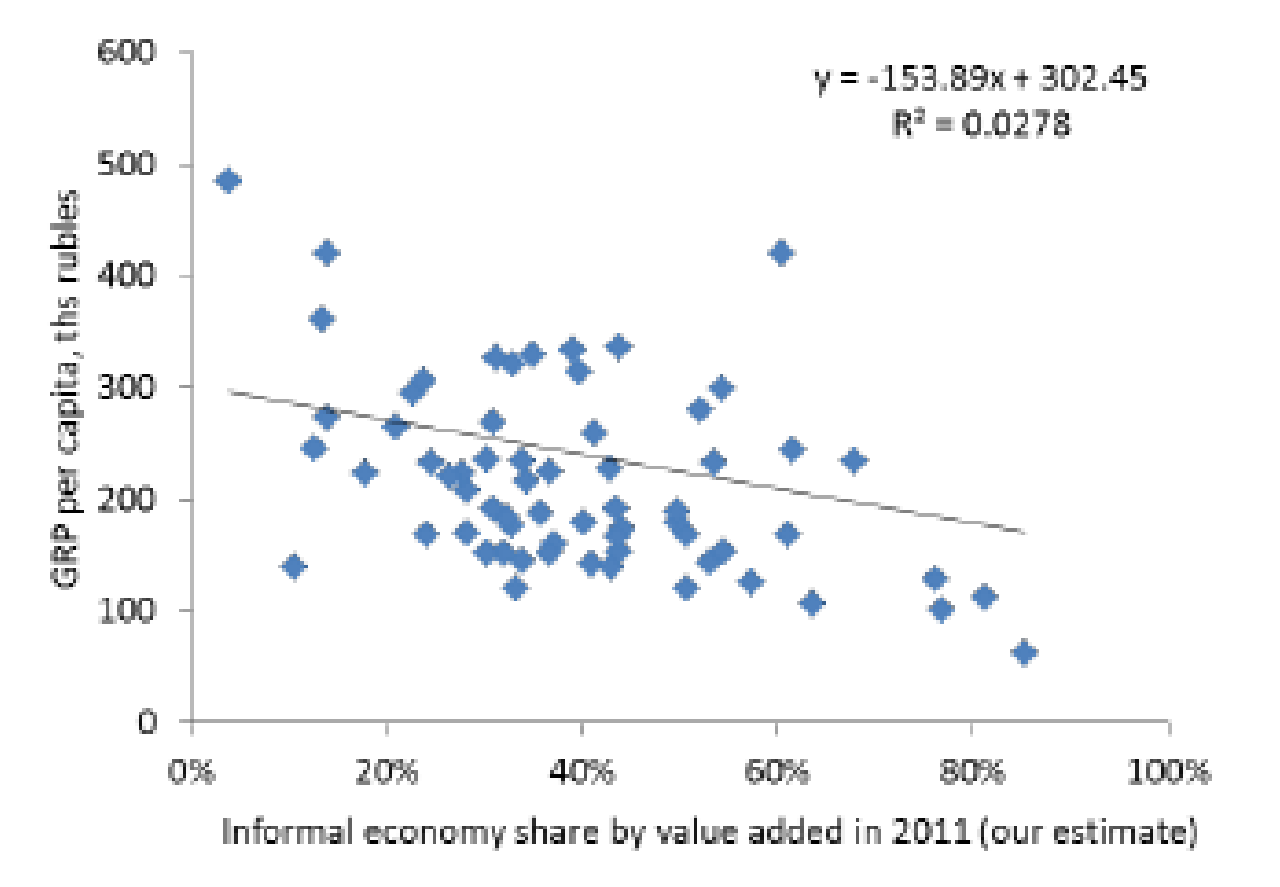
**Figure 5. Comparison with the unemployment rate (by methodology of International Labor Organization) by Russian regions in 2011**




**Official unemployment rate** is supposed to be positively correlated with informal economy share because informal economy absorbs officially unemployed people. Correlation between these two indicators in 2011 is 38% which is pretty high.

# Informal economy and economic conditions in Russian regions

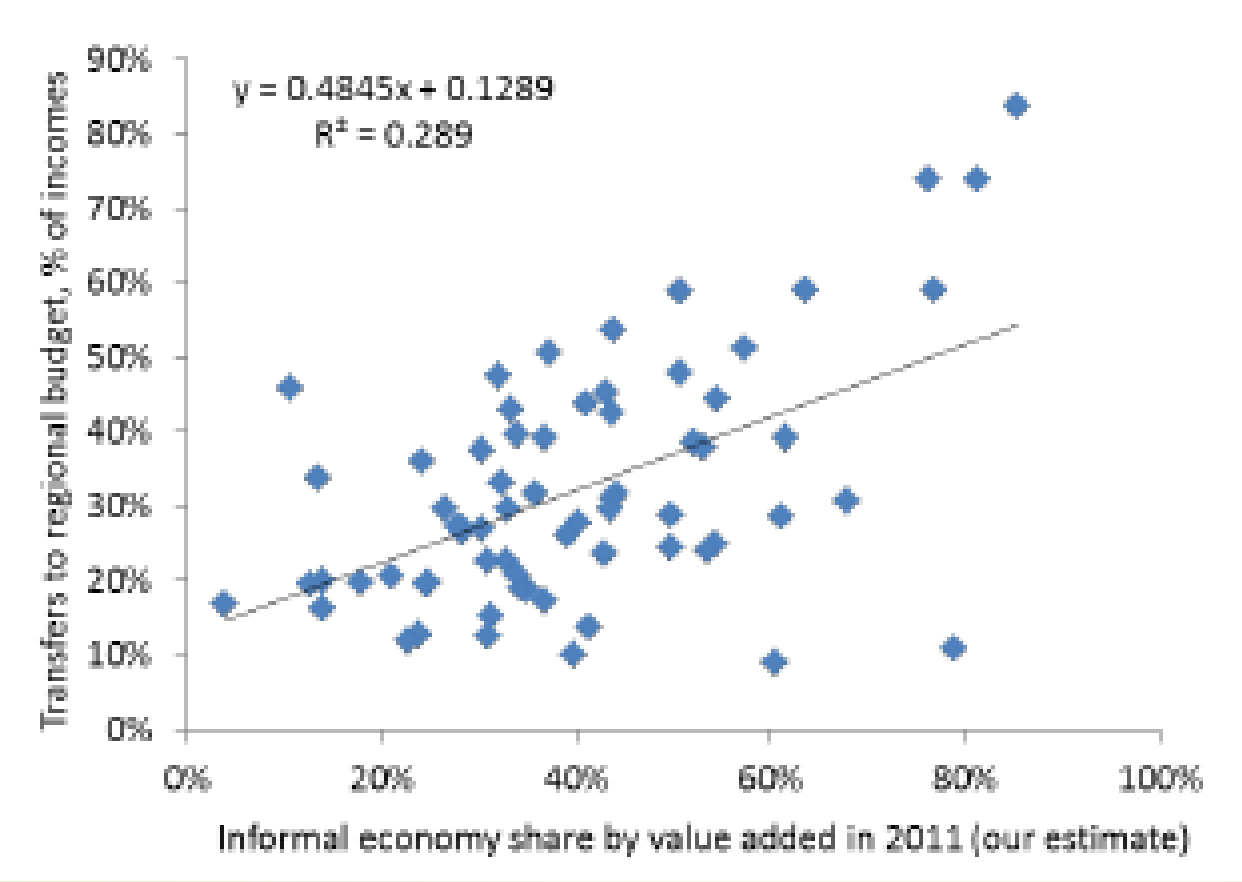
**Figure 6. Comparison with GRP per capita by Russian regions in 2011**




**GRP per capita** has negative correlation (-17%) with informal economy share which corresponds to our expectations. The higher level of formal income in the region, the higher opportunities in formal sector which becomes relatively more attractive than informal sector.

# Informal economy and economic conditions in Russian regions

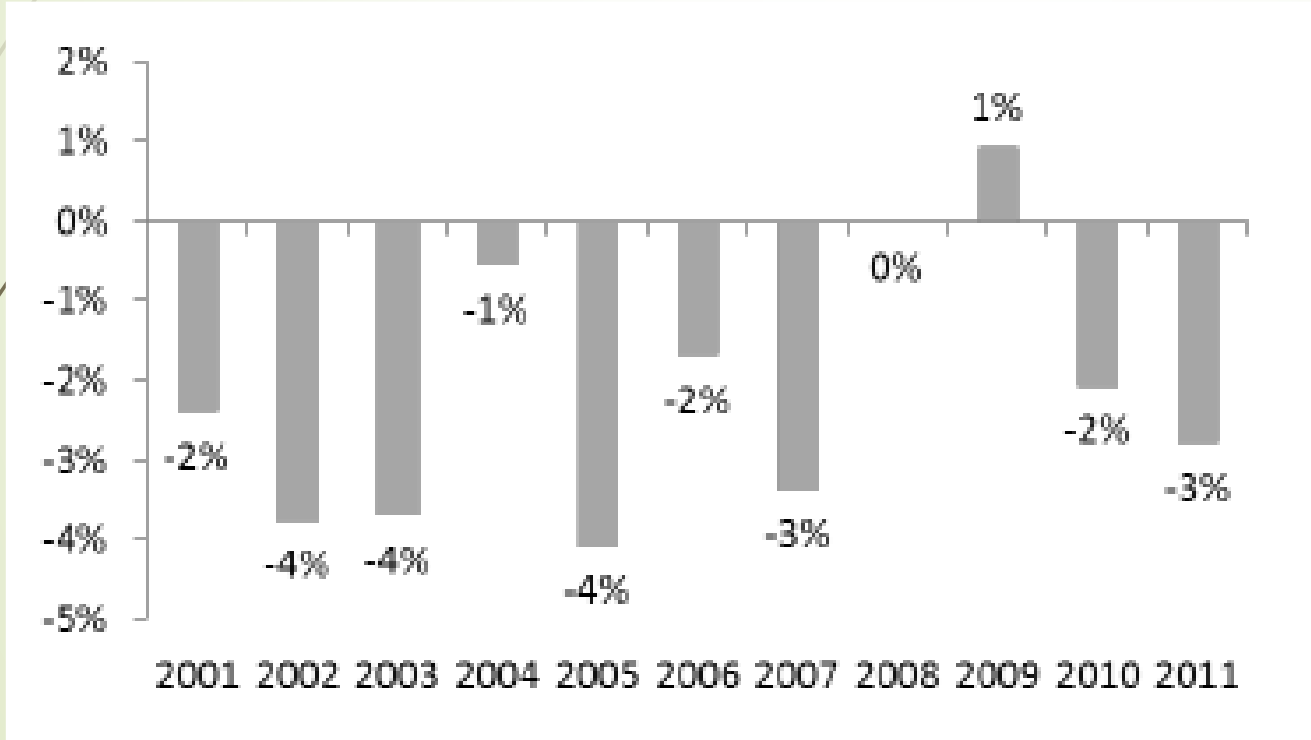
**Figure 7. Comparison with transfers to the regional budget (as % of GRP) by Russian regions in 2011**




**Transfers from federal to regional budgets** (in terms of their share in total income of regional budget) have the strongest correlation with informal economy share at 54%. Indeed, the higher share of informal activities the lower ability of regional government to collect taxes. In order to maintain necessary social spending such regions needs external financing from the Federal government.

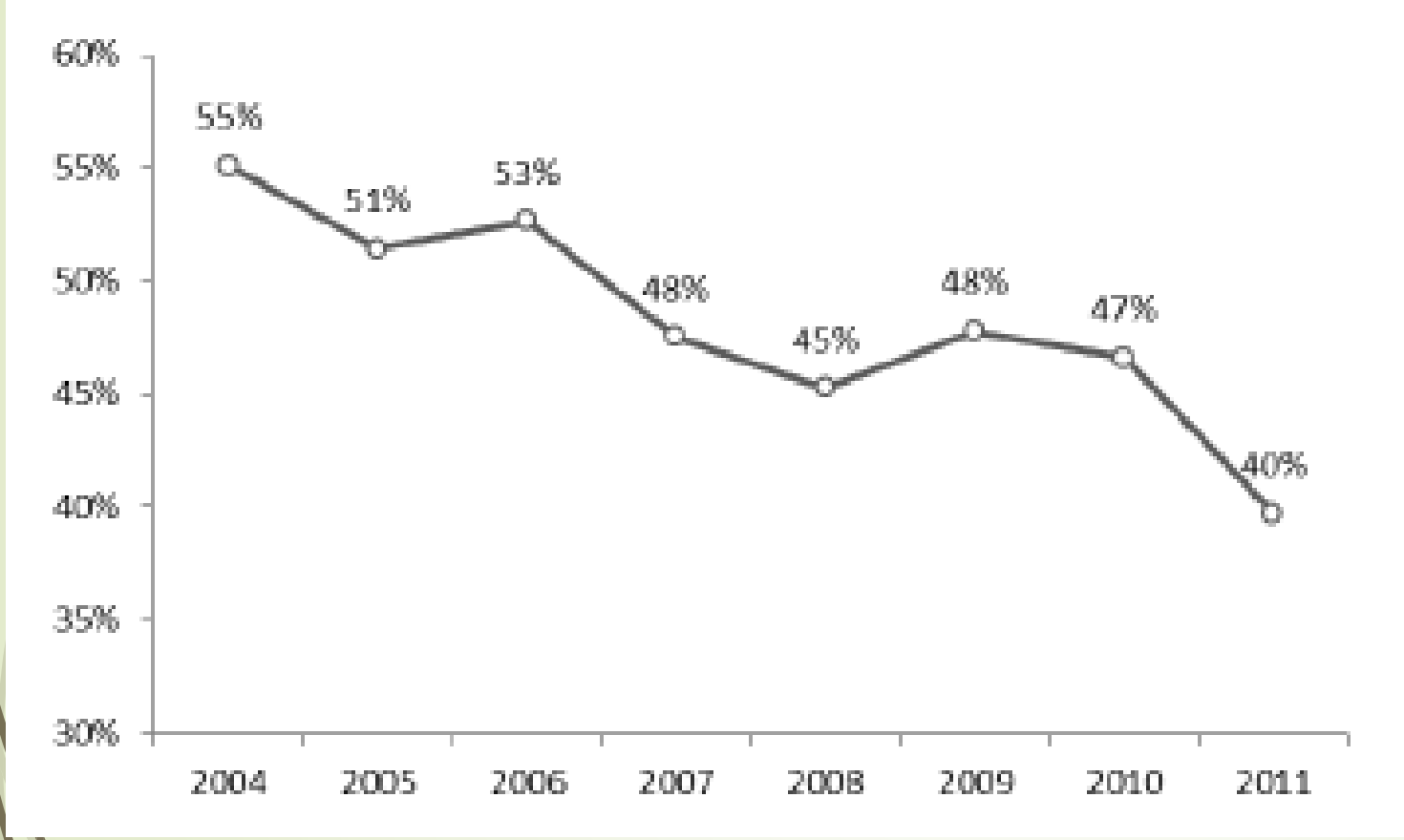
# Empirical results on dynamics of informal economy share in Russian regions over 2004-2011

**Figure 8. Dynamics of informal economy share in Russian Federation estimated by augmented electricity consumption method**




Cumulative dynamics of informal economy share in 2004-2011 lies in the range -30 - +30 percentage points across different regions. Only 16 from 65 regions witnessed an increase in informal economy share over this period.

**Figure 9. Informal economy share in Russia, % (on the basis of regional sample covering 66% of Russian GDP)**




Finally we can calculate informal economy in Russia as a sum of regional informal economies. Our sample covers 66% of total Russian gross regional product. We excluded from analysis city of Moscow and Saint-Petersburg which have rather ambiguous results on informal economy share. Informal economy share has decreased from 55% in 2004 to 40% in 2011 with slight growth in 2009 during economic slump.

Main conclusions from this analysis are the following:

1. Cross-section variation of electricity consumption per output in Russian regions is explained by the model with electricity consumption per unit of GRP as dependent variable and a number of independent variables: electricity prices, shares of particular industries in GRP (metals, mining, chemicals, electricity generation, non-metal mineral products, transport machinery, paper, and construction). Adjusted $R_2$ for a sample of 67 regions in 2011 is 87%.

2. Informal economy is positively correlated with unemployment (correlation in 2011 is 38% - pretty high), negatively correlated with GRP per capita (-17%).

3. Transfers from federal to regional budgets (in terms of their share in total income of regional budget) have the strongest correlation with informal economy share at 54%. The higher share of informal activities the lower ability of the regional government to collect taxes. In order to maintain necessary social spending such regions needs external financing from the Federal government.

4. Majority of Russian regions experienced decline of informal economy share over 2004-2011. Only 16 from 65 regions witnessed an increase in informal economy share over this period.

5. Informal economy share in the whole regional sample (which covers 66% of Russian GDP) has decreased from 55% in 2004 to 40% in 2011 with slight growth in 2009 during economic crisis.

# References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Thank
you