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Informality, Inequality and ICT in Transition economies

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ABSTRACT

In this paper we investigate if the informal sector(IS) can reduce income inequality when human capital is applied in the usage of ICT for production in the IS. Utilizing panel data for 16 Transition countries we demonstrate that when the quality of instutions is low, that there is a negative relationship between the size of the IS and the level of income inequality. We also show that ICT reduces income inequality and that it causes the IS to have a positive effect on the income inequality if investment in ICT is above 1.4% of GDP. We also consider implications for policymaking.

JEL classification: E26, O15, O17.

Keywords: Informal Sector; Shadow Economy; Income Inequality; Transition Countries; ICT; Institutional quality.

I. Introduction

This paper investigates if the informal sector (*IS*) contributes to reducing income inequality when human capital is applied in the usage of *ICT*. We perform our analysis on Transition countries where these countries are characterised by weak institutions and high income inequality. We ask the following questions in this paper: Is the size of informal sector a determinant of income inequality in Transition countries? This effect of the *IS* on inequality is altered if we consider human capital applied in the usage of *ICT* in the *IS*?

We attempt to answer the above questions by providing empirical evidence using four different estimates of *IS* and three proxies of *ICT* investment. This a relevant point because in this literature the reliability of data is always an issue of concern. We show that the results strongly depend on employed data.

High income inequality is a problem in Transition economies and so we show using a theoretical model that the *IS* can reduce income inequality because of investment in *ICT* by agents with higher levels of human capital from the formal sector (*FS*) into the *IS*. The application of human capital in the usage of *ICT* increases productivity in the *IS*. The presence of low quality institutions hampers the productivity of human capital in the FS (Fedderke and Luiz, 2002). Consequently, the *IS* enables agents to augment the fall in their incomes in the *FS* following the decline in the quality of institutions.

The next section summarizes literature. Section 3 sketches the theoretical hypotheses. Sections 4 and 5 introduce the empirical approach and the dataset, respectively. Section 6 reports findings for a panel data of sixteen transition countries. Section 7 summarizes and concludes.

II. Literature

This paper contributes to a growing strength of literature that explains the size of *IS* as consequence of two main factors: income inequality and weak institutions.

We begin by describing some of the relevant literature explaining the relationship between the size of the informal sector and income inequality in Transition countries. The first published papers dealing empirically with the relationship between inequality and informality within transition economies are Rosser et al. (2000, 2003). They found a strong positive relationship between income inequality and the size of the *IS*. This is because the informal sector reduces the amount of tax revenue thereby reducing the effectiveness of government's redistributive policies. According to Rosser et al. (2000), greater income equality might help to control the growth of the *IS* in some Transition economies. The evidence that a large informal sector is associated with higher levels of income inequality is also supported by Ahmed et al. (2007) using a global data set. Their results also show a strong positive relationship between income inequality and the size of *IS*.

However, the direction of causation between the size of the informal sector and income inequality relationship remains ambigous. The ambiguity that exists in the correlation between the informal sector and income inequality is highlighted by Gutierrez-Romero (2007) using data from Latin America and Sub-Saharan Africa. These are the two regions with the largest *IS*. She demonstrates that the correlation between the *IS* and income inequality changes sign according to the level of economic development. There is a positive correlation of 0.25 between the size of *IS* and income inequality for developed countries. However, there is a negative correlation of -0.14 for developing countries.

The significance of the quality of institutions as a key determinant of the size of the informal sector is shown by Chong and Gradstein (2007). In essence, they argue that in the presence of low enforcement of property rights, poor individuals have a limited capacity to extract a

larger share of resources. Consequently, individuals prefer to operate in the *IS*, "*where although less productive, they are able to fully retain their production output*" (Chong and Gradstein, 2007, p. 160).

There has been a wide discussion in many circles about the interaction between human capital and *ICT*. For instance, O'Mahony et al. (2008) discusse how an increase in technology increases the demand for skilled labour. Others highlight the role of *ICT* in developing human capital particularly developing countries[1]. An OECD report showed that investment in *ICT* contributed to growth in all OECD countries particularly in the United States which had the largest effect[2]. Finally, a firm level study conducted by *Statistics Norway* showed that the use of *ICT* improves business performance and that the benefits from using *ICT* increases with the skills level of workers[3].

From the foregoing, we investigate if this positive effect is relevant also for Transition countries. As a consequence of missing values in *ICT* statistics for European Eastern countries we use two alternative proxies: the number of internet users per 100 people and the patent applications by patent office divided to country population (in thousand).

III. Theoretical Consideration : Agent–Investor

Equations (1) and (2) describe the agent's preferences. Here, (E_0) is the expectation operator, β is the discount factor, C_t is the aggregate consumption, that is, the sum of the consumptions in the *FS* (c_{1t}) and the *IS* (c_{2t}). Assume that goods consumed in the *FS* and the *IS* are perfect substitutes. Furthermore, assume that *U* is continuously differentiable and concave such that *U* is increasing in c_{1t} and c_{2t}.

[1] Caincross and Pöysti (undated) ICT's for education and building human capital.
[2] OECD countries for which data was available including France, Portugal, Ireland, Austria, Italy, Germany, Finland, Belgium, Spain, Greece, Canada, U.K, Sweden, Denmark, Netherlands, Australia, Japan and U.S.A.
[3] Statistics Norway (2009).

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t) \quad (1)$$

where $0 < \beta < 1$, $c_{1t} \geq 0$, *and* $c_{2t} \geq 0$

$$C_t = \log[c_{1t} + c_{2t}] \quad (2)$$

Production in the Formal Sector

Equation (3) represents production in the *FS*. A proportion of output/income in the *FS* is produced using human capital. We define human capital in broad terms as ability of a human being to "frame knowledge, experience, skill and competency"[4]. Thus, A_t is technology, h_{1t} is the stock of human capital in the *FS*, and α is the elasticity of the capital stock. The amount of human capital used in production depends on the quality of institutions *(q)*. In this model, the higher is *q*, the lower the quality of the institutions. A higher *q* reduces the stock of human capital available for production in the *FS*.

$$y_{1t} = \phi A_t h_{1t}^{\alpha - q} \quad (3)$$

with $A_t \geq 0$; $h_{1t} \geq 0$; $\alpha \geq 0$; and $0 \leq q < 1, \alpha < q$

Production in the Informal Sector

Equation (4) represents production in the *IS*. Production in the *IS* also depends on the stock of human capital *(h_{2t})*. We assume that the stock of human capital used in production in the *IS* is lower than the *FS* in order to remain hidden from the authorities. Consequently, λ is smaller than α. Following (Renooy, 1990), the *IS* has limited access to resources such as technology and property rights. Consequently, the *IS* depends on the *FS* for its supply of inputs. Furthermore for simplicity, we assume that all output produced is consumed with the *IS*.

[4] "Human Capital and Its Measurement" in 3rd OECD World Forum on "Statistics, Knowledge and Policy" Charting Progress, Building Visions and Improving Life.

$$y_{2t} = Ah_{2t}^{\lambda} \tag{4}$$

with $A_t \geq 0;\ 0 \leq h_{2t} < h_{1t}, \alpha > \lambda$

The Evolution of Human Capital

Equation (5) shows that total human capital stock is the sum of human capital in the FS and IS respectively. Equation (6) shows that stock of human capital depends on the amount time spent in school and ICT. The accumulation of human capital stock through training follows from the Lucas model (1988). Furthermore, studies have shown that in the informal sector, growth in human capital is mainly acquired through apprenticeships (Blunch et al., 2001). In terms of the link between ICT and human capital: a report by the Kramer et al.(2007) shows that ICT contributes to the development of human capital by expanding economic opportunities. Zon (2001) develops a theoretical model in which he shows that ICT accumulates through the spill-over effects of knowledge. In our paper, the link between ICT and human capital is shown by (7) where (1-ϕ) proportion of output in the FS is invested in ICT.

$$h_t = h_{1t} + h_{2t} \tag{5}$$

$$h_{t+1} = (1-L)h_t + ICT_t \tag{6}$$

$$(1-\phi)Ah_{1t}^{\alpha-q} = ICT_t \tag{7}$$

The Budget Constraint

Equations (8) and (9) present the combined budget constraints for the agent in the *FS* and the *IS*. The left hand side shows that agent's income and the right hand side shows that this income is used to purchase consumption (c_{1t}) and invest in ICT .

$$y_{1t} = c_{1t} + ICT_t \tag{8}$$

$$\phi Ah_{1t}^{\alpha-q} = c_{1t} + h_{1t+1} + h_{2t+1} - h_{1t}(1-L) - h_{2t}(1-L) \tag{9}$$

Competitive Equilibrium

The model is solved as a recursive competitive equilibrium using the dynamic programming approach proposed by Bellman (1957). We now describe this equilibrium according to McGrattan et al. (1997). In this model, there are two state variables: technology *A*, and the total human capital stock in both the *FS* and the *IS*, h_t. The representative agent solves c_{1t} and c_{2t} in terms of tomorrow's human capital stock h_{1t+1} and h_{2t+1} and, therefore, chooses the level of human capital stock that maximizes utility. The value function in Equation (10) solves the agent's optimization problem:

$$V(A_t, h_{1t}, h_{2t}) = \underset{h_{1t+1}, h_{2t+1}}{Max}\ U(c_{1t} + c_{2t}) + \beta E_t V(h_{1t+1}, h_{2t+1}) \tag{10}$$

Substituting for c_{1t} and c_{2t} from Equations (3) and (9) yields equation (11) below:

$$V(h_{1t}, h_{2t}) = \underset{h_{1t+1}, h_{2t+1}}{Max}\ U\left(\phi A_t h_{1t}^{\alpha-q} - h_{1t+1} - h_{2t+1} + h_{1t}(1-L) + h_{2t}(1-L) + A_t h_{2t}^{\lambda}\right) + \beta E_t V(h_{1t+1}, h_{2t+1}) \tag{11}$$

We follow Busato and Chiarini (2004) and define a dynamic recursive equilibrium as consisting of a value function $V(A_t, h_{1t}, h_{2t})$, a decision rule (h_{1t}, h_{2t}), and policy functions $\Theta = (q, \alpha, \lambda)$ such that:

1. Representative agent/investor maximizes the present value of his discounted intertemporal utility as in (11) subject to the budget constraint (10) ;
2. Government balances its budget in every period;
3. Market-clearing conditions hold in the *IS* where goods are not traded;
4. Market-clearing conditions hold for each market, that is, in the capital, technology, consumption, and investment markets;

5. Walras' Law holds[6].

The solution to the maximization problem in equation (11) produces the first-order conditions (F.O.Cs) for the capital stocks in the *FS* and the *IS*.

First-Order Conditions (F.O.C)

Equations (12) and (13) are the F.O.Cs showing how the agents will choose h_{1t+1} and h_{2t+1}

F.O.C wrt h_{1t+1}

$$U'c_t = E_t \beta U c_{t+1}\left[(\alpha - q)\phi A_{t+1} h_{1t+1}^{\alpha-q-1} + (1-L)\right] \tag{12}$$

F.O.C wrt h_{2t+1}

$$U'c_t = E_t \beta U c_{t+1}\left[\lambda A_{t+1} h_{2t+1}^{\lambda-1} + (1-L)\right] \tag{13}$$

Steady-State Solutions

The F.O.Cs are used to derive the steady-state solutions to the stocks of human capital in the *FS* and *IS*. The solutions are shown in equations (14) and (15), respectively.

$$h_1^{ss} = \left(\frac{\frac{1}{\beta} - (1-L)}{\phi A(\alpha - q)}\right)^{\frac{1}{\alpha-q-1}} \tag{14}$$

$$h_2^{ss} = \left(\frac{\frac{1}{\beta} - (1-L)}{\lambda A}\right)^{\frac{1}{\lambda-1}} \tag{15}$$

From equations (14) and (15), we can compute the steady-state solutions to output in the *FS* and the *IS* shown below:

[6] This implies that any excess demand in one sector has to be balanced by an excess supply in another sector. Therefore, there is no excess demand in the economy at any given point in time.

$$y_1^{ss} = \phi A \left[\frac{\frac{1}{\beta} - (1-L)}{\phi A(\alpha - q)} \right]^{\frac{1}{\alpha - q - 1}} \tag{16}$$

$$y_2^{ss} = A \left[\frac{\frac{1}{\beta} - (1-L)}{\lambda A} \right]^{\frac{1}{\lambda - 1}} \tag{17}$$

Comparative Statics

We use comparative statics to examine the impact of a decline in the quality of institutions on the size of the informal sector as well as income inequality. Let I be defined as the relative size of the *IS* in the steady-state such that

$$I^{ss} = \frac{y_2^{ss}}{y_1^{ss}} \tag{18}$$

We measure the level of income inequality (z) as the difference between steady-state income in the *FS* and *IS* as shown in (19). A positive result implies an increase in income inequality and vice versa.

$$z = y_1^{ss} - y_2^{ss} \tag{19}$$

Equation (20) shows the total derivative of I with reference to q. Given the magnitude of the parameters, a decline in the quality of institutions (an increase in q) increases the relative size of *IS*. Our result conforms to the wider literature that weak institutions are associated with a larger size of the *IS* (e.g. Chong and Gradstein, 2004; Bovi and Dell' Anno, 2010).

$$\frac{dI}{dq} = \frac{-\frac{1}{\phi}\left[\frac{\frac{1}{\beta}-(1-L)}{\phi A(\alpha-q)}{(q-\alpha)(q-\alpha+1)^2}\right]\left[\frac{\frac{1}{\beta}-(1-L)}{A\lambda}\right]^{\frac{1}{\lambda-1}}}{\left[q-\alpha-\alpha In\left(-\frac{\frac{1}{\beta}-(1-L)}{\phi A(\alpha-q)}\right)+qIn\left(\frac{\frac{1}{\beta}-(1-L)}{\phi A(\alpha-q)}\right)+1\right]} > 0 \qquad (20)$$

where: $0 \leq \alpha < 1$; $0 \leq L < 1$; $0 \leq q < 1$; $0 < \beta < 1$; $0 < \lambda < 1$; $\alpha > \lambda$; $q > \alpha$.

Equation (21) shows how we compute the impact of an decrease in instititional quality on income inequality. This provides the argument for our main testable hypothesis:

Hypothesis I: *Ceteris Paribus, an increase in institutional quality reduces income inequality. An increase in q reduces the marginal returns to productivity in the FS relative to the IS. Consequently, the agent allocates more human capital and invests more ICT towards production in the IS. This reduces the income gap between the FS and IS.*

$$\frac{dz}{dq} = \frac{\delta y_1^{ss}}{\delta q} - \frac{\delta y_2^{ss}}{\delta q} \qquad (21)$$

$$\frac{dz}{dq} = \left[\frac{A\phi}{\left(\frac{\frac{1}{\beta}-(1-L)}{\phi A(\alpha-q)}\right)(q-\alpha)(q-a+1)^2}\right]\left[q-\alpha-\alpha In\left(-\frac{\frac{1}{\beta}-(1-L)}{\phi A(\alpha-q)}\right)+qIn\left(\frac{\frac{1}{\beta}-(1-L)}{\phi A(\alpha-q)}\right)+1\right] < 0$$

IV. Empirical model

We use a panel regression to examine the effect of the size of the *IS, ICT* , human capital and institutional quality on income inequality. Caroli and Van Reenen (1999) and Breshnahan et al. (2002) have shown that at the firm level, differences in skills are important for the usage of *ICT*. In order to show that *ICT* affects the level of human skills, we include an interaction term between *L* and *ICT*. Furthermore, we add an interaction term between *IS* and *ICT*. This is to examine if *ICT* enables the *IS* to affect income inequality. The empirical model is shown below in (22):

$$GINI_{it} = \lambda_i + a_1(IS_{it}) + a_2(ICT_{it}) + a_3(L_{it}) + a_4(q_{it}) + a_5(IS_{it} * ICT_{it}) + a_6(L_{it} * ICT_{it}) + \varepsilon_{it} \qquad (22)$$

The empirical model is estimated for sixteen transition countries from 1990 to 2001, 1990-2004 and 1999-2007 according to availability of the IS estimates. *GINI* is the Gini coefficient which is used as a measure of income inequality, *IS* is the size of the informal sector, *ICT* is Information and Communication Technology (both hardware and software) or one of his proxies, assuming that a proxy of human capital stock is the time spent in school, *L* refers to the gross enrolment rate to the secondary school, *q* is an index of institutional quality[7], λ_i captures cross-section specific effects (fixed or random) and ε comprises measurement errors and country specific shocks which is assumed to be white noise.

The expected signs of coefficients based on exiting literature are: $a_1 > 0$, $a_3 < 0$, $a_4 < 0$. For the parameters a_2, a_5 and a_6 different hypotheses can hold. On the one hand, we expect a negative relationship as an increase in *ICT* should lead to a negative relationship between the *IS* and human capital respectively on income inequality. This is because when *q* is low then the *IS* can benefits from *ICT* as the agents in the formal sector transfer *ICT* and human skills for production in the *IS*. On the other hand, the sign of these parameters could be positive. An

[7] High q = low quality and low q = high quality.

increase in *ICT* could cause a positive relationship between the *IS* and human capital since the *IS* have limited capacity to access to *ICT*. An increase in *ICT* increases the differences in skill between the formal and informal sector respectively. Therefore it could be argued that an increase in *ICT* leads to a positive relationship between human capital and income inequality.

V. Data source and variables

This section explains the sources of the data used to measure the variables described in section 4. For the analysis, we have constructed a panel of annual data from 1990 to 2007 for 16 Transition countries[8]. To improve the reliability of the econometric exercise we use different proxy measures for the same variables. In our view, this may increase the robustness of the estimates across measurement errors. The panel data consists of eleven variables which we describe in turn below.

The income inequality (GINI) is measured by Gini's index of income distribution. The data are retrieved form the TransMONEE[9].

One of the most important issues in the empirical literature on informal sector is about the reliability of its estimates. The *IS* is characterised by a myriad of definitions[10] and a variety of methods have been developed to estimate the *IS*. However these methods produce wide

[8] Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Slovak Republic, Slovenia, Ukraine.

[9] Data downloaded from: http://www.transmonee.org/. Table 10.9 Distribution of income: Gini coefficient. TransMONEE 2012 Database.

[10] According with the definition of Informal Sector in Transition Economies adopted by the World Bank-Europe and Central Asia, the IS covers a wide range of labour market activities that combine two groups of different nature. On the one hand, the IS is formed by the coping behaviour of individuals and families in economic environment where earning opportunities are scarce (survival activities e.g. casual jobs, temporary jobs, unpaid jobs, multiple job holding etc.). On the other hand, the IS is a product of rational behaviour of entrepreneurs that desire to escape state regulations (e.g. tax evasion, avoidance of labour regulation and other government or institutional regulations, no registration of the company etc.). http://lnweb90.worldbank.org/eca/eca.nsf/Sectors/ECSPE/2E4EDE543787A0C085256A940073F4E4?OpenDocument.

variations in estimates of *IS*. We attempt to control for this issue by applying four alternative measures of *IS* reported by Feige and Urban (2008) and Buehn and Schneider (2012). According to Feige and Urban, the relationships between recorded, unrecorded, observed and unobserved income may be described as: Y = total economic activity; Y_R = recorded economic activity (measured output; GDP)*;* Y_{RO} = recorded observed economic activity*;* Y_{IUI} = recorded unobserved economic activity [measured (imputed) Non Observed Economy]*;* Y_{UR} = unrecorded activity. Given the foregoing definitions, the total economic activity (*Y)* and the total unobserved and imputed unobserved component (Y_{TUI}) are:

$Y = Y_{RO} + Y_{IUI} + Y_{UR}$ and $Y_{TUI} = Y_{RO} + Y_{IUI}$.

With this classification, we extract from Feige and Urban (2008), the estimates of Y_{TUI} obtained by the currency approach (Informal sector currency) and by the modified electric consumption (Informal sector electricity)[11] and Y_{IUI} based on authors' inquiry to the national statistical agencies of the Transition countries on the amount of non-observed economy (NOE) already included in the official NIPA estimates of GDP. Feige and Urban (2008) contacted directly the national agencies to enlarge the time span of the NOE imputations in national accounts covered in the United Nations Economic Commission for Europe (United Nations, 2003). We label these estimates reported in Feige and Urban (2008 - Table 1, p. 292) as "Informal sector by UN". With reference of Buehn and Schneider (2012 - Table 3, pp.160-161), they estimate the shadow economy as percentage of GDP by MIMIC approach (informal sector by MIMIC) over the period 1999-2007.

[11] Data are provided from 1990 to 2001.

TABLE 1. Estimates of the Informal Sector - country averages

	Informal Sector (currency)	*Informal Sector (electricity)*	*Informal Sector by UN*	*Informal Sector (MIMIC)*
Romania	16.24	15.70	16.37	32.59
Poland	16.52	7.46	15.45	27.20
Hungary	17.30	29.09	16.00	24.41
Bulgaria	18.41	21.89	19.33	35.30
Slovak Republic	19.25	12.53	14.23	18.13
Czech Republic	20.36	17.76	5.10	18.37
Estonia	21.75	15.50	7.03	31.18
Russian Federation	23.33	25.82	12.07	43.80
Latvia	25.70	14.43	16.40	29.21
Slovenia	28.02	23.25	6.34	26.23
Ukraine	29.02	27.51	20.00	49.72
Belarus	29.88	23.59	10.35	46.41
Lithuania	30.91	22.66	19.18	32.04
Macedonia	38.15	32.01	14.77	37.64
Kazakhstan	44.16	24.73	28.82	41.14
Moldova	45.78	35.39	30.52	44.45
Average	**26.55**	**21.83**	**15.02**	**33.56**
Observations	**192**	**192**	**115**	**142**
Time period	***1990-2001***	***1990-2001***	***1990-2004***	***1999-2007***

Concerning Information and Communication Technology, we calculate the ratio between investment in telecoms with private participation and the GDP. Furthermore, we consider as proxy of *ICT* the number of Internet users per 100 people and the ratio between patent applications by patent office, broken down by resident and non-resident, and the population (in thousand). These two alternative variables have the important characteristic to have less missing values than the ratio between investment in telecoms with private participation and the GDP. In particular *ICT*, Internet users per 100 people and the ratio between patent applications and the population count for 70%, 19% and 15% of missing values for the period 1990-2001 and 50%, 2% and 6% of the missing values over the range 1999-2007.

With reference to years of education (L), we include a measure of gross enrolment rate to the secondary school. This variable is defined as the number of pupils enrolled in secondary, regardless of age, expressed as a percentage of the population in the theoretical age group for secondary education. In particular, secondary education is provided at high schools, teacher-

training schools at this level, and schools of a vocational or technical nature. The population of the age group that officially corresponds to the secondary level of education generally begins between 13 and 15 years of age and finishes between 17 and 18 years of age. Data on *ICT* and education are retrieved from World Bank Development Indicators (WDI, release 2012).

For the indicator of institutional quality (q), we calculate an index based on the average of eight of the fourteen indexes published by the European Bank for Reconstruction and Development (EBRD) transition indicators (Index of Transition)[12]. The (EBRD) index of Transition is the arithmetic average for each country of the following indicators: small scale privatisation, enterprise restructuring, price liberalisation, trade and forex system, competition policy, banking reform and interest rate liberalisation, securities markets and non-bank financial institutions, overall infrastructure reform. The original measurement scale for the EBRD indicators ranges from 1 to 4, where 1 represents little or no change from a rigid centrally planned economy and 4 represents the standards of an industrialised market economy. To fit with our definition of q adopted in the theoretical model, the original index is rescaled to have that a high q for low institutional quality and low q for high quality of institutional context. Therefore the rescaled index is equal to the maximum value (three) if

[12] In appendix A we also use an alternative index of institutional quality: the Index of Economic Freedom published by *The Wall street Journal* and *The Heritage Foundation*. "A comprehensive definition of economic freedom should encompass all liberties and rights of production, distribution, or consumption of goods and services. The highest form of economic freedom should provide an absolute right of property ownership; fully realized freedoms of movement for labour, capital, and goods; and an absolute absence of coercion or constraint of economic liberty beyond the extent necessary for citizens to protect and maintain liberty itself." Index of Economic Freedom (2009, p. 10). Data downloaded from: http://www.heritage.org/index/.

the country has a rigid centrally planned economy while the minimum (zero) indicates a national economy with the characteristics of the advanced market economy[13].

VI. Empirical Results

We utilize a panel analysis approach, where alternative estimators of panel equation would be suitable for this analysis. The Hausman (1978) test is applied to assist in making the decision between fixed effect and random effect approaches. It implies the nonexistence of a significant correlation between country specific effects and explanatory variables. We find that the Hausman test frequently gives more support to fixed effect than to random effect model. We also perform the Redundant Fixed effects test to decide on the relevance of pooled versus fixed effects regressions. According with the redundant fixed effects, three restricted specifications are estimated. The first set consists of two tests that evaluate the joint significance of the cross-section effects using sums-of-squares (F-test) and the likelihood function (Chi-square test). The corresponding restricted specification is one in which there are period effects only, the remaining specifications evaluate the joint significance of the period effects, and of all of the effects, respectively. All of the results suggest that the cross sections effects are statistically significant.

Unfortunately both residuals with random and fixed panel specification often exhibit serial correlation and heteroskedasticity[14]. According with these outputs, we apply a feasible GLS

[13] In appendix A the rescaled version of the Index of Economic Freedom is calculated by the following formula: q_{it}=1-(Index of Economic Freedom$_{it}$/100). Therefore q_{it} it is graded using a scale from 0 to 1, with 1 representing the minimum freedom.

[14] It is well known that random effect methods fail to provide consistent estimators for the foregoing dynamic panel data (DPD) model. To the opposite Instrumental and GMM first-differenced estimators, like the well-used Arellano and Bond (1991), have appealing properties for N large, being consistent and also asymptotically efficient. Unfortunately, the finite-sample performance of GMM-DPD estimators turns out to be very poor when the cross-sectional dimension is small, as demonstrated in a number of Monte Carlo experiments (Kiviet, 1995; Judson and Owen, 1999; Bruno, 2005), which makes the Arellano and Bond estimator as well as other GMM estimators unfeasible in our case.

specification with fixed effect (FEGLS) model using cross section weights and "Cross-Section SUR" method to correct standard errors and covariance. The FEGLS estimator with cross-section weights controls for a different residual variance for each cross section while, the Cross-section SUR method handles cross-section correlation (period clustering). The latter method is a variant of the so-called Panel Corrected Standard Error (PCSE) methodology proposed by Beck and Katz (1995).

Table 2 reports the results of eq. (22). FEGLS take into account both unobserved countries-specific effects (λ_i) and for a different residual variance for each cross-section. LSDVs include only country fixed effects (λ_i) but not GLS weights. For both FEGLS and LSDV we do not report the dummies for the sake of brevity. The numbers in parenthesis are the t-ratios. In both FEGLS and LSDV models, the Jarque-Bera tests often reveal that kurtosis and skewness of distribution of the error-term are often not normal. As a result, we have also performed a set of robustness checks of the estimates in appendix. The estimates reported in the appendix A are obtained by Dynamic-LSDV, LSDV, FEGLS and Random-GLS. They confirmed findings showed in table 2.

TABLE 2. Dependent Variable: Gini Index of Income Distribution

		LSDV (1)	FEGLS (2)	FEGLS (3)	LSDV (4)	FEGLS (5)	FEGLS (6)	LSDV (7)	LSDV (8)	LSDV (9)	FEGLS(10)	LSDV (11)	LSDV (12)
Informal Sector (currency)		0.19 (0.77)	-0.02 (-0.72)	-0.12*** (-3.16)	--	--	--	--	--	--	--	--	--
Informal Sector (electricity)	a_1	--	--	--	-0.26*** (5.50)	0.005 (0.22)	0.56 (1.55)	--	--	--	--	--	--
Informal Sector by UN		--	--	--	--	--	--	0.33 (0.94)	0.17 (0.93)	0.53*** (3.08)	--	--	--
Informal Sector (MIMIC)		--	--	--	--	--	--	--	--	--	0.69*** (3.24)	0.66** (2.07)	0.90*** (2.84)
Investment ICT/GDP		-0.29 (-0.71)	--	--	0.17* (1.94)	--	--	0.95* (1.99)	--	--	0.09** (2.25)	--	--
Internet user per 100 people	a_2	--	-0.001* (-1.73)	--	--	-0.008 (-1.36)	--	--	0.01 (0.79)	--	--	0.003 (0.81)	--
Patent percapita		--	--	-0.493* (-1.89)	--	--	-0.68*** (-3.05)	--	--	-0.83** (-2.06)	--	--	-0.99** (-2.66)
School Enrolment (secondary)	a_3	-0.004 (-1.03)	-0.004 (-0.11)	-0.000 (-1.11)	0.00 (0.24)	0.00 (0.06)	-0.00 (-1.52)	0.007* (2.14)	0.00 (1.35)	-0.001 (-0.51)	0.00 (0.71)	-0.00 (-1.61)	-0.003** (-2.48)
Index of Transition	a_4	-0.07*** (-3.56)	-0.07*** (-11.53)	-0.05*** (-9.43)	-0.09*** (-8.18)	-0.07*** (-11.88)	-0.05*** (-10.65)	-0.01 (-0.42)	-0.07*** (-3.52)	-0.02** (-1.88)	-0.08** (-2.61)	-0.12*** (-2.87)	-0.09*** (-2.73)
ICT*Inf.Curr./ Electr/ UN/MIMIC		-0.32 (1.26)	--	--	-0.23** (-2.53)	--	--	-1.16* (-1.84)	--	--	0.00 (0.94)	--	--
Internet*Inf.Curr./ Electr/ UN/MIMIC	a_5	--	-0.01 (-1.16)	--	--	-0.00 (-0.18)	--	--	-0.00 (-0.58)	--	--	-0.0001** (-2.65)	--
Patent*Inf.Curr./ Electr/ UN/MIMIC		--	--	0.105 (0.48)	--	--	0.09 (0.60)	--	--	-0.48 (-1.22)	--	--	-0.15 (-0.40)
ICT*School Enrol.		0.00 (0.82)	--	--	-0.00 (-1.55)	--	--	-0.01* (-2.00)	--	--	-0.001*** (-2.83)	--	--
Internet*School Enrol.	a_6	--	0.0001* (1.72)	--	--	0.00 (1.17)	--	--	-0.00 (-0.83)	--	--	-0.00 (-0.04)	--
Patent*School Enrol.		--	--	0.005** (2.15)	--	--	0.007*** (3.15)	--	--	0.009** (2.20)	--	--	0.011*** (2.89)
Observ./ Cross-sect.		32/8	88/14	103/14	32/8	88/14	99/16	23/7	63/14	68/14	48/9	82/15	80/15
Periods		1991-2001	1990-2001	1990-2001	1991-2001	1990-2001	1990-2001	1992-2001	1992-2004	1992-2004	1999-2007	1999-2007	1999-2007
R^2-adjusted		0.744	0.936	0.911	0.783	0.941	0.909	0.885	0.906	0.861	0.945	0.895	0.900
F-test (p-value)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Durbin-Watson		2.056	1.852	1.641	2.006	1.883	1.529	1.706	1.525	2.276	1.643	1.556	1.363

*Note: ***, **, *Denote significant at 1, 5 and 10 level, respectively. For FEGLS are used cross-section weights. Standard Errors are corrected with cross-section SUR method.*

Table 3 summarizes the signs of estimated coefficients according with the estimation method of the *IS* based on the currency, electricity, national accounting and MIMIC approach. Institutional quality and index of patent per capita produce the most robust results in terms of negative correlation with income inequality. At the contrary, the signs and statistical significance of the other regressors are not robust to change the source of data.

TABLE 3. Summary results - dependent variable: *Gini Index*

		Informal Sector (currency)	***Informal Sector (electricity)***	***Informal Sector by UN***	***Informal Sector (MIMIC)***
Informal sector	a_1	≤ 0	≤ 0	≥ 0	> 0
ICT/GDP	a_2	$= 0$	> 0	> 0	> 0
Internet user per 100 people	a_2	< 0	$= 0$	$= 0$	$= 0$
Patent per capita	a_2	< 0	< 0	< 0	< 0
School Enrolment (secondary)	a_3	$= 0$	$= 0$	≥ 0	≤ 0
Index of Transition	a_4	< 0	< 0	< 0	< 0
Proxy ICT * Informal Sector	a_5	$= 0$	≤ 0	≤ 0	≤ 0
Proxy ICT * School Enrolment	a_6	≥ 0	≥ 0	≥ 0	$\geq, < 0$

These results highlight the problem of measuring the relative size of the informal sector which is a hidden entity. The variety of methods used in measuring the size of *IS* generates substantial variation in the size of the estimates. These differences show that the relationship between the size of *IS* and income inequality is undetermined and it should be interpreted with caution. These discrepancies in the signs of coefficients underscore the inherent problems of using estimates of the *IS* in empirical analysis as highlighted in Ahmed et al. (2007).

Table 3 shows that ICT investment as percentage of GDP is for the most part of regressions positively related to income inequality. The number of internet users per 100 people was also used as an alternative measure of *ICT* and it is not statistically significant at 5% level. At the

contrary, we find that an increase in the number of patents per capita is correlated with an increase in income inequality.

The coefficient of secondary school enrolment has ambiguous sign. We motivate this (unexpected) result considering that, the stock of human capital inherited from the socialist period was high by the standard of other countries at similar levels of economic development. According to Micklewright (1999) in a number of Central and Eastern European countries, and in the Baltics, enrolment rates in general secondary schools followed different trends. Substantial increases have taken place in Romania, Poland and Latvia. However, general secondary enrolment rates are more or less unchanged in Russia, Ukraine and Belarus and have deteriorated notably in countries in the Caucasus and Central Asia for which data are available. Thus this complex picture makes difficult to find common trend in education statistics among Transition countries. In this sense, to find (expected) negative sign only for the regressions analysed over the period 1999-2007 (i.e. when the estimates of the IS are provided by the MIMIC approach) is not surprising. In the latter period the switch from socialist to post-communist educational system was at an advanced stage, thus educational official statistics are more reliable and comparable than in the previous years.

Concerning the index of institutional quality (e.g. Index of Transition), it is significant and with the expected negative sign (i.e. hypothesis I). In line with a priori expectation institutional infrastructure has an important effect on income inequality.

Concerning the interaction terms, the sign of a_5 remains ambiguous. The sign is negative and significant when the number of internet users per 100 people is used as a proxy for ICT investment. The negative sign of a_5 reveals that the *IS* benefits from using *ICT* and this contributes to reducing income inequality. However, this interaction term is always statistically not significant when *IS* is estimated by currency approach.

The interaction term a_6 is undetermined. For the most part of estimated regressions it is positive but it became negative if ICT investment interacts with gross enrolment rate to the secondary school. However is quite robust the result that a positive interaction between the number of patents per capita and human capital increases income inequality.

In summary, we find no clear relation between *IS* and *ICT*, which is interesting in that it goes against most of the existing literature. Unambiguous results are only when the higher the patent application per capita is used as proxy of ICT investment and the index of transition reforms. For both the variables higher is the patent application per capita and the quality of institutional infrastructure, the lower will be income inequality in Transition countries.

The following question: Why do estimates of the *IS* using different methods show different statistical relationships? We view the differences in the results of the relationship between the *IS* and income inequality as a spillover of the ongoing debate on the derivation of the *IS* estimates themselves. While a large literature exists on the shortcomings of some of these methods[15], here we highlight on the weaknesses of the *IS* estimates based on the National Income and Product Account (NIPA) procedures. These procedures aim to produce exhaustive measures of Gross Domestic Product that includes accounting for the Non-Observed Economy (NOE). The measurement of the NOE is based on trying to account for missing data as a result of underground activities, illegal activities, informal sector (involves the production of legitimate goods and services that do not pass through formal channels), household production and deficiencies in data collection). Feige and Urban (2008) refer to these estimates as "Imputed Unobserved Income" (IUI). With respect to the transition countries, some of the information used in the construction of *IS* estimates used by the UN are derived from statistics compiled by national agencies. Feige and Urban (2008) argue that

[15] See Schneider (2005) for currency and physical input approach and Dell'Anno and Schneider (2008) for MIMIC method.

during the transition period, there was a major change in statistical practice from the Material Product System (MPS) to the System of National Accounts (SNA). The process of this change could have potentially been affected by political manipulation. This in addition to the presence of a substantial unobserved economy would have undermined the accuracy of statistics from these national agencies. Consequently there could be an understating or overstating of estimates of the *IS* based on the NIPA procedures. Feige and Urban (2008) find various degrees of divergence between estimates of *IS* based on macro models such as the currency method and the latter. The differences between these estimates points to the fact that exhaustive of *IS* estimates based on NIPA procedures should not necessarily decrease the reliance of *IS* estimates based on macro models. In this paper, we concur with most of the literature that all estimates of *IS* should be interpreted with caution.

VII. Conclusion

This paper examined if the *IS* affects income inequality in countries where the level of institutional quality is low.

The empirical analysis is based on a panel regression based on 16 Transition countries between 1990 to 2007. We showed the effect of *IS* on income inequality when the quality of institutions is low depends on the limited reliability of *IS* data. This result reveals as existing literature on this relationship to be interpreted with caution as it is sensitive to the method of estimating of *IS*. In particular we find that estimates of the "Informal sector by UN" and by MIMIC approach show a positive relationship with income inequality. The result of the latter concurs with most of the empirical literature. At the contrary, a negative/insignificant relationship between *IS* estimates based on currency and physical input method and Gini index is estimated.

We interpret this ambiguous finding as a further evidence of the problems of working with estimates of the *IS* in terms of their reliability. Our results concur with the conclusions of Ahmed et al. (2007) and Dell'Anno and Piirisild (2007) that no method of estimating of the *IS* can be considered as a robust measure. As a caveat, we urge caution in the use of these results for policy recommendations as it does strongly support the role of *ICT* in the *IS*.

On the positive side, our study has highlighted the complementarities between education and *ICT*. The significance of the interaction term shows that policies should be directed towards education that supports the development of building high level of *ICT* skills.

With reference to the relationship between *IS* and *ICT*. We assume that the *IS* is unable to adopt of *ICT* as it involves a huge cost. Consequently, its access to *ICT* is mainly through the *FS*. Therefore, polices aimed at increasing access to *ICT* would reduce the productivity gap between the formal and informal sectors respectively.

In conclusion, *ICT* cannot be seen as a panacea but rather a vital element when a country develops the right fundamentals coupled with strong institutions and well functioning markets. Parham et al. (2001) showed based on studies in Australia that "*ICT* driven growth" was led by the strong interaction between structural reform and the adoption of *ICT*.

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Appendix A: Estimates with alternative estimators and specifications

		Dyn	FEGLS	FEGLS	RE	Dyn	LSDV	LSDV	RE	Dyn	LSDV	LSDV	RE	Dyn	LSDV	RE
Gini inc. (t-1)	γ	0.22 (1.12)	--	--	--	0.36*** (3.46)	--	--	--	0.13 (0.76)	--	--	--	0.12 (0.57)	--	--
Informal Sector (currency)	a_1	0.11 (0.68)	-0.02 (-0.72)	-0.12*** (-3.16)	0.28* (1.71)	--	--	--	--	--	--	--	--	--	--	--
Informal Sector (electricity)		--	--	--	--	0.08 (1.45)	-0.01 (-0.17)	0.26** (2.276)	0.05 (1.34)	--	--	--	--	--	--	--
Informal Sector by UN		--	--	--	--	--	--	--	--	0.03 (0.13)	-0.13** (-0.55)	0.54*** (3.08)	0.15 (1.06)	--	--	--
Informal Sector (MIMIC)		--	--	--	--	--	--	--	--	--	--	--	--	0.55* (1.91)	0.90*** (2.82)	0.49*** (2.65)
Investment ICT/GDP	a_2	-0.56* (-1.83)	--	--	0.07 (0.69)	--	--	0.17* (1.92)	--	--	--	--	--	--	--	--
Internet user per 100 people		--	-0.009* (-1.73)	--	--	--	--	--	-0.00 (-0.15)	0.01 (0.54)	0.00 (0.03)	--	--	--	--	--
Patent percapita		--	--	-0.49* (-1.89)	--	-0.10 (-0.26)	-0.019 (-0.24	--	--	--	--	-0.83** (-2.06)	0.01 (0.14)	-1.41** (-2.54)	-0.99** (-2.66)	0.00 (0.63)
School enrolm. Secondary	a_3	-0.01* (-2.04)	-0.00 (-0.10)	-0.001 (-1.11)	0.00 (0.16)	0.00 (0.17)	0.002*** (2.97)	0.00 (0.17)	0.002 (0.43)	0.002** (2.06)	0.00 (0.78)	-0.001 (-0.51)	0.00 (1.21)	-0.004** (-2.28)	-0.003** (-2.48)	-0.003 (-0.43)
Index of Econ. Freedom	a_4	--	--	--	--	--	-0.11 (-1.50)	--	--	--	-0.04 (-0.41)	--	-0.02 (-0.25)	--	--	--
Index of Transition		-0.04 (-1.20)	-0.07*** (-11.5)	-0.05*** (-9.43)	-0.07*** (-4.96)	-0.02** (-2.03)	--	-0.09*** (-6.00)	-0.08*** (-9.65)	-0.06** (-2.37)	-0.10*** (-2.77)	-0.02** (-1.88)	-0.05** (-2.07)	-0.04 (-0.94)	-0.09*** (-2.74)	-0.06* (-1.91)
ICT*Inf.Curr./Elect/UN/MIMIC	a_5	-0.35* (-1.93)	--	--	-0.14** (-2.73)	--	0.25 (1.25)	-0.23* (-1.83)	--	--	--	--	--	--	--	--
Internet*Inf.Curr./Elect/UN/MIMIC		--	-0.005 (-1.16)	--	--	--	--	--	-0.00 (-0.78)	-0.01 (-0.77)	0.00 (0.31)	--	--	--	--	-0.001*** (-2.89)
Patent*Inf.Curr./Elect/UN/MIMIC		--	--	0.11 (0.48)	--	-0.06 (-0.24)	--	--	--	--	--	-0.48 (-1.22)	-0.13 (-0.39)	0.31 (-0.96)	-0.15 (-0.40)	--
ICT*School Enrol.	a_6	0.01* (1.87)	--	--	-0.00 (-0.24)	--	--	-0.00 (-1.32)	--	--	--	--	--	--	--	--
Internet*School Enrol.		--	0.0001* (1.72)	--	--	--	--	--	--	-0.00 (-0.63)	-0.00 (-0.23)	--	--	--	--	-0.00 (-0.02)
Patent*School Enrol.		--	--	0.01** (2.15)	--	0.00 (0.16)	--	--	0.00 (0.04)	--	--	0.009** (2.20)	--	0.01** (2.56)	0.01*** (2.89)	--
Obs./ Cross-sect.		25/7	88/14	103/14	32/8	88/14	58/13	32/8	88/14	56/13	51/13	68/14	51/13	61/12	80/15	82/15
Periods		'91-'01	'90-'01	'90-'01	'91-'01	'91-'01	'95-'01	'91-'01	'90-'01	'93-'04	'95-'04	92-'04	'95-'04	'00-'07	'99-'07	'99-'07
R^2*-adjusted*		0.896	0.936	0.911	0.564	0.884	0.895	0.783	0.634	0.913	0.935	0.861	0.293	0.929	0.900	0.102
F-test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.028
Durbin-Watson		4.070	1.852	1.641	1.718	2.343	1.249	2.006	0.948	1.839	1.662	1.276	1.049	1.857	1.363	1.350
Cross-sect. Eff.		Fixed	Fixed	Fixed	Rand.	Fixed	Fixed	Fixed	Rand.	Fixed	Fixed	Fixed	Rand.	Fixed	Fixed	Rand

Note: ***, **, *Denote significant at 1, 5 and 10 level, respectively. For FEGLS are used cross-section weights. Standard Errors are corrected with cross-section SUR method.*