Some Problems with Electricity and Money Methods When Used to Measure Tax Evasion in a Transition Economy[1]

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Abstract

An easy and popular method for measuring the size of the underground economy is to use macro-data such as money demand or electricity demand to infer what the legitimate economy needs, and then to attribute the remaining consumption to the underground economy. Such inferences rely on the stability of parameters of the money demand and electricity demand equations, or at very least on knowledge of how these parameters are changing. We argue that the pace of change of these parameters (such as velocity) is too variable in transition economies for the above methods of estimating the size of the underground economy to be applicable. We make our point by using Czech Republic and other transition country data from the financial and electricity sectors.

Keywords: Informal economy, shadow economy, underground economy, macro estimates of shadow economy, transition.

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1. Introduction

This paper points out the weaknesses of so-called macro methods of estimating the underground economy in countries making the transition from centralized to decentralized markets. A macro-method discerns the size of the underground economy from a functional form in which some observable macro variable depends on another observable macro variable and on the unobservable underground economy. The researcher infers the size of the underground economy by manipulating the functional form and plugging into the observable macro-variables information on their levels. For example, the "currency-ratio" method of estimating the underground economy holds that there is a stable ratio of currency in the legal economy to demand deposits and that this ratio enters into an equation relating the size of the underground economy to the size of the official economy. All one need know is the currency ratio in the official economy, then one plugs measured GDP into the above-mentioned relation, and out comes the size of the underground economy. Confidence in the macro method rests on the assumption that the functional relations one postulates between the dependent and independent variables are correct, and that the parameter estimates with which one rounds out these equations (such as the ratio of currency to demand deposits) are accurate and stable. Without such assurance the researcher is using a yardstick that changes in unpredictable ways. The present paper focuses on the instability of this yardstick.

We find that the instability of parameters used in macro-methods may be of such size as to throw off estimates of transition underground economies to the point where such estimates are nearly useless both as indicators of the *level* of the underground economy, and, more seriously, useless as measures of the *trend* in the size of the underground economy. Estimates of the extent of underground activity only work when deep structural parameters related to tastes and technology and production conditions are stable or changing in some predictable fashion. Such is not the case for transition economies.

We review in detail two macro methods of estimating the underground sector---the money use and electricity consumption methods. Money use methods include the currency ratio method and currency demand method. Both are difficult to defend for

transition economies because of intensive financial and technical innovation during transition. The number of financial products liable to affect currency demand grows at a much greater and more variable pace in transition economies than they do in mature western economies. One is tempted to infer from the huge growth in currency demand in the Czech and Slovak Republics in the 1990's that the underground economy was booming. We show that growth in currency demand was related to factors that had nothing to do with the underground economy. Electricity methods that use electricity consumption to measure the size of the underground economy are, when applied to transition economies, as problematic as money use methods. Price deregulation, and the introduction of long-overdue technologies move electricity demand in ways difficult to attribute to underground economy growth.

We shall illustrate the above two critiques of macro methods with data from varying transition countries, but principally with reference to the Czech Republic. The Czech Republic is an interesting case because it can be argued that it has largely finished its transition and so that the last twelve years of its economic history supply us with a completed experiment. We focus on the electricity and currency ratio methods because we have assembled detailed information on these sectors. Our plan is to lay bare the assumptions underlying the two methods and then to show why these assumptions are problematic for transition economies.

2. Electricity as a Measure of the Underground Economy

The electricity method of measuring the underground economy holds that the underground economy can be measured by using a single economic indicator, namely, electricity consumption. Daniel Kaufman and Aleksandr Kaliberda (1996) are prominent champions of this method. Lacko (1998, 2000) is also an innovator in the electricity method field.

To measure the size of the underground economy in the Ukraine and other FSU countries, Kaufman and Kaliberda began with the assumption (based on previous studies of the Soviet economy) that in 1989, most of these countries had an underground sector of 12% of GDP. They also assume that electricity consumption reacts with unit

elasticity to economic growth. If an economy had GDP of $100 billion in 1989, then it had an underground economy worth $12 billion. If electricity consumption economy grew 10% in the next year this must mean the true economy grew by 10%. So the true economy's size would be $123.2 billion in 1990. One would then subtract government estimates of the official economy to get at underground economy size in 1990.

An objectionable feature of some electricity methods is that they postulate either a one-to-one relation between electricity consumption and GDP, or a stable relationship between electricity consumption and GDP. In more sophisticated applications of these methods, such as Kaufman Kaliberda (1996), the objectionable assumption is that there exists a steady rise in the efficient use of electricity so that the output elasticity of electricity consumption is decreasing at a constant rate.

It is quite possible for electricity consumption to change for reasons that have nothing to do with output changes. Kaufman and Kaliberda (1996) recognize the problem and explain that these reasons for electricity consumption change fall into two negatively correlated categories that offset each other in biasing estimates of the underground economy. In the category of downward bias consider that if an economy is changing its output-mix by moving from the primary to the secondary sector, electricity consumption will decline with no overall change in output. One might then wrongly infer the underground economy has shrunk. We might be led into a similar bias if electricity prices are increasing relative to other energy prices, and if industry is becoming more efficient at using electricity. Factors that could bias our estimates of the underground economy upward are the substitution of electricity for other sources, such as natural gas, and higher overhead and fixed electricity use during an economic downswing. A glance at each of the listed items shows that they could belong to either category. If electricity prices are falling then this factor should be taken out of the downward bias category and put into the upward bias category. If the output mix is shifting more towards the primary sector then it too should be placed into the upward bias category. One can play this logic game to show that all factors listed above might, under the right circumstances, be lumped into just one category. In such a case there would be no negative correlation between categories upon which Kaufman and Kaliberda could base their hope of producing estimates of the underground economy that are unbiased.

An example from the Czech Republic that considers household and industry efficiency in electricity use can show why the Kaufman-Kaliberda method will likely produced biased estimates of the underground economy. Table 1 shows that in the Czech Republic, sometimes the price of electricity relative to natural gas and other sources rose and sometimes it fell. No stable patter can be gleaned.

Table 1. Growth rate (in percent) of household price indexes in the Czech Republic

Indexes	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Electricity	69.7	0.0	5.1	9.0	12.0	14.8	15.3	44.1	0.0	15.1
Natural gas	126.7	0.0	6.5	10.0	10.5	15.2	15.2	47.6	0.0	15.1
Other heating (coal, etc.)	216.1	3.2	25.5	16.5	17.3	10.3	34.4	22.0	2.9	4.3

Source: Czech Statistical Office, Authors' computations

The unstable pattern in prices combined with changes in household production technologies to change demand for electricity in patterns in ways that would have been hard to predict. During the early 1990's, citizens of the Czech Republic massively converted from heating with domestic coal ovens to heating with gas and electricity. Czechs also began to invest heavily in durables such as refrigerators, washing machines, dishwashers, televisions, and home computers. These upgrades to domestic life may account for part of the rise in household consumption of electricity during the transition period. The steep rise in electricity prices in 1997 may account for the downward trend in electricity consumption later on. So, in the early years, electricity prices would have belonged to the upward bias category and in later years to the downward bias category. Now consider industry. During transition Czech industry was rapidly finding new ways of reducing its energy consumption by adopting innovative production techniques. Table 2 shows that even though Czech electricity output was increasing, noxious emissions dove.

Table 2. Waste and electricity production

Year	SO2 (kT)	NOx (kT)	CO (kT)	Dust (kT)	Production of Electricity (TWh)
1980	2148	731	894	1267	53
1985	2161	795	899	1015	58
1990	1876	742	891	631	63
1991	1776	725	1101	592	61
1992	1538	698	1045	501	59
1993	1419	574	967	441	59
1994	1278	434	1026	355	59
1995	1091	412	874	201	61
1996	946	432	886	179	64
1997	700	423	877	128	65
1998	443	413	767	86	65
1999	269	390	686	67	65
2000	266	400	650	56	73
2001	251	332	649	54	74

Source: Czech Statistical Office, Ministry of Environment

The noxious emissions noted above come from electricity generation and industrial production. Part of the dive in pollution came from the Czech parliament's adoption of EU environmental regulations far ahead of the prescribed deadlines. It might be argued that environmental compliance leads to less efficient methods of producing electricity, but this ignores that in the period above the Czech Republic transformed itself into a net exporter of electricity. Industry was producing more output with less electricity. Increases in energy efficiency were continuous and would have biased underground economy calculations downward. When we combine this observation with the observation on household electricity demand we get both effects negating each other at first and adding to each other later. The point is that we cannot blithely assume changing output mixes of different sectors will cancel the bias with which each threatens estimates of the underground economy.

Maria Lacko (2000) also finds a failure to account for the changing industry output-mix to be a major problem with the Kaufman-Kaliberda method and has championed her household electricity consumption as a substitute. Lacko believes households faced no change in their domestic production output mix. Crudely put, as changes in domestic production output mix would be difficult to control for, the absence of change in household output mix need not be controlled for in an econometric model, which seeks to estimate the underground economy in the following manner. Lacko examines a

times-series of cross sections of transition countries and postulates a regression between the size of the underground economy (which she calls H) and independent variables such as tax rates and the level of government spending. She simultaneously postulates a regression in which the size of the underground economy is an independent variable in a regression explaining household electricity consumption. Readers must be cautious in reading Lacko's presentation of this, her equation (1). In principle the equation includes the real price of consumption of 1 kWh of residential electricity, but later we learn that in practice "The price variable PR_{ij} was not included in the estimated function, mainly due to lack of data."

Her technique for getting estimates of H, the underground economy, is to substitute the right hand side of the H regression, which consists of measurable variables and parameters that can be estimated as proxies for H, in the right hand side of the electricity regression. She then estimates the electricity regression and attributes that part of the dependent variable explained by her substitution from the H equation as being the size of the underground economy.

Quite apart from the question of whether she has correctly formulated the H equation, her estimates rely on the assumption of stable regression estimates. She is assuming that the manner in which people use electricity does not change. Our critique of the Kaufman Kaliberda (1996) method was based on the overwhelming prevalence of such changes. Lacko hopes to avoid the critique of unstable regression parameters by asserting that the household output mix is constant during transition. Even if such were the case, the way in which households produced domestic goods changed radically throughout the 1990's. If household production methods are rapidly changing the parameters of the household demand for electricity equation must also be changing rapidly. Presumably such a change could be controlled for with a time trend variable, but if the rate of technology change forces the use of a time-trend longer than the time-series available on household electricity use, regression parameters of the electricity use equation may suffer from bias. Lacko includes in her household electricity use equations the ratio of energy sources other than electricity energy to all energy sources in household energy consumption in order to control for household substitution between various energy sources: if one uses more gas, one will use less electricity. Inclusion of this variable seems to us to simply be like including part of an identity in a regression.

Even if we were to accept this control we would emphasize as before that it does not provide a sufficient number of data points to explain changes in all regression coefficients in the household electricity use equation.

In summary, because of the shifting reasons for electricity demand, none of the electricity methods we have described above holds much promise for giving us an idea of the size of the underground economy, and more seriously, of giving us an idea of how this economy is changing. By not taking into account the changing reasons for electricity consumption that have nothing to do with underground economy growth, electricity methods produce estimates of the underground economy that have nothing to do with hidden economic activity.

Efforts to explain the size of the underground economy using data that "code" irrelevant forces into underground economy estimates can lead to absurd results such as the one we present in Table 3 with data taken from Eliat and Zines (2000) which illustrates that false assumptions used to divine the size of the underground economy cause estimates of the shadow economy to be correlated with omitted factors, such as shifts in the weather. At the outset we note that Eliat and Zinnes claimed their estimates of underground activity are robust with respect to weather. We find otherwise (and we use data starting in 1996-1997 because we do not want to use earlier estimates of the shadow economy were not confirmed by other authors to be robust and reliable).

Table 3: Explaining the Share of the shadow economy by average winter temperature and relative changes (compared to EU level using PPP prices) for Visegrad's countries

	Share of shadow economy on GDP	
	Plain OLS	Plain OLS in differences (~ Fixed effects)
Average temperature in winter months (January-March, November to December)	1.33 (0.83)	-1.53*** (0.40)
Ratio of Total Final Energy Consumption using 1990 prices (PPP) to EU level	-29.29*** (7.47)	7.34 (8.60)
Constant	82.01*** (16.08)	Not applicable
Number of observation	30	26
R-squared	0.54	.39

(Standard errors are in parentheses)* *significant on 10% level, ** significant on 5% level, *** significant on 1% level. No constant is presented for the OLS in differences because in such a regression the constant disappears.*

The dependent variable is the underground economy estimated using electricity methods and the data come from the Czech Republic between 1990-1997, Hungary between 1990-1997, Poland between 1990-1996, and Slovakia between 1990-1996. Three categories of independent variables should appear in the right hand side of the above regression. As we discussed, electricity consumption will depend on weather, technological progress, and different patterns of price liberalization. If these forces are mistakenly subsumed in underground economy estimates based on electricity methods, we should find them significant in a regression in which these forces appear as variables explaining the size of the underground economy.

We were not able to get any variable that could be used as a cross-country consistent proxy for price liberalization in the energy sector, and so we used only two factors, average winter temperature, and a proxy for technological progress in electricity consumption (ratio of total final energy consumption using 1990 prices, PPP, to the EU level) to explain the size of the underground economy (the R-squared of our regressions suggests that even these two factors explain a great deal of variation in the underground economy).

The first and second columns of Table 3 refer to OLS estimation of the share of the shadow economy as a percent of GDP, as a function of average winter temperatures and a proxy for technological progress in electricity consumption (the ratio of total final energy consumption using 1990 prices, PPP, to the EU level). Even when we ignore country effects, each of the factors we include could explain about 27 and 54 percent of the total variation, respectively. Results become even more striking if we take into account particular country effects and run a model (third column) in which we regress year-to-year increases in the share of the shadow economy on year-to-year changes in winter temperature, and on changes in the above-discussed proxy for technological progress in the electricity sector. Column 3 clearly indicates that increases in macro estimates of the shadow economy are very well explained by decreases in average winter temperature. In other words, the regressions above show that weather fluctuations explain a significant part of the variation in the size of the underground economy, estimated via the electricity macro method. Such

results suggest that electricity macro estimates of the underground economy should not be taken seriously.

In summary, because of the shifting reasons for electricity demand none of the electricity methods we have described above holds much promise for giving us an idea of the size of the underground economy, and more seriously of giving us an idea of how this economy is changing. As we shall see in the next section, similar critiques cripple monetary approaches to measuring the underground economy in transition economies.

3. Monetary approach - Currency Ratio and Currency Demand Methods

The two main currency methods for estimating the underground economy are those of Guttman (1977) and Tanzi (1983). Guttman's approach for money closely parallel's Kaufmann and Kaliberda's (1986) approach for electricity, and Tanzi (1983) is in the spirit of Lacko (2000). We are aware of only two studies to have applied these methods to transition economies (Chandler et al. 2003, and Öğünç and Yilmaz 2000).

Currency methods depend for their validity on the assumption of stable or predictably changing currency-demand deposit ratios and velocity. In transition economies currency-demand deposit ratio and velocity are bound to be very unstable. Instability in money demand is due to catch-up effects in the banking sector of transition economies. Many previously non-existent financial services and products find their way to market in a brief time. The pace of financial innovation may be much higher than in developed economies. Financial innovation can destabilize money demand as these forces buffet the motives for holding cash. To see this more clearly consider the following. In the pre-transition period a handful of state-owned savings-and-loans type banks made up the banking sector. Due to a lack of competition the scope of banking services was very limited. Following transition, foreign banks entered financial markets and introduced competition. Competition narrows the gap between the level of financial services provided in transition and developed economies. Obviously, some products such as cheques were never introduced in transition countries, as they were already outdated and superseded by credit and debit cards.

Money demand in transition countries can also change for the following reasons:

1) A lack of credit is a feature of early transition economies and forces people to hold cash. As credit widens (see Table 4 showing the growth in credit cards), cash holdings fall. There is also a commercial side to the instability in money demand. Bank failures during transition can force agents to change their cash-holding strategies towards holding increasing amounts of cash. At the same time transition economies experience great ups and downs in taxes. These tax changes will in turn move people to vary how they transact in cash in order to avoid their obligations to government.

Table 4: Year to year increases in the number of EC and MC (credit&debit cards)

Countries	96/95	97/96	98/97	99/98	00/99
Czech Rep.	58%	48%	33%	29%	129%
Hungary	149%	85%	70%	30%	24%
Poland	467%	143%	76%	153%	54%
Slovakia	31%	22%	13%	54%	31%
Total EC/MC	15%	18%	20%	13%	13%

Source: EC and MC statistics, authors' computation

2) At times the real interest rate was negative in several transition countries, including in the Czech Republic. A negative interest rate can force people out of demand deposits into cash holdings.

3) Artis and Lewis (1974) argue that in the UK in 1974, due to the changes in banking regulations brought about by the *Competition and Credit Control Act*, the currency to demand deposit ratio changed in ways that are hard to measure. The same must be true of transition countries where regulations were in a greater flux than they were in the UK. Many transition countries changed their regulations quite frequently, slowly introducing deposit insurance (with changed upper limits for the amount insured). A prominent example is the change in the minimum reserve requirements in the Czech Republic as Table 5 shows:

Table 5. Czech Republic Minimum Reserve Requirement Rates 1992-2002

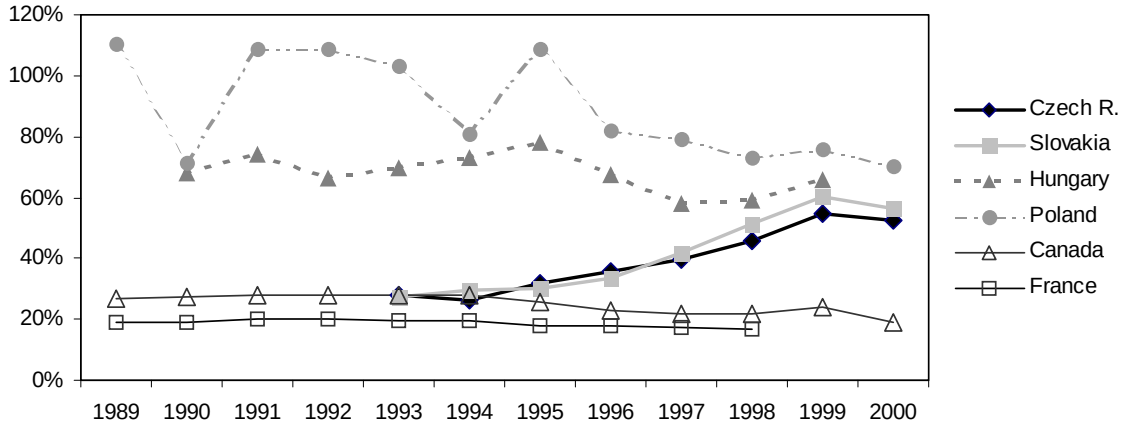
	Rates (percent) effective by:									
	10/92	2/93*	7/93	8/94	8/95	8/96	5/97	8/98	1/99	10/99
Demand deposits	9	9-12	9	12	8.5	11.5	9.5	7.5	5	2
Time deposits	3	3-4	3	12	8.5	11.5	9.5	7.5	5	2

* Lower rate was used for banks with deposits up to 25 billion CZK, otherwise the higher rate was applied. Source: CNB, Monetary indicators.

4) Almost all transition countries succumbed to banking crises in the 1990's. The loss and return of depositor confidence was bound to at first raise, and then depress the currency to demand deposit ratio in ways that are hard to measure. We can state that during two years (starting in the second half of 1995, ending in 1997) Czech banks saw an exodus of deposits, which can be attributed to a lack of trust in banks after several bank failures. After several central bank interventions the credit of banks was restored and withdrawn money appeared in deposits again (giving an enormous rise in annual savings ratios in 1997 or early 1998).

To get a feeling for the volatility of currency to demand deposit ratios, consider Figure 1. The pattern of currency to demand deposit ratios is strikingly diverse for the Visegrad transition countries. Whereas in the Czech and Slovak Republics the ratio increases with time, in Hungary and Poland the time trend is ambiguous. In the case of Poland the ratio is significantly volatile. In contrast, the figures for France and Canada are very stable. This supports the argument against the applicability of the macro method to transition economies. Especially in case of Hungary and Poland it is clear that volatility in the currency to demand deposit ratio is not explainable alone by a surge in the informal sector but rather by shocks in the monetary and financial sectors.

Figure 1 - Currency to Demand ratios, Visegrad countries, France and Canada



Special attention should go to trends in the Czech and Slovak Republics. The time trends of both countries seem to be very close to each other, with a shock in Slovakia in 1995, which caused a temporary decrease of cash use. In 1995 Slovakia introduced officially monitored cash registers in order to eliminate tax evasion and consequently fatten state coffers. Such a regulatory change is likely to show up in temporarily lower demand for cash while the participants in the informal economy accommodate this shock.

Conclusion

Money and electricity measures of tax evasion suffer two flaws. They do not finger whom it is that evades, and they do not provide a consistent and reasonable estimate of the magnitude of evasion. More seriously these measures can say little about how the underground economy is changing. We hope to have shown that two classes of "macro" estimates of the underground economy rely on assumptions that are questionable for mature economies and unrealistic for transition economies.

Our critique is not entirely original. Practitioners of macro-methods for estimating the underground economy understand that their estimates rely on the realism of their model and on the constancy of their assumptions about key parameters in their model. We have shown that assumptions about the size and stability of key parameters in macro

models, such as the velocity of money and the structure of electricity demand, are doubtful for mature economies and unrealistic for transition economies. Measuring the size of the underground economy in transition economies may be an impossible task, but measuring how it changes may be feasible by using surveys of individuals that yearly ask people about what they believe is the size of the underground economy and whether or not they in engage in underground economic activities. Such surveys have been little exploited by those who would measure the underground economy and promise to be the next frontier in its measurement.

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