A model of the informal economy with an application to Ukraine

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14.04.2009

Main questions

- Quantify size of Ukrainian informal sector using micro-data
- What socio-economic factors affect allocation of labor among L.M. states with varying degrees of informality?
- Does the structure of labor compensation inherited from Soviet times affect allocation between formal and informal sectors?
  How?
- What is the relationship between informality and size of employer firm?

Estimates of the informal economy

- Existing measures of the size of the informal economy in Ukraine have been based on physical inputs data
- Indicate a large informal sector from the start of transition and expansion.
- Johnson et al (1998) - informal activity accounted for around 16% of GDP in 1989/90, rising to over 47% by 1994/95
- Lacko (1999) had a yet higher estimate of around 54% at the latter date
- Schneider (2005) places the informal sector share of GDP at around 53/54% in 2001-2003
- In short, Ukraine in the 1990s appears to have had one of the sharpest rates of increase in the informal economy
- Slow and partial nature of reforms and the continuing high level of payroll taxation. Payroll tax rate above 40%.

Description of data

- The ULMS dataset – 2003 and 2004 rounds, representative sample of Ukrainian households.

- Extensive information on households' income and expenditure, as well as information on individuals relating to employment, working hours, earnings, non-monetary benefits and other components of income.

- The first round - 4056 households and 8641 individuals in 2003 with a retrospective questionnaire covering some – but not all – questions for the years, 1986, 1991, 1997-2001 and 2003. A second round - late 2004, covered nearly 3500 households with 7201 individuals. The reference period for the second round was 2003 and 2004.

Measures of informal sector

- We put together a number of estimates of the size of the informal economy – as measured by **shares of total employment** - for 1991, 1997, 2003 and 2004
- The first column - Measure 1 - the share of employment in informal activity outside of agriculture: individuals with an unregistered job, those who are self employed or have a second job or are involved in occasional supplementary work.
- The second column - Measure 2 - the share augmented by individuals involved in non-agricultural household production and sale of agricultural goods on a secondary basis.
- The third column - Measure 3 - further augments by including all individuals involved in agricultural production for their own use.

Estimates of informal employment

- **Table 1: Ukraine: informal sector employment in 1991, 1997, 2003 & 2004 (% of all working)**

	1991	1997	2003	2004
Measure1	10	17	13	17
Measure2	16	26	16	23
Measure3	50	65	58	66

Transition matrices across various employment states for 2003/2004

- Calculated for individuals present and employed in both periods.
- **Table 2: Transition matrix for 2003/ 2004 (%)**
- N obs = 2824

	Formal only	Formal / Informal	Informal only
Formal only	90	6	4
Formal/Informal	45	35	20
Informal only	28	4	68

A model of the informal economy

- Economy populated by *three types of firms*: state, private formal and private informal firms. All types can employ both full-time and part-time labour.
- State sector firms:
- Full-time employees in the state sector receive monetary wages and also non-monetary or social benefits.
- Part-time employees receive only non-monetary benefits.
- State firms pay payroll taxes for their full-time employees but not for their part-time ones.
- Part-time employees working in the state sector can also work in the private sector and receive a wage.
- That wage will, however, be discounted by the probability of detection for not paying taxes, if they work informally.

The utility of the state firm is given by:

$$U\left(N_f^S, N_p^S, w^S\right) = N_f^S w^S\left(1-\tau_0\right) + N_p^S\left(\theta w_p^I\left(1-\varphi\right) + \left(1-\theta\right) w_p^F\left(1-\tau_0\right)\right) + Mb \qquad (1)$$

where;

θ = share of part-time employees who work in the informal private sector;

b = social or non-monetary benefits provided by the state sector;

N_f^S = full-time employment in the state sector;

N_p^S = part-time employment in the state sector;

w^S = state sector wage;

τ_0 = payroll tax paid on full-time state sector employees;

φ = probability of detection when not paying taxes;

w_p^I = part-time wages in the informal private sector and,

w_p^F = part-time wages in the formal private sector.

We also suppose that the state sector's total employment is fixed at M - in other words, the state sector does not hire or fire, it only moves workers between full-time and part-time employment.

$$N_f^S + N_p^S = M \qquad (4)$$

With a quadratic production function and assuming substitutability of part-time for full-time labour - albeit with some efficiency loss $\delta \in [0,1]$ - the firm's zero-profit constraint can be written as:

$$p\sqrt{N_f^S(1-\delta) + M} = M(1-s)b + N_f^S w^S(1+\tau) \qquad (5)$$

where s = subsidy rate provided by the government to cover the cost of providing social or non-monetary benefits
and τ = the rate of payroll tax that the firm pays on its full-time employees.

Model I:

Solving for the state sector's full-time labour supply N_f^S (and imposing an additional constraint that the slope of the LHS at the solution point is less than the slope of the RHS), we get:

$$p\sqrt{N_f^S(1-\delta)+M} = M(1-s)b + N_f^S w^S(1+\tau) \tag{6}$$

$$\frac{p(1-\delta)}{2\sqrt{N_f^S(1-\delta)+M}} < w^S(1+\tau) \tag{7}$$

The second constraint can be written as:

$$N_f^S > \left(\frac{p(1-\delta)}{2w^S(1+\tau)}\right)^2 * \frac{1}{1-\delta} - \frac{M}{(1-\delta)} \tag{8}$$

Then solving for N_f^S; we can find part-time state sector employment N_p^S from

$$N_p^S = M - N_f^S \tag{9}$$

This gives us the supply of part-time labour to the private sector.

Private sector firms

Private firms can choose whether to be in the formal sector and pay payroll taxes

or be in the informal sector by comparing the relative pay-offs to both states, V^F and V^I .

Private informal firms do not pay payroll tax but face the probability of being detected - φ, with the corresponding fine F -

Private formal sector firms pay the payroll tax on both full- and part-time labour.

Both private informal and formal firms maximize profit subject to
the supply of part-time labour,
the wage parity condition,
and the condition for equilibrium in the market for part-time labour:

$$N_p^I + N_p^F = N_p^S \qquad (11)$$

We assume that the constraint on the supply of full-time labour for private firms is not binding.

Informal private sector

If the firm chooses to be informal, it receives an expected payoff of

$$V^I = \max[(1-\varphi)(N_p^I + N_f^I)\{p\sqrt{N_f^I + (b)N_p^I} - w_f^I N_f^I - w_p^I N_p^I\} - (1-(1-\varphi)^{N_p^I + N_f^I})F \quad (12)$$

The firm faces the following optimization problem:

$$Max[(1-\varphi)\{p\sqrt{N_f^I + (b)N_p^I} - w_f^I N_f^I - w_p^I N_p^I\}] - (1-(1-\varphi))F \quad (13)$$

with respect to $(N_f^I, N_p^I, w_f^I, w_p^I)$ and subject to $((6),(8),(9))$.

Formal private sector

If the firm chooses to be formal, its payoff is given by:

$$V^F = \max[p\sqrt{N_f^F + (b)N_p^F} - w_f^F N_f^F (1+\tau) - w_p^F N_p^F] \quad (14)$$

The firm maximizes profit

$$Max[p\sqrt{N_f^F + (b)N_p^F} - w_f^F N_f^F (1+\tau) - w_p^F N_p^F] \quad (15)$$

with respect to $N_f^F, N_p^F, w_f^F, w_p^F$ and subject to the constraints given by ((6),(8),(9))

Model I: Comparative statics

Deriving the first order conditions, we can now sign the effect of a change in subsidies (s), benefits (b), payroll tax rate (τ), detection probability (φ) and prices (p) on employment in the various sectors and states.

Table 3: Comparative statics

N	S	b	m	T	φ	p
N_f^S	+	-	+	-	+	+
N_f^I	+	-	-	+	-	+
N_p^I	-	+	+	+	-	-
N_f^F	+	-	-	-	+	+
N_p^F	-	+	+	-	+	-

Increase in subsidy financing for social benefits raises full-time employment in the state sector, the informal and formal private sectors while clearly reducing formal/informal work.

An increase in social benefits works in the opposite direction.

By contrast, an increase in the tax rate unambiguously raises part-time work in the state and the informal sectors, i.e., formal/informal work.

An increase in the detection probability, as expected, lowers part-time activity in the informal sector.

Model II:

The strategy of employment maximization underpinning Model I is inefficient.

We now assume that workers maximize rents (in our case of linear utility, the total wage bill)

with respect to wages and full-time (formal sector only) employment,

subject to a zero-profit constraint.

In this case, the optimization problem of the state sector firm looks as follows:

$$\begin{aligned} &Max \quad U\left(N_f^S, N_p^S, w^S\right) = N_f^S w^S \left(1-\tau_0\right) + N_p^S \left(\theta w_p^I \left(1-\varphi\right) + \left(1-\theta\right) w_p^F \left(1-\tau_0\right)\right) + Mb \\ &w.r.t. \left(N_f^S, w^S\right) \end{aligned} \tag{16}$$

$$\begin{aligned} &subject \quad to \\ &p\sqrt{N_f^S (1-\delta) + M} = M(1-s)b + N_f^S w^S (1+\tau) \end{aligned} \tag{17}$$

Graphically, condition (17) could be represented in the space $\left(N_f^S, w^S\right)$ as a set of inverted U-shaped lines.

The efficient combination of $\left(N_f^S, w^S\right)$ will be found at the point where $MRS = MRT$:

$$MRT = \frac{dw^S}{dN_f^S} = -\frac{\pi_{N_f^S}}{\pi_{w^S}} = -\frac{\frac{p(1-\delta)}{2\sqrt{N_f^S(1-\delta)+M}} - w^S(1+\tau)}{N_f^S(1+\tau)} = \frac{w^S(1+\tau) - \frac{p(1-\delta)}{2\sqrt{N_f^S(1-\delta)+M}}}{N_f^S(1+\tau)} \tag{18}$$

$$MRS = \frac{dw^S}{dN_f^S} = -\frac{U_{N_f^S}}{U_{w^S}} = -\frac{w^S(1-\tau_0) - \left(\theta w_p^I(1-\varphi) + (1-\theta) w_p^F(1-\tau_0)\right)}{N_f^S(1-\tau_0)} \tag{19}$$

$$Sign\left(MRS\right) = - \qquad sign\left\{w^S(1-\tau_0) - \left(\theta w_p^I(1-\varphi) + (1-\theta) w_p^F(1-\tau_0)\right)\right\} \tag{20}$$

Case 1: The net wage in the formal sector greater than the expected wage in the formal/informal sector

$$w^S(1-\tau_0) > \left(\theta w_p^I(1-\varphi) + (1-\theta) w_p^F(1-\tau_0)\right) \qquad (21)$$

Here, the indifference curves of the state firm insiders are negatively sloped.

The optimal tangency point $\left(N_f^S, w^S\right)^{OPT}$ will lie to the right of the zero-slope point of the iso-profit (zero-profit) curve.

The formal sector firm is in the diminishing marginal product part of the iso-quant.

The value of the marginal product is less than the marginal (wage) cost.

Case 2: The net wage in the formal sector is less than the expected wage in the formal/informal sector.

$$w^S\left(1-\tau_0\right)<\left(\theta w_p^I\left(1-\varphi\right)+\left(1-\theta\right)w_p^F\left(1-\tau_0\right)\right) \tag{22}$$

In this case, the indifference curves are positively sloped.

The optimal tangency point $\left(N_f^S, w^S\right)^{OPT}$ will lie to the left of the zero-slope point of the iso-profit (zero-profit) curve.

The formal sector firm is in the increasing marginal product part of the iso-quant.
The value of the marginal product is greater than the marginal (wage) cost.

Case 3: The net wage in the formal sector equals the expected wage in the formal/informal sector

$$w^S(1-\tau_0) = \theta w_p^I(1-\varphi) + (1-\theta) w_p^F(1-\tau_0) \tag{23}$$

The indifference curves of the state firm insiders are horizontal.

The optimal tangency point $\left(N_f^S, w^S\right)^{OPT}$ will be at the zero-slope point of the iso-profit (zero-profit) curve.

Here the value of the marginal product is equal to the marginal (wage) cost.

These three possible outcomes have different implications for our main question of interest - **the impact of social benefits on formal vs. formal/informal vs. informal sector employment.**

Consider **Case 1**: as social benefits increase from b_0 to $b_1 > b_0$, the zero-profit curve shifts down, and the optimum $\left(N_f^S, w^S\right)^{OPT}$ shifts in,

resulting in

lower wages and lower formal sector employment and higher formal/informal employment.

We call this property the "attaching" property of social benefits, in the sense that,

despite lower expected wages in the formal/informal sector, a higher level of social benefits leads to an inflow of workers into that sector.

A higher subsidy would have an opposite effect to that of an increase in benefits, leading to higher formal sector employment.

A positive shock to aggregate demand (higher p) would also lead to higher formal sector employment,

but higher wages as well.

Table 4: Comparative statics 2

N	s	b	m	τ	φ	p
N_f^S	+	-	+	-	+	+
N_f^I	+	-	-	+	-	+
N_p^I	-	+	+	+	-	-
N_f^F	+	-	-	-	+	+
N_p^F	-	+	+	-	+	-

However, **Cases 2 and 3** produce drastically different results.

In Case 2, as social benefits increase and the zero-profit curve shifts down, the optimal point $\left(N_f^S, w^S\right)^{OPT}$ shifts down to the right of the old optimum,

so that formal sector employment is higher,

while formal sector wages are lower than before

and formal/informal employment decreases.

Higher prices bring about lower formal sector employment but also higher wages.

Case 3 offers much the same results.

Interpretation: when the *formal sector wage is higher than that in the mixed sector*,

the indifference curves have the standard negative slope →

full-time employment of insiders is an economic "good" to them →

a decrease in benefits (or an increase in the subsidy to benefits) that shifts the iso-profit curve up

will lead to a higher "consumption" of the preferred type of employment,

so that full-time employment of insiders goes up and the mixed sector employment drops.

The opposite happens when *benefits are higher* in this case → iso(zero)-profit curve shifts

down and the firm's insiders can afford less of its preferred (full-time) employment type now

→ they shift workers from full-time into the (cheaper) mixed employment.

Testing the model with Ukrainian data

Empirics: mixed multinomial logit estimation of sector choice

The revealed choice between J alternative sectors for work y_{it} is observed for individual worker *i* on occasion *t*.

The choice set contains just three alternatives: being employed in the informal sector, being employed in the formal sector, or holding multiple jobs in the formal/informal (mixed) sector.

Associated with each alternative sector *j* is a probability of being employed in this sector *i*, π_{it}^{j}.

Predictors of labour allocation (sector choice) include the economic and socio-demographic characteristics of individual *i* and contextual factors, which operate on the firm and sector levels.

The predictors reside in a matrix of explanatory variables $X_{it} = (x_{it}^{1}, \ldots, x_{it}^{J})$, with x_{it}^{j} being a column vector associated with the probability π_{it}^{j}.

We use an extension of the multinomial logit model,

where the response probabilities π_{it}^{j} depend on the nonlinear transformations of the linear function $X_{it}\beta_{j} + u_{i}$,

and where arising from heterogeneity between individuals, individual-specific random intercepts u_{i} account for intra-individual correlation caused by multiple observations for individual *i*.

With a predictor vector $x_{it}{}^{j}$ that includes a constant term, and with the last among $j = 1,...,J$ alternatives as the reference category, the conditional probability of a particular choice j can be written as follows:

$$\Pr\left(y_{it} = j \mid X_{it}, u_i\right) = \pi_{it}^{j} = \frac{\exp\left(\alpha_j + X_{it}\beta_j + u_i\right)}{\sum_{k=1}^{J-1} \exp\left(\alpha_j + X_{it}\beta_k + u_i\right)} \qquad (24)$$

The effect of x_{im} (the mth characteristic for individual i) on the logit of choice j relative to choice k (i.e. on the log-odds) is obtained as the contrast $\beta_{jm} - \beta_{km}$.

The random effects u_i are assumed to be independent and identically distributed according to a normal distribution.

In our specification, the vector u_i allows for random variation in intrinsic preferences across individuals with respect to their choice of employment sector choice

but remains constant over time and between alternatives for work.

Hypotheses

Model II: Effect of social benefits depends on the ratio of expected formal to formal/informal wages

in both sign and magnitude.

The sign is dependent upon the **wage ratio being more or less than unity**.

To test this proposition, an **interaction** variable between **the wage ratio dummy** taking the value of one if the relative wage is greater than one, and the **social benefits** variable is used.

We would expect **a negative coefficient on this interaction** variable.

We also include a second interaction term that is constructed as the product of the predicted wage ratio and the benefits variable.
This second interaction term is expected to show the impact of changes in the wage ratio on the relative magnitude of the effect of social benefits on sector choice.

Alternatively, our conjecture based on the conclusions from **Model I** is that

work in the formal/informal sector will be **positively** (negatively) influenced by the **provision of social benefits** (subsidies to benefits),
and whether workers have experienced compulsory leave (temporary lay-offs) – an indicator for the level of activity in the firm.

It therefore implies that the first interaction term discussed above will be insignificant.

We use a panel sub-sample of the ULMS that contains information for all the variables for

6160 observations in 2003 and 2004.

The regression coefficients represent log-odds ratios.

A positive coefficient for an independent variable implies

higher odds of observing an individual being in the destination sector *j* rather than in the sector taken as the reference category.

Table 5. Estimation of the sector choice model using mixed logit

Dependent variable: Log Odds **Reference category: Work in Formal/Informal Sector**	**Work in Formal Sector**	**Work in Informal Sector**
Independent variables:		
<u>Worker characteristics</u> (Socio-economic controls):		
Age	0.0345	-0.062*
	(0.027)	(0.037)
Age squared	-0.001*	0.001
	(0.000)	(0.001)
Female	0.167*	0.318**
	(0.086)	(0.142)
Education (relative to Education1 = diploma of high school (general secondary))		
Education2 (incomplete professional higher)	-0.826*	-0.994
	(0.467)	(0.637)
Education3 (bachelors, masters, candidates)	0.434	-0.421
	(0.450)	(0.651)
Education4 (all the other: grades 1-6, grades 7-9, grades 10-11, PTU diplomas …)	-0.414*	-0.525*
	(0.248)	(0.275)
Settlement type (relative to Village) - Included as continuous variable	0.477***	0.330***
	(0.033)	(0.043)
Location (Oblast) dummies	Not included	Not included

Employer characteristics and wage differences across sectors:		
Social benefits (relative to Benefits_group1 = No social benefits)		
Benefits16_group2 (1 or 2 benefits, count of benefits1-6)	1.280***	-1.665***
	(0.272)	(0.382)
Benefits16_group3 (3 benefits)	1.268***	-3.011***
	(0.385)	(0.560)
Benefits16_group4 (4-6 benefits)	1.150**	-3.190***
	(0.501)	(0.899)
Subsidy to benefits dummy	-0.004	-2.047***
	(0.173)	(0.342)
Predicted formal sector wage/ Predicted formal/informal sector wage	1.241***	0.841*
	(0.430)	(0.480)
Benefits × (Predicted formal sector wage/ Predicted formal/informal sector wage)	-0.322	-0.247
	(0.197)	(0.295)
Dummy =1 if (Predicted formal sector wage/ Predicted formal/informal sector wage)>1	dropped	dropped
Benefits × Wage Ratio Dummy	-0.614***	-0.794***
	(0.160)	(0.262)
Compulsory leave	Not included	Not included
Employer size (relative to Employer size 1 = 1-9 employees, ie micro firms)	Not included	Not included
Year dummy for 2004	0.771***	1.701***
	(0.064)	(0.048)
Constant	-1544.943***	-3406.27***
	(127.488)	(95.465)
Variance of random intercepts	3.573 (0.387)	
No. of observations	6160	6160

Reported: coefficients (log odds ratios), robust standard errors in parentheses.

Significance levels: * - 10%, ** - 5%, *** - 1%.
Weighted by sample (population) weights.

Table 5A. Estimation of the sector choice model using mixed logit (set of regressors corresponding to that in Table 2.1 of Appendix 2)

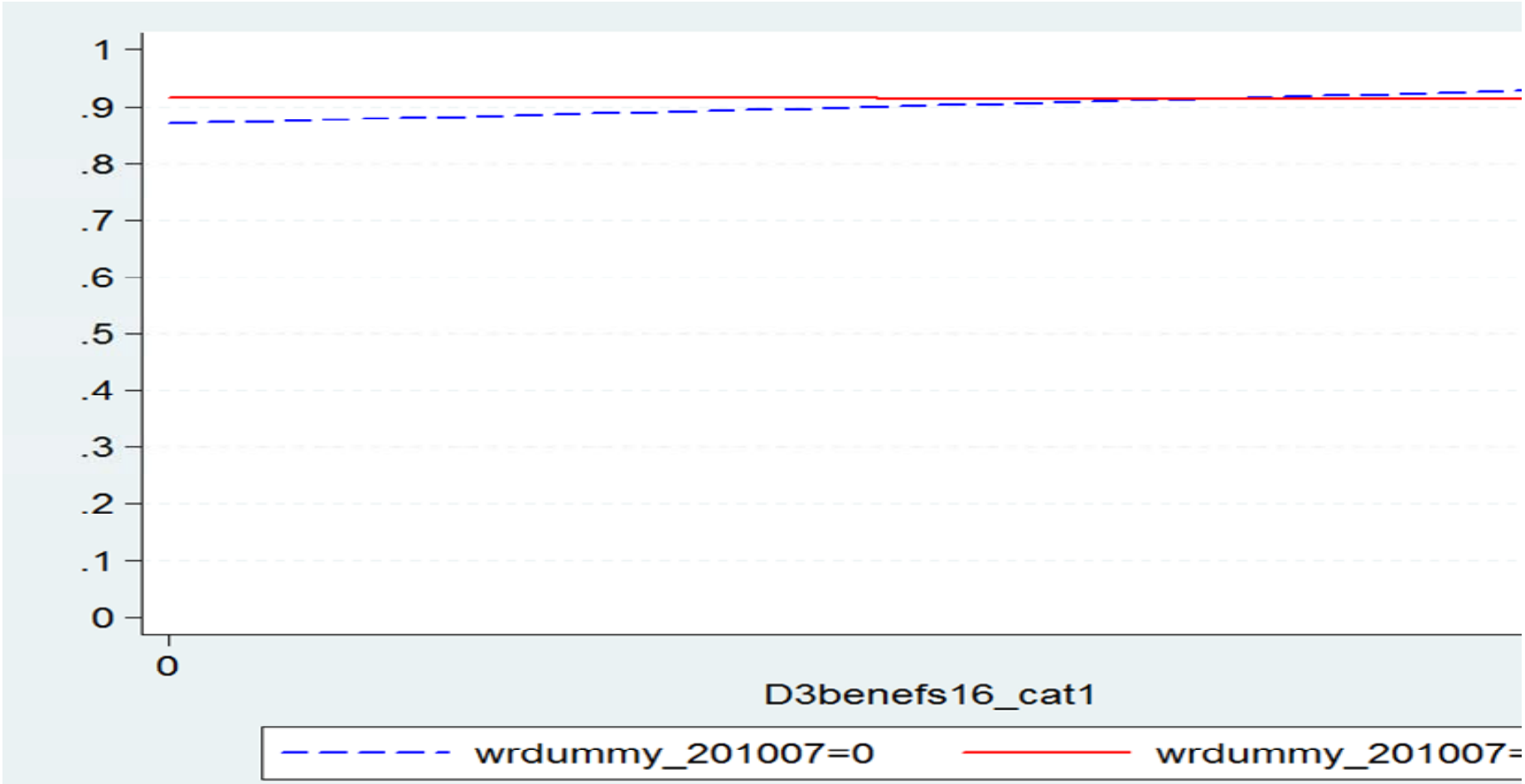
Dependent variable: Log Odds **Reference category: Work in Formal/Informal Sector**	**Work in Formal Sector**	**Work in Informal Sector**
Independent variables:		
Worker characteristics (Socio-economic controls):		
Age	0.158***	0.064*
	(0.030)	(0.038)
Age squared	-0.002***	-0.001**
	(0.0004)	(0.001)
Female	0.046	0.209
	(0.082)	(0.141)
Education (relative to Education1 = diploma of high school (general secondary))		
Education2 (incomplete professional higher)	-1.533***	-1.696***
	(0.475)	(0.642)
Education3 (bachelors, masters, candidates)	-0.290	-1.050
	(0.498)	(0.679)
Education4 (all the other: grades 1-6, grades 7-9, grades 10-11, PTU diplomas …)	-1.307***	-1.406***
	(0.274)	(0.230)
Settlement type (relative to Village) - Included as continuous variable	0.338***	0.189***
	(0.028)	(0.039)
Location (Oblast) dummies	Not included	Not included

Employer characteristics and wage differences across sectors:		
Social benefits (relative to Benefits_group1 = No social benefits)		
Benefits16_group2 (1 or 2 benefits, count of benefits1-6)	2.024***	-0.962***
	(0.292)	(0.372)
Benefits16_group3 (3 benefits)	1.026***	-3.225***
	(0.257)	(0.467)
Benefits16_group4 (4-6 benefits)	.117	-4.118***
	(0.301)	(0.634)
Subsidy to benefits dummy	-0.026	-2.101***
	(0.173)	(0.342)
Predicted formal sector wage/ Predicted formal/informal sector wage	dropped	dropped
Benefits × (Predicted formal sector wage/ Predicted formal/informal sector wage)	dropped	dropped
Dummy =1 if (Predicted formal sector wage/ Predicted formal/informal sector wage)>1	-0.164	-.788***
	(0.323)	(0.336)
Benefits16_group2 × Wage Ratio Dummy	-2.584***	-2.141***
	(0.629)	(0.842)
Benefits16_group3 × Wage Ratio Dummy	-1.828***	-1.450
	(0.560)	(0.984)
Benefits16_group4 × Wage Ratio Dummy	dropped	dropped
Compulsory leave	Not included	Not included
Employer size (relative to Employer size 1 = 1-9 employees, ie micro firms)	Not included	Not included
Year dummy for 2004	0.969***	1.922***
	(0.0004)	(0.068)
Constant	-1943.548***	-3850.498***
	(0.907)	(136.963)

Changes in Pr(Formal)accounting for the total effect of the D3Benefs16_cat1, wage ratio dummy and their interaction

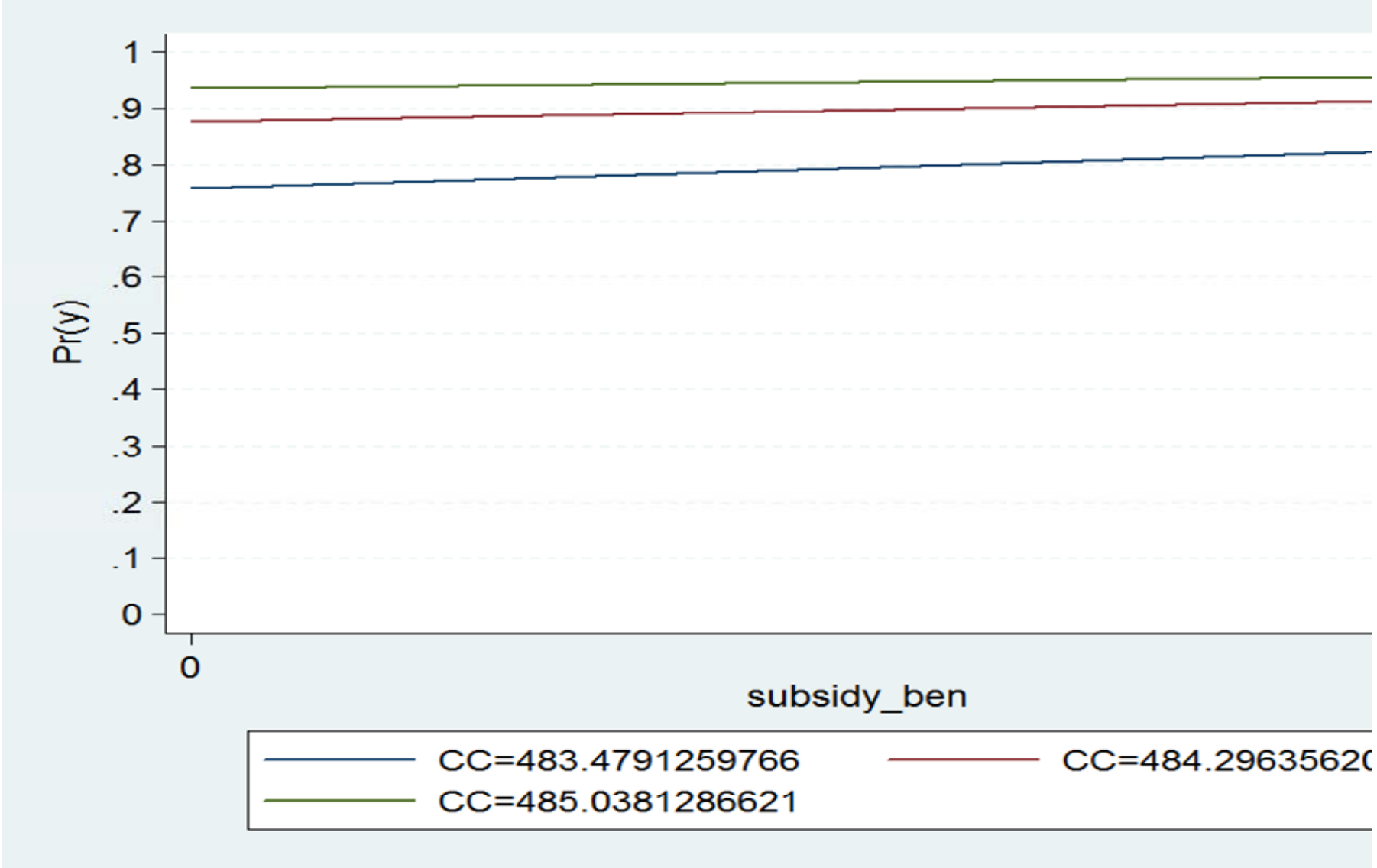
```
**For CC=484.9765625** (median)

           |   D3benefs16_cat1
wrdummy_201007 |   0           1
---------+--------------------
         0 |   0.87 (A)    0.93 (B)    (B-A) =   0.06
         1 |   0.92 (C)    0.91 (D)    (D-C) =  -0.01
                       (D-C) minus (B-A) =  -0.07
```

Figure 2.1: Pr(*F*) by x1 (D3benefs16_cat = 1 if benefs16=3) and x2 (wage ratio dummy) accounting for x1x2 when other covariates take median values



Effect of subsidy on Formal employment

Figure 2.2: Pr(*Formal*) by Subsidy to benefits when other covariates are at the median, at 20 per cent and at 80 per cent.



Conclusions

- Social benefits play attaching role to the mixed formal/informal sector for high enough wage ratio
- This finding supports Model II of insider firm behaviour (joint max of wages and employment)
- Higher subsidy to benefits encourages full-time formal employment
- Higher relative formal sector wage associated with larger formal sector employment
- Social benefits play attaching role to the mixed formal/informal sector therefore influencing the purely informal sector
- Formal/informal sector employment more widespread in rural localities; evidence on age/gender/education mixed.