Estimating the impact of price regulation on quality of service in post

16th CPDE

Portugal

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Outline

- Introduction
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Introduction

- Quality of service is an important element of postal economics and regulation
  - Many regulators regulate quality at a variety of ways (e.g., Ireland, UK, Portugal), often via targets, charters, and fines/bonuses, other
  - Concern over whether price caps give correct incentives for optimal quality has been looked at in a number of papers and in a number of jurisdictions
- Quality regulation presents particular challenges to regulator/companies
  - Regulator must estimate the optimal trade-off between higher quality and additional cost (if correct quality incentives are to be given)
    - Regulatory policy could give incentive to make quality too high or too low
    - For example, too high quality
      - Could be a barrier to emerging competition or
      - Could require incumbent post to keep price too high, allowing competitors to enter with lower price, lower quality and lower cost
  - Probably in part due to these challenges, many regulators have focused on regulating quality “directly” (e.g., fines, targets) or not at all (formally)
- However, this raises the question of should the regulator worry about regulated price (margin) as a (significant) element of quality incentives?
  - <u>Fundamental question</u>: does the regulated price (margin) give posts incentive/disincentive to provide quality?

Review

- Seminal work on relationship between price, monopoly, quality and social welfare from Spence (1975): key results
  - Unregulated monopolist may provide quality higher or lower than socially optimal level
    - Monopolist's incentive to provide quality depends on whether demand is complement (e.g., food) or substitute (e.g., cars) to quality
- Recent empirical work in other regulated industries has focused on whether incentive regulation might give poor incentives to provide quality (e.g., Sappington RNE 2003)
  - However, a more fundamental question arises as to whether a "regulated" monopolist has the same incentives as the unregulated monopolist
    - (as opposed to focus on the form of the price control, e.g., whether price cap or COS regulation gives different quality incentive properties)

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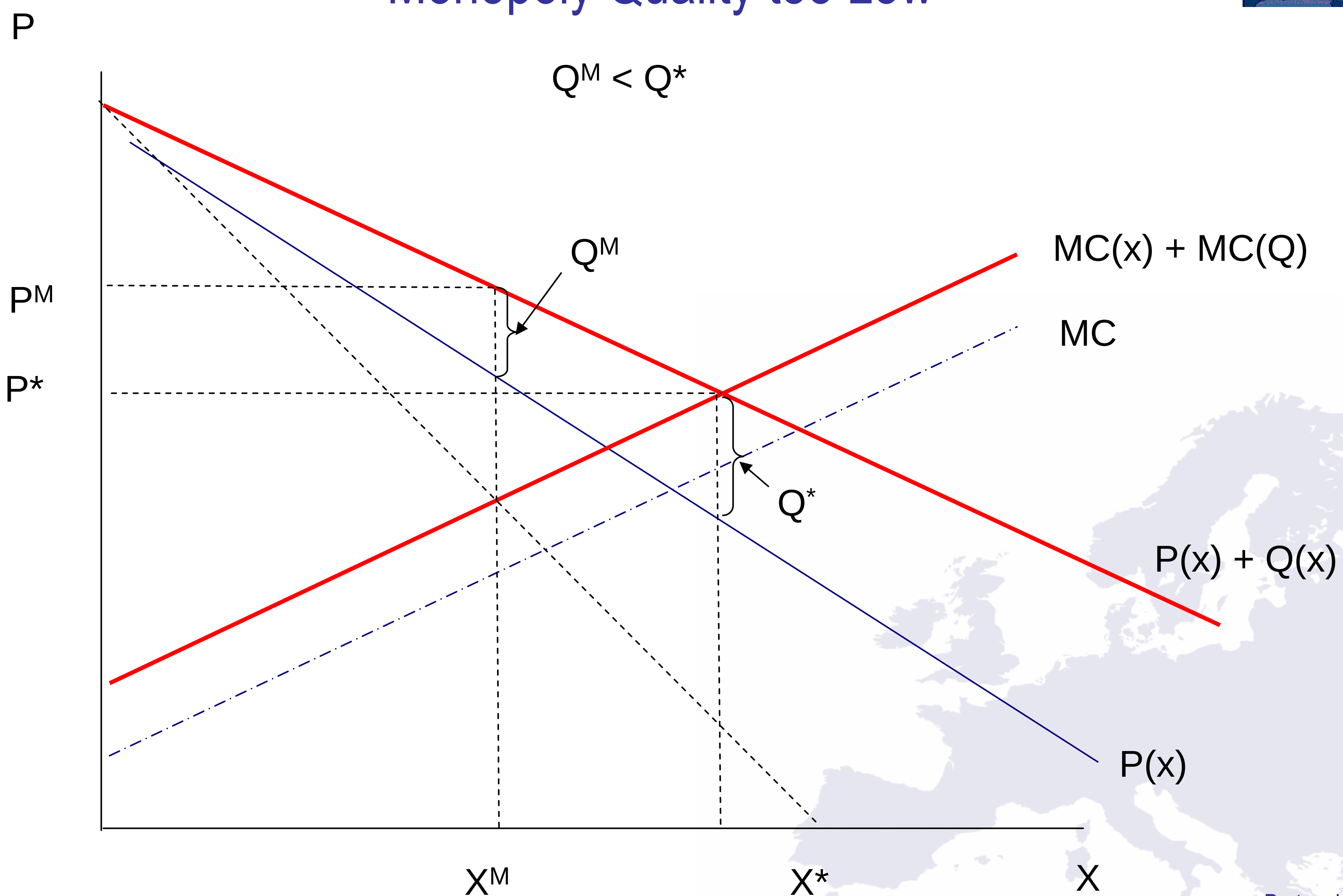
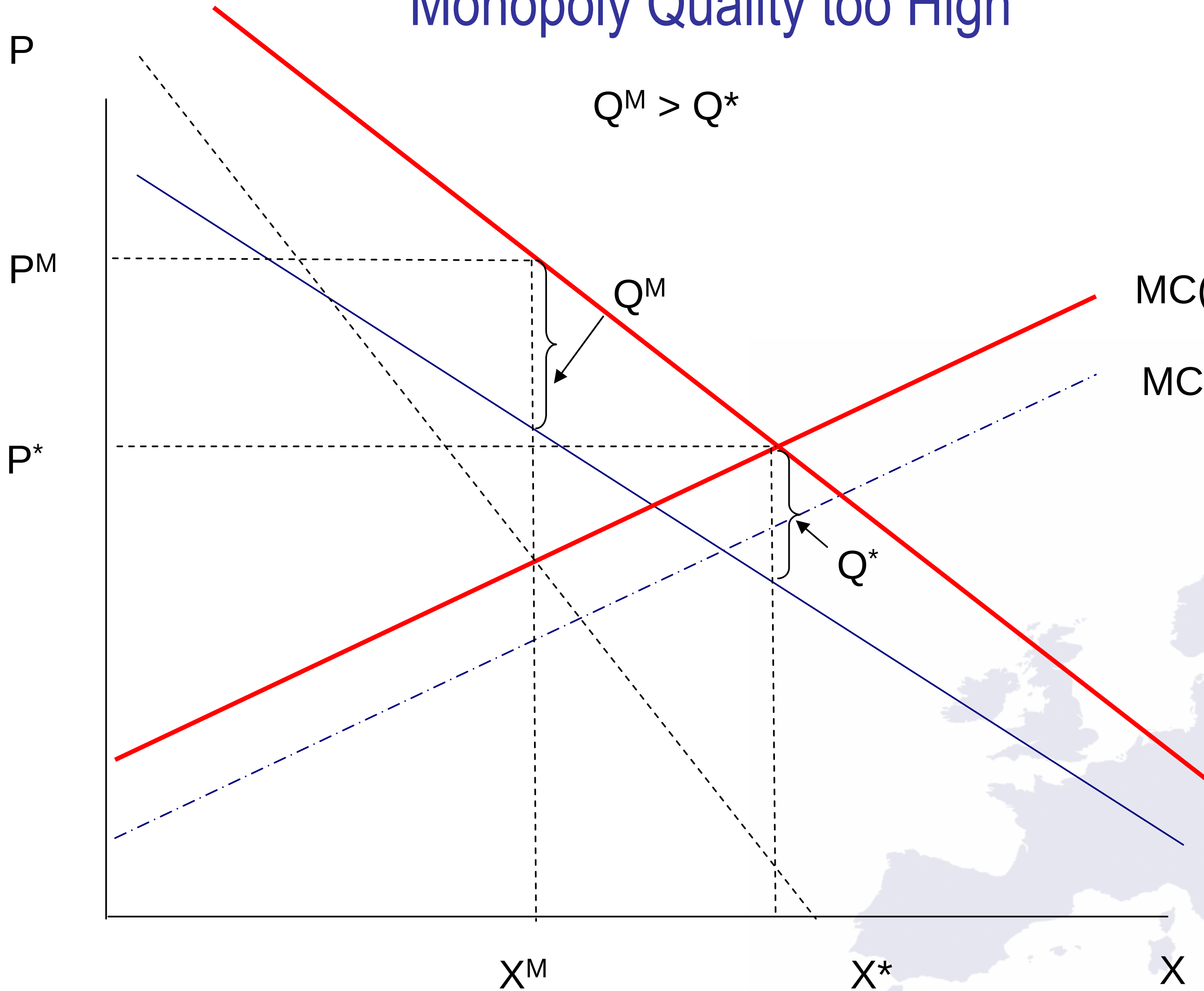
    - (as opposed to focus on the form of the price control, e.g., whether price cap or COS regulation gives different quality incentive properties)

Quality and Monopoly
Monopoly Quality too Low



Quality and Monopoly
Monopoly Quality too High



Model

- The models starts with a price-regulated monopolist who maximises profits, and derives quality as a function of other variables (quality is the choice variable)
  - Profit, with *p*-bar fixed price, *D* demand, *C* cost and *q* quality

$$\pi = \overline{p}D\left(\overline{p}, q\right) - C\left(D\left(\overline{p}, q\right), q\right)$$

$$\ln\left(\overline{p} - C'\right) = \ln\left(\frac{\partial C}{\partial q}\right) - \ln\left(\frac{\partial D}{\partial q}\right)$$

  - We assume the cost function has the translog form (1st order)
  - We assume the demand function has the form

$$D(\overline{p}, q) = \frac{a}{\overline{p}} q \qquad \ln D_q = \ln a - \ln \overline{p}$$

Model

- Rearranging and substituting between the FOCs and the cost function and adding an assumed error term gives an estimating equation

$$\ln q = \alpha + \sum_i \beta_i \ln p_i + \beta_D \ln D + \beta_t \ln t + \beta_{pc} \ln\left[(\overline{p} - C')D_q\right] + \varepsilon$$

- Rearranging gives the following equation, with the last term notably a function of the PCM-LI and a demand shifting parameter "a"

$$\ln q = \alpha + \beta_w \ln p_w + \beta_D \ln D + \beta_t \ln t + \beta_{pc}\left(\ln\left[(\overline{p} - C')/\overline{p}\right] + \ln a\right) + \varepsilon$$

- Above β are parameters, *D* is total demand, *t* is time, *p* is input price(s) (wage), p-bar is regulated price, C' is marginal cost, and a is a demand shifting variable, taken to be GDP
  - Note the model implies a restriction on the demand shift variable coefficient and the pcm variable coefficient

Data

- The model requires data on quality *q*, which should be a function of input prices, p_w, demand, *D*, and margins, *pcm*, and the log a demand shift variable, GDP
- Quality variable is average number of days to deliver, input price is wage (total labour cost/total FTEs), demand is all domestic + international letter post items
- The data are from UNEX, UPU, Amadeus, IPC, OECD, and other sources
- Variables were all put into real USD values based on OECD data on inflation, exchange rates, and PPP
- Of particular interest is the PCM variable
  - We used two methods to create this variable
    - Using the method of Cohen et al (2004), we estimate the AC function for each post using a panel with fixed effects and then marginal costs are estimated from dC/dQ{AC*Q} = MC of the predicted values/equations
    - We also used an accounting method using Amadeus data according to the method of (Collins and Preston 1969): PCM = (TR – wages – materials)/TR

Estimation

- Model as specified is linear in logs and amenable to standard panel estimation techniques
- An observation is a quality realisation for a "country pair", while the rest of the observations are annual
- We estimated fixed effects (fe), between group effects (be), and random effects (re) models using standard estimation software (STATA)
- The Hausman test was performed and pointed to either the fixed effects or random effects model
  - (somewhat inconclusive depending on Ho)
  - Fixed effects model preferred based on R^2 and intuitive appeal

Results

- Fixed effects model regression results below

```
Fixed-effects (within) regression               Number of obs      =      1253
Group variable (i): co_codest_n                 Number of groups   =       252

R-sq:  within  = 0.3263                         Obs per group: min =         1
       between = 0.0257                                        avg =       5.0
       overall = 0.0864                                        max =         8

                                                F(4,997)           =    120.72
corr(u_i, Xb)  = -0.3954                        Prob > F           =    0.0000

------------------------------------------------------------------------------
   lnavg_dys |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lnpcm_gdp |  -.0095476    .005418    -1.76   0.078    -.0201797    .0010844
         lnt |  -107.5202   8.716373   -12.34   0.000    -124.6248   -90.41569
       lnvol |  -.0385698   .0132326    -2.91   0.004    -.0645369   -.0126028
      lnwage |   .4249338   .0690602     6.15   0.000     .2894138    .5604538
       _cons |   814.6853   65.53687    12.43   0.000     686.0792    943.2913
-------------+----------------------------------------------------------------
     sigma_u |   .2580639
     sigma_e |  .16076737
         rho |  .72041027   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(251, 997) =     5.38            Prob > F = 0.0000
```

Results

- Interpreting the results
  - Lnpcm_gdp
    - The price cost margin has a significant and expected sign impact on quality
    - An increase in pcm of about 1% leads to an increase in quality (reduction in the average number of days) of about 0.01% (times GDP)
      - at the sample mean of lngdp (about 7.9), this implies
    - 0.08% decrease in the avg number of days due to PCM impacts
  - Lnt
    - Time trend or unexplained exogenous quality increase over time has been the largest and statistically significant impact on quality (quality increasing with time)
  - Lnvol
    - Volume has a significant and positive impact on quality (reduced avg #days)
    - This *is* the expected sign, to the extent that higher volume gives more incentive to raise quality, but unaccounted for capacity constraints may be at work)
  - Lnwage
    - The wage has a significant and (unexpected) sign impact on quality, with a 1% rise in the wage leading to a 0.21% increase in the average number of days

Conclusions

- The model as derived provides a sound theoretical basis for the estimation of the impact of regulated prices (via margins) on quality
- The model and evidence suggest margins have a significant and positive impact on quality
  - Although in absolute terms the magnitude of the impact is not large
  - With a feedback effect from quality→volume, the impact of quality could be about 50% higher
- Higher wages seem to have a negative impact on quality, but it is difficult to interpret this result
  - Could be proxy for inflexibility in work practices, other related factors
  - Could be spurious as possibly higher quality posts reduced labour force
    - Although, regression of lnwage on lnt positive and significant

Directions for future research

- Have advanced along the path of understanding the interactions between regulation, margins, and quality
- Data availability, accuracy, and timeliness is always important
  - Continued effort to keep international data up to date, ensure coverage, etc, not to be undervalued
- Still a long way from designing optimal regulator incentives for regulated posts
  - Is the level of margin needed consistent with Consumers' willingness to pay?
  - What implications of this research for the form of the price control and other forms of regulation?
  - How does the USO interact with the incentives to provide quality?
    - USO could imply higher or lower margins, and higher or lower quality

Annex slides

Model Derivation Details

- The models starts with a price-regulated monopolist who maximises profits
  - Profit, with *p*-bar fixed price, *D* demand, *C* cost and *q* quality

$$\pi = \bar{p}D(\bar{p},q) - C(D(\bar{p},q),q)$$

  - FOC's are

$$\frac{\partial \pi}{\partial q} = \bar{p}\frac{\partial D}{\partial q} - \left[\frac{\partial C}{\partial D}\frac{\partial D}{\partial q} + \frac{\partial C}{\partial q}\right] = 0$$

  - Rearranging, and taking the log:

$$(\bar{p} - C') = \frac{\partial C}{\partial q} \Big/ \frac{\partial D}{\partial q} \qquad \ln(\bar{p} - C') = \ln\left(\frac{\partial C}{\partial q}\right) - \ln\left(\frac{\partial D}{\partial q}\right)$$

Model Derivation Details

- The translog cost function (Jorgenson, Christensen, Lau 1973) using our notation
- We take a first order approximation, so the higher order terms drop out

$$
\begin{aligned}
\ln C = {} & \alpha_0 + \sum_i \alpha_i \ln p_i + \alpha_D \ln D + \alpha_q \ln q + \alpha_t \ln t + \\
& \tfrac{1}{2} \sum_J \sum_i \gamma_{ij} \ln p_i \ln p_j + \tfrac{1}{2}\gamma_D (\ln D)^2 + \tfrac{1}{2}\gamma_q (\ln q)^2 + \tfrac{1}{2}\gamma_t (\ln t)^2 + \\
& \sum_i \gamma_{iD} \ln p_i \ln D + \sum_i \gamma_{it} \ln p_i \ln t + \sum_i \gamma_{iq} \ln p_i \ln q + \\
& \gamma_{Dq} \ln D \ln q + \gamma_{Dt} \ln D \ln t + \gamma_{qt} \ln q \ln t
\end{aligned}
$$

Model Derivation Details

- Ignoring the higher order terms (making it a first order approximation), taking the anti-log of the above, taking the partial derivative, and then taking the log of that, gives a logarithmic derivative equation for the marginal cost of q

$$\ln\left[\frac{\partial C}{\partial q}\right] = \alpha_0(\alpha_q) + \sum_i \alpha_i \ln p_i + \alpha_D \ln D + (\alpha_q - 1)\ln q + \alpha_t \ln t$$

  - Rearranging and substituting into the previous equation from the FOC:

$$\ln q = (-\alpha_0\alpha_q/(\alpha_q - 1)) + \sum_i (-\alpha_i/(\alpha_q - 1))\ln p_i + (-\alpha_D/(\alpha_q - 1))\ln D + (-\alpha_t/(\alpha_q - 1))\ln t + (1/(\alpha_q - 1))\ln(\overline{p} - C') + (1/(\alpha_q - 1))\ln(D_q)$$

Model Derivation Details

- We don't really care whether we recover specific values of the original parameters, so the above is a linear in the coefficients equation that with the addition of an assumed random error term can be estimated

$$\ln q = \alpha + \sum_i \beta_i \ln p_i + \beta_D \ln D + \beta_t \ln t + \beta_{pc} \ln\left[(\overline{p} - C')D_q\right] + \varepsilon$$

- We assume that the demand function has the form:

$$D(\overline{p}, q) = \frac{a}{\overline{p}} q \qquad \frac{\partial D}{\partial q}(\overline{p}, q) = \frac{a}{\overline{p}} \qquad \ln D_q = \ln a - \ln \overline{p}$$

$$\ln q = \alpha + \sum_i \beta_i \ln p_i + \beta_D \ln D + \beta_t \ln t + \beta_{pc}\left(\ln\left[(\overline{p} - C')/\overline{p}\right] + \ln a\right) + \varepsilon$$

Data additional details

- Demand was taken to be volume of all letter post items international + domestic from UPU data
- The marginal cost estimates were based on total cost and volume figures from Amadeus, and population figures from UPU
- For 3 of the PCM estimates, PCM’s <0 were predicted based on odd MC predictions; for these posts, we substituted the accounting-based PCM estimates

Results-additional details

- Random effects model regression results below

```
Random-effects GLS regression                   Number of obs      =      1253
Group variable (i): co_codest_n                 Number of groups   =       252

R-sq:  within  = 0.3179                         Obs per group: min =         1
       between = 0.0335                                        avg =       5.0
       overall = 0.1165                                        max =         8

Random effects u_i ~ Gaussian                   Wald chi2(4)       =    352.83
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
   lnavg_dys |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lnpcm_gdp |  -.0093502   .0038985    -2.40   0.016    -.0169912   -.0017092
         lnt |  -78.39383   6.407404   -12.23   0.000    -90.95211   -65.83555
       lnvol |  -.0068206   .0074082    -0.92   0.357    -.0213405    .0076992
      lnwage |   .2082241   .0462029     4.51   0.000     .1176681      .29878
       _cons |   594.8978   48.25406    12.33   0.000     500.3216     689.474
-------------+----------------------------------------------------------------
     sigma_u |  .15929592
     sigma_e |  .16076737
         rho |  .49540271   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Results-additional details

- Between group effects model regression results below

```
Between regression (regression on group means)  Number of obs      =      1253
Group variable (i): co_codest_n                 Number of groups   =       252

R-sq:  within  = 0.2806                         Obs per group: min =         1
       between = 0.1549                                        avg =       5.0
       overall = 0.0477                                        max =         8

                                                F(4,247)           =     11.32
sd(u_i + avg(e_i.))=  .1864326                  Prob > F           =    0.0000

------------------------------------------------------------------------------
   lnavg_dys |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lnpcm_gdp |  -.0104674   .0057341    -1.83   0.069    -.0217614    .0008266
         lnt |   57.14274   12.45311     4.59   0.000      32.6149    81.67058
       lnvol |   .0170623   .0093035     1.83   0.068    -.0012621    .0353866
      lnwage |   .0802899   .0591304     1.36   0.176    -.0361742    .1967539
       _cons |  -434.5968   94.33483    -4.61   0.000       -620.4   -248.7935
------------------------------------------------------------------------------
```

Results-additional details

- Random effects model *without* the restriction that coefficients on lnpcm = lngdp

```
Random-effects GLS regression                   Number of obs      =      1253
Group variable (i): co_codest_n                 Number of groups   =       252

R-sq:  within  = 0.3161                         Obs per group: min =         1
       between = 0.0336                                        avg =       5.0
       overall = 0.1180                                        max =         8

Random effects u_i ~ Gaussian                   Wald chi2(5)       =    353.90
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

------------------------------------------------------------------------------
   lnavg_dys |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   lnpcm_avg |  -.0180171   .0087034    -2.07   0.038    -.0350756   -.0009587
       lngdp |  -.0077521   .0041529    -1.87   0.062    -.0158917    .0003875
         lnt |  -79.88712   6.548511   -12.20   0.000    -92.72196   -67.05227
       lnvol |  -.0054227   .0075076    -0.72   0.470    -.0201373    .0092919
      lnwage |   .2113169   .0462726     4.57   0.000     .1206242    .3020095
       _cons |    606.166   49.32113    12.29   0.000     509.4984    702.8337
-------------+----------------------------------------------------------------
     sigma_u |  .15916769
     sigma_e |  .16083168
         rho |  .49480015   (fraction of variance due to u_i)
------------------------------------------------------------------------------
 test lnpcm_avg = lngdp

 ( 1)  lnpcm_avg - lngdp = 0

           chi2(  1) =    1.24
         Prob > chi2 =    0.2654
```

Results-additional details

- Fixed effects model *without* the restriction that coefficients on lnpcm = lngdp and test

```
Fixed-effects (within) regression               Number of obs      =      1253
Group variable (i): co_codest_n                 Number of groups   =       252

R-sq:  within  = 0.3264                         Obs per group: min =         1
       between = 0.0248                                        avg =       5.0
       overall = 0.0867                                        max =         8

                                                F(5,996)           =     96.54
corr(u_i, Xb)  = -0.3995                        Prob > F           =    0.0000

------------------------------------------------------------------------------
   lnavg_dys |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lnvol |  -.0386261   .0132385    -2.92   0.004    -.0646047   -.0126475
      lnwage |   .4269367   .0692308     6.17   0.000     .2910818    .5627916
         lnt |  -107.2675   8.737898   -12.28   0.000    -124.4143   -90.12067
  lnpcm_avg |  -.0064796   .0087047    -0.74   0.457    -.0235613     .010602
       lngdp |  -.0108998    .006196    -1.76   0.079    -.0230585    .0012589
       _cons |   812.7566   65.70275    12.37   0.000     683.8249    941.6883
-------------+----------------------------------------------------------------
     sigma_u |  .25875546
     sigma_e |  .16083168
         rho |  .72132633   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(251, 996) =     5.33            Prob > F = 0.0000

test lnpcm_avg = lngdp

 ( 1)  lnpcm_avg - lngdp = 0

       F(  1,   996) =    0.20
            Prob > F =    0.6525
```

Results-additional details

- Summary statistics for key variables

Variable	Obs	Mean	Std. Dev.	Min	Max
avg_dys	2154	2.679851	.7728875	1.8	8.3
vol_tot	1798	3.22e+09	5.50e+09	4.87e+07	2.68e+10
wage	2063	43989.36	12806.89	22089.2	78787.5
pcm_avg	2696	.5289433	.3842853	.0280134	1.848848
gdp	2999	103768.7	270832.6	66.99138	1485300