Lecture 3
Differences in Technology and Differences in Capital Stocks

Barcelona, June 18

Differences in capital

- Recall from lecture 1: significant cross-country variation in *reproducible* K/L
- Lucas (1990) pointed out this required at least one of the following:
  - Complementary variation in other factors of production (e.g. human capital) or technology
  - Downstream financial frictions
- Today's lecture is about the relative importance of these, or other explanations

Key distinction between explanations

- Complementary inputs/technology: financial returns from installing capital equalized across countries
- Downstream financial frictions: higher returns in capital-poor countries
- Lecture's main finding:
  - neither is right!
  - returns lower in poor countries
- Explanation
  - complementary inputs/technology worse in poor countries coupled with *upstream* financial frictions

Standard approaches to estimating MPKs

- Comparisons of interest rates
- Regressions of ΔY on ΔK
- Calibration. E.g. Lucas' calculation:

$$y = k^{\beta} h^{1-\beta}$$

$$MPK = \beta k^{\beta-1} h^{1-\beta} = \beta y^{\frac{\beta-1}{\beta}} h^{\frac{1-\beta}{\beta}}.$$

With $\beta = 0.4$ and using estimates of h (from Krueger, 1968) gives a India-US difference of 5

- Take a different approach

First pass: one sector model

- Constant returns and competitive markets

$$\text{Capital Income in country } c = MPK_c \times M_c$$

Then

$$MPK_c = \frac{\text{Capital Income}}{M_c} = \frac{\alpha_c Y_c}{M_c}$$

where α_c is measured capital share in income (country specific!)

- No functional form assumptions
- No need to estimate complementary factors or technology

First two estimates of *MPK*

Using total capital share

$$MPKN_c = \alpha_{W,c} \frac{Y_c}{M_c}$$

Using reproducible capital share

$$MPKL_c = \alpha_{M,c} \frac{Y_c}{M_c}$$

Second pass: J-sector model

Equipment-investment decision in sector 1 when cost of borrowing is R^*

$$\frac{P_{1,c}(t)MPK_{1,c}(t) + P_{M,c}(t+1)(1-\delta)}{P_{M,c}(t)} = R^*$$

Abstracting from capital gains

$$\frac{P_{1,c}MPK_{1,c}}{P_{M,c}} = R^* - (1-\delta)$$

Domestic no-arbitrage: $P_j MPK_j = P_1 MPK_1$

Capital income: $\sum_j P_j MPK_j M_j = P_1 MPK_1 \sum_j M_j = P_1 MPK_1 M$

Capital share $\alpha = P_1 MPK_1 M/(P_Y Y)$

Hence

$$\frac{P_{1,c}MPK_{1,c}}{P_{M,c}} = \frac{\alpha_c P_{Y,c} Y_c}{P_{M,c} M_c}$$

Estimates 3 and 4

Total capital share with price correction

$$PMPKN_c = \frac{\alpha_{W,c} P_{Y,c} Y_c}{P_{M,c} M_c} = \frac{P_{Y,c}}{P_c} MPKN_c,$$

Reproducible capital share with price correction

$$PMPKL_c = \frac{\alpha_{M,c} P_{Y,c} Y_c}{P_{M,c} M_c} = \frac{P_{Y,c}}{P_{M,c}} MPKL_c$$

Reinterpretation of estimates 1 and 2

$$\frac{\alpha Y}{M} = \frac{1}{\sum_j \frac{Y_j/Y}{MPK_j}}$$

("physical" MPK)

Data

- α_W : from Bernanke and Gurkaynak (2001), via Gollin (2002). 1-labor share. Various corrections to NA figures to deal with non-corporate sector. *1980-1995 average!*
- Estimates of total wealth and its components (based on present value of estimated rents). *2000!*
- Begin with 1995 cross-section
- Note: some differences in results relative to QJE paper due to use of PWT 6.3 instead of PWT 6.1 (and, to lesser extent, on focus on 1995 instead of 1996)

From wealth shares to income shares

- Payment per dollar-worth of reproducible (natural) capital r_M (r_N).
- No arbitrage requires

$$r_M + \frac{P'_M(1-\delta_M)}{P_M} = r_N + \frac{P'_N(1-\delta_N)}{P_N}$$

- If

$$\frac{P'_M(1-\delta_M)}{P_M} \approx \frac{P'_N(1-\delta_N)}{P_N}$$

- Then

$$r_M \approx r_N$$

- Share of reproducible capital in total capital income

$$\frac{\alpha_M}{\alpha_W} = \frac{r_M P_M M}{r_M P_M M + r_N P_N N} = \frac{P_M M}{P_M M + P_N N}$$

- Results consistent with alternative estimates for selected countries

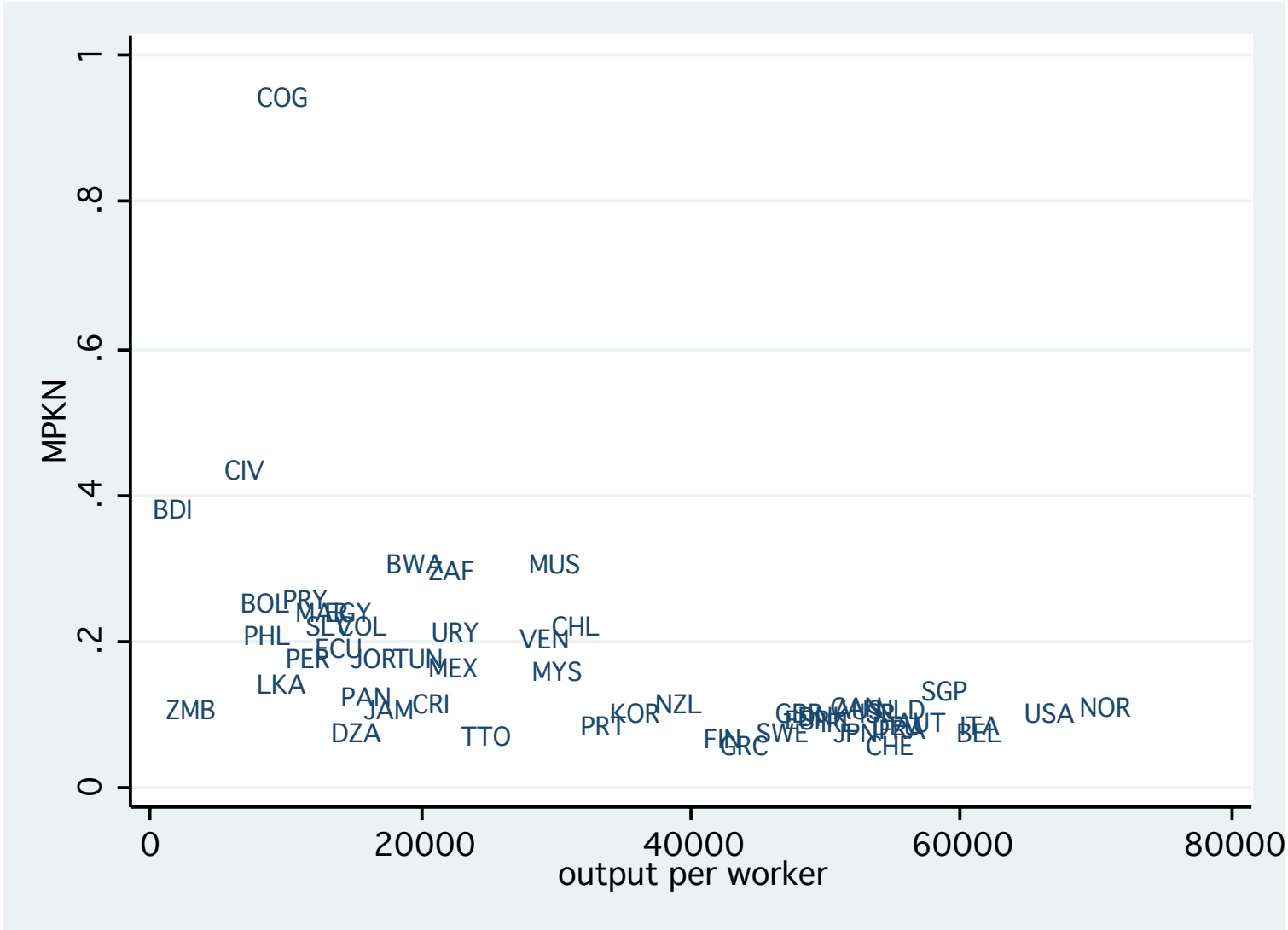
(Another) Caveat

$$\frac{\alpha_M}{\alpha_W} = \frac{P_M M}{P_M M + P_N N}$$

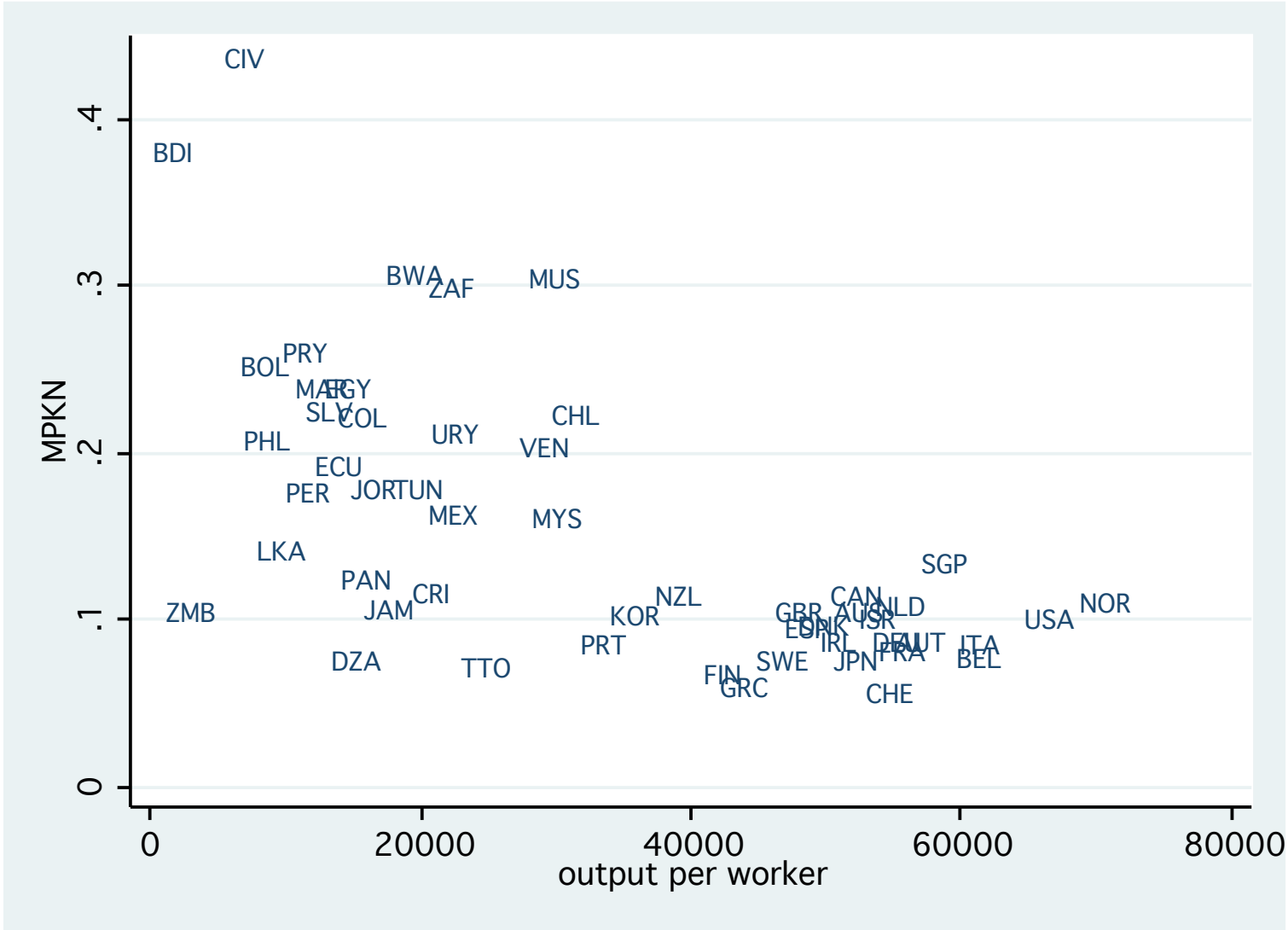
In principle need P_M and P_N to be domestic prices

Need to assume variation in P_M/P_N small relative to variation in M/N

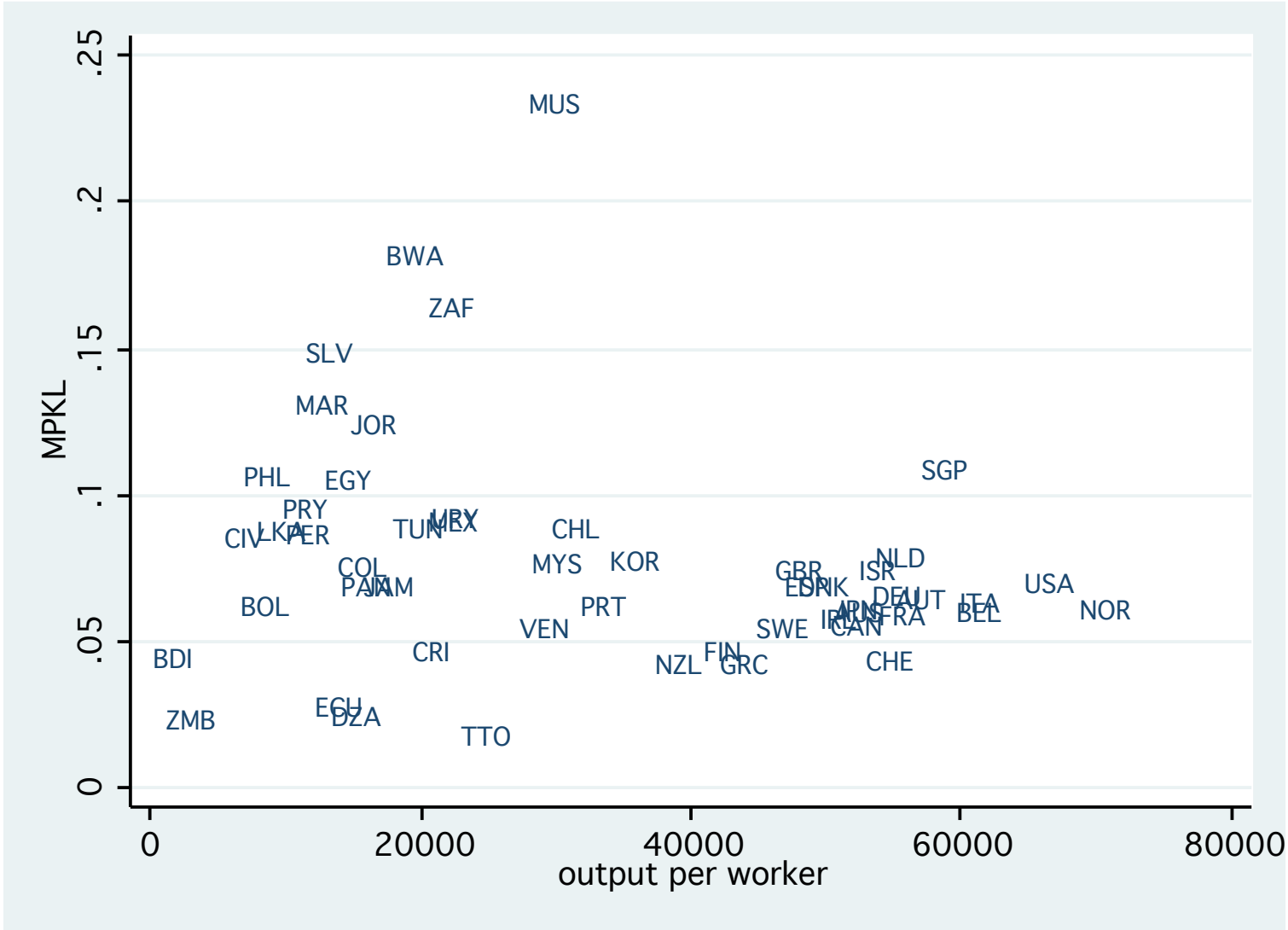
Naive Measure



Dropping outliers



Accounting for natural capital (but not for prices)



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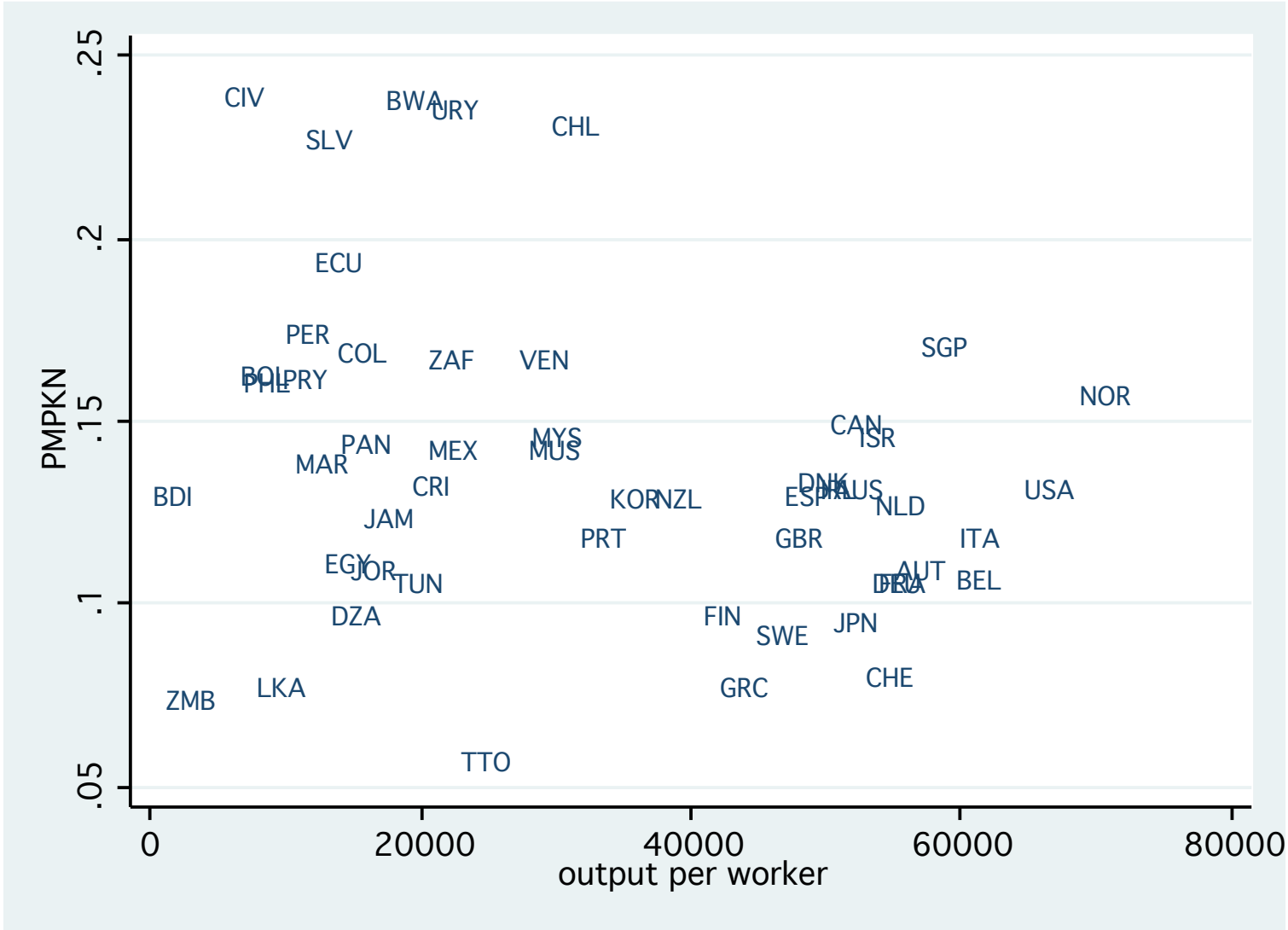
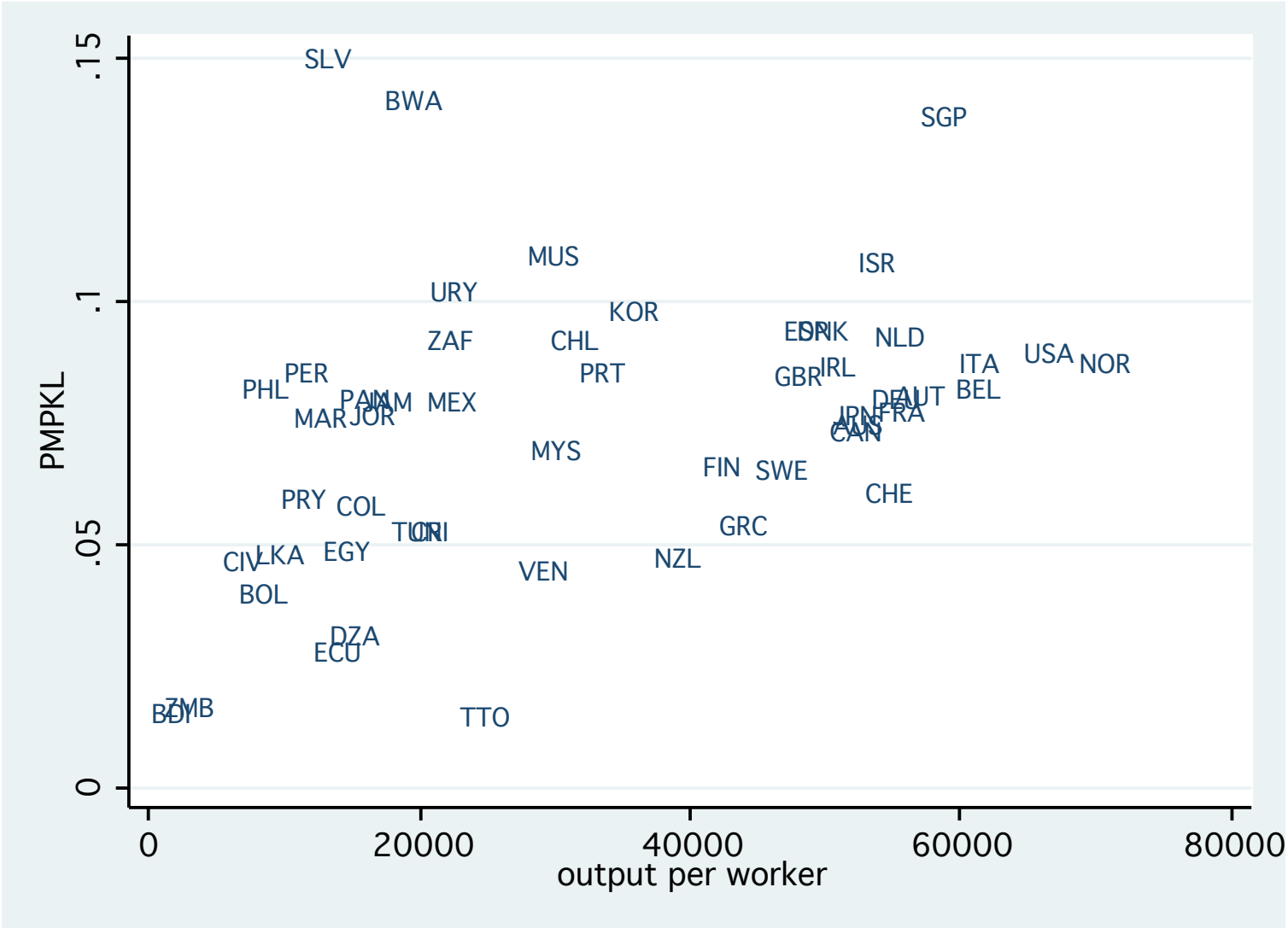
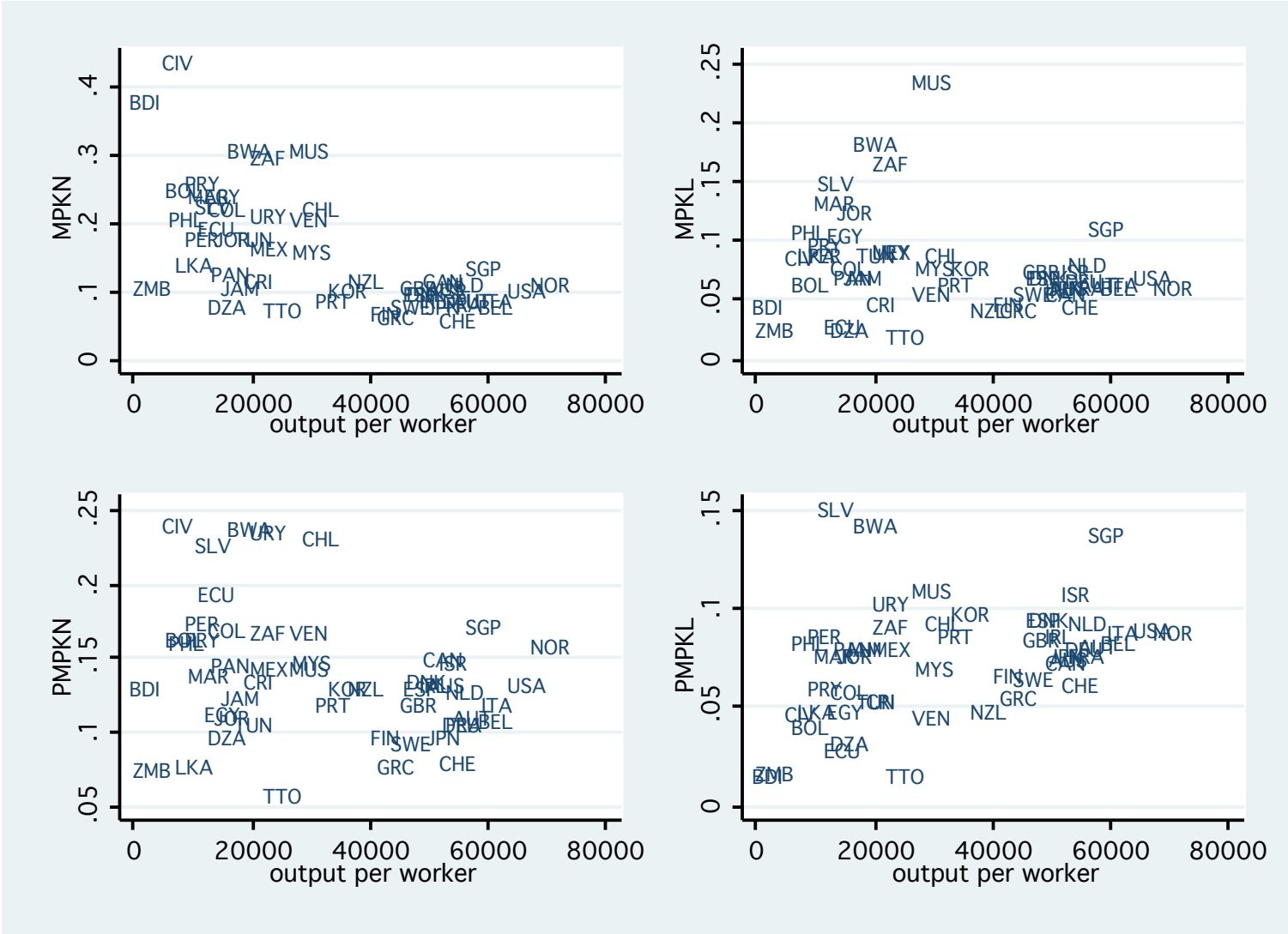


Accounting for prices and natural capital



Four measures of the return to (a dollar worth of) capital



Average Return to Capital in Poor and Rich Countries

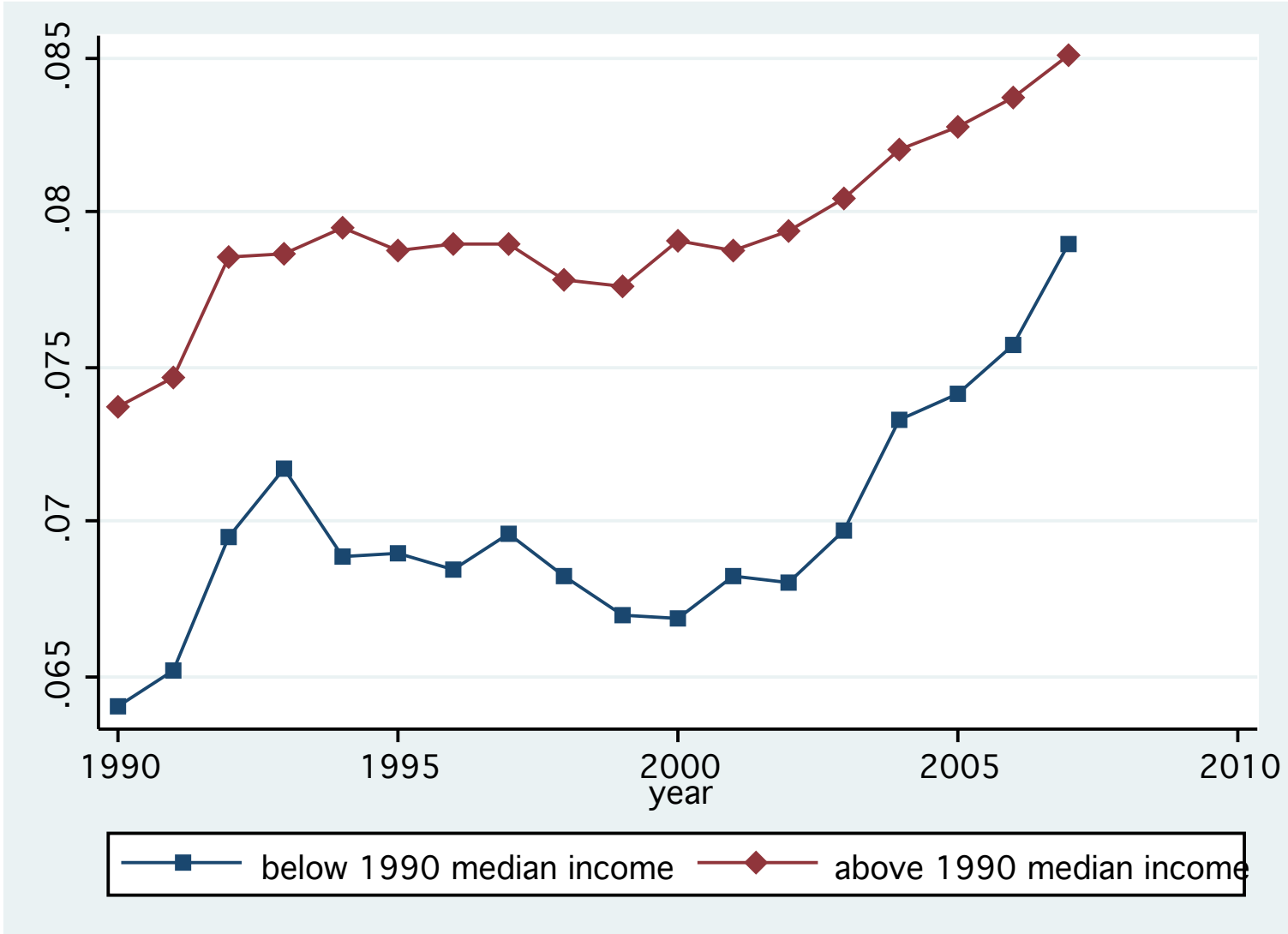
	Rich Countries	Poor Countries
MPKN	0.09 (0.02)	0.21 (0.09)
MPKL	0.06 (0.01)	0.09 (0.05)
PMPKN	0.12 (0.02)	0.15 (0.05)
PMPKL	0.08 (0.02)	0.07 (0.03)

MPKN: naive estimate. *MPKL* : after correction for natural-capital. *PMPKN*: after correction for price differences. *PMKL*: after both corrections. Rich (Poor): GDP at least as large (smaller than) Portugal. Standard Deviations in Parentheses.

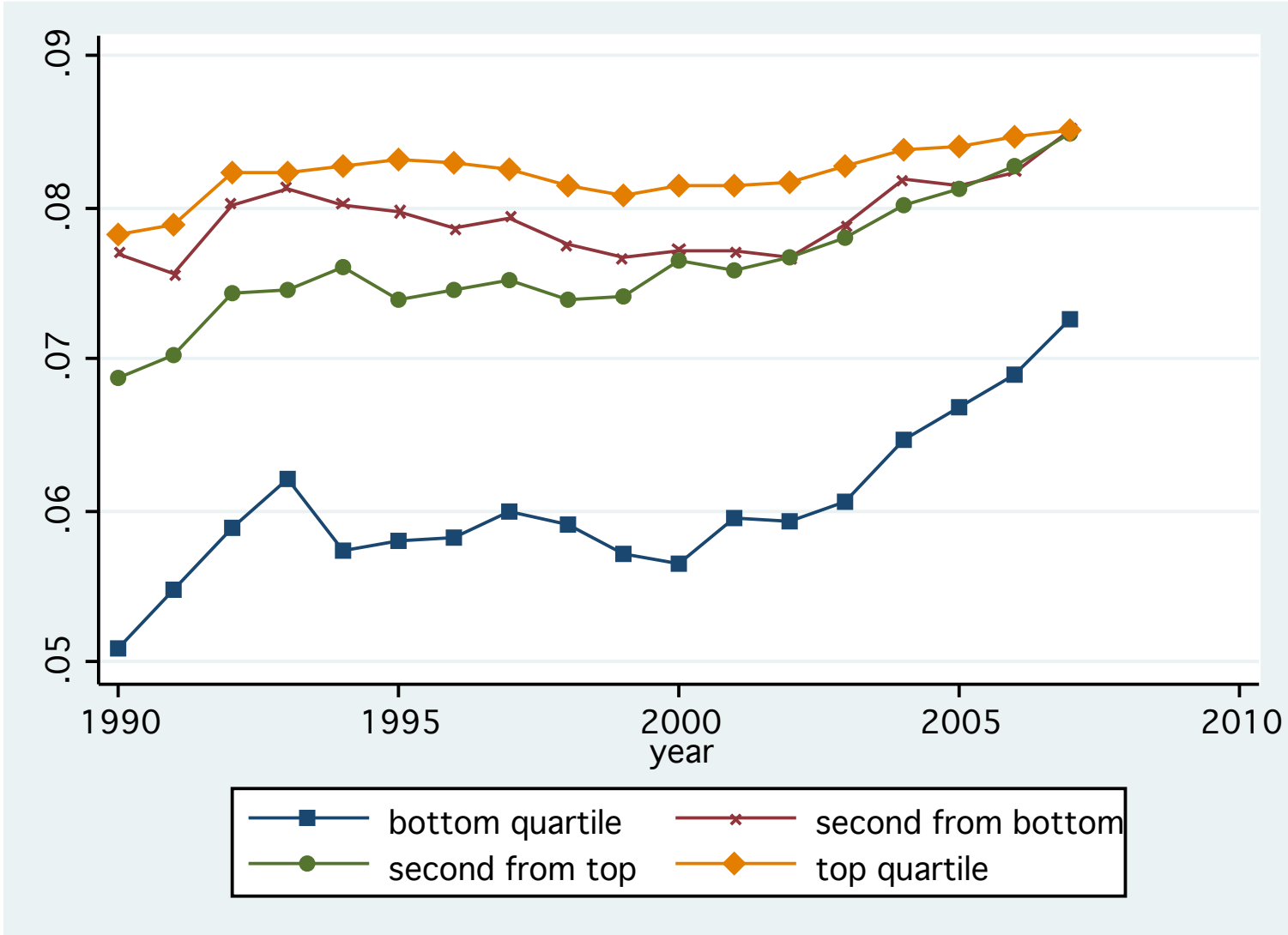
A look at the times series

- Warning: only Y, M, P_Y, and P_M are varying. Capital shares constant!
- Still, results too intriguing to omit

Average return in rich and poor countries



Average return by quartile



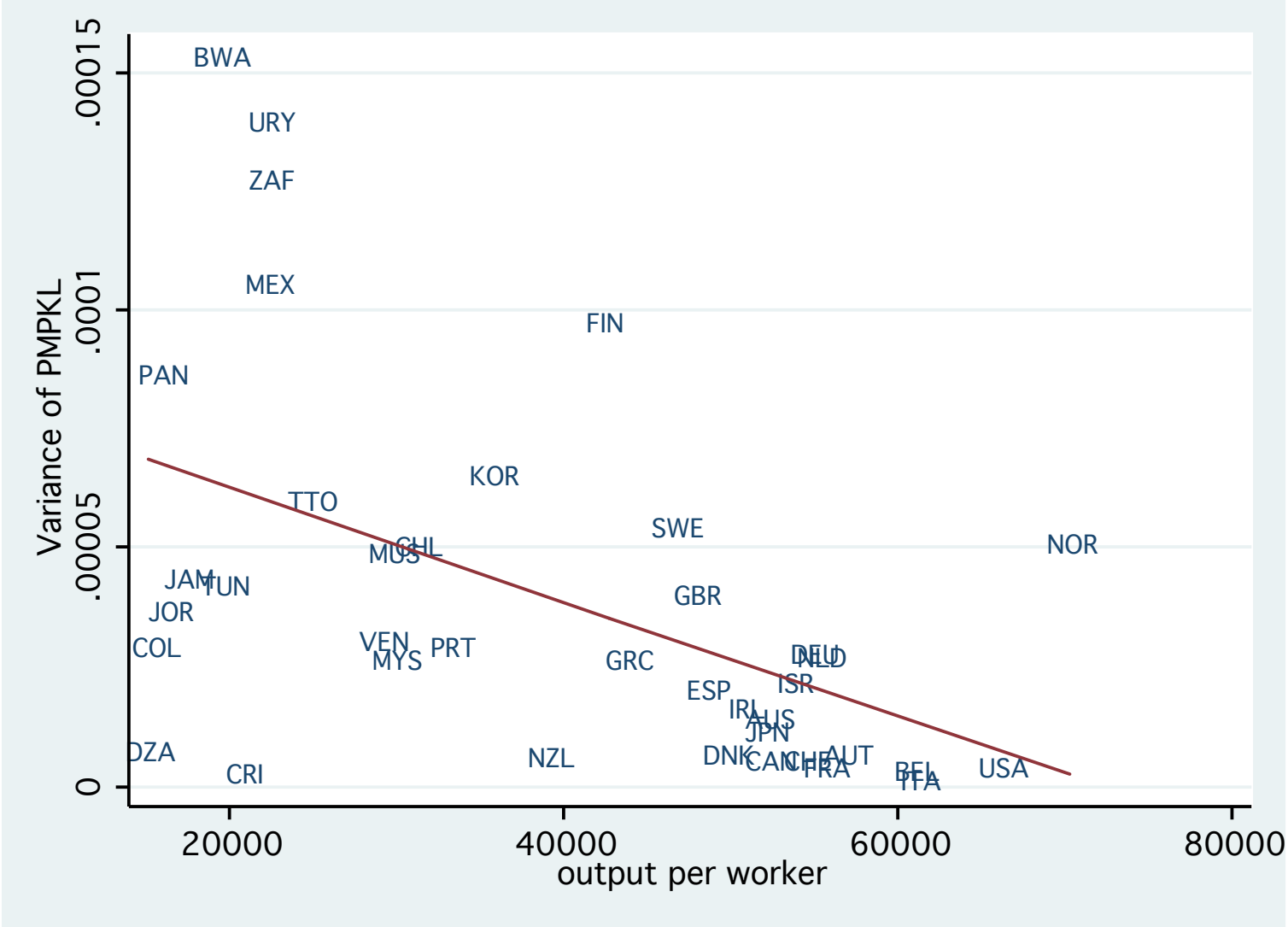
Summary and Interpretation

- Top three quartiles: returns very close
- Bottom quartile: returns consistently *lower* than in r.o.w.
- Lucas asked exactly the wrong question
- Need capital-market frictions, but *upstream* not downstream
- Possible upstream frictions
  - financial repression in poor countries
  - lack of access to sophisticated intermediation in poor countries
- Very different from downstream frictions (agency costs/default/fear of expropriation) usually postulated
- Generalized convergence over time (all frictions getting smaller?)

Risk

- Proximity of top three quartiles suggests closely integrated capital markets
- Still, poorer countries in this group are more volatile: why don't they pay a risk premium?

Volatility of PMPKL (in top three quartiles)

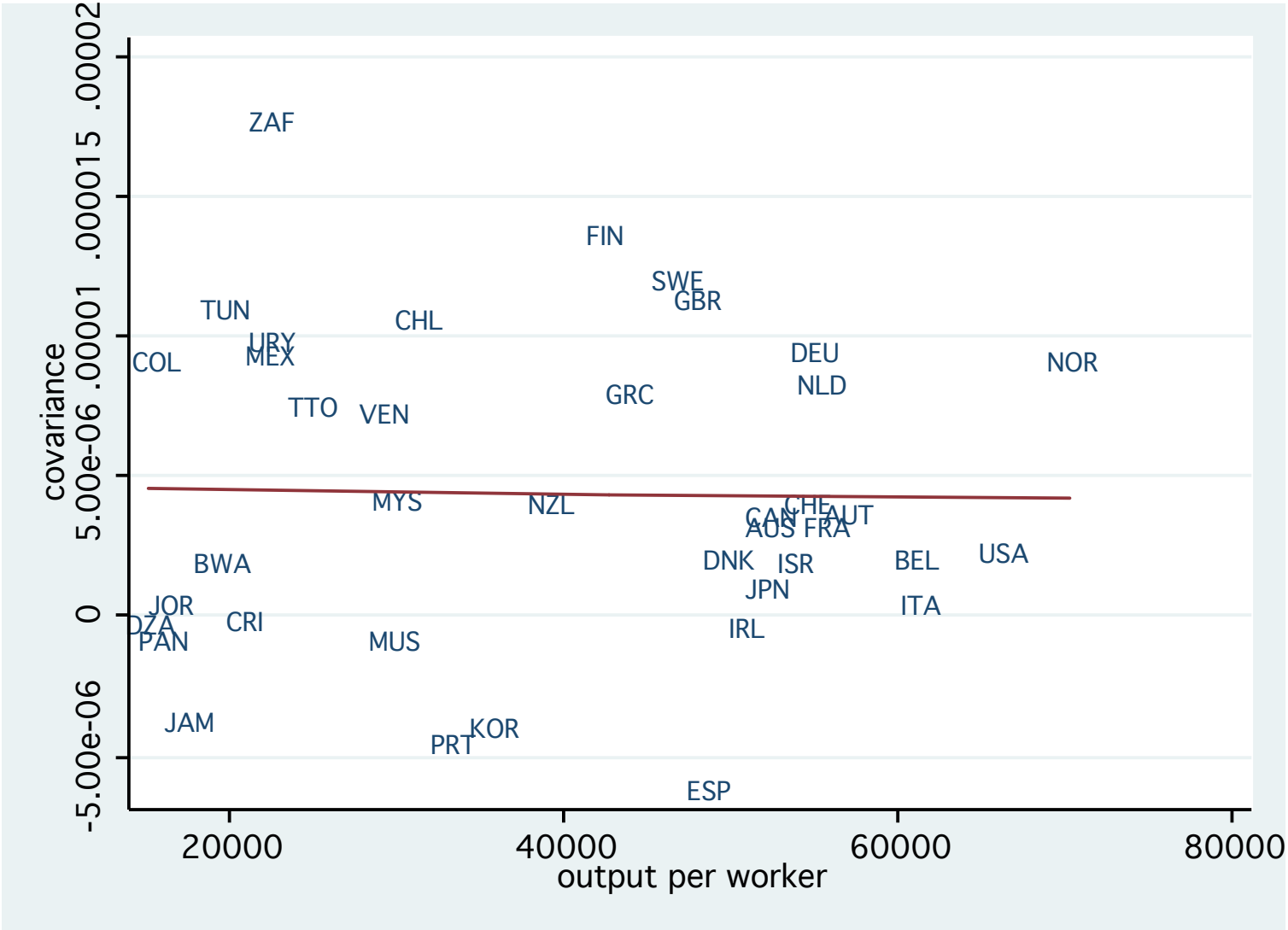


t-stat = -3.56 (Singapore omitted)

But asset pricing models emphasize covariances

- Construct synthetic portfolio of capital stocks, with weights equal to each country's weight in world capital stock
- (Tracks closely average PMPKL of top quartile)
- Compute each country covariance with world portfolio

Covariance of PMPKL (top three quartiles)

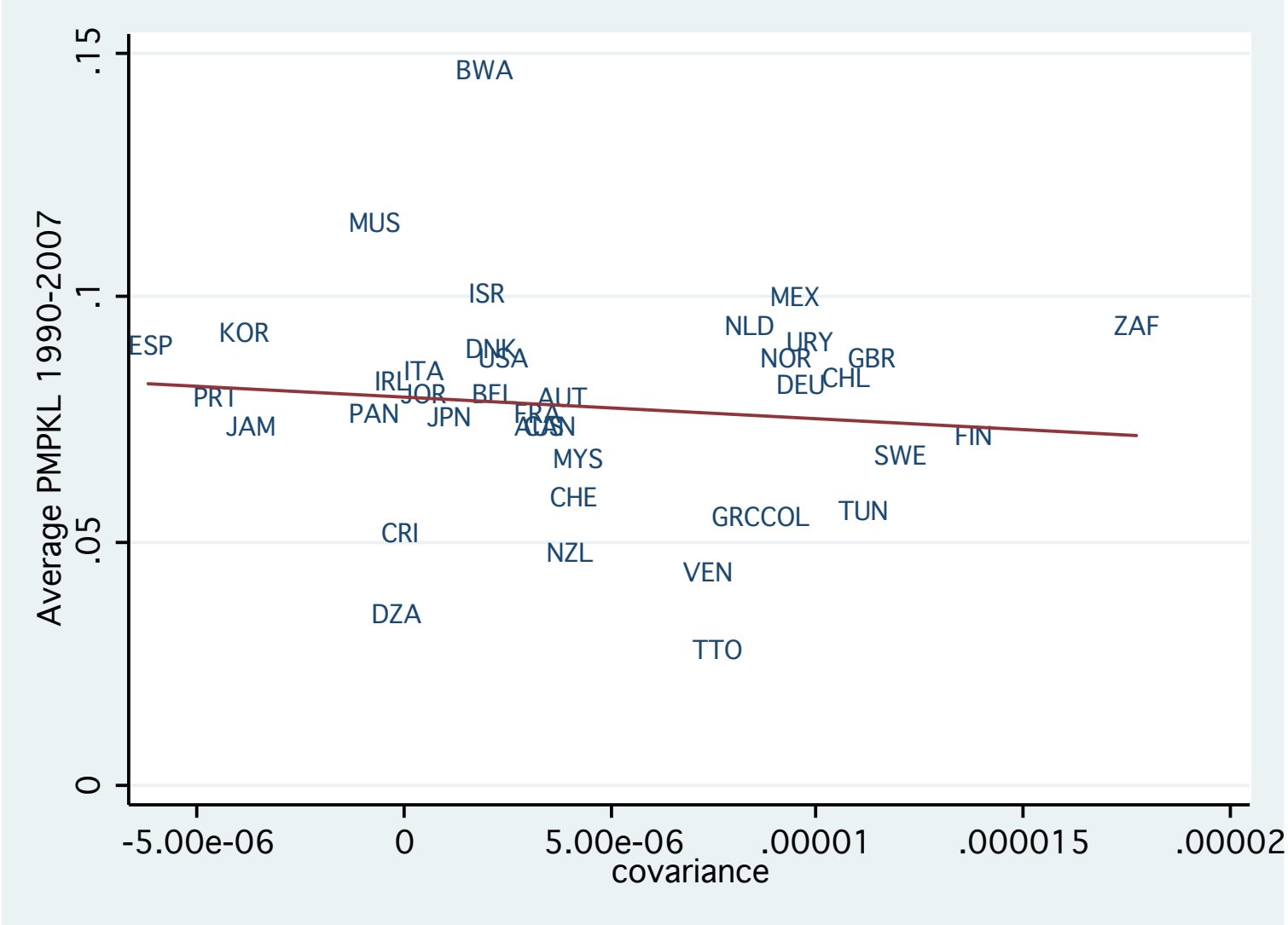


(t-stat = -0.11)

However

The last result would be more convincing if the covariance term had predictive power for rates of return ...

... but it doesn't



(t-stat = -0.68)

Deadweight loss calculation

Counterfactual world GDP if existing M redistributed to equalize MPKs

(Abstract from changes in aggregate M)

(Not a normative exercise!)

Counterfactual calculations

Have to assume Cobb-Douglas

$$Y_{cj} = M_{cj}^{\alpha_c}(\text{stuff}_{cj})^{1-\alpha_c}$$

Domestic no arbitrage

$$\frac{P_{cj}}{P_{Mc}}\alpha_c(M_{cj})^{\alpha_c-1}(\text{stuff}_{cj})^{1-\alpha_c} = PMPK_c$$

Under counter-factual of international no arbitrage

$$\frac{P_{cj}}{P_{M}}\alpha_c(M^*_{cj})^{\alpha_c-1}(\text{stuff}_{cj})^{1-\alpha_c} = PMPK^*$$

Dividing last two

$$M^*_{cj} = \left(\frac{PMPK_c}{PMPK^*}\right)^{\frac{1}{1-\alpha_c}} M_{cj}$$

Aggregating across sectors

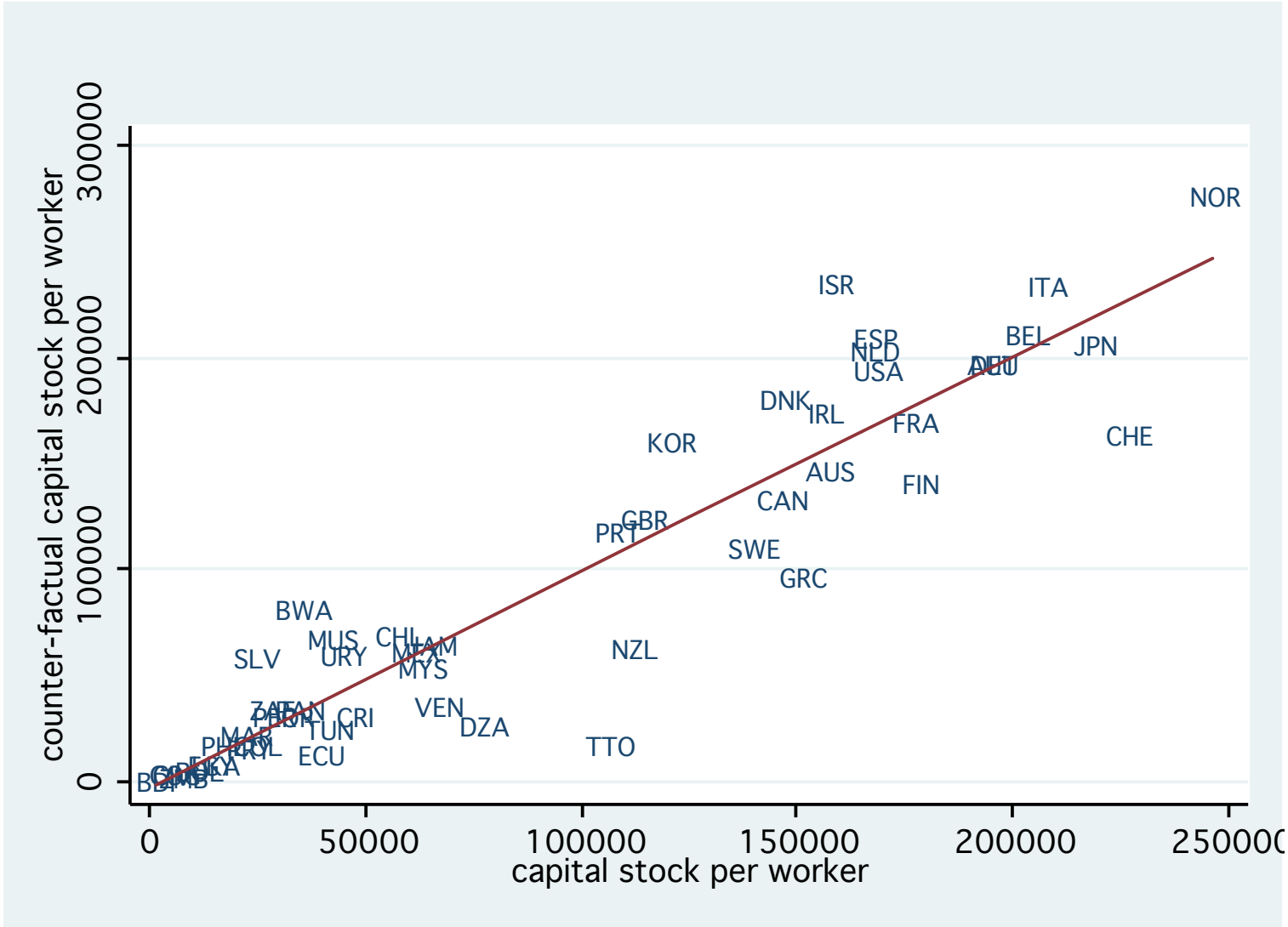
$$M^*_c = \sum_j M^*_{cj} = \sum_j \left(\frac{PMPK_c}{PMPK^*}\right)^{\frac{1}{1-\alpha_c}} Mcj = \left(\frac{PMPK_c}{PMPK^*}\right)^{\frac{1}{1-\alpha_c}} M_c$$

Aggregating across countries

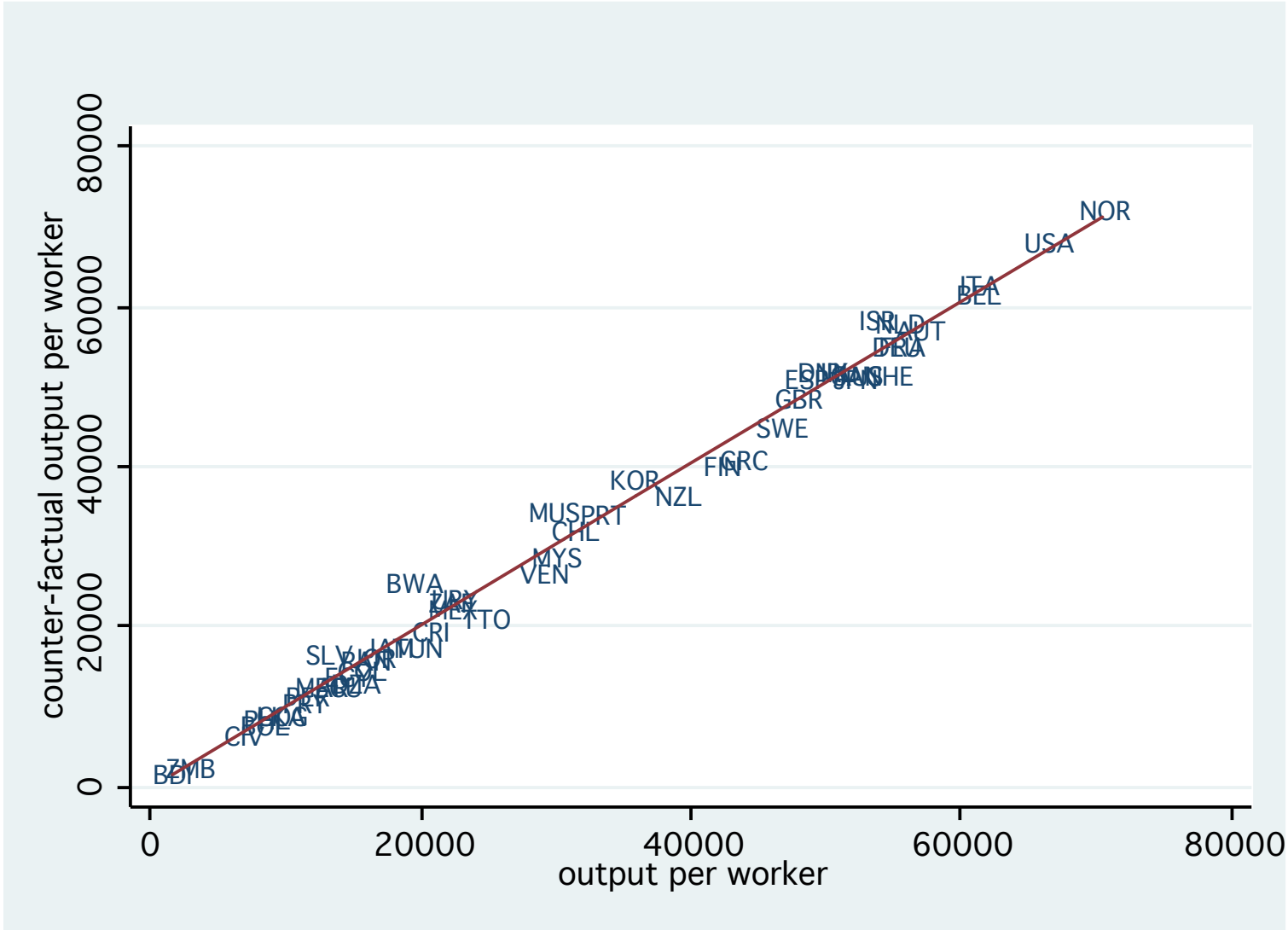
$$\sum M^*_c = \sum M_c = \sum \left(\frac{PMPK_c}{PMPK^*}\right)^{\frac{1}{1-\alpha_c}} M_c.$$

Solve for $PMPK^*$ and then compute M^*_c and Y^*_c

Counterfactual Capital



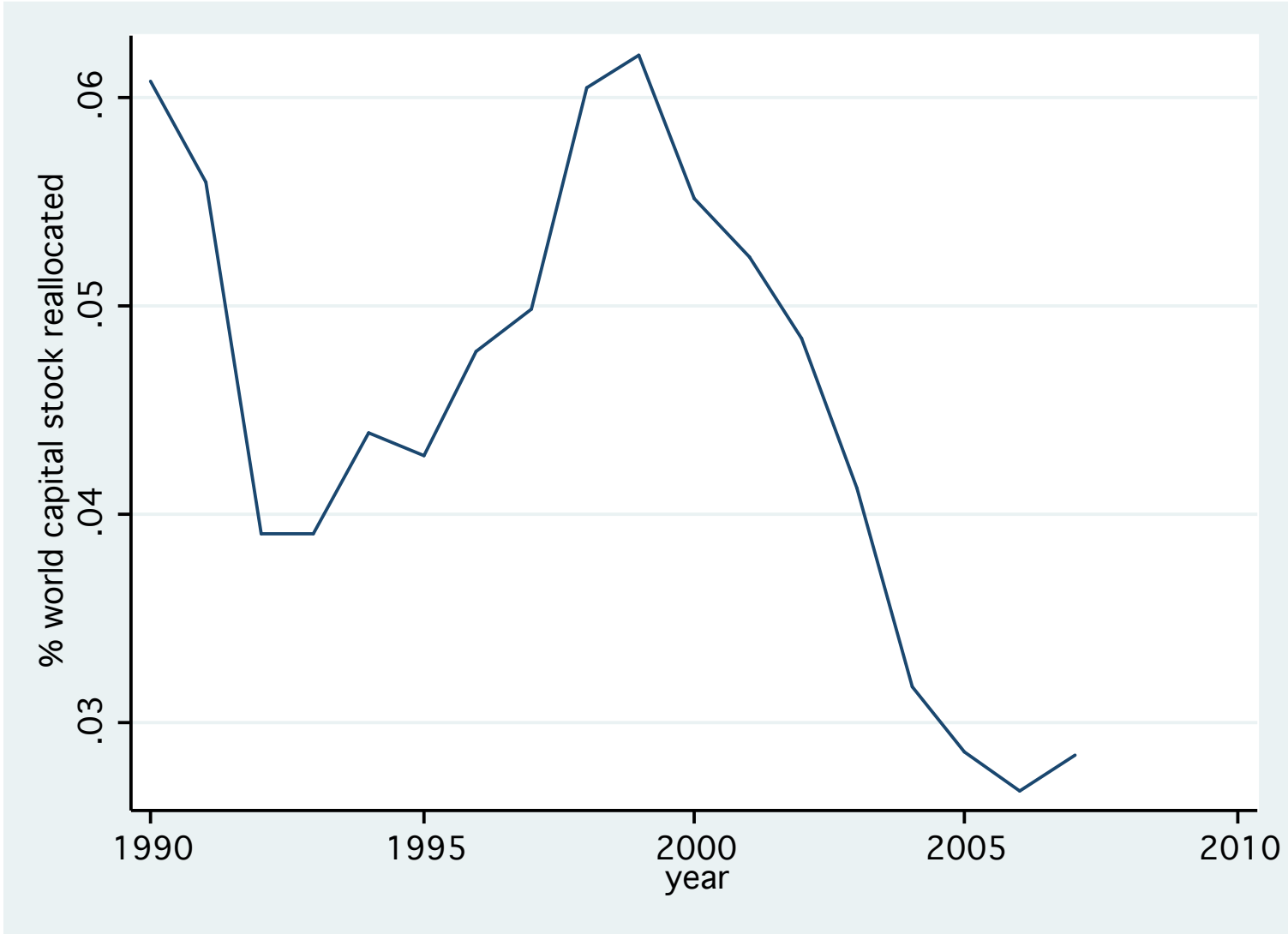
Counterfactual Output



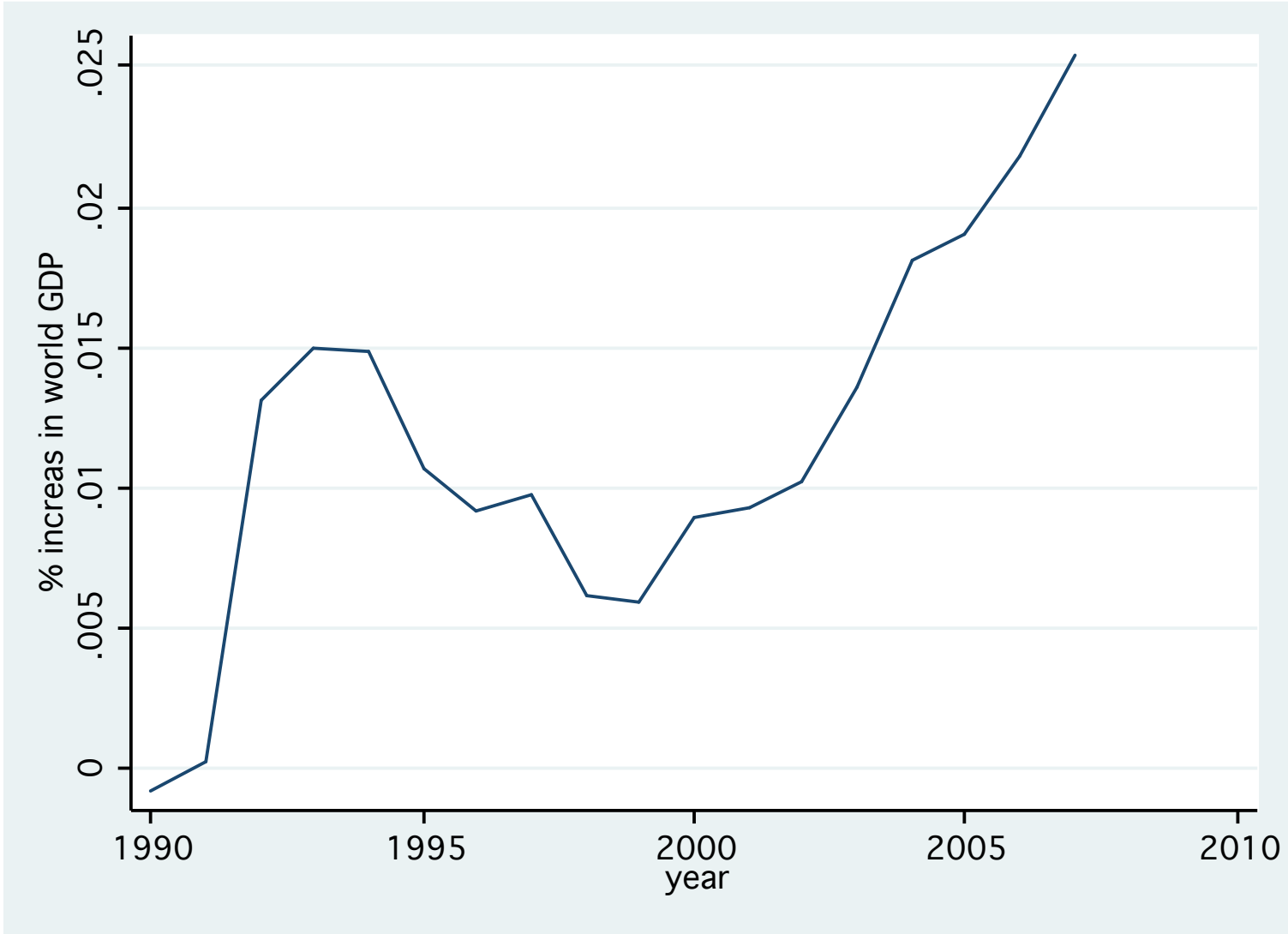
Magnitudes by quartile

	1st	2nd	3rd	4th
counterfactual change in capital	-.25	.06	-.02	.06
counterfactual change in GDP	-.02	.02	.01	.01

Magnitude of required reallocation



Dead Weight Loss



Conclusions

- No evidence of downstream credit frictions
- Evidence of upstream frictions from poorest quartile
- Welfare costs of such frictions seemingly modest
- And severity of frictions diminishing

Implication for aid policy

Large poor-rich "physical" *MPK* differentials usually seen as good reason to increase aid flows

But reversed poor-rich "financial" *MPK* differentials imply upstream friction needed for aid to stick

Whether this is optimal is a difficult question, and may depend on reasons for relative-price differences

Theories of P_Y/P_M

Taxes on capital purchases (e.g. Chari et al.).

Relative productivity of investment sector (e.g. Hsieh and Klenow).

Broader conclusions

Results underscore importance of technology differences.

Indeed, technology differences so severe that countries with lower K/L have lower MPK!