METR Analysis: Theory and Overview of Policy Applications

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Part I – METR as a Key Policy Tool and Metric

Overview of METR analysis

- METR=marginal effective tax rate.
- Commonly used to assess extent to which tax system is discouraging / neutral / encouraging to investment.
- METRs provide summary measure of net effect of main tax parameters / rules affecting net profitability of investment:
  - Statutory corporate income tax rate(s).
  - Tax depreciation methods and rates.
  - Investment tax credits; R&D tax allowances, credits.
  - Capital taxes (on capital stocks).
  - Sales tax on capital goods (inputs).
  - Interest deductibility.
  - Shareholder taxes (dividends, capital gains) affecting cost of funds.
  - Inventory accounting methods.

Advantages of METR analysis

- Based on corporate and personal (shareholder) income tax structure – input data available/specified in tax law.
- METRs measured on disaggregate basis, by:
  - asset type (e.g. buildings, machinery & equipment, inventories)
  - sector (e.g. manufacturing, construction transport, trade, services)
  - investor (taxable, tax-exempt, non-resident)
  - financing mix (debt, retained earnings, new equity, other).
- Aggregate METRs derived from disaggregate METRs.
- Empirical work estimating impact of tax reform on investment relies on METR measure.
- Provides main framework to consider income tax base broadening (used extensively to support low rate / base broadening tax reforms in many countries).

Example of METR application in Canada

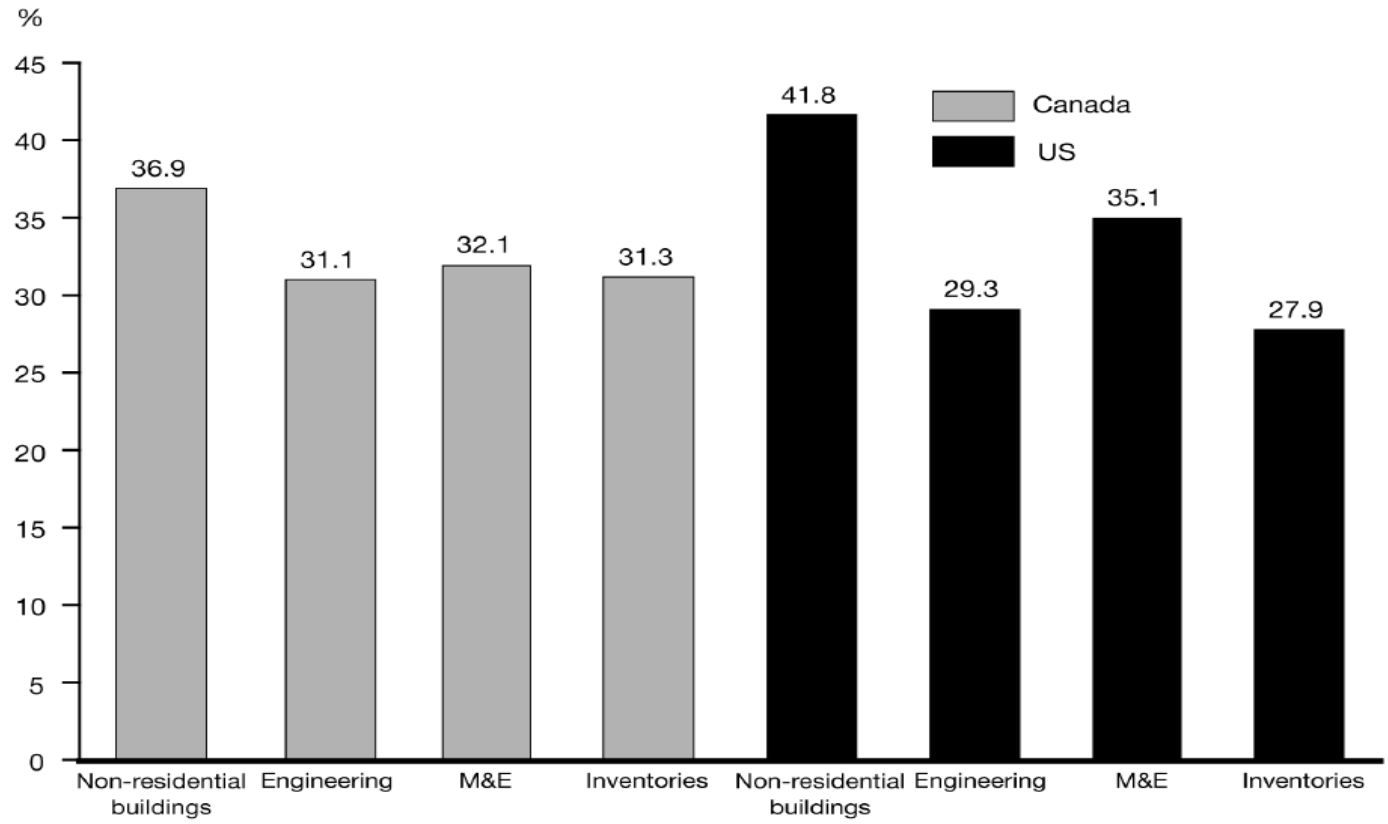
- Pre-2005: METR used internally to develop tax reform:
  - 1987: METR used to show sectors with low METRs (mining), high METRs (services); METR differences between large/small firms.
  - 1997: Technical Committee established to review business tax structure, develop revenue neutral tax recommendations to lower the statutory CIT rate, financed by base broadening that would address "unacceptably large variation in effective tax rates".
  - 2000 and 2003 budgets: internal applications to guide reform.
- 2005: METR becomes key metric (not just statutory CIT) for comparing tax competitiveness across countries.
- 2006: Goal set to have lowest METR in G7 by 2011.
  - METR used to highlight need for federal and provincial reforms.
  - METR sets anchor for successive budgets.

Canadian METRs by asset type

(2005 Tax Expenditure Paper, Canada)

Chart 4

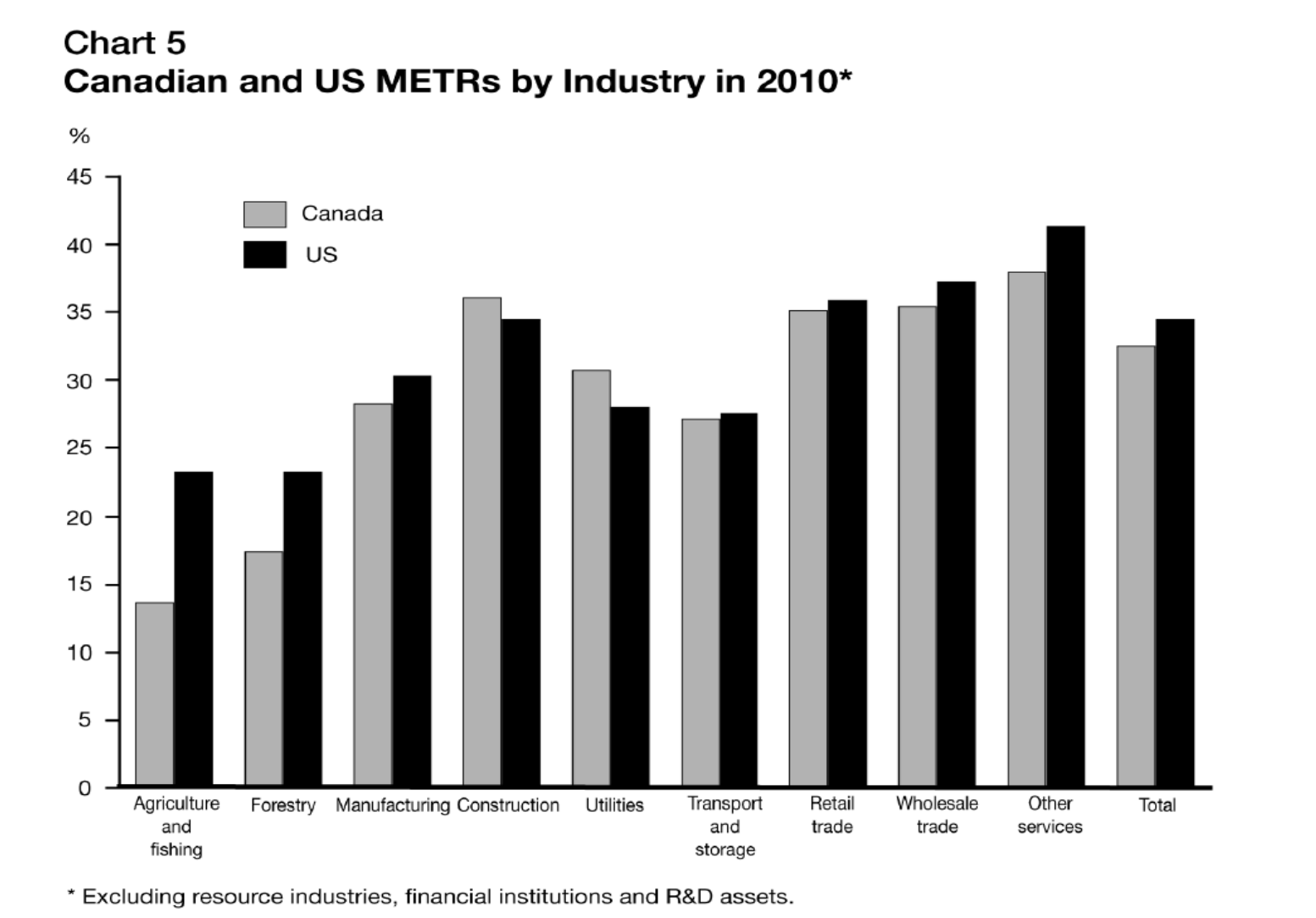
Canadian and US METRs by Asset in 2010*



* Excluding resource industries and financial institutions.

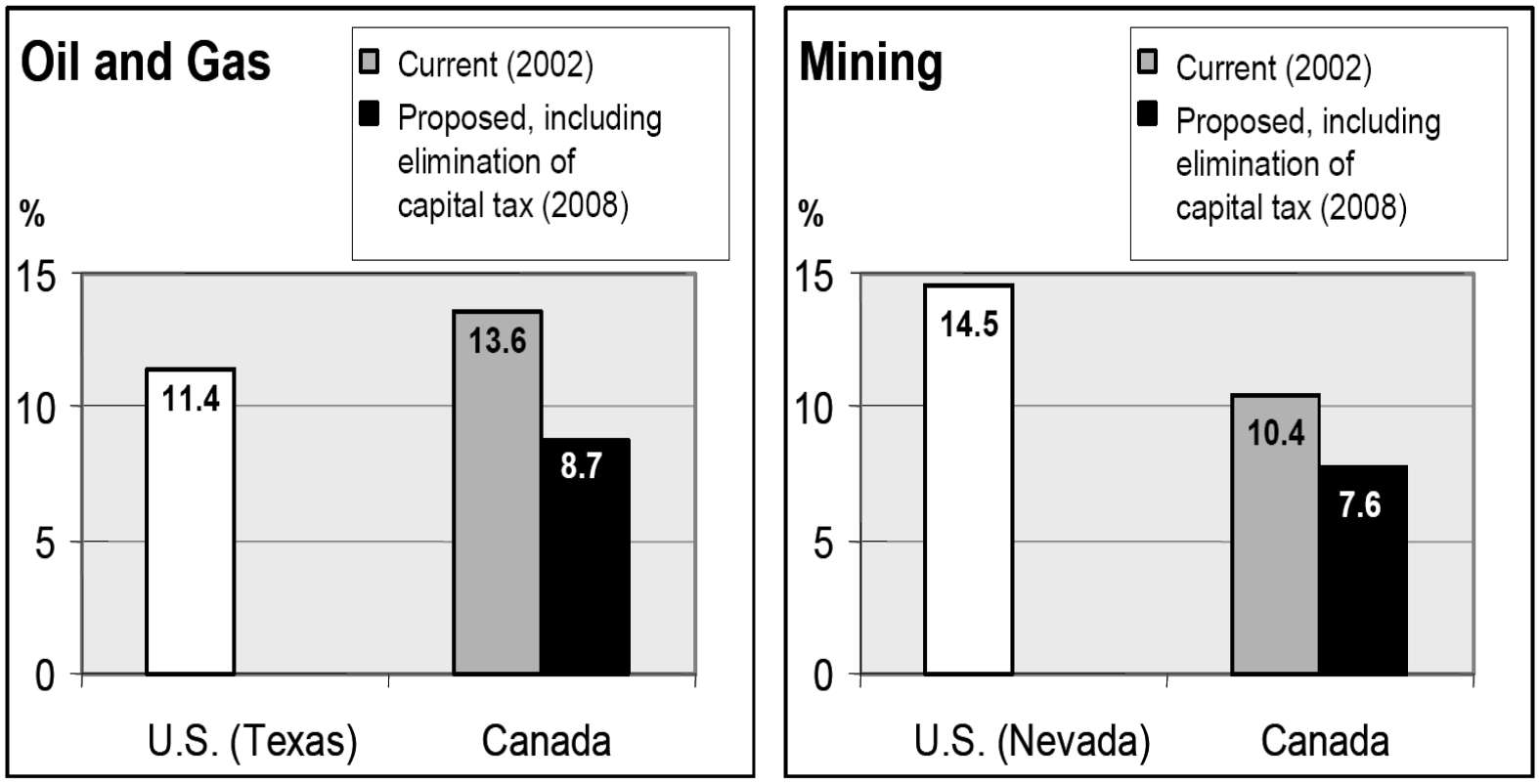
Canadian METRs by sector

(2005 Tax Expenditure Paper, Canada)



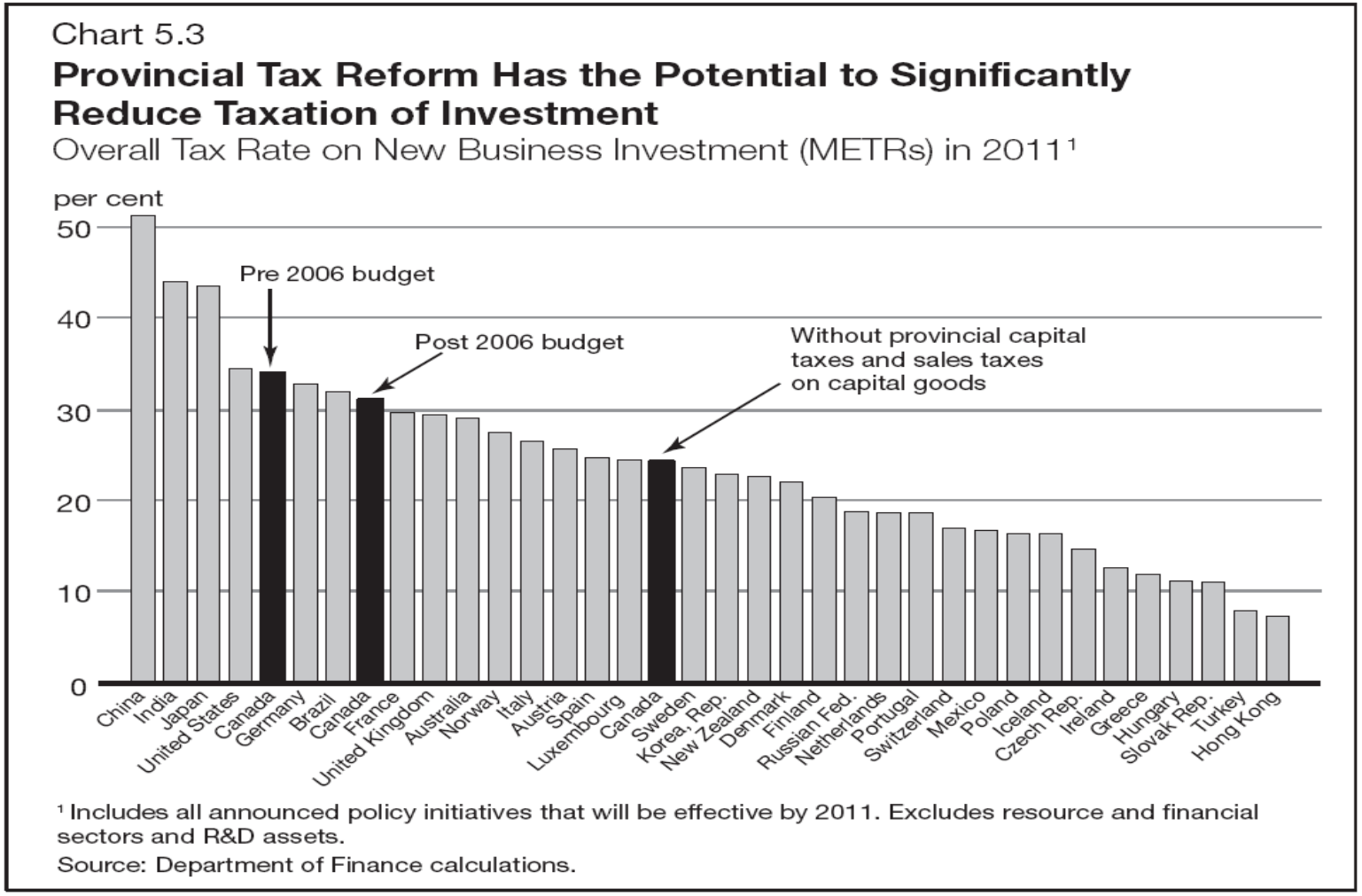
METR application to resource taxation, Canadian Budget 2003

Canada–U.S. (Federal and Provincial/State) Marginal Effective Tax Rates

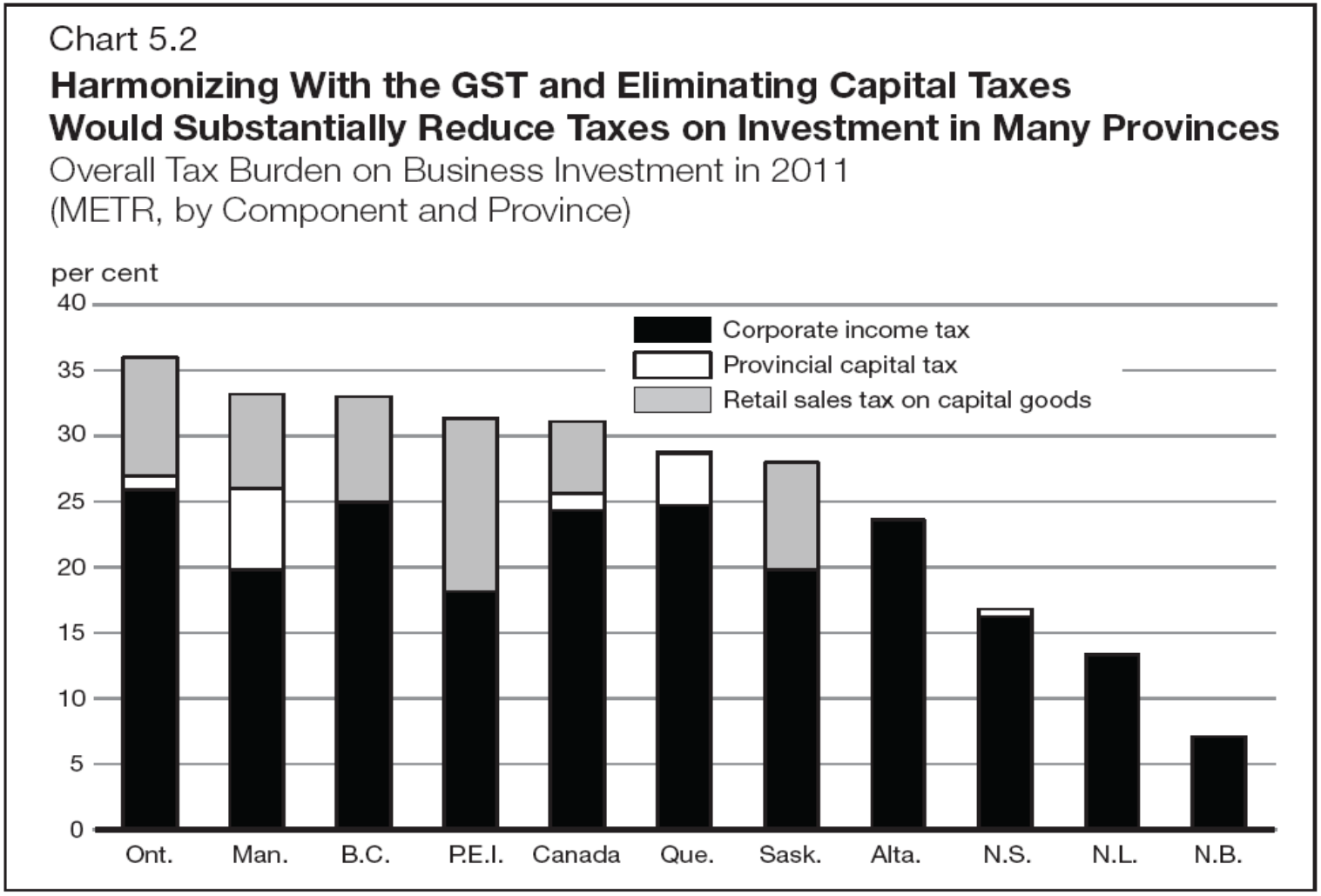


Note: Current (Canada) includes all announced changes to provincial tax rates. Calculations have been done by the Department of Finance. Additional information is available on request.

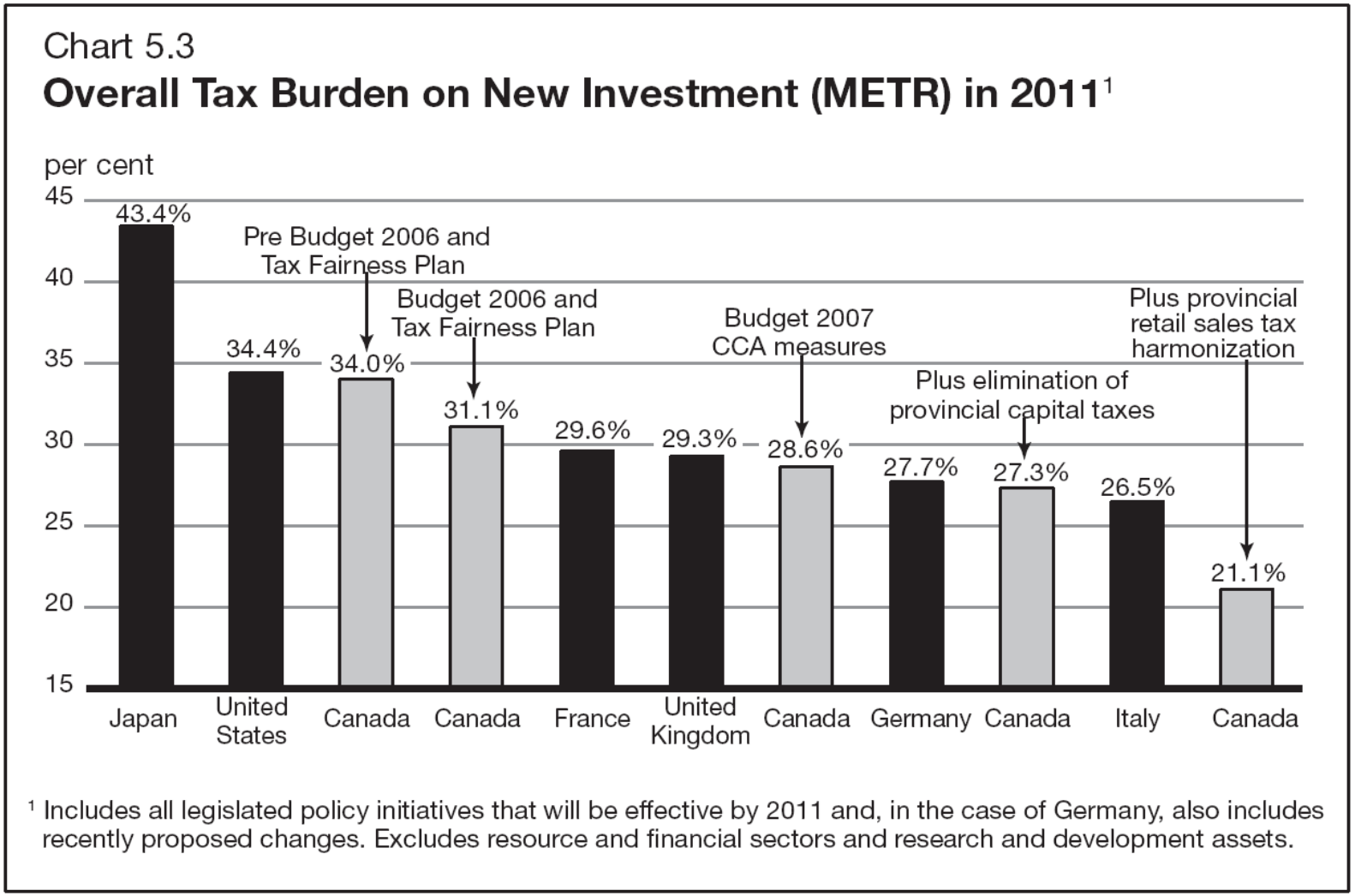
METR application in *Advantage Canada*, 2006



METR application in *Advantage Canada*, 2006



METR application in Canadian Budget, 2007



Part II – METR Analysis – Review of the Basics

METR for investment – closed economy case –

- METR=(Rg-Rn)/Rg
  - Rg = pre-tax rate of return on physical capital K
    - **Not observable** in capital markets.
    - Solve for Rg using theory of investment.
  - Rn = after-tax rate of return to shareholders
    - **Observable** in capital markets.
- Solving Rg – invest in K up to point where after-tax marginal product of capital = after-tax marginal cost.
  - $MPK(1-u)=(R_f+\delta)(1-A)$
  - Using this equilibrium condition, can solve for MPK, and thus $Rg=MPK-\delta$.

METR for investment – open economy case –

- $METR=(Rg-r^{*})/Rg+(r^{**}-Rn)/r^{**}$
  - Rg = pre-tax rate of return on physical capital K (not observable - solve for Rg using theory of investment).
  - r^{*} = after-corporate tax rate of return, based on r^{**}, taking into account interest deductibility (measureable based on r^{**}).
  - r^{**} =pre-personal tax rate of return to shareholders, determined in international capital market (observable)
  - Rn = after-tax rate of return to shareholders (observable).
- Corporate METR to analyse tax effects on investment:
  - $METR_C=(Rg-r^{*})/Rg$
- Personal METR to analyse tax effects on savings:
  - $METR_P=(r^{**}-Rn)/r^{**}$

Using profit maximization condition to solve for Rg

- METR / $METR_C$ – assumes profit maximization – invest up to point where after-tax benefit=after-tax cost at the margin (on last unit of capital purchased):
- $MPK(1-u)=(R_f+\delta)(1-A)$
  - MPK=marginal product of capital ($\Delta Y/\Delta K$)
  - u = basic corporate income tax rate
  - R_f = cost of funds=$\beta i^*(1-u)+(1-\beta)\rho^*$
  - i^* = interest rate on bonds
  - ρ^* = required rate of return on equity shares (fixed in open economy model; dependent on personal tax rates in closed economy model)
  - δ = actual 9economic) depreciation
  - A = present value of tax relief (e.g. depreciation (capital cost) allowances, investment tax credits) on purchase of one unit of capital.
- $Rg=MPK-\delta$

Assessment of corporate METR

- $METR_C=(R_g-r^*)/R_g$
  - If $METR_C$ >0, tax distortion ↓ investment.
  - If $METR_C$ <0, tax distortion ↑ investment.
  - If $METR_C$ =0, tax neutrality (no effect).

METR assessment of impact of corporate tax incentives

Increase in tax parameter	*Transmission mechanism*	*Impact on Rg and METR©*	*Impact on investment*
Corporate tax rate (u)	decreases net return on business profits	increases	decreases
	decreases cost of debt finance	decreases	increases
	increases value of capital cost allowance	decreases	increases
Capital cost allowance rate (α)	decreases effective cost of physical capital	decreases	increases
Investment tax credit rate (ψ)	decreases effective cost of physical capital	decreases	increases

Illustration of METR closed/local economy, no tax

R_n=MRRS =marginal required rate of return on domestic savings (debt + equity financing) =marginal cost of domestic funds

R_g=MPK-δ=(ΔY/ΔK)-δ =marginal product of capital, net of economic depreciation

METR=(R_g–R_n)/R_g=0

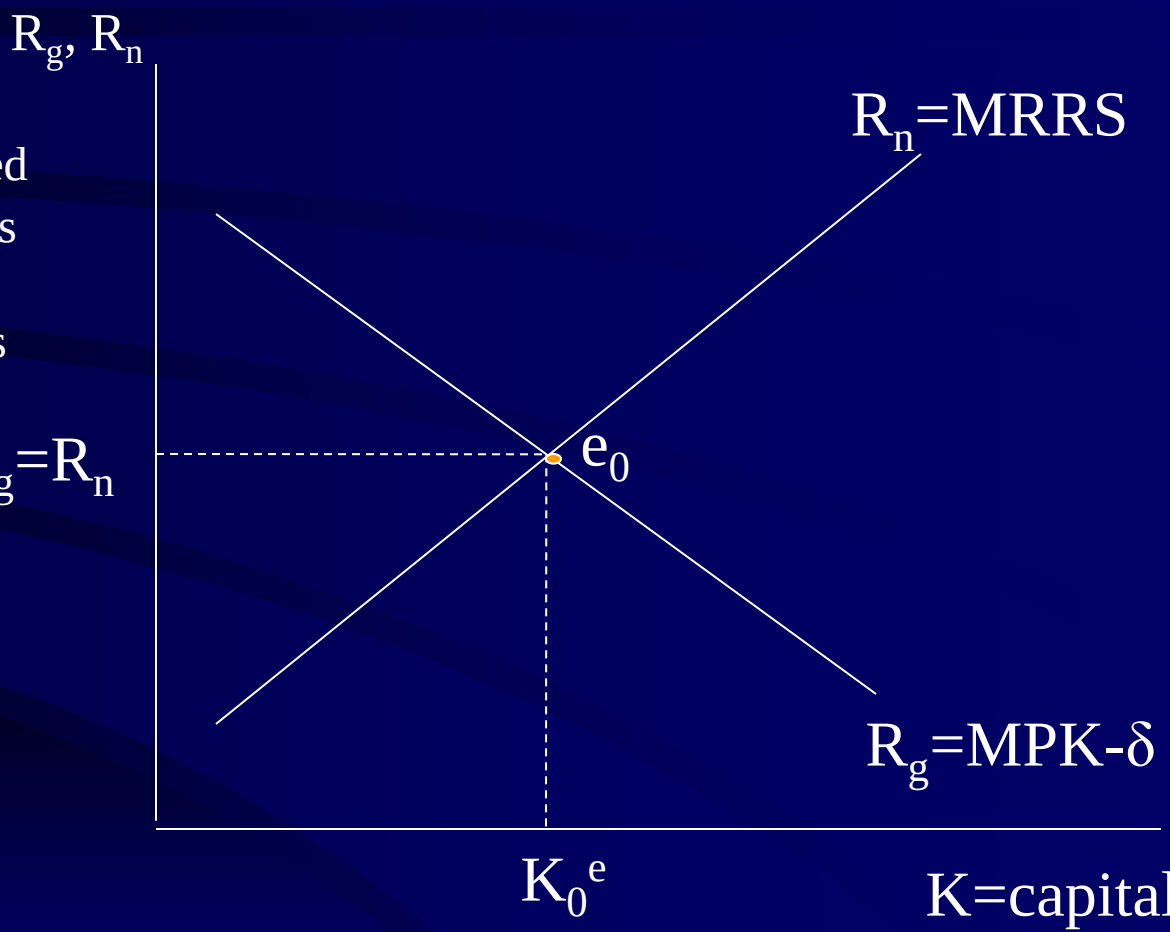
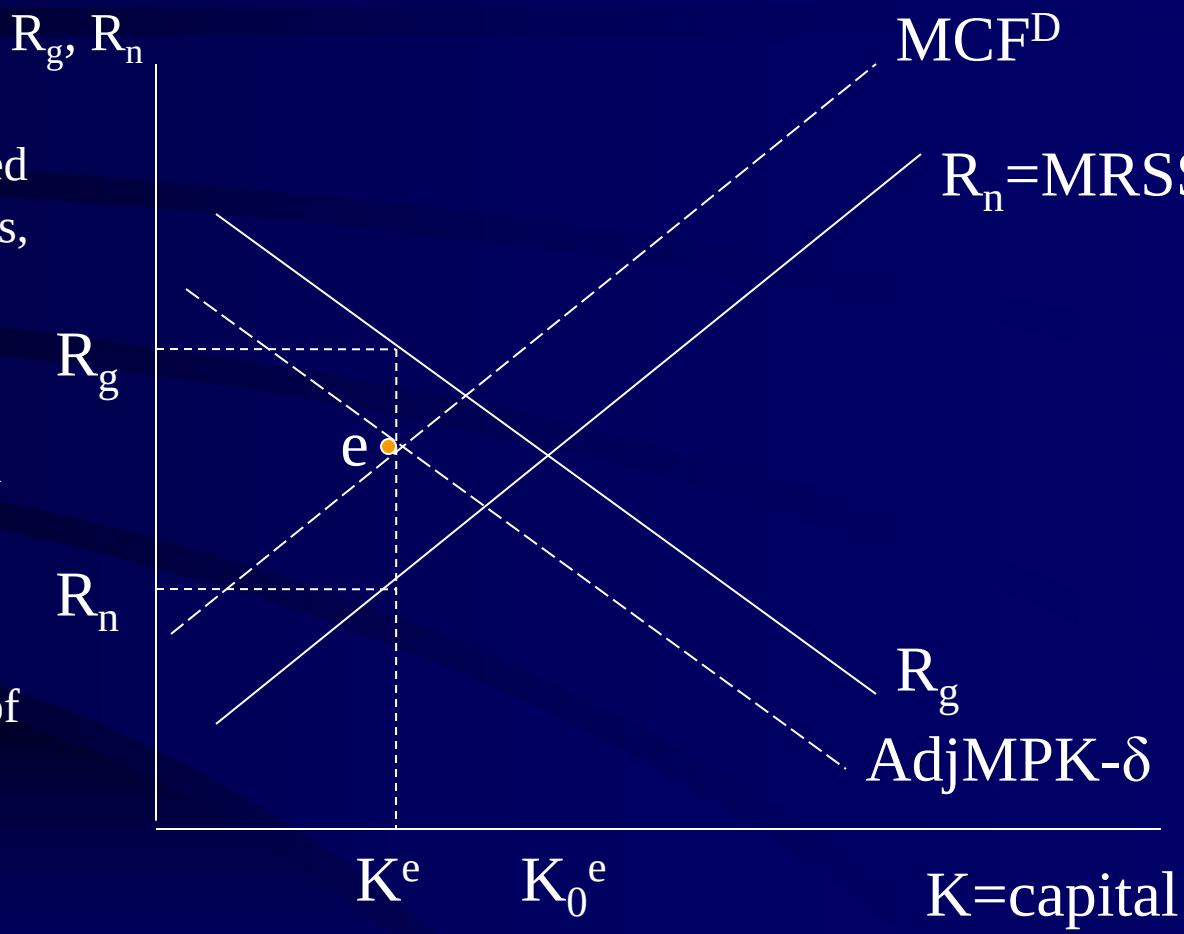


Illustration of METR closed/local economy, with tax

R_n=MRRS =marginal required rate of return on domestic savings, net of personal income tax

MCF^D =marginal cost of domestic funds at corporate level

AdjMPK-δ=tax adjusted marginal product of capital, net of economic depreciation



METR=$(R_g–R_n)/R_g$ >0 (tax distortion discouraging investment)

Illustration of METR open economy, no tax

R_n=MRRS =marginal required rate of return on domestic savings =marginal cost of domestic funds

r^*=fixed required rate of return on finance (set in global capital market)

R_g=MPK-δ =marginal product of capital, net of economic depreciation

X=supply of domestic capital

METR=$(R_g–R_n)/R_g$=0

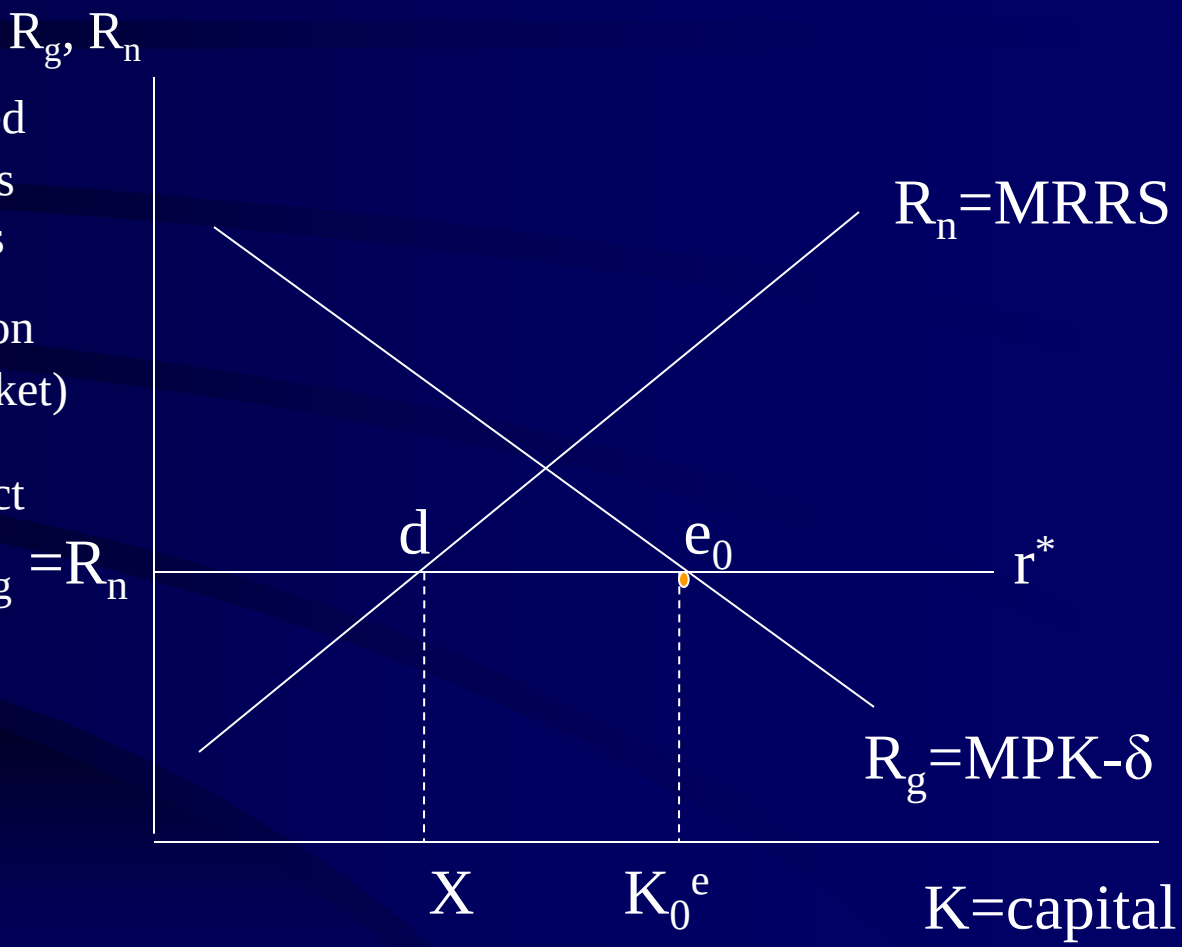


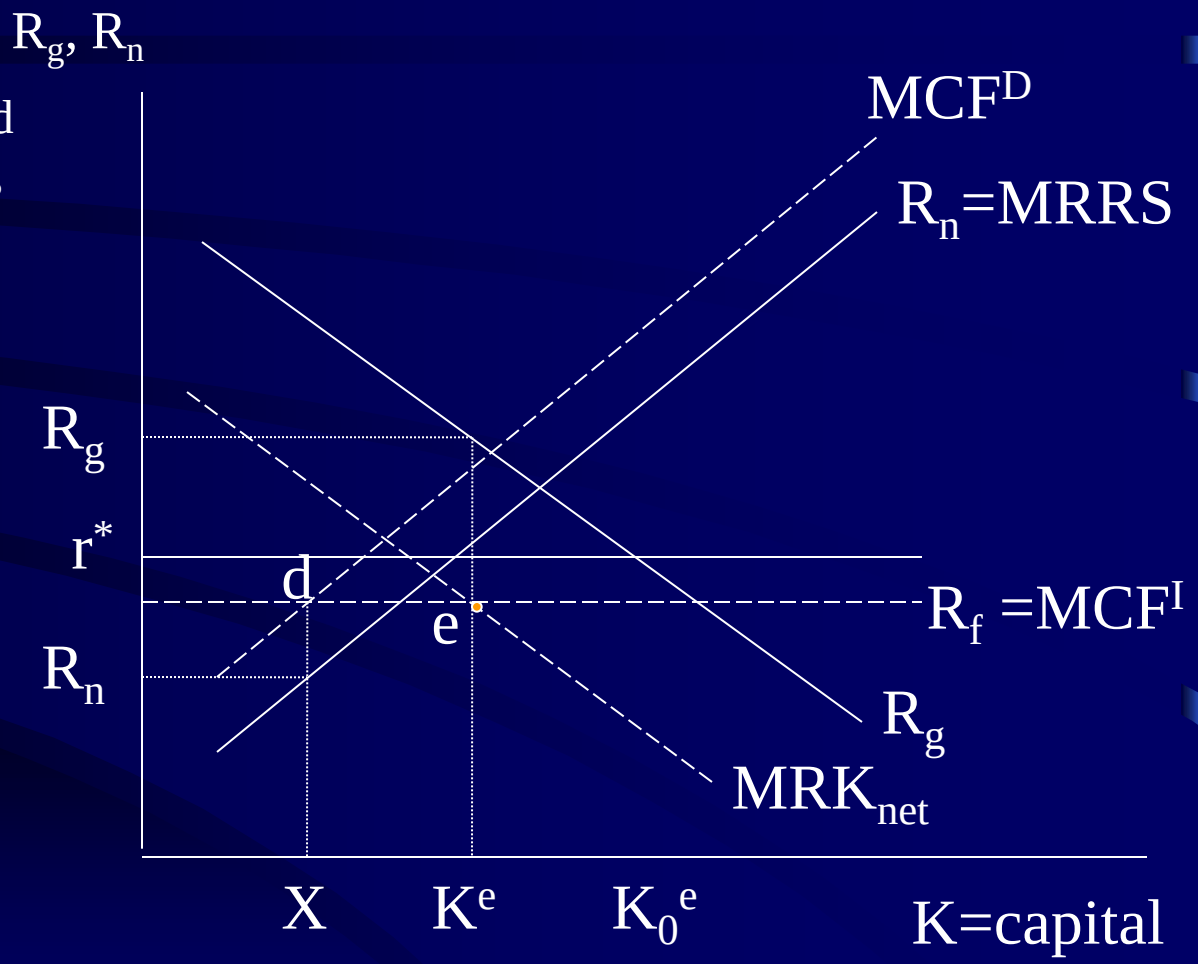
Illustration of METR open economy, with tax

R_n=MRRS =marginal required rate of return on domestic savings

MCF^D =marginal cost of domestic funds at corporate level

r^*=fixed required rate of return on finance (set in global market)

R_f=MCF^I =marginal cost of global funds at corporate level



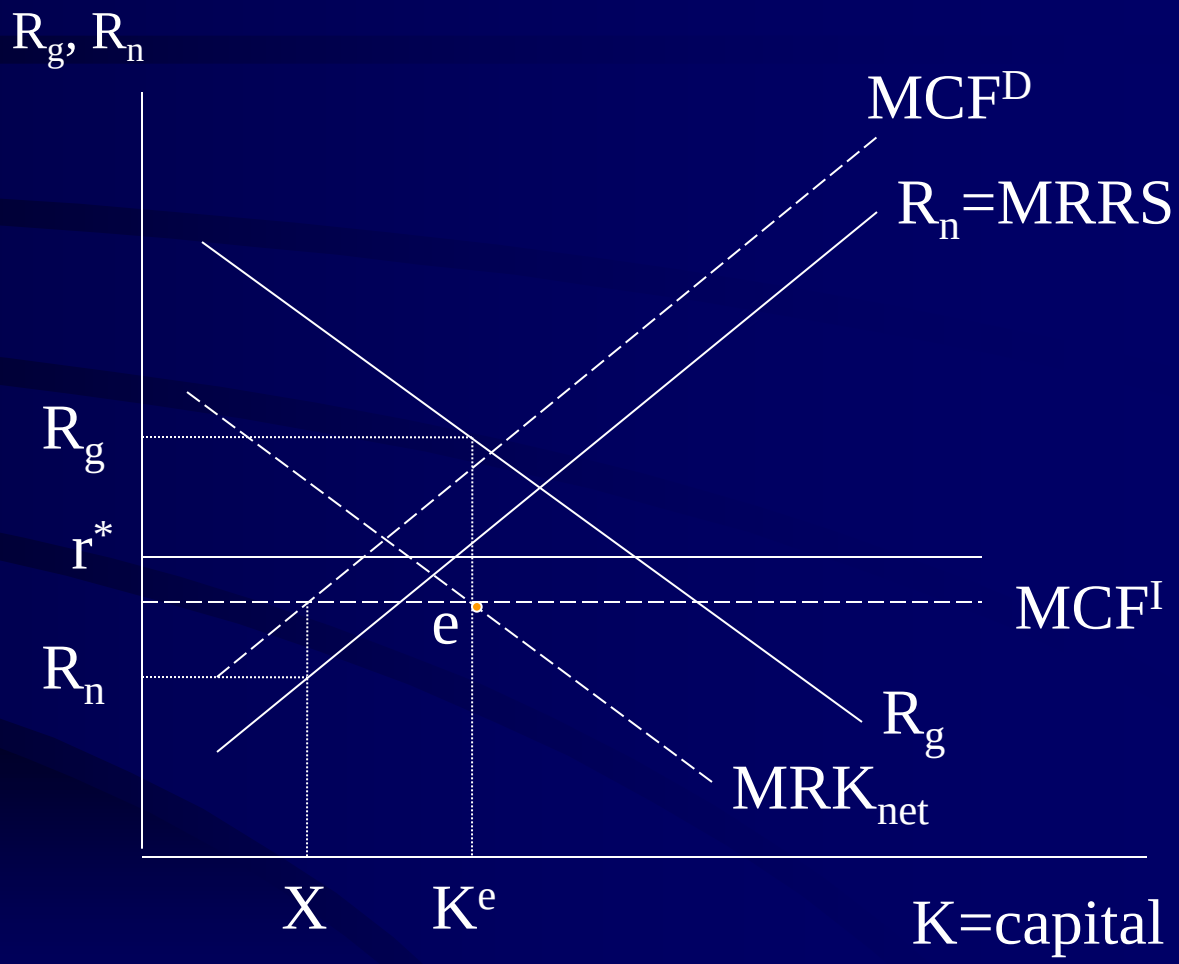
$METR=(R_g–R_n)/R_g >0$ (tax distortion discouraging investment)

Illustration of METR open economy, with tax

$METR=(R_g-R_n)/R_g$
$=METR_C+METR_P$

$METR_C=(R_g-r^*)/R_g>0$

$METR_P=(r^*-R_n)/R_g>0$

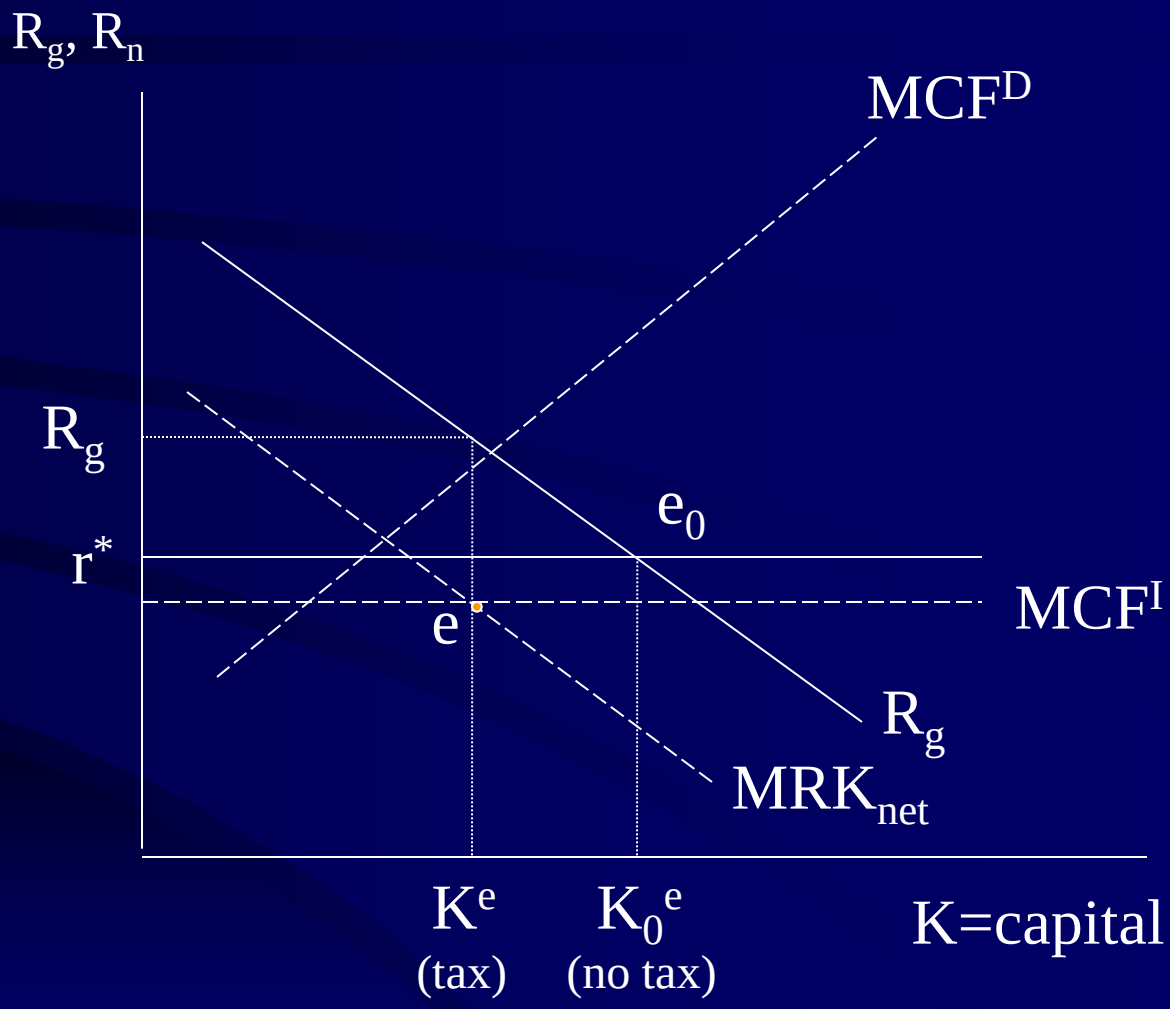


$METR_C$ applied to assess tax distortion to investment
$METR_P$ applied to assess tax distortion to savings

Illustration of Corporate METR (open economy)

$METR_C=(R_g–r^*)/R_g >0$

$METR_C$ typically used to assess tax distortion to investment (open economy assumption applied widely)



Corporate METR

- $METR_C=(R_g-r^*)/R_g$

  where

  - $R_g=MPK_n=(\Delta Y/\Delta K)-\delta$=marginal product of capital, net of economic depreciation (profit maximizing rate),
  - r^*=required rate of return on (debt + equity) finance, net of corporate tax (exogenous – set in global capital market).

- If $METR_C > 0$, tax distortion ↓ investment.
- If $METR_C < 0$, tax distortion ↑ investment.
- If $METR_C = 0$, tax neutrality (no effect).
- Need to measure $R_g=(\Delta Y/\Delta K)-\delta$ to solve for $METR_C$ – based on assumption of profit maximization.

Consider first solving for R_g in the simple no-tax case

- Profit-maximizing firm invests in K just up to the point where the marginal benefit=marginal cost.
- Marginal benefit per unit K -- the increase in output (Y) from last unit of capital K invested:

  $\Delta Y/\Delta K$ (where $\Delta Y/\Delta K \downarrow$ as $K\uparrow$) (*see Annex I*)
- Marginal cost per unit K -- consists of two parts:

  R_f (cost of finance to the firm)

  δ (rate of economic depreciation)
- Thus, the profit-maximizing condition given by:

  $(\Delta Y/\Delta K)=(R_f+\delta)$

  Or equivalently

  $R_g=(\Delta Y/\Delta K)-\delta=R_f$

Cost of finance R_f in no-tax case

- Cost of finance in no-tax case is a weighted average of (pre-tax) rates on debt and equity:

  $R_f = r^* = \beta i^* + (1-\beta)\rho^*$

  β=fraction debt finance

  $(1-\beta)$=fraction of equity finance

  i^*=rate of interest on debt (exogenous)

  ρ^*=required rate of return on equity net of corporate tax (exogenous)

- Note that in the charts, the components of r^* are not shown (r^* depicts a weighted average).

Now solving for corporate METR in the simple no-tax case

- $METR_C=(R_g-r^*)/R_g$

  where

  $R_g=R_f$

  $R_f=r^*=\beta i^* + (1-\beta)\rho^*$

Therefore,

$METR_C=0$

Consider a simple CIT system

- Statutory corporate income tax (CIT) levied at a single rate denoted by u (e.g. u=0.25).
- Interest expense is tax deductible; cost of equity is not tax deductible.
- Declining-balance tax depreciation at rate α (single capital type for illustrative purposes) – let z measure present discounted value (PV) of depreciation allowances, per currency unit of capital.
- Investment tax credit, at rate ψ, per currency unit.
- Effective purchase price of one currency unit of capital = (1-A) where $A=\psi+z$.

Present value of tax depreciation allowances (z)

Period	Beginning period UCC	Capital cost allowance (CCA)	Tax value of CCA	Present value at beginning of t of stream of CCA	End of period UCC
t	1	α	$u\alpha$	$u\alpha/(1+Rf)$	$(1-\alpha)$
t+1	$(1-\alpha)$	$\alpha\ (1-\alpha)$	$u\alpha\ (1-\alpha)$	$u\alpha\ (1-\alpha)/(1+Rf)^2$	$(1-\alpha)^2$
t+2	$(1-\alpha)^2$	$\alpha\ (1-\alpha)^2$	$u\alpha\ (1-\alpha)^2$	$u\alpha\ (1-\alpha)^2/(1+Rf)^3$	$(1-\alpha)^3$
t+n	$(1-\alpha)^n$	$\alpha\ (1-\alpha)^n$	$u\alpha\ (1-\alpha)^n$	$u\alpha\ (1-\alpha)^n/(1+Rf)^{n+1}$	$(1-\alpha)^{n+1}$

Present discounted value of sum of tax depreciation allowances, per unit of investment:

$$z=PV_t= u\alpha\Sigma_{x=t}(1-\alpha)^{x-t}/(1+R_f)^{x-t+1} = u\alpha/(R_f+\alpha)$$

Solving for R_g and $METR_C$

- After-tax marginal benefit (MB) of investment:

  $MPK(1-u)=(\Delta Y/\Delta K)(1-u)$

- After-tax marginal cost (MC) of investment:

  $(R_f+\delta)(1-A)$ where $R_f=\beta i^*(1-u)+(1-\beta)\rho^*$

- Profit maximizing investment condition (MB=MC):

  $MPK(1-u)=(R_f+\delta)(1-A)$

- Solving for R_g

  $R_g=MPK_n=MPK-\delta=(R_f+\delta)(1-A)/(1-u)-\delta$

- Solving for $METR_C$

  $METR_C=(R_g-r^*)/R_g$

  with $R_g=(\beta i^*(1-u)+(1-\beta)\rho^*+\delta)(1-A)/(1-u)-\delta$

  and $r^*=\beta i^*(1-u)+(1-\beta)\rho^*$

Recall illustration of Corporate METR (open economy)

Equilibrium condition:

$MPK(1-u)=(R_f+\delta)(1-A)$

or,

$AdjMPK-\delta=R_f$

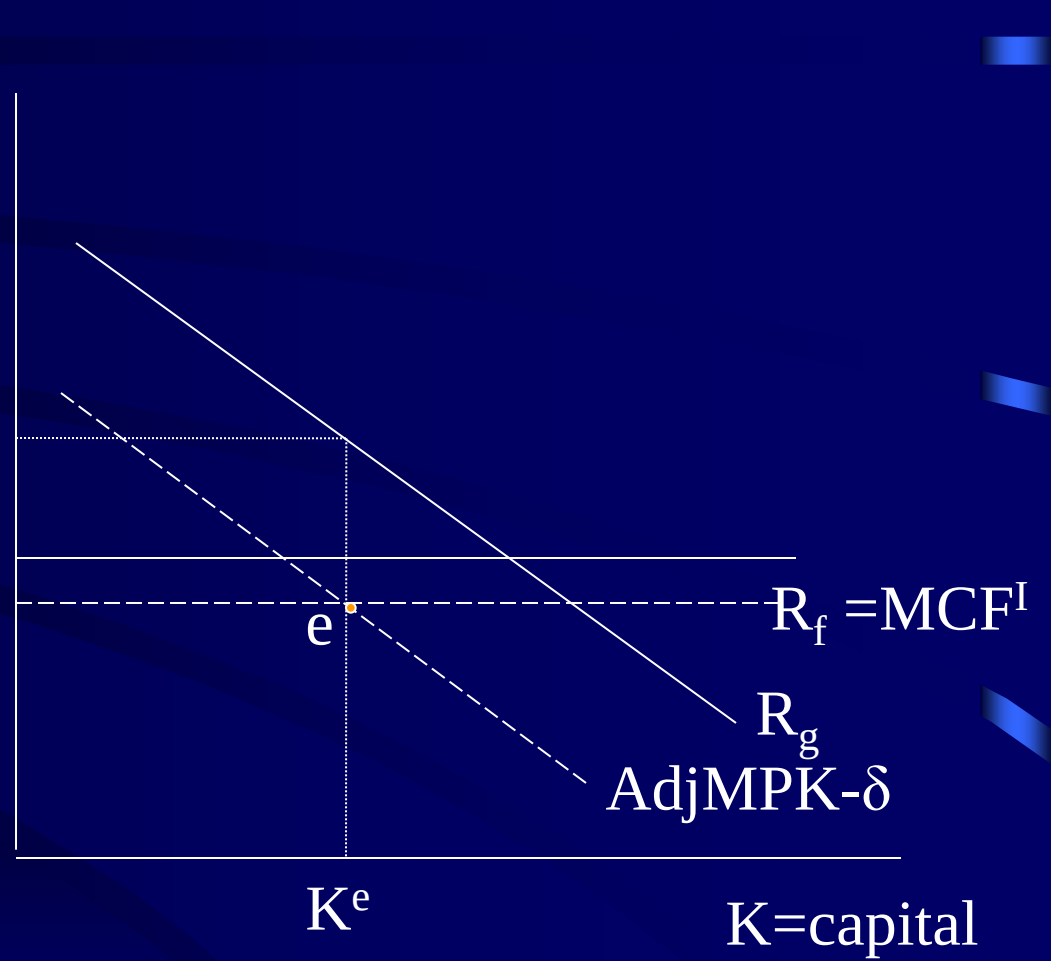
where

$AdjMPK=MPK(1-u)/(1-A)$

$R_f=MCF^I=\beta i^*(1-u)+(1-\beta)\rho^*$

$R_g=MPK-\delta=(R_f+\delta)(1-A)/(1-u)-\delta$

$METR_C=(R_g-r^*)/R_g>0$



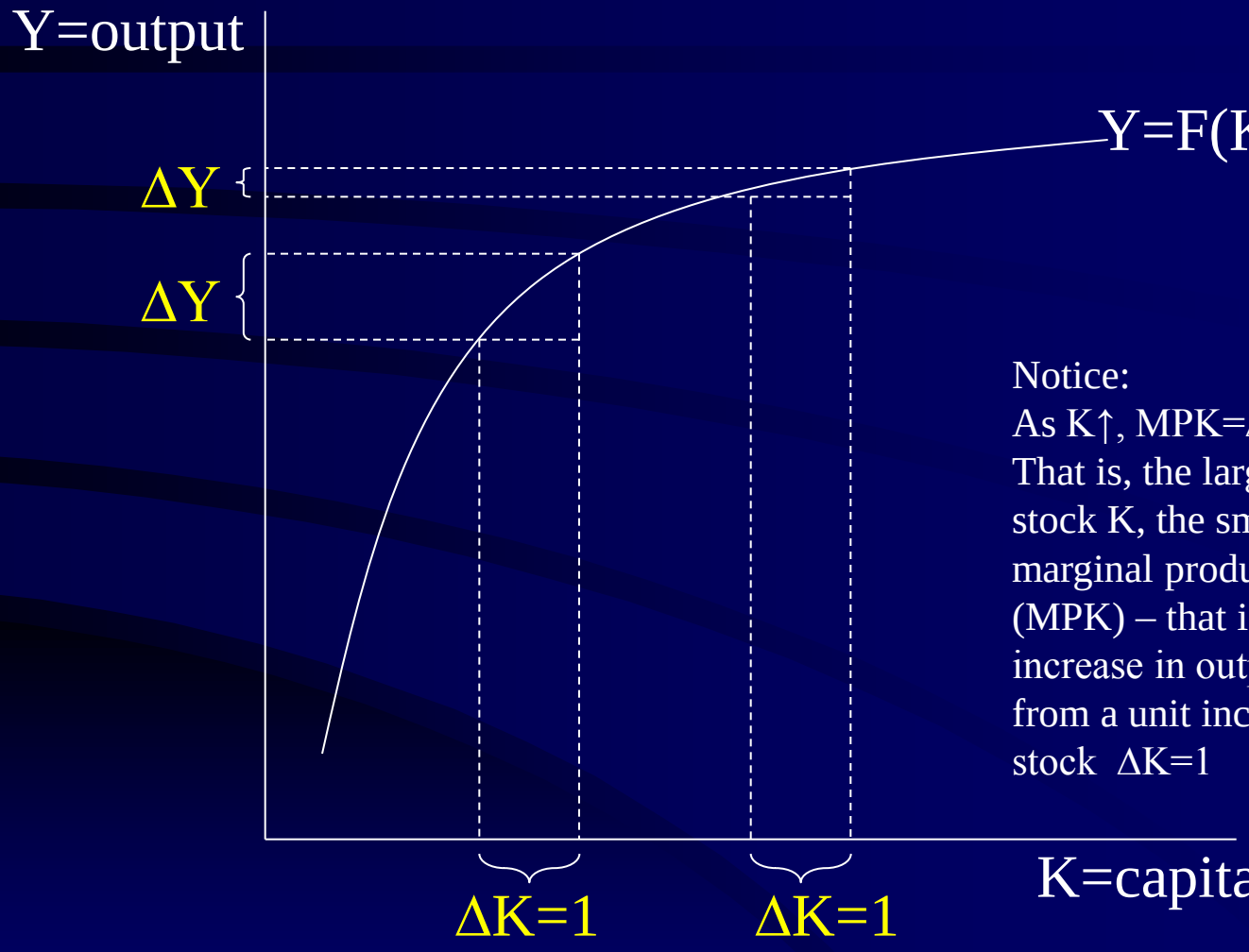
Applications to R&D

- Recall METR – assumes firms invest up to point where after-tax benefit=after-tax cost at the margin
  - $MPK(1-u)=(R_f+\delta)(1-A)$
- Consider rearranging this equilibrium condition:
  - $MPK=(R_f+\delta)(1-A)/(1-u)$
- Consider B-index:
  - B-index=(1-A)/(1-u)
- Compare equilibrium expression and B-index:
  - B-index ignores term $(R_f+\delta)$ – ignores tax considerations relating to cost of finance, and differences between actual and tax depreciation.
  - Both assume application of statutory CIT rate (at rate u).

Annex I - Declining Marginal Productivity of Capital

$MPK=(\Delta Y/\Delta K) \downarrow$ as $K \uparrow$

Output Y as a function of capital K



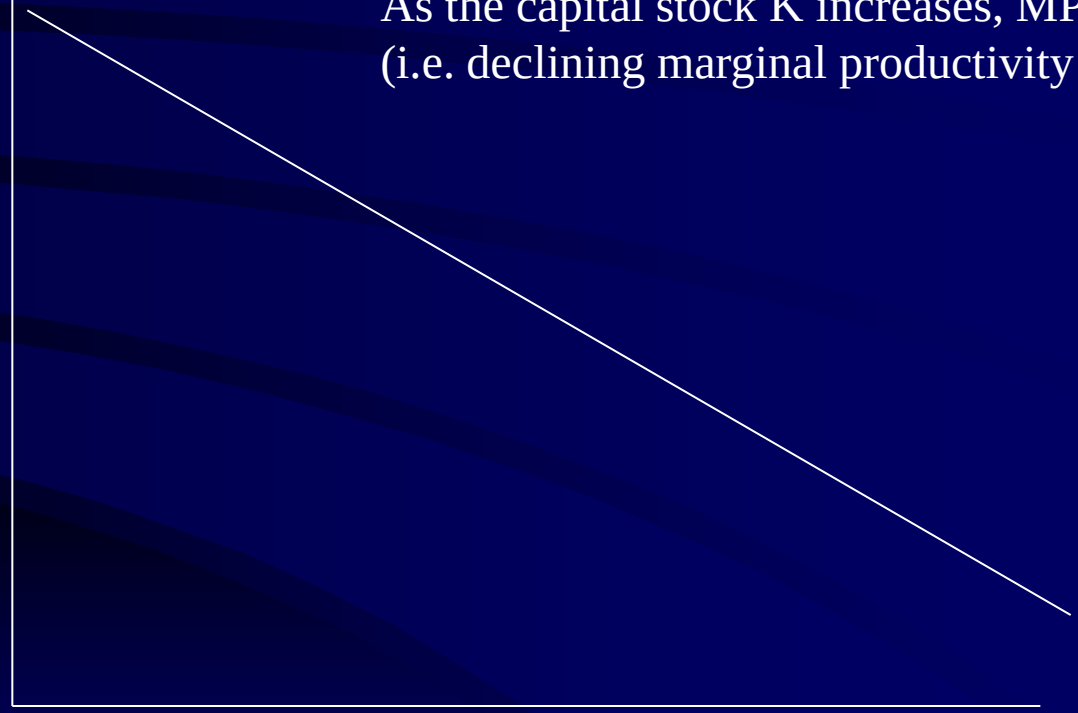
Notice:
As K↑, MPK=ΔY/ΔK ↓
That is, the larger the capital stock K, the smaller is the marginal product of capital (MPK) – that is, the smaller is the increase in output ΔY resulting from a unit increase in the capital stock ΔK=1

Y=F(K) means Y is a function of (i.e. depends on) the size of the capital stock K

Declining marginal productivity of capital

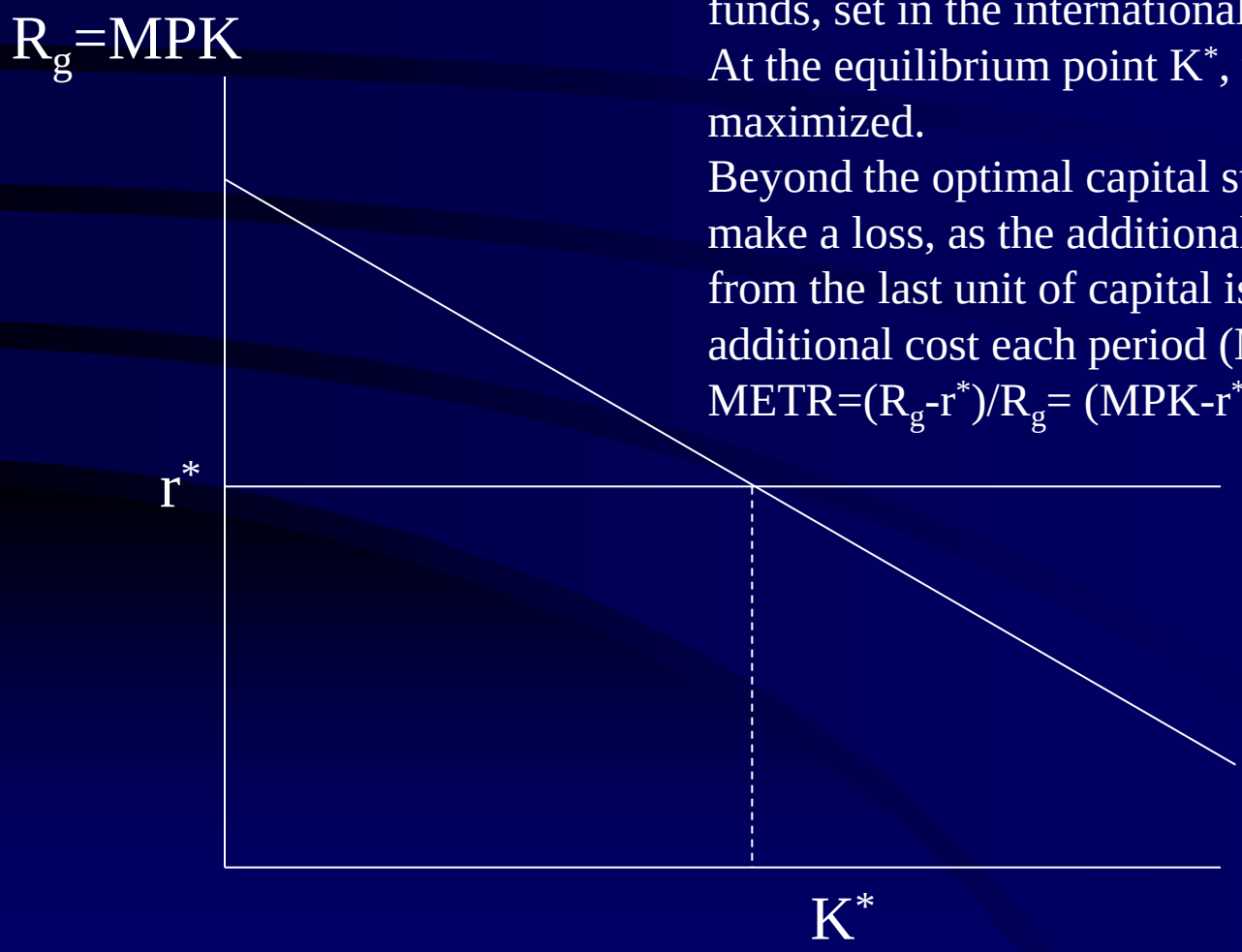
MPK=ΔY/ΔK

As K↑, MPK=ΔY/ΔK ↓ (see last slide).
As the capital stock K increases, MPK declines (i.e. declining marginal productivity of capital)



K=capital stock

The open economy, no tax case (ignoring depreciation, inflation)



Optimal for the firm to increase the capital stock just up to the point where MPK=r^* where r^* is the cost of funds, set in the international capital market.

At the equilibrium point K^*, where MPK=r^*, profit is maximized.

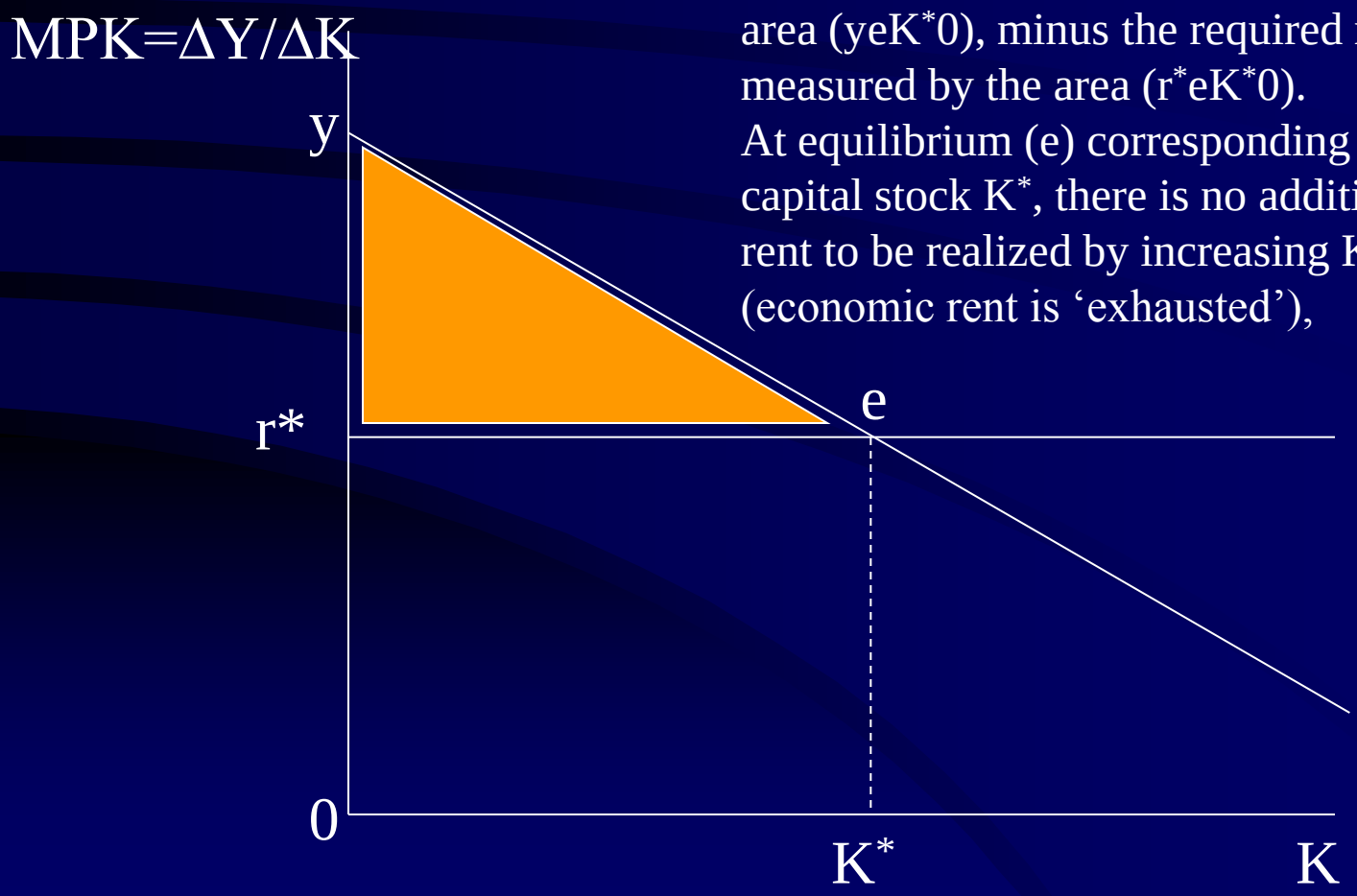
Beyond the optimal capital stock K^*, the firm would make a loss, as the additional output each period from the last unit of capital is less is than the additional cost each period (MPK<r^*).

METR=$(R_g-r^*)/R_g$= $(MPK-r^*)/MPK=0$

Annex II - Illustrative (simplified) Analysis of CIT Reforms and Welfare Effects using METR

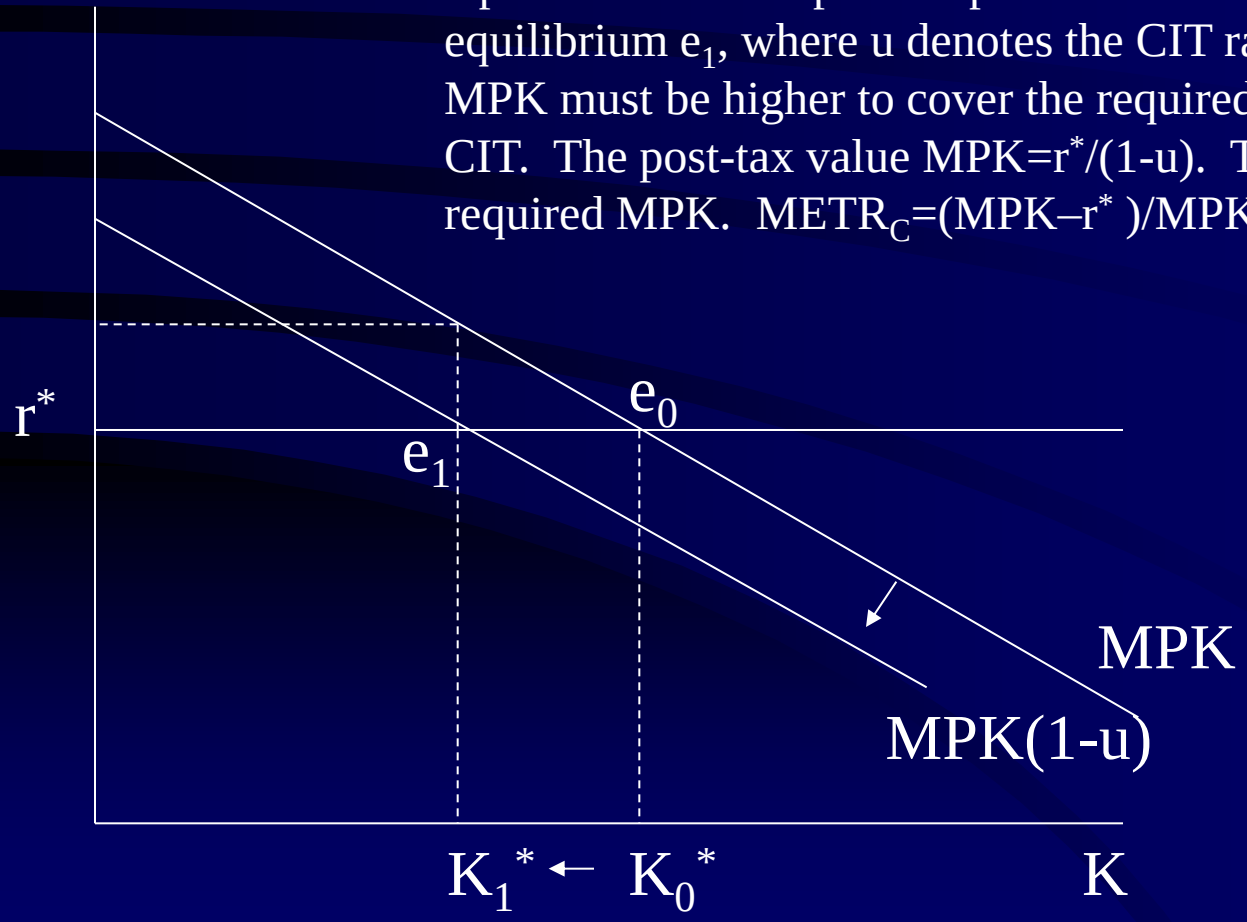
The open economy, no tax case ignoring depreciation

The yellow triangular area (yer*) measures the amount of 'surplus' (i.e. pure profit, or 'economic rent') earned by the firm's shareholders.
The surplus equals total output, as measured by the area (yeK*0), minus the required return, as measured by the area (r*eK*0).
At equilibrium (e) corresponding to the optimal capital stock K*, there is no additional economic rent to be realized by increasing K, with MPK=r* (economic rent is 'exhausted'),



Introducing corporate income tax (CIT) (assuming equity finance, ignoring depreciation)

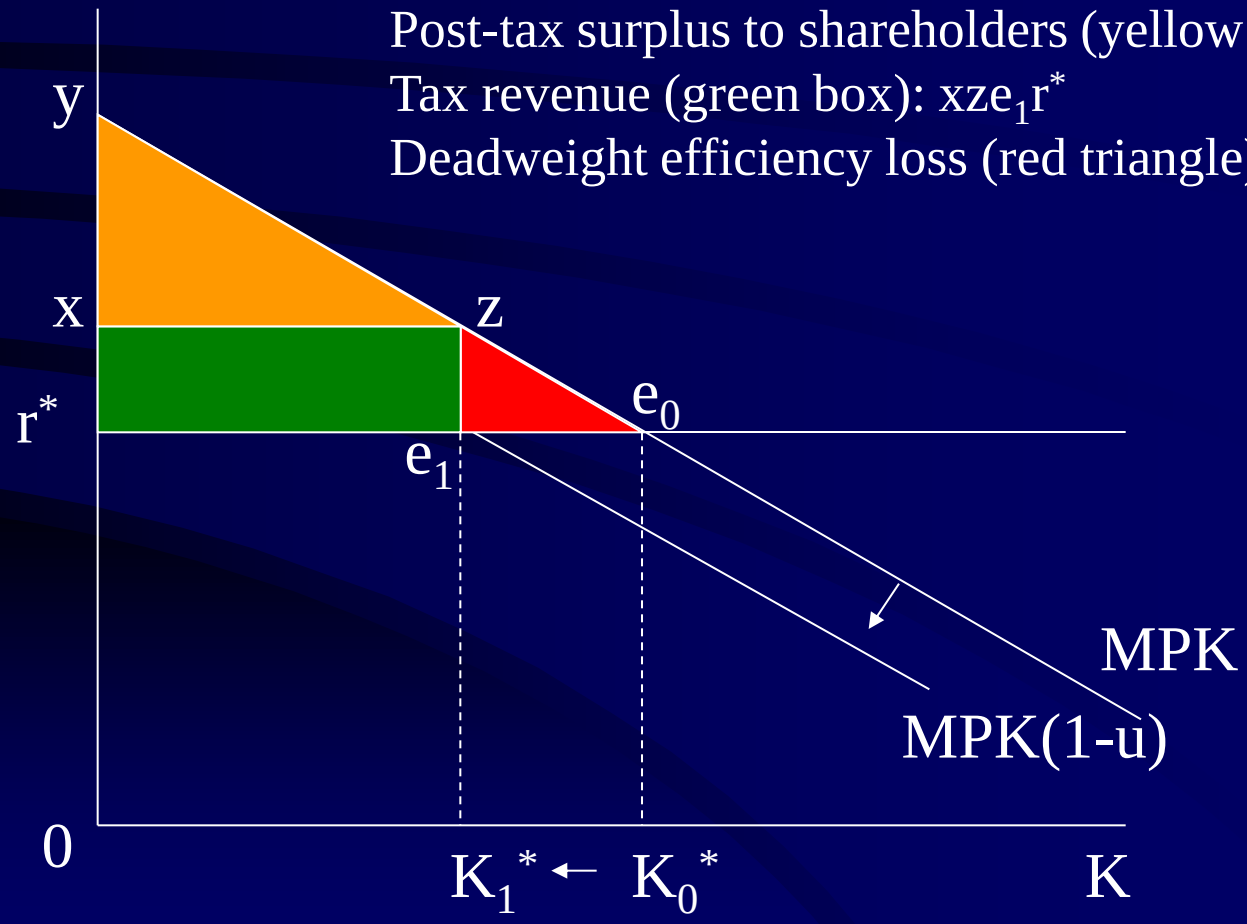
Introduction of CIT at rate u, that taxes revenues on investment, but does not give a deduction for the cost of funds (return on equity) reduces the optimal capital stock from K_0^* (in the no-tax case) to K_1^*.
Optimal to invest up to the point where $MPK(1-u)=r^*$, at post-tax equilibrium e_1, where u denotes the CIT rate. With CIT, the value of MPK must be higher to cover the required return on equity and pay for CIT. The post-tax value $MPK=r^*/(1-u)$. The larger is u, the higher is required MPK. $METR_C=(MPK-r^*)/MPK=[(r^*/(1-u)]-r^*)/[r^*/(1-u)]=u$



Welfare analysis of introducing CIT (assuming equity finance, ignoring depreciation)

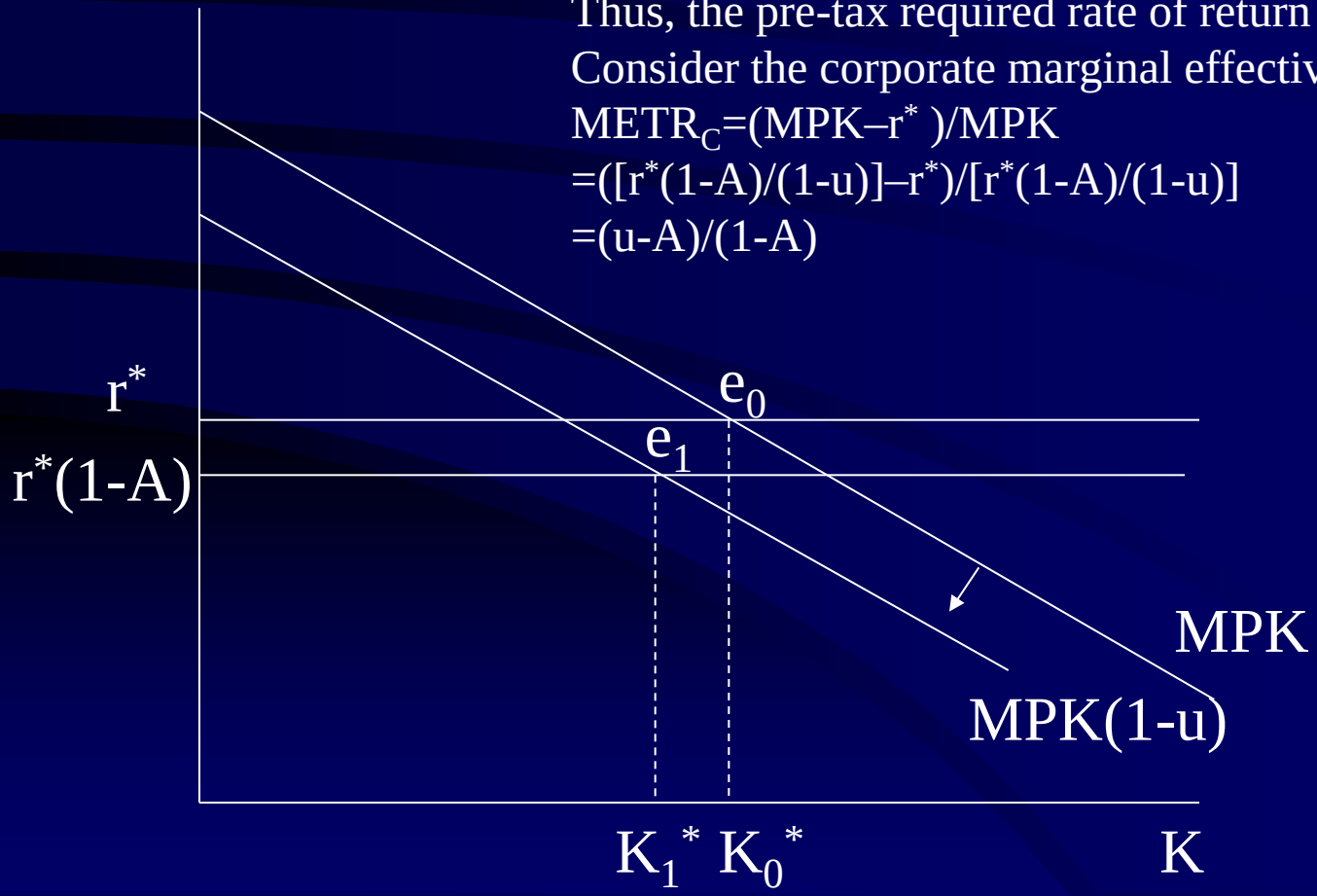
Pre-tax surplus to shareholders: ye_0r^*

Post-tax surplus to shareholders (yellow triangle): xyz
Tax revenue (green box): xze_1r^*
Deadweight efficiency loss (red triangle): ze_0e_1



Introducing CIT with investment tax credit (equity finance, ignoring depreciation)

Let A = rate of investment tax credit (e.g. 5%)
At equilibrium e_1, $MPK(1-u)=r^*(1-A)$
Thus, the pre-tax required rate of return $MPK=r^*(1-A)/(1-u)$
Consider the corporate marginal effective tax rate:
$METR_C=(MPK-r^*)/MPK$
$=([r^*(1-A)/(1-u)]-r^*)/[r^*(1-A)/(1-u)]$
$=(u-A)/(1-A)$



Introducing CIT with debt finance (no equity finance, ignoring depreciation)

Introduction of a corporate income tax (CIT) at rate u, that taxes revenues and gives a deduction for interest expense on fully debt financed investment does not impact the optimal level of investment (government shares in the benefits and the costs).

Optimal to invest up to the point where $MPK(1-u)=r^*(1-u)$ which is equivalent to $MPK=r^*$.

$METR_C=(MPK-r^*)/MPK=0$