Risk, Intangible Capital and Interindustry Differences in Rates of Return

Evidence from Germany

Axel Werwatz, Bernd Görzig, Martin Gornig,
Motivation

“In a competitive environment rates of return to capital tend to be randomly distributed around some normal [equilibrium] rate”

Neumann, Böbel, Haid (1979)

→ There should be no persistent differences in rates of return to capital

- We take up an EUKLEMS- social planner perspective
- Our focus: rate of return differences across sectors
- Are there persistent differences in return to capital?
- ... even if we adjust for risk and intangible capital?
Our analysis proceeds in four steps

**Step 1:** *Convergence*?  
β- or σ-convergence over 1970-2007

**Step 2:** Adjusting for *risk*  
Sharpe ratio; CAPM

**Step 3:** Adjusting for *intangible capital*  
augment KLEMS by EUKLEED data

**Step 4:** Explaining adjusted returns  
effect of competition (*entry*)
Primary data set

- EUKLEMS-data for Germany
- Our focus: rates of return on capital

Auxiliary data set

- INNODRIVE (Eukleed)
- micro data for nearly 1.4 million establ. in Germany
- information on own account intangible capital (Step 3)
- 1999 – 2003 for 25 industries
- LEED-data is also base for entry rate (Step 4)
<table>
<thead>
<tr>
<th>EUKLEMS industry</th>
<th>EUKLEMS No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, hunting, forestry, fishing*</td>
<td>AtB</td>
</tr>
<tr>
<td>Mining and quarrying*</td>
<td>C</td>
</tr>
<tr>
<td>Food, beverages and tobacco</td>
<td>15t16</td>
</tr>
<tr>
<td>Textiles, leather and footwear</td>
<td>17t19</td>
</tr>
<tr>
<td>Wood and of wood and cork</td>
<td>20</td>
</tr>
<tr>
<td>Pulp, paper, printing, publishing</td>
<td>21t22</td>
</tr>
<tr>
<td>Coke, refined petroleum, nuclear fuel</td>
<td>23</td>
</tr>
<tr>
<td>Chemicals and chemical products</td>
<td>24</td>
</tr>
<tr>
<td>Rubber and plastics</td>
<td>25</td>
</tr>
<tr>
<td>Other non-metallic mineral</td>
<td>26</td>
</tr>
<tr>
<td>Basic metals and fabricated metal</td>
<td>27t28</td>
</tr>
<tr>
<td>Machinery, nec</td>
<td>29</td>
</tr>
<tr>
<td>Electrical and optical equipment</td>
<td>30t33</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>34t35</td>
</tr>
<tr>
<td>Manufacturing nec.; recycling</td>
<td>36t37</td>
</tr>
</tbody>
</table>

* Not included in the EUKLEED data

<table>
<thead>
<tr>
<th>EUKLEMS industry</th>
<th>EUKLEMS No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity, gas, water supply</td>
<td>E</td>
</tr>
<tr>
<td>Construction</td>
<td>F</td>
</tr>
<tr>
<td>Sale, repair of motor vehicles etc.</td>
<td>50</td>
</tr>
<tr>
<td>Wholesale trade, commission trade</td>
<td>51</td>
</tr>
<tr>
<td>Retail trade; repair of household goods</td>
<td>52</td>
</tr>
<tr>
<td>Hotels and restaurants</td>
<td>H</td>
</tr>
<tr>
<td>Transport and storage</td>
<td>60t63</td>
</tr>
<tr>
<td>Post and telecommunication</td>
<td>64</td>
</tr>
<tr>
<td>Financial intermediation</td>
<td>J</td>
</tr>
<tr>
<td>Real estate activities*</td>
<td>70</td>
</tr>
<tr>
<td>Other business activities</td>
<td>71t74</td>
</tr>
<tr>
<td>Public administration*</td>
<td>L</td>
</tr>
<tr>
<td>Education*</td>
<td>M</td>
</tr>
<tr>
<td>Health and social work</td>
<td>N</td>
</tr>
<tr>
<td>Other community; personal services</td>
<td>O</td>
</tr>
</tbody>
</table>
Step 1: convergence during 1970-2007?
Step 1: convergence during 1970-2007?

\[ y_{iT} = \alpha + (1 - \beta)y_{i1} + \epsilon_i \]

- \( \beta \approx 0 \) → tight relationship
- \( \beta \approx 1 \) → no relationship
- \( \beta \approx 0 \) → no convergence.

\[ \sigma \text{-convergence} \]

Does the variance shrink?

\[ \beta \text{-convergence} \]

Do high-return sectors in T tend to be already high-return sectors in period 1?
Step 1: $\sigma$-convergence

Standard deviation (SD) and inter-quartile range (IQR) over time

Industrial rate of return on capital

Declines in early 70s and after unification
Step 1: $\sigma$-convergence

$\hat{\sigma}_{t_1} / \hat{\sigma}_{2007}$

$H_0 : \frac{\sigma_{t_1}}{\sigma_T} \leq 1 \quad H_0 : \frac{\sigma_{t_1}}{\sigma_T} > 1$

$s$-convergence

Rolling variance ratio shows some periods of decline but not uniformly.
Step 1: $\beta$ - convergence

We fix $T=2007$ and roll leftward from 1970

\[ y_{iT} = \alpha + (1 - \beta)y_{i_{t-1}} + \varepsilon_i \]

Convergence beta over time - last year = 2007

$\beta \approx 0 \rightarrow$ no convergence
$\beta \approx 1 \rightarrow$ convergence

$\beta$ usually $\leq 0.5 \rightarrow$ relative positions fairly stable
Step 1: F-Test of equal means

Box plots of return distributions by sector over 1970-2007 period

ANOVA F-Test always rejects equal average returns across sectors
Step 1: Summary

• Return distribution across sectors does vary over time
• Sub-periods of declining variability
• Some movements of relative positions of sectors
• However, considerable amount of persistency
  (This is in line with earlier results, e.g. Qualls 1974, Jacobson 1988)

• What can account for persistent differences in average returns?
  ▪ Risk (→ Step 2)
  ▪ Intangible capital (→ Step 3)
  ▪ Competition / (Lack of) entry (→ Step 4)
Step 2: Adjusting for risk

- Rate of return differences could be “justified” by differences in risk
- No clear cut way to define and measure risk at industry level.
- We take up perspective of “social planner” who tries allocate capital across industries in order to maximize expected output (e.g. Eberly and Wang (2011))
- We use two methods
  1. Sharpe ratios
  2. CAPM betas
Step 2: Adjusting for risk - Sharpe ratio

\[
SR_{ex,j} = \frac{\hat{\mu}_j}{\hat{\sigma}_j} = \frac{\bar{r}_j}{S_j}
\]

\[
SR_{ex,Fin} = \frac{0.1527}{0.0486} \approx 3.14
\]

mean: 0.1527, sd: 0.0486, Sharpe ratio: 3.1398
Step 2: Adjusting for risk - Sharpe ratio

Means vs SDs - 1970-2007, all sectors

\[ SR_{ex,j} = \frac{\hat{\mu}_j}{\hat{\sigma}_j} = \frac{\bar{r}_j}{S_j} \]
Step 2: Adjusting for risk - Sharpe ratio

**Average returns vs Sharpe ratios - 1970-2007, all sectors**

- Formula: $SR_{ex,j} = \frac{\bar{r}_j}{S_j}$
- Correlation: $corr = 0.770$, rank correlation: $0.700$
Step 2: Adjusting for risk - Sharpe ratio

Does risk-adjusting compress the distribution of average returns across sectors?
To answer this question original returns and Sharpe ratios will be put on the same scale

$$\bar{r}_j$$  
$$SR_{ex,j} = \frac{\bar{r}_j}{S_j}$$

$$Z_{\bar{r}_j} = \frac{\bar{r}_j - \bar{r}}{S_{\bar{r}}}$$  
$$Z_{SR_{ex,j}} = \frac{SR_{ex,j} - \bar{SR}_{ex}}{S_{SR_{ex,j}}}$$

regression to the mean?

$$\bar{r}_j$$  
$$S_{\bar{r}_j} \cdot SR_{ex,j} = S_{\bar{r}_j} \cdot \frac{\bar{r}_j}{S_j}$$

kernel densities
Step 2: Adjusting for risk - Sharpe ratio

\[ Z_{SR_{ex,j}} = \frac{SR_{ex,j} - \overline{SR}_{ex}}{S_{SR_{ex,j}}} \]

Regression to the mean - Sharpe

- Standardized unadjusted return vs. standardized adjusted return
- Regression line
- 45° line
- corr: 0.770, risk-adjustment: Sharpe, 1970-2007, all sectors

\[ Z_{r_{ij}} = \frac{\bar{r}_{ij} - \bar{r}}{S_{r}} \]
Step 2: Adjusting for risk - Sharpe ratio

Density

average returns 1970-2007

unadjusted risk-adjusted (Sharpe)

based on all sectors
Step 2: Adjusting for risk - Sharpe ratio

Summary: Sharpe ratio

- Adjusting for risk by dividing sectoral average rates of return by their standard deviations somewhat reduces variability in returns

- **Sharpe ratio:**
  - Risk = time series variation of returns

- **CAPM**
  - some of these fluctuations are irrelevant
  - all that matters is correlation with aggregate return
**Step 2: Adjusting for risk - CAPM**

**CAPM** equilibrium relationship for sector i

\[
E[r_i] - r_f = \beta_i \left( E[r_M] - r_f \right)
\]

\[
\Rightarrow \frac{E[r_i] - r_f}{\beta_i} = \left( E[r_M] - r_f \right)
\]

→ So after adjusting with sector-specific betas, average excess returns should equal aggregate excess return.
Step 2: Adjusting for risk - CAPM

**CAPM** estimating equation

\[ r_{it} - r_{ft} = \alpha_i + \beta_i [r_{Mt} - r_{ft}] + \varepsilon_{it} \]

- \( t=1970, \ldots, 2007 \)
- \( r_f = \) risk free rate
  - return of government bonds
- \( r_M = \) return of market portfolio
  - we use capital-weighted average KLEMS return
Step 2: Adjusting for risk - CAPM

\[ \text{CAPM estimating equation} \]

\[ r_{it} = \alpha_i + \beta_i r_{M} + \epsilon_{it} \]

- \( r_{it} \): Return of sector \( i \)
- \( r_{M} \): Market excess return
- \( \beta_i \): Beta
- \( \epsilon_{it} \): Error term

1970-2007, beta: -0.200

FINANCIAL INTERMEDIATION
Step 2: Adjusting for risk - CAPM

As of yet, too many implausible and imprecisely estimates $\beta$s
Step 3: Adjusting for intangible capital [1999-2003]

Intangible capital

- INNODRIVE (Eukleed)
- own account production of ICT, R&D and org. capital via employment characteristics at the establishment level
- IC is aggregated to sectoral level
- INNODRIVE return ratios:

\[
\frac{\text{rate of return of sector } i \text{ with IC}}{\text{rate of return of sector } i \text{ without IC}}
\]

is applied to EUKLEMS rates of returns

→ IC adjusted rates of return for 25 industries
→ 1999 – 2003 figures are collapsed by industry
Step 3: Adjusting for intangible capital [1999-2003]

Kernel densities of Sharpe ratios

with and without adjusting for intangible capital

sd_70_07 used for adjusting
Step 3: Adjusting for intangible capital [1999-2003]

1999-2003 - Risk only

- Standardized risk adjusted return vs. Standardized unadjusted return
- Regression line: corr: 0.810, risk-adjustment: Sharpe, 1999_2003_sd_70_07, all sectors
- 45° line

DIW BERLIN
Step 3: Adjusting for intangible capital [1999-2003]
Step 3: Adjusting for intangible capital

Summary of Step 3:
- Adjusting for intangible capital leads to additional reduction in variability of returns across sectors
- However: substantial differences remain

“Because competition acts to direct resources towards uses offering the highest returns, persistently unequal returns mark the presence of either natural or contrived impediments to resource flows”

Rumelt (1979)

→ Step 4: entry rate
= average employment share of new establishments from 1999 - 2003 for each sector
Step 4: Accounting for entry [1999-2003]

Regression of risk and IC adjusted returns on entry

Regression equation:

\[
\text{IC adjusted Sharpe ratio} = -2.360 \times \text{entry share} + 1.569 \times \text{Constant}
\]

- \( \text{entry share} \) coefficient: -2.360 (0.96)
- \( \text{Constant} \) coefficient: 1.569 (2.98)**
- \( R^2 \) = 0.04
- \( N \) = 25

Averaged data 1999-2003, \( R^2 = 0.04 \)
Summary

• Using EUKLEMS-data for Germany we study rate of return differences across sectors

• By and large, persistent differences in return to capital

• Adjusting for risk (via Sharpe ratio) and intangible capital (using INNODRIVE-Eukleed data) somewhat diminishes these differences.

• How can remaining differences be explained?

• Weak evidence for effects of barriers to ressource flows (to competition)