Production processes, tasks and skill requirements and their influence on the costs of apprenticeship training

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T.A.S.K.S. (Technology, Assets, Skills, Knowledge, Specialisation)
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Motivation

- **Dual system of vocational education and training (VET) in Germany**
    => – work force with certificable intermediate skills
        – orderly school-to-work-transition and low youth unemployment

- **Firms` costs of VET are (partly) very high**
    => Cost-benefit-surveys (CBS)
        – by the Federal Institute for Vocational Education and Training (BiBB)
        – at regular intervals

- **Average training costs dropped dramatically between 2000 and 2007**
    – from   about **€20,000** for a three-year training program   in 2000
    – to   about **€13,000** for the same training program   in 2007

- **Why ??**
    – hypothesis
    – empirical test

Overview

Theoretical background

• Tasks and the German system of VET

• Changes in production and organizational processes

⇨ Change of tasks

↕

⇨ Change of skill requirements
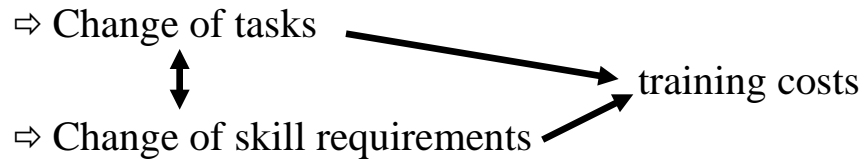
training costs

From the change of tasks to the change of training costs: hypothesis

Empirical Test

• Dataset and cost-benefit-model (CBM)

• Empirical strategy

  – simple OLS-regression on the pooled data

  – matching and simulation techniques

• Empirical evidence

Conclusions

Firms' costs of vocational education and training (VET)

- **Gross costs**: $C_0 = w_0^a + c_0^t + X_0$

- **Net costs:** $NC_0 = (w_0^a + c_0^t + X_0) - MP_0^a = C_0 - MP_0^a$

w_0^a = wages of apprentices

c_0^t = cost for the training personnel

X_0 = other training costs, e.g. expenses for material and infrastructure

MP_0^a = apprentices' productive contributions = benefits of training

Firms' returns of VET

$$P \cdot \left((MP_n^s - MP_n^u) - (w_n^s - w_n^u) \right) = P \cdot (MP_n^s - w_n^s) \text{ supposing that } (MP_n^u - w_n^u)$$

MP_n^s, MP_n^u = productive contributions of a graduated apprentice
and an unskilled worker respectively

w_n^s, w_n^u = wage of a graduated apprentice
and an unskilled worker respectively

P = probability that the graduated apprentice will stay in the firm

Literature:
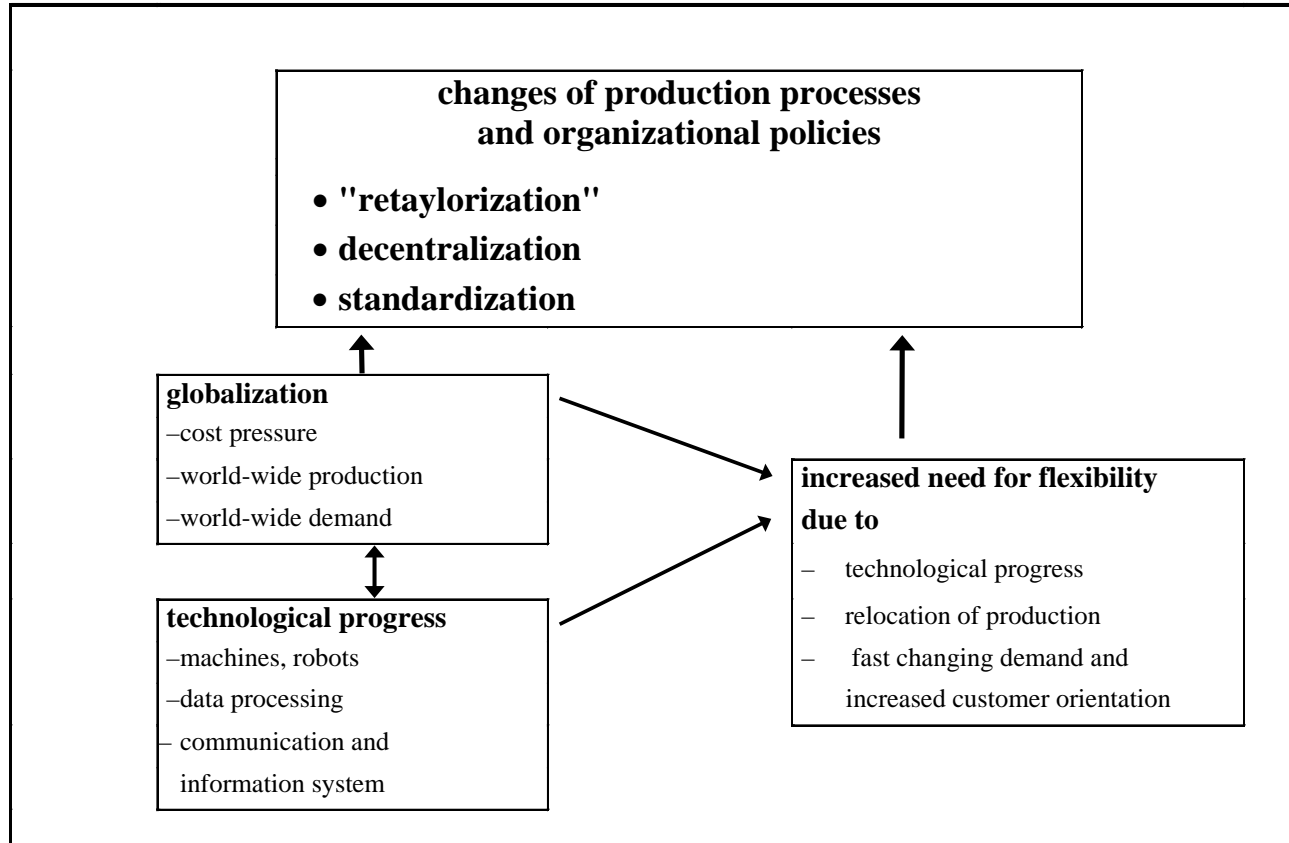## Models of apprenticeship training
build on net costs of VET

⇨ **Production-oriented models of training:**
   Firms bear **no net costs** of training

⇨ **Investment-oriented models of training**
   Firms bear **high net costs** of training   – the German case –
   and (must) have **returns of VET**

„Trends" in work organization and its driving forces

**changes of production processes
and organizational policies**

- **"retaylorization"**
- **decentralization**
- **standardization**

globalization

–cost pressure

–world-wide production

–world-wide demand

technological progress

–machines, robots

–data processing

– communication and

information system

**increased need for flexibility
due to**

– technological progress

– relocation of production

– fast changing demand and

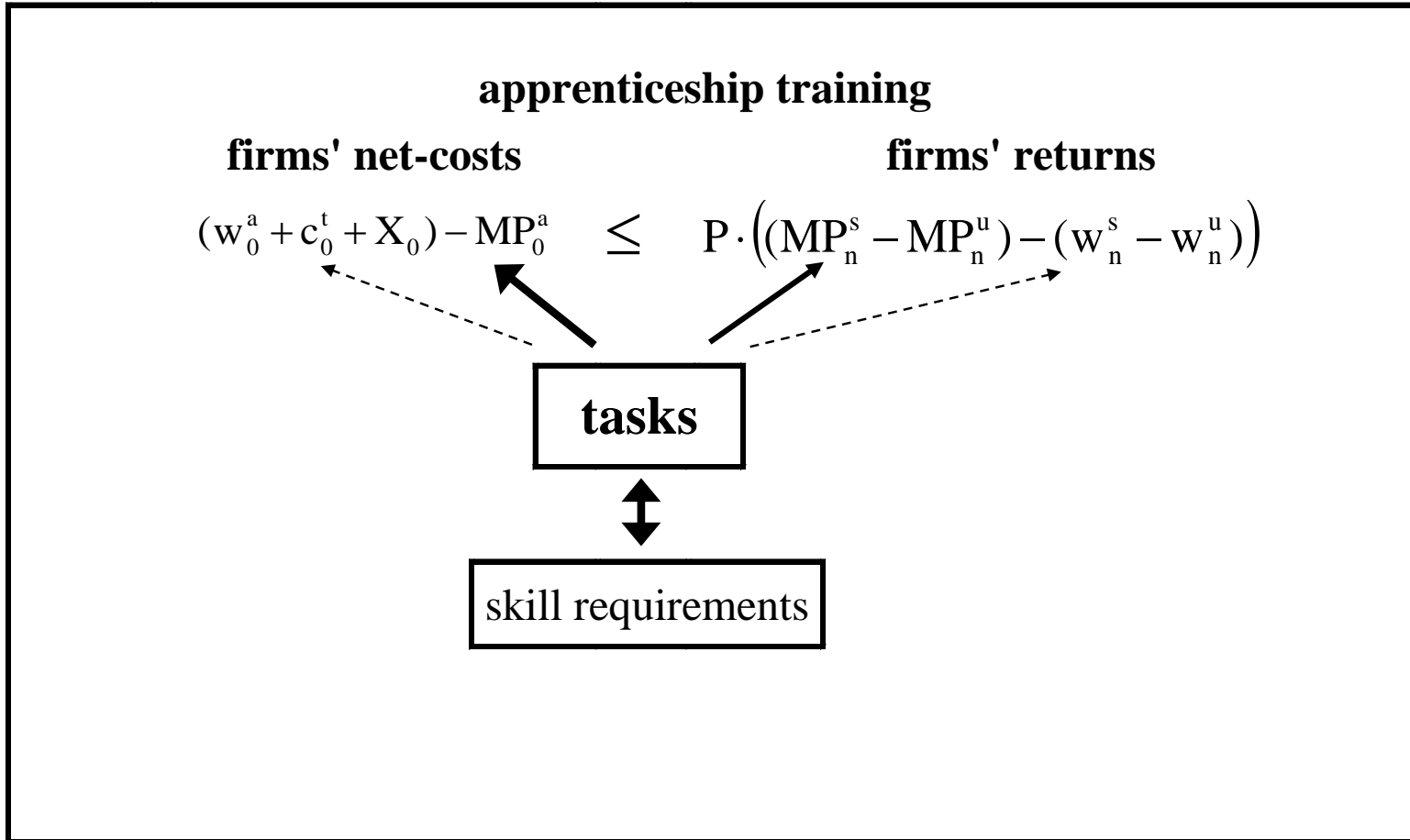increased customer orientation

Empirical evidence for these "trends" in work organization

- **Large number of case studies**
  - manufacturing sector
    e.g. electrical industry, automotive manufacture, machine and plant construction
  - service sector
    e.g. banks, insurances, IT- and multimedia companies

Basis idea:

Tasks at the work place have changed and influence net costs and returns of VET

apprenticeship training

firms' net-costs   **firms' returns**

$$(w_0^a + c_0^t + X_0) - MP_0^a \leq P \cdot \left((MP_n^s - MP_n^u) - (w_n^s - w_n^u) \right)$$

tasks

skill requirements

„Retaylorization"   or
returning to higher specialization

Reweightening

returns of specialization

↑

due to

– increased need of flexibility

   . frequent conversions of production

   . high labor turnover

– concept of process security
   (result of too complex production
   processes)

coordinating the activities of different workers

↓

due to

– data processing

– new information and
   communication technologies

Decentralization

Specialization did not only take place within plants, but also

- **between different production sites of the same company**
  - "new decentralization"
  - "decentralized centralization"

- **worldwide**
  especially relocation of production to
  - countries with low labor costs   and/or
  - countries with low-valued currencies

Standardization

- **The process of restructuring demanded standardization,** especially of
  - tools
  - software
  - products
  - work procedures

- **That led to „holistic" production concepts** e.g.
  - automobile industry
  - banks
  - auditing companies

..

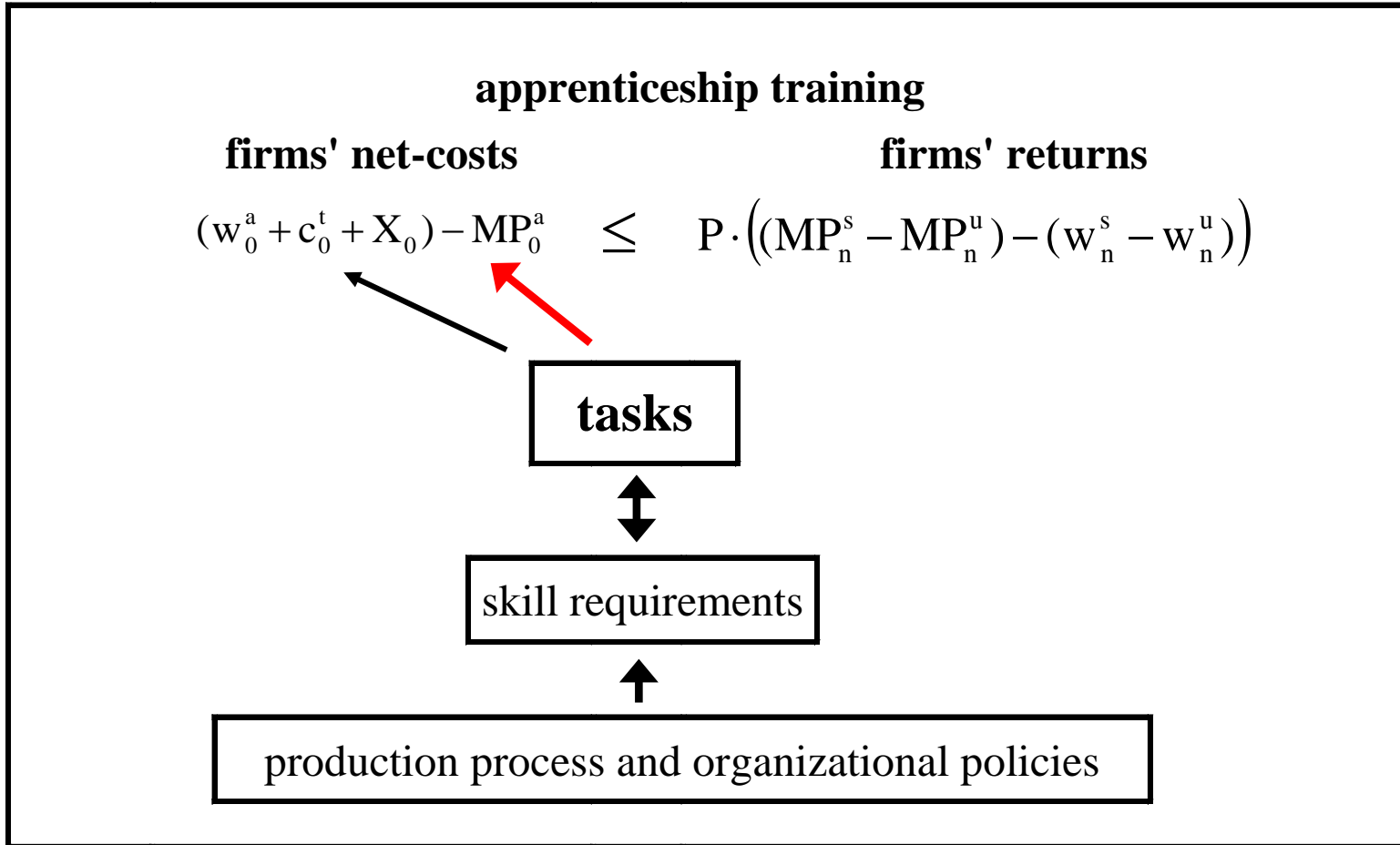# From the change of tasks to the change of training costs

The organizational restructuring of production and work led to:

- **A greater heterogeneity of tasks and skill requirements**

  – many skilled employees
    . have fewer different tasks
    . their tasks are more narrowly defined than in the past

  – some employees
    . have to carry out an increasing number of different tasks
    . they need multiple skills.

  – Heterogeneous instead of homogeneous workgroups

- **Less need for general and firm-specific expert knowledge and more need for social and communicative competence**

- **A change in the training behavior of firms**

  1. Apprentices' instruction at the workplace starts sooner

  – they are assigned a small number of different tasks with lower skill requirements and less accident-sensitive production processes

  – they can learn "in the process" and can improve their social and communicative competence on the job.

  2. The time apprentices spent in internal courses and in company training centers is reduced.

Resulting hypothesis:

Changes of work organization and tasks led to
- higher productive output of apprentices and
- lower gross costs

apprenticeship training

firms' net-costs **firms' returns**

$$(w_0^a + c_0^t + X_0) - MP_0^a \quad \leq \quad P \cdot \left((MP_n^s - MP_n^u) - (w_n^s - w_n^u)\right)$$

tasks

skill requirements

production process and organizational policies

Empirical Test – Data Set

= Cost benefit surveys (CBS) of the BIBB

- Two "independent" samples of firms in 2000 (n=1,991) and 2007 (n=2,185) are **pooled**

- **Dependent variable**:
  firms' net costs

- **Independent variables**:

  – firms' characteristics (structure variables, revenue and labor market situation)

  – year-dummy

  ≠ parameters of the cost model to "construct" the net costs

Details – see paper

Empirical Test – Cost Model

How were firms' training costs measured?

1. Direct measurement (-> cost accounting of the firms)

   e.g. – wages of apprentices
   – expenses for materials

2. "Construction" of costs as their direct measurement is not possible

a) **Productive contribution of apprentices**:
Apprentices can perform tasks that otherwise
would be carried out by unskilled workers or skilled workers.

$$MP_0^a = h_0^u w_0^u + p_0^s h_0^s w_0^s$$

$h_0^u, h_0^s =$ time on work usually done by unskilled and skilled workers respectively

$w_0^u, w_0^s =$ wage of unskilled and skilled workers respectively

$p_0^s =$ relative productivity measure (skilled work)

b) **Costs of trainers** c_0^t – see paper

...

=> **Net costs** are constructed

$$NC_0 = (w_0^a + c_0^t + X_0) - MP_0^a = w_0^a + ((1 - p_0^t)h_0^t w_0^t) - (h_0^u w_0^u + p_0^s h_0^s w_0^s)$$

Descriptives

	Firms' net costs					
	2000		**2007**		**Change of firms'**	
					net costs	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**absolute**	**in %**
Firm-size						
< 10 employees	6317	6181	4026	8263	2291	36.27
10 to 49 employees	6798	7010	4672	8562	2126	31.27
50 to 499 employees	7287	8008	5130	10000	2157	29.60
500 or more employees	13336	10408	12380	13393	956	7.17
Vocational field						
Industry and commerce	7395	7042	5348	9269	2047	27.68
Skilled crafts	6516	6510	4408	8139	2108	32.35
Agriculture	3729	6307	1234	5909	2495	66.91
Independent professions	4715	5547	1873	7182	2842	60.28
Economic sector						
Manufacturing	7222	7330	4406	8213	2816	38.99
Wholesale and retail trade	5808	5462	4578	8502	1230	21.18
Services I	6014	6164	3768	7416	2246	37.35
Services II	7492	7463	5973	10196	1519	20.27
Administration/education/health	5191	5044	2513	8378	2678	51.59
Region						
East	4848	4819	3886	7114	962	19.84
West	7094	7062	4460	8819	2634	37.13
Company training center						
No	6480	6592	3884	7891	2596	40.06
Yes	11943	8856	14298	14188	-2355	-19.72
Total	**6606**	**6702**	**4370**	**8574**	**2236**	**33.85**

Source: BIBB-Cost-Benefit-Survey (CBS) 2000 and 2007

Empirical Test – Descriptive Analysis

see paper – discussion

Empirical Test – Simple OLS-Regression

- on **pooled** data

- **dependent variable**: net costs

- **independent variables**:
  - variable of interest: year-dummy
  - controls: size; region economic sector; revenue situation; labor market situation, interaction terms => 3 different models

Results (see **table 3** in the paper**):**

– net costs are significantly lower in 2007 (compared to 2000)
   . descriptive analysis: net costs$_{2007}$ – net costs$_{2000}$ = – 2,236
   . year-dummy ranges between –2,564 and – 2,408

=> the large differences in the net costs of training between 2000 and 2007 **cannot be explained** by structural variables and the revenue and labor market situation of firms

Problem:

– It is not possible simply to include the **parameters** of the (constructed) **net costs** in the OLS because they enter the dependent variable (net costs) by construction

Net cost regression

	Model I	Model II	Model III
Year (2007 = 1)	**-2408.02*** **	**-2563.75*** **	**-2327.53*** **
Number of workers on the external labor market	212.51*	64.66	221.07*
Matching quality of workers from the external labor market	290.41**	314.02**	294.44**
Current profit situation	-178.25	-169.64	-162.86
Expected profit situation	262.37	308.47*	264.06
Expected development of the number of employees	-127.86	-119.41	-110.56
Share of apprentices with upper secondary education	290.23**	208.47	264.79**
Share of employees with tertiary education	405.72***	331.93**	419.61***
Years of training participation	74.71	180.9	58.41
Region (West = 1)	1626.62***	1550.13***	2201.14***
Firm-size	Yes	Yes	Yes
Vocational field	Yes	No	Yes
Economic sector	Yes	No	Yes
Vocation	No	Yes	No
Company training center	9520.18***	8382.45***	7276.10***
Interaction Year/Region			-910.84
Interaction Year/Firm-size	No	No	Yes
Interaction Year/Vocational field	No	No	Yes
Interaction Year/Economic sector	No	No	Yes
Interaction Year/Training center			3687.18***
Constant	6634.49***	9232.47***	6446.76***
N	4086	4086	4086
R-sq	0.199	0.247	0.204
p-values in second row; * p<0.10, ** p<0.05, *** p < 0.01			

Source: BIBB-Cost-Benefit-Survey (CBS) 2000 and 2007

Empirical Strategy – Matching Analysis as a "Way Out"

- Approach first developed by Dionisius et al. (2009)
  (Comparison of firms' training costs in Germany and Switzerland)

- **Nearest neighbour matching** (often used to evaluate ALMP)
  - "twins" of similar training firms in 2000 and 2007
  - matching variables: size; region economic sector; revenue situation; labor market situation
  - =>**counterfactual values** of the different parameters in the cost-benefit model used to construct the **net costs**
  - **parameters** used in the matching procedure
    - . allocation of tasks at the workplace
    - . relative productivity level of apprentices doing skilled tasks
    - . days spent in training centers and in internal courses
    - . training hours
    - . apprentices' wage costs
    - . trainers' wages

- **Re-estimation** of the **cost-benefit model**:
  - We replace step by step the parameters in the net cost equation by counterfactual values
  - =>we estimate the effect of hypothetically moving a firm step by step form 2000 to 2007
    (and vice versa).

Empirical Strategy – assumption of unconfoundedness or conditional independence assumption (CIA)

see discussion

## Empirical Strategy – Re-Estimation of the Cost-Benefit Model

- **Procedure**

  We replace step by step the parameters in the net cost equation by counterfactual values

  =>we simulate the effect of hypothetically moving a firm step by step from 2000 to 2007 and from 2007 to 2000 respectively

- **Results** (see graph 4 in the paper: net costs with matched variables)
  - The change of the task allocation has the biggest effect on the net costs:
    . Net costs of firms that train in 2007 would increase by more than €3,000 if they allocated the tasks for apprentices as firms training in the year 2000
    . Vice versa, net costs of firms training in 2000 would drop by well over €2,000 if firms having trained in 2000 allocated apprentices' tasks in the same way as firms in 2007.
  - Compared to the effect of task allocation, all other cost-benefit parameters included in this simulation are of lesser importance.

Matching results

Net Costs with matched variables

Legend: ■ 2000 ■ 2007
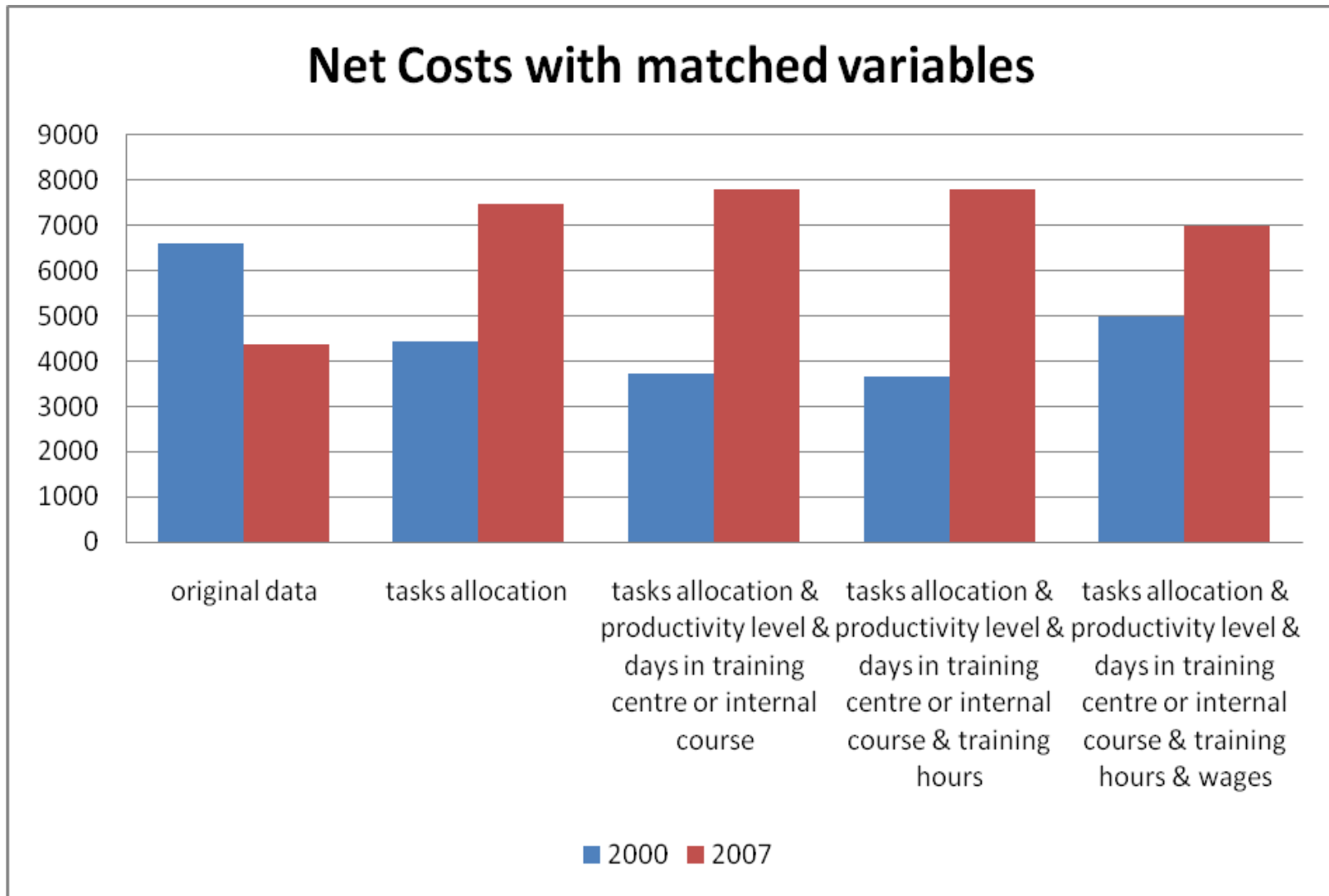
Source: BIBB-Cost-Benefit-Survey (CBS) 2000 and 2007

Empirical Strategy – Re-Running the Pooled OLS-Regression with the Counterfactual Values for the Net Costs

- **Results** (see table 4 and 5 in the paper)
  - The year-dummy decreases enormously, i.e. there would be nearly no difference in net training costs if the training behaviour of firms had not changed.
  - The most important factor responsible for the change in net costs is the change in allocating tasks to apprentices.

Net cost regression with matched values

	Model I	Model II	Model III
Year (2007 = 1)	**318.98**	**185.31**	**269.35**
Number of workers on the external labor market	119.78	2.67	126.41
Matching quality of workers from the external labor market	261.01**	272.16**	265.90**
Current profit situation	-124.74	-112.18	-131.44
Expected profit situation	223.57	260.81	217.73
Expected development of the number of employees	-322.76**	-306.71**	-295.64*
Share of apprentices with upper secondary education	216.92*	114.34	200.91*
Share of employees with tertiary education	399.22***	357.16***	397.13***
Years of training participation	-35.75	55.1	-41.52
Region (West = 1)	1979.99***	1901.32***	2285.56***
Firm-size	Yes	Yes	Yes
Vocational field	Yes	No	Yes
Economic sector	Yes	No	Yes
Vocation	No	Yes	No
Company training center	7943.80***	6904.23***	7341.10***
Interaction Year/Region			-514.9
Interaction Year/Firm-size	No	No	Yes
Interaction Year/Vocational field	No	No	Yes
Interaction Year/Economic sector	No	No	Yes
Interaction Year/Training center			1030.71
Constant	6450.44***	8604.66***	6365.94***
N	4086	4086	4086
R-sq	0.215	0.262	0.218
p-values in second row; * p<0.10, ** p<0.05, *** p < 0.01			

Source: BIBB-Cost-Benefit-Survey (CBS) 2000 and 2007

Conclusions

Starting point:

– Changes in the organization of working processes led to a redefinition of tasks
  to be performed by workers.

– Hypothesis:
   This change of tasks was a major reason for the sharp decrease of firms' training costs
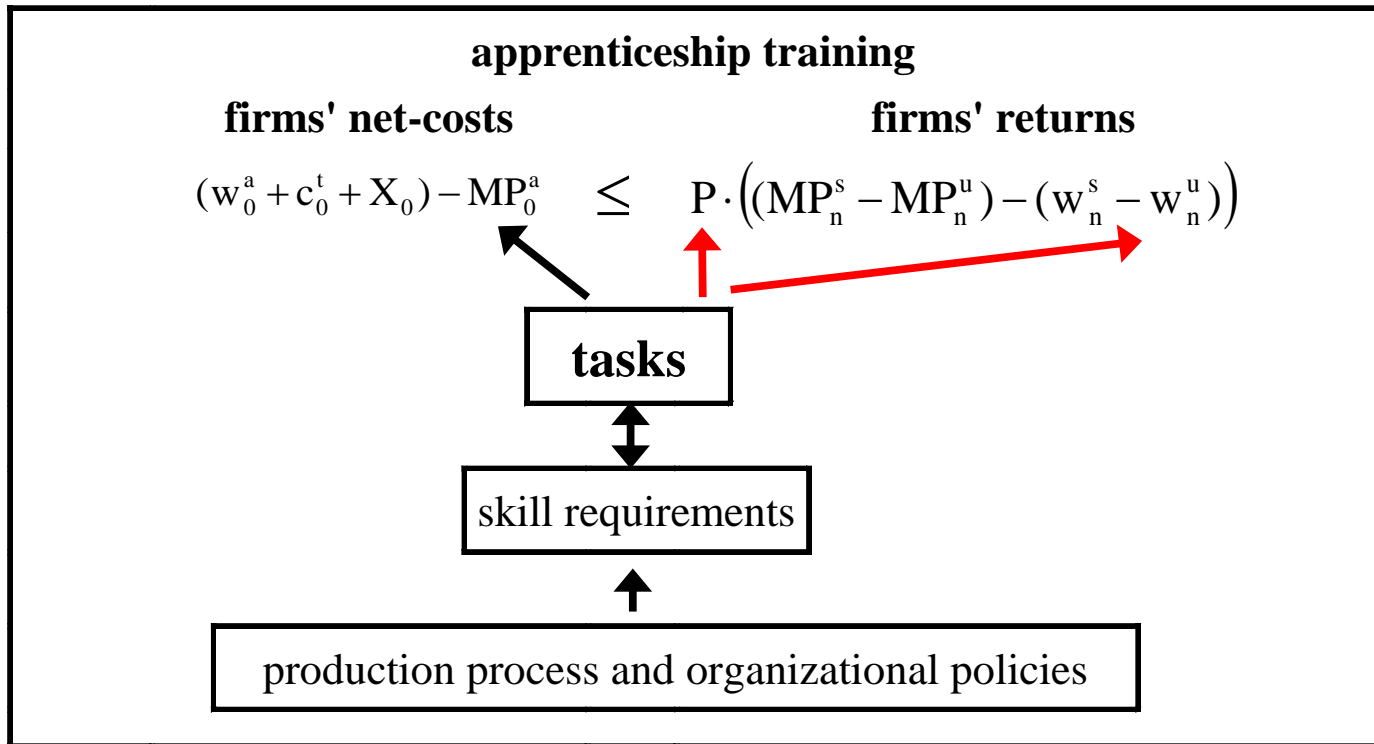
Empirical Analysis and Results:

– Apprentices spend more time on productive tasks and less time on instruction or
  self-learning.

– The decrease in firms' net costs of apprenticeship training is mainly driven by these
  changes in the organization of training

Alternativ explanations for the decrease in training costs:

– Differences in the ability of apprentices.

– Changes in labor market institutions resulting in
   . lower average tenure
   . and higher skill-specific wage-differentials.
   That could have reduced the firms' willingness to accept high(er) training costs.
   Investing in human capital becomes riskier leading firms to either reduce their training
   costs or not train at all.
 .

Further explanations of the decrease of firms' training costs: Lower returns of appren-
ticeship training due to   – higher wage-specific wage differential
                             – lower average tenure

apprenticeship training

firms' net-costs   **firms' returns**

$$(w_0^a + c_0^t + X_0) - MP_0^a \quad \leq \quad P \cdot \left((MP_n^s - MP_n^u) - (w_n^s - w_n^u)\right)$$

tasks

skill requirements

production process and organizational policies

Empirical strategy – assumption of unconfoundedness or conditional independence assumption (CIA)

= there are no unobserved covariates effecting both
  – treatment assignment
    i.e. firms' decision not to train any longer (or to start training
    between 2000 and 2007)
  – outcome, i.e. parameters of the net costs

!! There might be such unobserved covariates, but

- **Rosenbaum-bound analysis shows**
  the sensitivity of the treatment effects to a violation of the CIA is very very low,
  especially for the productive time of apprentices (h_0^u, h_0^s)

- For our **hypothesis** it is **not so important,** if the effect of the change of the
  productive time of apprentices between 2000 and 2007 would be 10% higher or
  lower.
  Crucial is that these parameters have by far the largest influence upon net costs.

  ! That's different from evaluating ALMP.

Literature
Models of apprenticeship training
building on net costs of VET

1. Firms bear **no net costs**: $NC_0 = 0$ if

$$MP_0^a = w_0^a + c_0^t + X_0$$

⇨ **Production-oriented models of training**
(see Lindley, 1975; Neubäumer, 1999; Fougère and Schwerdt, 2002)

2. Firms bear **high net costs**: $NC_0 >> 0$ if

$$w_0^a = w_0^u$$

(w_0^u = wage of an unskilled worker in period 0)

⇨ **Investment-oriented models of training**
(see Acemoglu and Pischke (1998, 1999a, 1999b, 2000) Franz (1982), Kempf (1985),
Lehne (1991), Neubäumer (1993, 1999))

⇨ Firms (must) have **returns of VET**
i.e. $MP_n^t > w_n^t$ and $P > 0$

From the change of tasks to the change of training costs

The organizational restructuring of production and work led to:

• A greater heterogeneity of tasks and skill requirements

- many skilled employees
  . have fewer different tasks
  . their tasks are more narrowly defined than in the past
  . they often have skilled routine jobs
  . they need less general and firm-specific expert knowledge

- some employees
  . have to carry out an increasing number of different tasks
  . they need multiple skills.

- Heterogeneous instead of homogeneous workgroups

• Less need for general and firm-specific expert knowledge and more need for social and communicative competence

• A change in the training behavior of firms

1. Apprentices' instruction at the workplace starts sooner

- they are assigned a small number of different tasks with lower skill requirements and less accident-sensitive production processes

- they can learn "in the process" and can improve their social and communicative competence on the job.

2. The time apprentices spent in internal courses and in company training centers is reduced,

Conclusions

➢ Globalization and increasing cost pressure for firms lead to a redefinition of tasks to be performed by workers

➢ Hypothesis: This had an impact on firms' training costs

➢ Empirical analysis shows that the decrease in firms' net costs of apprenticeship training was mainly driven by changes in the organization of training:

➢ Apprentices spend more time on productive tasks and less time on instruction or self-learning

➢ A number of alternative explanations for the decrease in training costs exist

➢ Further research necessary