# The relationship between research and teaching in HEIs: recent empirical findings


Politecnico di Torino

Domenico Augusto Maisano

# RESEARCH & TEACHING

- They are the two predominant knowledge-dissemination activities of academics.
- For most HEIs, these activities are closely connected, with mutual stimulation and improvement.
- However, the policies of many HEIs generally promote research at the expense of teaching:
  - Career advancements (and salaries) are linked only to research results;
  - Teaching evaluation (if any) does not affect any incentives/penalties;
  - HEIs generally encourage young researchers to pursue research activities. They rarely offer training paths for teaching.

# STATE OF THE ART

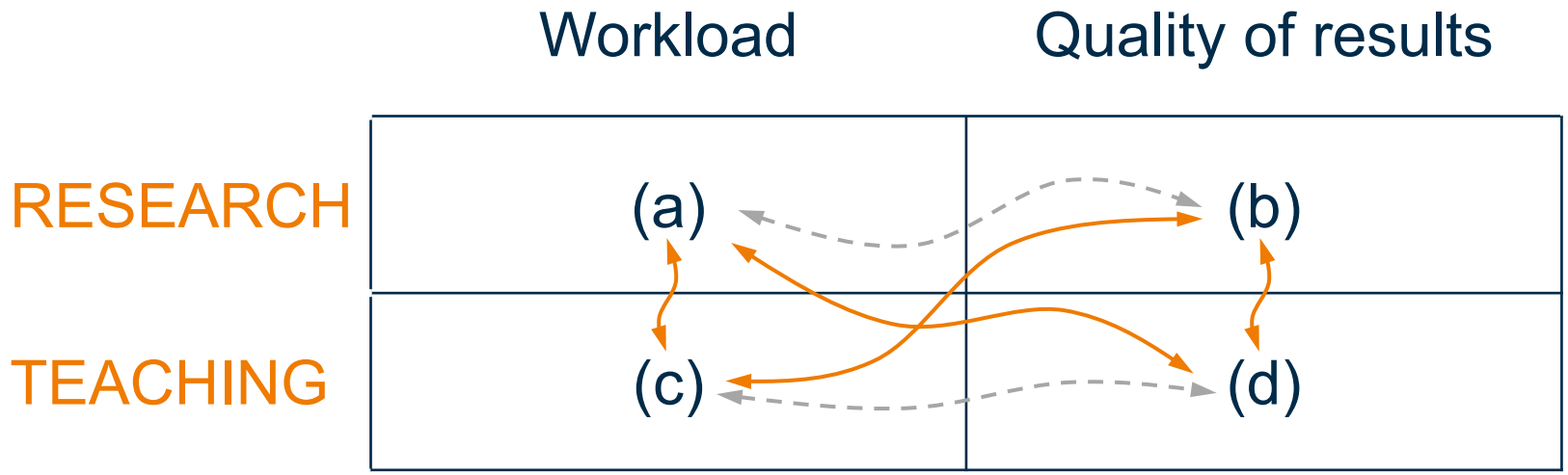
- The research-teaching link has been investigated for over half a century, with often conflicting conclusions.
  - "There is a positive mutual stimulus".
  - "Research and teaching are most often disconnected and even in conflict".
  - "There is a positive correlation concerning excellent academics, which sounds like: *Best researchers are often best teachers*".
  - "Good teachers are not necessarily good researchers (and *vice versa*)".
  - "There's a potential synergy between research and teaching that should be cultivated and stimulated with appropriate institutional tools/incentives".

# WHY SUCH CONTRADICTIONS?

- Studies rely on relatively small samples of academics.
- Evaluations are qualitative and based on the results of subjective indicators.
- Heterogeneous analysis methodologies in different socio-cultural contexts.
- Several results were observed in different disciplines.

# GOAL

- Analyzing the link between research and teaching from the dual perspective of workload and quality of results obtained by individual academics.




[item #1] [item #2]

(a) vs. (b)
(a) vs. (c)
(a) vs. (d)
(b) vs. (c)
(b) vs. (d)
(c) vs. (d)

Research questions: "Is there any (direct/inverse) link between [item #1] and [item #2] for individual academics?"

# METHODOLOGY (Sample selection)

- Each tenured academic from Italian universities belongs to one-and-only-one specific discipline (SSD), around 370 in all, with significant differences in terms of propensity to publish and cite.
- We have selected a sample of PoliTO academics, who belong to 16 disciplines and were active in the period from 2013 to 2020.

| Discipline | Abbreviation (SSD) | Staff number (*N*) | |
|---|---|---|---|
| | | PoliTO | All Italian universities |
| A. Chemical foundations of technologies | CHIM/07 | 11 | 140 |
| B. Physics of matter | FIS/03 | 15 | 292 |
| C. Structural mechanics | ICAR/08 | 14 | 256 |
| D. Thermal engineering and industrial energy systems | ING-IND/10 | 12 | 127 |
| E. Applied mechanics | ING-IND/13 | 23 | 162 |
| F. Mechanical design and machine construction | ING-IND/14 | 22 | 140 |
| G. Design methods for industrial engineering | ING-IND/15 | 4 | 75 |
| H. Manufacturing technology and systems | ING-IND/16 | 16 | 134 |
| I. Industrial mechanical plants | ING-IND/17 | 5 | 129 |
| J. Materials science and technology | ING-IND/22 | 19 | 188 |
| K. Excavation engineering and safety | ING-IND/28 | 5 | 18 |
| L. Electrical engineering | ING-IND/31 | 14 | 158 |
| M. Business and management engineering | ING-IND/35 | 8 | 168 |
| N. Telecommunications | ING-INF/03 | 26 | 291 |
| O. Information processing systems | ING-INF/05 | 43 | 583 |
| P. Mathematical analysis | MAT/05 | 14 | 583 |
| | **Total** | **251** | **3444** |

# METHODOLOGY (Sample selection)

- For each academic, only papers published on international scientific journals from 2018 to 2020 were considered.
- Publications produced later were excluded as they are still too "immature" in terms of citation impact.
- For each paper, the following data were also collected:
  - Issue year (i.e., 2018, 2019 or 2020);
  - Number of co-authors;
  - Number of citations obtained by journal papers up to the time of data collection (i.e., October 2022).

# METHODOLOGY (Research)

1) normalization by no. of co-authors

***(a) Discipline-normalised total no. of papers, fractionalized by no. of co-authors:***

$$P_j = \frac{\text{Total no. of fractionalized papers by the academic } j \text{ (from PoliTO)}}{\text{Avg. tot. no. of fractionalized papers by all Italian academics in the same discipline of } j} = \frac{\sum_{\forall i \text{ by } j}\left(\frac{1}{a_{i,j}}\right)}{\left\{\frac{\sum_{\forall k \in All}\left[\sum_{\forall i \text{ by } k}\left(\frac{1}{a_{i,k}}\right)\right]}{N}\right\}},$$

2) discipline normalization

$j$ being the academic of interest from PoliTO;

$All \equiv \{\ldots, j, \ldots\}$ being the set of academics from all Italian universities, in the same discipline of $j$;

$k$ being a generic academic $\in All$;

$N = |All|$ being the cardinality of the set $All$;

$i$ being the generic $i$-th paper by the $j$-th/$k$-th academic;

$a_{i,*}$ being the number of co-authors of the $i$-th paper by the $j$-th/$k$-th academic (i.e., "*" in the subscript).

**1st Indicator → Quadr. (a)**
$P_j$ will be used as a proxy for the research workload

# METHODOLOGY (Research)

***(b) Discipline-normalised average no. of citations per paper:***

$$C_j = \frac{\sum_{\forall y}\left\{\frac{\text{Avg . no . of cites per paper issued in the year } y\text{, for the academic } j \text{ (from PoliTO)}}{\text{Avg . no . of cites per paper issued in the year } y\text{, for all Italian academics in the same discipline of } j}\right\}}{\text{no . of issue years}} = \frac{\sum_{\forall y}\left\{\frac{\frac{\sum_{\forall i \text{ by } j,y}\left(c_{i,j,y}\right)}{|i \text{ by } j,y|}}{\left(\frac{\sum_{\forall k \in All}\left[\frac{\sum_{\forall i \text{ by } k,y}\left(c_{i,k,y}\right)}{|i \text{ by } k,y|}\right]}{N}\right)}\right\}}{3}$$

2) age-normalization

1) discipline-normalization

$j$ being the academic of interest from PoliTO;

$All \equiv \{\ldots, j, \ldots\}$ being the set of academics from all Italian universities, in the same discipline of $j$;

$k$ being a generic academic $\in All$;

$N = |All|$ being the cardinality of the set $All$;

$i$ being the generic $i$-th paper by the $j$-th/$k$-th academic;

$c_{i,*,y}$ being the total number of citations obtained up to the moment of data collection (i.e., October 2022) by the $i$-th paper of the $j$-th/$k$-th (i.e., "*" in the subscript) academic of interest, issued in the $y$-th year;

$|i \text{ by } *, y|$ being the total number of papers, issued in the year $y$, of the $j$-th/$k$-th academic of interest;

$y \in \{2018, 2019, 2020\}$ being the single issue year (the total issue years are $|y|=3$).

**2nd Indicator → Quadr. (b)**

$C_j$ will be used as a proxy for the quality of research results

# METHODOLOGY (Teaching)

$$w_j = \sum_{\forall c \text{ by } j} \left( s_{c_j} \cdot ECTS_{c_j} \right), \quad (4)$$

**3rd Indicator → Quadr. (c)**
$w_j$ will be used as a proxy for the teaching workload

$c$ being each course taught by $j$ during the three-year reference period (2017-18, 2018-19 and 2019-20);

$s_{c_j}$ being the number of students in the specific $c$-th course held by $j$;

$ECTS_{c_j}$ being the number of ECTS credits associated with each $c$-th course held in the reference period by $j$.

$w_j$ can be interpreted as the total number of credits obtained by students who attended the course(s) held by $j$, i.e., a proxy for the quantitative impact of these course(s) on the student population. This indicator is currently used in PoliTO as a proxy for the teaching workload of individual faculty members.

This aggregation through a multiplicative model is typical of indicators that aggregate heterogeneous quantities (e.g., in this case, number of students and number of ECTS credits) (Franceschini et al, 2019; 2022).

# METHODOLOGY (Teaching)

| Aspect | Question | |
|---|---|---|
| Course period | q1. | Is the overall teaching load acceptable? |
| | q2. | Is the teaching schedule well organized? |
| Course organization | q3. | Have the examination procedures been clearly defined and explained? |
| | q4. | Was the teaching done consistently with what stated on the "Teaching Portal"? |
| | q5. | Was my prior knowledge sufficient for understanding the subject matter? |
| | q6. | Is the workload required by this course commensurate with the credits awarded? |
| | q7. | Are the course materials (both recommended and provided) adequate for the study of the subject matter? |
| | q8. | Are supplemental educational activities (tutorials, labs, seminars, visits, etc.) useful for learning the subject matter? |
| Teaching effectiveness | q9. | Does the teacher (academic) adhere to teaching schedules? |
| | q10. | Is the teacher (academic) available to provide clarification and explanation? |
| | q11. | Does the teacher (academic) interact effectively with students, stimulating their interest in the subject matter? |
| | q12. | Does the teacher (academic) clearly present the topics? |
| | q13. | Do you believe that the teacher (academic) has effectively coordinated the teaching activities of his/her collaborators (if any)? |
| Infrastructure | q14. | Are the classrooms appropriate? |
| | q15. | Are the facilities and equipment for supplemental instructional activities appropriate? |
| Interest and satisfaction | q16. | Am I interested in the topics of this course (regardless of how they were taught)? |
| | q17. | Am I satisfied with how this course was taught (regardless of my personal interest in the topics)? |
| | q18. | For the purpose of learning, is course attendance helpful? |

$$e_{c_j} = \frac{\sum_{q=q9}^{q13} \left( e_{c,q_j} \right)}{5}$$

Table 1. Example of questionnaire submitted to PoliTO students at the end of each (B.Sc. or M.Sc.) course (translation from Italian). Each of the eighteen questions (q1 to q18) is evaluated on a four-level ordinal scale, 1 = "Definitely not", 2 = "More no than yes", 3 = "More yes than no", 4 = "Definitely yes", expressing an increasing level of liking/satisfaction regarding a certain aspect of interest.

# METHODOLOGY (Teaching)

The second indicator, which depicts the average teaching effectiveness, is defined as:

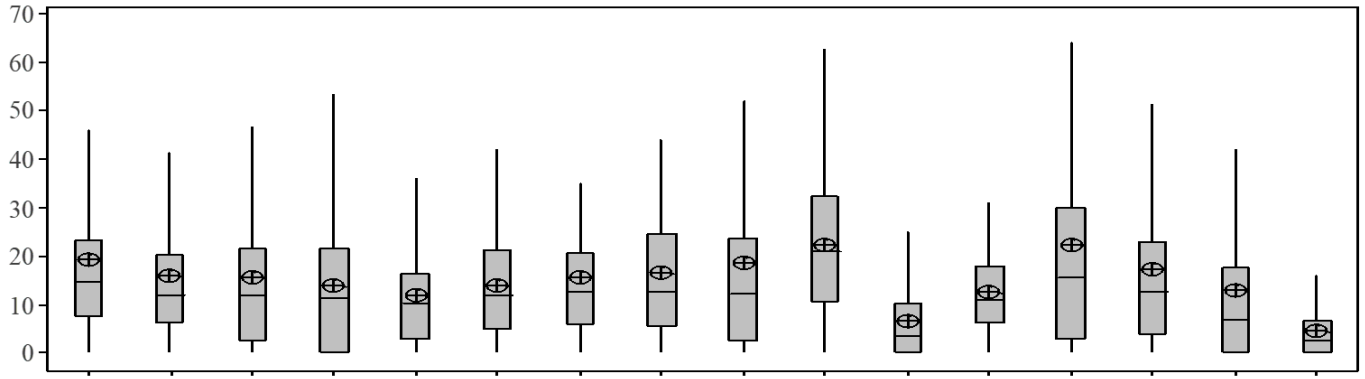
$$e_j = \frac{\sum_{\forall c \text{ by } j}\left(e_{c_j} \cdot ECTS_{c_j}\right)}{\sum_{\forall c \text{ by } j}\left(ECTS_{c_j}\right)} . \quad (5)$$

**4th Indicator → Quadr. (d)**
$e_j$ will be used as a proxy for the quality of teaching results

$e_j$ is actually a weighted average of the $e_{c_j}$ values (cf. Eq. 3) with respect to the corresponding ECTS credits; it will be used as a proxy for the quality of teaching.

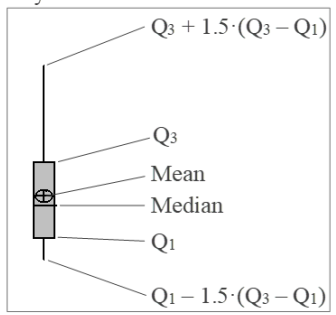
# RELEVANCE OF NORMALIZATIONS

Boxplot of the average citations per paper for individual academic, discipline by discipline (articles issued in 2018)

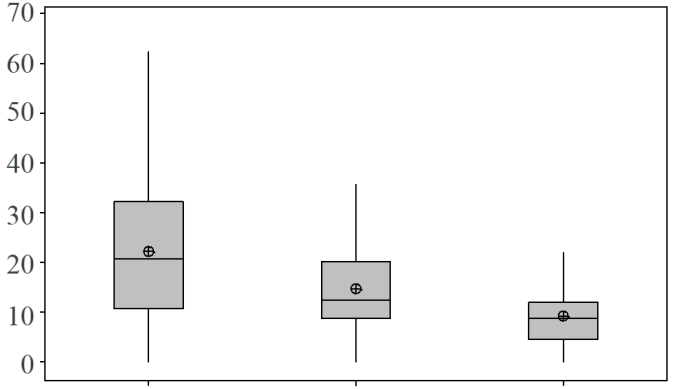



| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 19.2 | 15.7 | 15.4 | 13.7 | 12.0 | 13.7 | 15.6 | 16.5 | 18.6 | 22.3 | 6.6 | 12.4 | 22.2 | 17.3 | 13.0 | 4.5 |
| St. dev. | 20.8 | 17.2 | 17.0 | 13.3 | 11.6 | 10.9 | 17.0 | 18.3 | 23.3 | 15.3 | 8.0 | 9.6 | 29.6 | 20.6 | 21.2 | 7.3 |
| $Q_1$ | 7.5 | 6.3 | 2.6 | 0.0 | 2.9 | 5.0 | 6.0 | 5.5 | 2.5 | 10.6 | 0.0 | 6.3 | 3.0 | 4.0 | 0.0 | 0.0 |
| Median | 14.6 | 12.0 | 12.0 | 11.3 | 10.3 | 12.0 | 12.4 | 12.6 | 12.3 | 20.7 | 3.4 | 11.0 | 15.6 | 12.6 | 7.0 | 2.5 |
| $Q_3$ | 23.3 | 20.3 | 21.6 | 21.4 | 16.3 | 21.4 | 20.4 | 24.5 | 23.5 | 32.4 | 10.3 | 18.0 | 29.7 | 23.0 | 17.7 | 6.4 |
| Min | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Max | 190.0 | 153.8 | 99.4 | 75.3 | 69.0 | 53.4 | 117.7 | 133.0 | 121.0 | 86.0 | 25.0 | 59.0 | 238.0 | 192.5 | 229.0 | 106.0 |
| N | 140 | 292 | 256 | 127 | 162 | 140 | 75 | 134 | 129 | 188 | 18 | 158 | 168 | 291 | 583 | 583 |

Key:

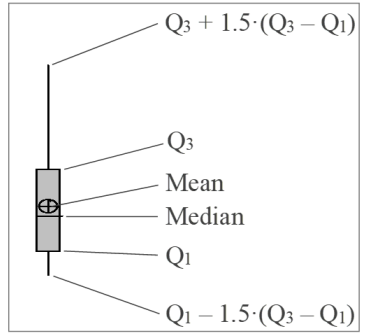



Boxplot of the average citations per paper for individual academic, referring to discipline J




| | 2018 | 2019 | 2020 |
|---|---|---|---|
| Mean | 22.3 | 14.7 | 9.3 |
| St. dev. | 15.3 | 10.3 | 7.6 |
| $Q_1$ | 10.6 | 8.7 | 4.5 |
| Median | 20.7 | 12.4 | 8.8 |
| $Q_3$ | 32.4 | 20.2 | 12.0 |
| Min | 0.0 | 0.0 | 0.0 |
| Max | 86.0 | 64.0 | 72.0 |
| N | 188 | 188 | 188 |

Key:



# RESULTING INDICATORS

| Discipl. | Academic | Acad. position | Gend. | (a) $P_j$ | (b) $C_j$ | (c) $w_j$ | (d) $e_j$ |
|---|---|---|---|---|---|---|---|
| A. CHIM/07 | A.1 | Associate | M | 0.678 | 1.064 | 10016 | 3.623 |
| A. CHIM/07 | A.2 | Associate | F | 0.663 | 0.690 | 11244 | 3.068 |
| A. CHIM/07 | A.3 | Associate | F | 1.402 | 1.043 | 10496 | 3.190 |
| A. CHIM/07 | A.4 | Full | F | 2.294 | 0.658 | 10802 | 2.769 |
| A. CHIM/07 | A.5 | Full | M | 1.687 | 2.412 | 12616 | 3.457 |
| A. CHIM/07 | A.6 | Associate | F | 1.720 | 1.552 | 17928 | 3.161 |
| A. CHIM/07 | A.7 | Full | M | 0.487 | 1.717 | 14860 | 3.274 |
| A. CHIM/07 | A.8 | Full | M | 1.698 | 4.179 | 19664 | 3.580 |
| A. CHIM/07 | A.9 | Associate | F | 0.559 | 1.059 | 10394 | 3.725 |
| A. CHIM/07 | A.10 | Assistant | F | 0.438 | 0.726 | 10678 | 3.566 |
| A. CHIM/07 | A.11 | Full | M | 1.265 | 1.255 | 3768 | 3.080 |
| B. FIS/03 | B.1 | Associate | F | 0.402 | 0.551 | 8934 | 2.875 |
| B. FIS/03 | B.2 | Associate | M | 1.300 | 0.774 | 5152 | 3.611 |
| B. FIS/03 | B.3 | Associate | M | 0.576 | 0.960 | 13800 | 3.454 |
| ... | ... | ... | ... | ... | ... | ... | ... |

# CORRELATION ANALYSIS

| (Sub-)set of academics | | $P_j$ vs. $C_j$ (a) vs. (b) | $P_j$ vs. $w_j$ (a) vs. (c) | $P_j$ vs. $e_j$ (a) vs. (d) | $C_j$ vs. $w_j$ (b) vs. (c) | $C_j$ vs. $e_j$ (b) vs. (d) | $w_j$ vs. $e_j$ (c) vs. (d) |
|---|---|---|---|---|---|---|---|
| Total | | **0.224*** | **0.129*** | 0.105 | 0.033 | 0.043 | -0.057 |
| | (N = 251) | (0.000) | (0.042) | (0.102) | (0.597) | (0.505) | (0.373) |
| Discipline | A. CHIM/07 | 0.327 | 0.239 | -0.516 | **0.656*** | 0.356 | 0.194 |
| | (N = 11) | (0.326) | (0.479) | (0.104) | (0.029) | (0.282) | (0.568) |
| | B. FIS/03 | **0.518*** | -0.163 | 0.281 | 0.068 | 0.078 | -0.457 |
| | (N = 15) | (0.048) | (0.563) | (0.310) | (0.809) | (0.783) | (0.087) |
| | C. ICAR/08 | 0.351 | 0.077 | -0.199 | -0.166 | -0.010 | 0.096 |
| | (N = 14) | (0.219) | (0.792) | (0.496) | (0.570) | (0.972) | (0.744) |
| | D. ING-IND/10 | **0.702*** | 0.310 | 0.106 | **0.592*** | 0.007 | **-0.639*** |
| | (N = 12) | (0.011) | (0.326) | (0.743) | (0.042) | (0.983) | (0.025) |
| | E. ING-IND/13 | 0.377 | 0.338 | -0.063 | 0.304 | 0.061 | 0.174 |
| | (N = 23) | (0.076) | (0.115) | (0.787) | (0.159) | (0.792) | (0.451) |
| | F. ING-IND/14 | 0.270 | **0.546*** | -0.191 | 0.066 | -0.264 | **-0.443*** |
| | (N = 22) | (0.224) | (0.009) | (0.393) | (0.771) | (0.235) | (0.039) |
| | G. ING-IND/15 | 0.916 | **0.965*** | 0.513 | 0.927 | 0.652 | 0.718 |
| | (N = 4) | (0.084) | (0.035) | (0.487) | (0.073) | (0.348) | (0.282) |
| | H. ING-IND/16 | -0.010 | -0.139 | 0.260 | -0.223 | 0.224 | 0.061 |
| | (N = 16) | (0.972) | (0.608) | (0.331) | (0.407) | (0.404) | (0.821) |
| | I. ING-IND/17 | **0.965*** | 0.716 | -0.077 | 0.692 | -0.087 | -0.668 |
| | (N = 5) | (0.008) | (0.174) | (0.902) | (0.195) | (0.890) | (0.218) |
| | J. ING-IND/22 | **0.469*** | 0.185 | 0.345 | 0.451 | -0.144 | -0.028 |
| | (N = 19) | (0.043) | (0.450) | (0.161) | (0.053) | (0.568) | (0.911) |
| | K. ING-IND/28 | 0.381 | 0.039 | -0.129 | -0.556 | -0.223 | -0.570 |
| | (N = 5) | (0.527) | (0.950) | (0.836) | (0.331) | (0.718) | (0.316) |
| | L. ING-IND/31 | **0.673*** | 0.322 | 0.527 | 0.022 | 0.362 | 0.261 |
| | (N = 14) | (0.008) | (0.262) | (0.053) | (0.940) | (0.204) | (0.368) |
| | M. ING-IND/35 | 0.665 | -0.426 | -0.324 | 0.253 | -0.648 | -0.151 |
| | (N = 8) | (0.072) | (0.292) | (0.433) | (0.545) | (0.083) | (0.721) |
| | N. ING-INF/03 | -0.002 | -0.179 | 0.126 | -0.242 | -0.098 | -0.303 |
| | (N = 26) | (0.993) | (0.381) | (0.558) | (0.234) | (0.648) | (0.150) |
| | O. ING-INF/05 | 0.142 | -0.062 | 0.129 | -0.192 | **-0.389*** | 0.051 |
| | (N = 43) | (0.362) | (0.691) | (0.411) | (0.217) | (0.010) | (0.747) |
| | P. MAT/05 | 0.253 | 0.114 | 0.400 | -0.044 | 0.512 | -0.431 |
| | (N = 14) | (0.382) | (0.698) | (0.175) | (0.881) | (0.074) | (0.142) |

| | Workload | Quality of results |
|---|---|---|
| RESEARCH | (a) $P_j$ | (b) $C_j$ |
| TEACHING | (c) $w_j$ | (d) $e_j$ |

| (Sub-)set of academics | | $P_j$ vs. $C_j$ (a) vs. (b) | $P_j$ vs. $w_j$ (a) vs. (c) | $P_j$ vs. $e_j$ (a) vs. (d) | $C_j$ vs. $w_j$ (b) vs. (c) | $C_j$ vs. $e_j$ (b) vs. (d) | $w_j$ vs. $e_j$ (c) vs. (d) |
|---|---|---|---|---|---|---|---|
| Acad. position | Full Profs. | **0.204*** | 0.064 | 0.126 | 0.134 | 0.172 | -0.081 |
| | (N = 112) | (0.031) | (0.504) | (0.185) | (0.158) | (0.069) | (0.395) |
| | Associate Profs. | 0.132 | 0.084 | 0.044 | -0.111 | -0.150 | -0.110 |
| | (N = 119) | (0.154) | (0.363) | (0.638) | (0.231) | (0.110) | (0.242) |
| | Assistant Profs. | **0.463*** | 0.170 | 0.199 | -0.049 | -0.127 | 0.231 |
| | (N = 20) | (0.040) | (0.474) | (0.430) | (0.836) | (0.614) | (0.356) |
| Gender | Male | **0.299*** | 0.119 | 0.120 | 0.089 | 0.032 | -0.042 |
| | (N = 189) | (0.000) | (0.102) | (0.103) | (0.225) | (0.663) | (0.574) |
| | Female | 0.083 | 0.174 | 0.043 | -0.075 | 0.080 | -0.103 |
| | (N = 62) | (0.521) | (0.176) | (0.745) | (0.560) | (0.545) | (0.435) |

# CORRELATION ANALYSIS

- Very few statistically significant correlations (i.e., p-value < 0.05).
- **(a) vs. (b)** The (weak) positive correlation between $P_j$ and $C_j$ confirms that research productivity and impact "go hand in hand".
- **(a) vs. (c)** The hypothesis of a negative link between research workload and teaching workload seems to be rejected.
- **(b) vs. (c)** Some correlations are only present at the level of specific discipline, such as that between $C_j$ and $w_j$ for disciplines "A" and "D".
- **(b) vs. (d)** Again, the lack of correlation shows that those academics who produce research with the highest average impact/diffusion to the scientific community are not necessarily the most didactically effective.
- **(c) vs. (d)** The study shows absence of correlation. The only exception is the "D" and "F" disciplines (cf. Table 3) for which a negative link is observed that would be interpreted as *Those who do less teaching tend do it better*.

# CONCLUSIONS

## Original contributions

- Partially contrasting with other studies, the present one reveals a certain decoupling between research and teaching. Firstly, there seems to be no negative link to support considerations like: "*Those who do more teaching tend to neglect research more*".
- The quality of teaching results seems to be unrelated to both (i) the quantity and (ii) the quality of research products.
- The results of the study can be taken into consideration by people involved in formulating incentive strategies within universities.
- A relevant aspect of the present study is the use of quantitative indicators built on a very large database (e.g., more than 3000 other Italian academics).

# CONCLUSIONS

## Limitations

- The indicators in use are still proxies for what they are meant to represent.
- The study is limited to academics from a single technical university: PoliTO. Therefore, results do not necessarily apply to other universities.
- The assessment of the research and teaching workloads could have been more in-depth by having additional specific data (e.g., about ongoing research projects, no. of students tutored for internships or dissertations, etc.).

## Future research

- Constructing a factorial plan to evaluate the effects and interactions of certain factors (discipline, gender, academic position, etc.).
- Extending the study to other technical and generalist universities.

# Thank you for your attention

domenico.maisano@polito.it
orcid.org/0000-0002-8154-4469
www.qualityengineering.polito.it