

TAKING
COOPERATION
FORWARD

 **4STEPS 3rd Partner Meeting**
10th March 2020 - online

 **D.T.1.3.1_ Setting up of the TML index_FINAL**

 RE:Lab - CNA_PBN

$$M_i = \frac{\sum_{i=1}^n M_{Di} * g_D}{\sum_{i=1}^n g_D}$$

The formula remains unaltered while dimensions that are taken into account when computing the TML are different or either differently constructed and/or measured, trying to shift the focus from formal achievements to firms' characteristics and behavior. In addition, we included two additional dimensions to take into account the actual efforts put in place by the firms to pursue Industry 4.0 innovations.



(1) RELATED VARIETY

Related variety is a key-concept in both evolutionary economic geography and economics of innovation, linking knowledge spillovers to overall economic growth and relying on Jacob's (1969) theory of externalities of agglomeration, consisting in inter-industrial spillovers (Gleaser et al., 1992). To generate these externalities a geographic area (usually either a urban/metropolitan or a regional area) should encompass a VARIETY of industries that must be cognitively related (Franken et al., 2007; Boshma, 2014) thus maximising learning opportunities, cross fertilization, etc.

It is usually measure through entropy indexes, relying input-output tables in order to postulate linkages between different sectors.



ENTROPY AS RV

$$D_i = \frac{\sum_i^n S_C + S_S}{n} - S_i$$

Where the entropy of the relative environment of firm i is proxied by the difference between the average of the sectors in which its suppliers and buyers are operating and the sectors in which the firm is operating. Of course, if the summation of the two terms is above or equal to zero we have Related variety and none otherwise.

This measure can be transformed in several ways:

- Operationalised as a dummy variable, 1 if $D_i > 0$ and 0 otherwise;
- Operationalised as a percentage of sectors exceeding the sectors in which the firm is operating;
- Translated into ordered variables and standardised scales starting from either the entropy score, the dummy or the percentage.



OPERATIONALISATION

Question number 4 in the 4steps questionnaire lists 27 sectors of economic activity and asks respondents to mark down all the sectors in which their firm is operating along with all the sectors in which its customers and suppliers are operating as well. As a result, we have 3 figures:

- a. the number of sectors in which the respondent's firm is operating;
- b. the number of sectors in which its customers are operating;
- c. the number of sectors in which its suppliers are operating.

We compute the "Related variety" dimension in 2 steps:

We compute the average number of sectors in which customers and suppliers are operating:

$$AVERAGE = (b + c)/2$$

We subtract this average from the sectors of the respondent's firm:

$$RELATED\ VARIETY = (AVERAGE - a)/a$$

In this way, we obtain a percentage number that can be either positive or negative.



(2) HR AND ABSORPTIVE CAPACITIES

Skilled workers (graduates) boost the accumulation and production of knowledge, increase the speed of learning capacities (Lucas, 1988) and enable better interactions between human and physical capital (see SBTC, Katz and Murphy, 1992; Acemoglu, 1996; Katz, 1999), favouring absorptive capacities and constituting a source of positive localisation externalities and/or brain-gap and path-dependence growth patterns (Pianta, 2005; Glaeser and Berry, 2006).

The share of graduates on the total labour force is of course a good proxy for the quality and concentration of good human capital. One may want to operationalise it only in terms of employees operating in R&D departments or other relevant occupations rather than the firm as a whole or, alternatively, can make reference to either external or internal flexibility (Caroli, 2007).



MEASURE FOR HC

“If you have a R&D office, please describe the composition of the staff” asking respondents to state the percentage of graduates or PhDs in two departments usually involved in innovation activities: R&D and “Ufficio tecnico”.

The measure is a simple average of the share of graduates in the two above mentioned offices:

$$HC_i = \frac{HE_RD_i + HE_UT_i}{2}$$



OPERATIONALISATION (HC)

Question number 7 in the questionnaire asks respondents to state how many employees are currently employed in R&D offices and technical offices and, among them, how many have a tertiary education background. We have 6 distinct figures as a result:

- a. Total Staff in R&D office
- b. Staff in R&D office with University degree (BA as minimum)
- c. Staff in R&D office with PhD
- d. Total Staff in in technical office
- e. Staff in technical office with University degree (BA as minimum)
- f. Staff in technical office with PhD



OPERATIONALISATION (HC) - 2

We now want to know what is the share of people working in these offices with a HE background. Once again, the process is articulated in 2 steps:

We compute the share of graduates in R&D and technical offices

$$HE_{RD} = \frac{b + c}{a} ; HE_{TO} = \frac{e + f}{d}$$

We compute the average share of graduates between the two offices:

$$HC = \frac{HE_{RD} + HE_{TO}}{2}$$

In this way, we obtain the overall percentage of people with at least a bachelor degree in these offices and the percentage will be positive.



(3) FUND RAISING AND BEHAVIOURAL ADDITIONALITY: PROJECT MANAGEMENT (PM)

Cooperation with innovation systems' building blocks (institutions, other firms, universities, etc.) and the capability to raise funds to be devoted to innovative activities can be considered a highly informative item that proxies firms' behaviour and attitudes (Nelson, 1993; Lundvall, 1992; Metcalfe, 1995; Giuliani, Pietrobelli and Rabelotti, 2005).

“Did the company participate in financed projects on research and innovation in the past?”

We build up three dummy variables that equal 1 if the firm has participated into, respectively a European, national or regional research project and 0 otherwise. Finally, we compute an average of the three dummies and express it in percentages.

Once again, the measure can be operationalised both as a percentage or a standardised variable.



OPERATIONALISATION (PM)

Question number 8 in the questionnaire asks responder whether their firm has participated in funded research projects. It is based on multiple choice answer so that the firm can participate in no projects at all or in EU, national and/or regional projects. We have to count how many types of projects the firm has participated into and then divide this figure by 3 (that is the maximum number of different types of projects one respondent can achieve). As a result, we will have positive percentage that equals either 0%, 33.3%, 66.6% or 100%.



(4) R&D AND BREADTH OF EXTERNAL KNOWLEDGE SEARCH

Innovation activities carried out by firms highlight the innovativeness potential of firms from a behavioural point of view. These can be identified with both internal and external R&D, technology purchases, reverse engineering and embodied technical change (Schumpeter, 1934; Oxford Handbook of Innovation, 2004; Swann, 2009; Vivarelli, 2014).

This is assessed via **question 8** in 4Steps questionnaire:

“How were your most important products and services developed (focus on the 3 most important products or services you offer on the market)?”

We build up a number of dummy variables that equal 1 if the firm has experienced each of the listed multiple responses and 0 otherwise. Finally, we compute an average of all the dummies and express it in percentages.

Once again, the measure can be operationalised both as a percentage or a standardised variable.



OPERATIONALISATION (RD)

Question number 5 is conceptually similar to question 8 as it is based on a multiple choice answer as well. In this case what is under scrutiny is how many different types of R&D activities/collaboration the firm has undertaken, with the possibility to mark down up to 9 alternatives. In this case, we have to mark down how many types of R&D the respondent has selected and divide them by 9. That simple, a positive percentage that equals 0%, 11.1%, 22.2%, 33.3%, ... or 100%.



(5) BREADTH OF INDUSTRY 4.0 ACTIVITIES

$$D_i = \frac{\sum_i^n A_t}{n}$$

We add a fifth dimension to the TML to take into account the number (out of nine) of Industry 4.0 technologies in which the firm is operating and/or is investing/purchasing as stated in section 2 of the questionnaire (investor/producer/both). By doing so we allow the TML to represent not only the potential of the firms but also the actual effort in innovative activities pursuing a comparative advantage in the relevant sectors.



(6) DEPTH OF INDUSTRY 4.0 ACTIVITIES

$$D_i = \frac{\sum_i^n A_t}{n}$$

We also add a sixth dimension to take into account the depth of the efforts put in place by the firm when it comes to investing into Industry 4.0



SYNOPSIS OF DATA SOURCES FOR FORMULAS

ID	Initials	Variable	Source	Operationalisation
1	RV	Realted Variety	Q4	Difference between the number of economic sectors of activity in which the respondent firm is operationg and the average number of sectors in which both its suppliers and customers are operating.
2	HC	Human Capital	Q7	Mean share of employees with at least a HE title in R&D and technical divisions
3	PM	Project Management	Q8	Share of potential channels of cooperation/fund raising explored/used by the firms
4	RD	Research & Development	Q5	Share of potential channels of R&D raising explored/used by the firms
5	BI	Breadth of Industry 4.0	Q13-18	Share of technologies used/produced by the firm on the 9 constituent I4.0 technologies
6	DI	Depth of Industry 4.0	Q13-18	Intensity of technologies use/production by the firm of the 9 constituent I4.0 technologies



PROCESS TO APPLY THE TML INDEX



• TML applied to the CRM

PBN applies the TML formula to the CRM system

TML computation

PBN provides each partners with an excel with the computation of the TML on all the national dataset

• Selection of Pilot companies

Each partner selects 10 companies to which to apply the TML

CRITERIA TO SELECT THE 10 PILOT COMPANIES

The criteria to select the 10 pilot companies is left open to each partner.

We hereby suggest two possible criteria:

- 1) Choosing the 10 companies which have the highest TML
- 2) Choosing a differentiated sample (e.g.: 5 with a high TML index, another 5 with a medium TML index)
- 3) ...

It is important that each partner explicitly motivates its choice, criteria and motivation.

