Directed technological change and technological congruence: A new framework for the smart specialization strategy

Cristiano Antonelli [1]
Christophe Feder [2]
Francesco Quatraro [1]

[1]University of Turin
[2]University of Aosta Valley

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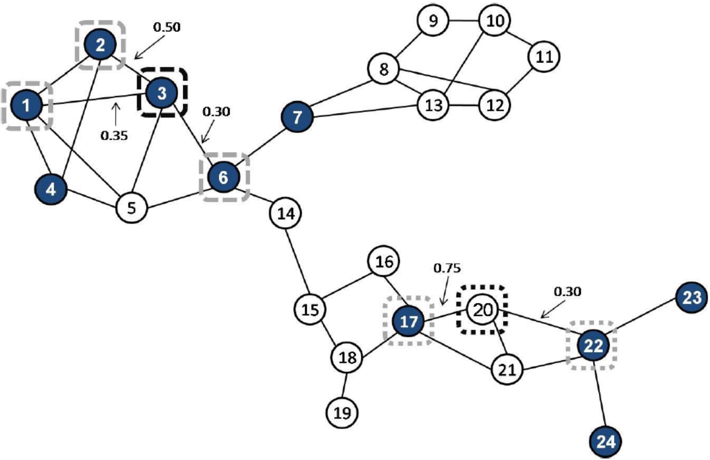
SMART SPECIALIZATION STRATEGY (S3)

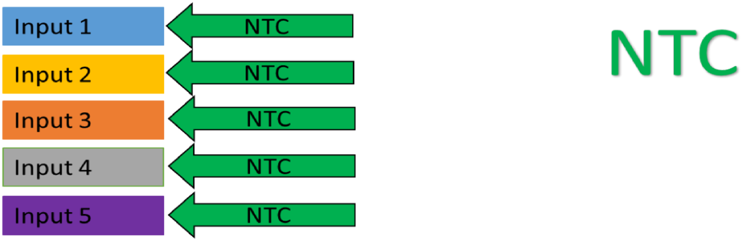
Regional Branching Process

Figure 1. The network of related industries in a region

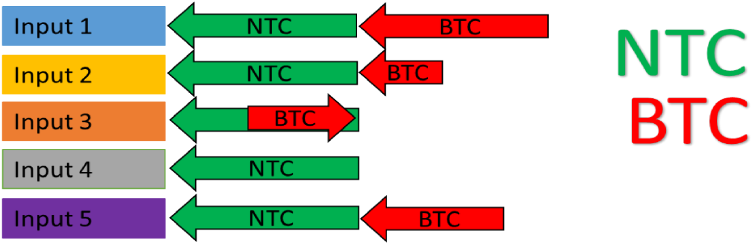


Source: Neffke et al. (2011), p. 249.

Neutral Technological Change - Solow (1957)



Biased Technological Change - Acemoglu (1998)



Technological Congruence - Abramovitz (1986)

- The notion of technological congruence allows to study the coherence between technology and factor markets.
- The technological congruence is the effects of the matching between the relative abundance of inputs and the characteristics of the technology.
- The technological congruence is the matching between the slope of isocost and the slope of isoquant.

Hypotheses

The levels of technological congruence are the cause of the biased components of TFP.

- The increase of the directional component of TFP will be larger, the larger is the bias of technological change in terms of the increase of the output elasticity of the production factor that has become less expensive;

- The larger the reduction of the slope of the isocost and the larger the increase of the reciprocal of slope of the isoquant, then the larger will be the rate of increase of TFP.

Hypotheses' Formalization

- $BTC = f\left(\frac{w}{r} - \frac{\alpha}{\beta}\right)$, with $f' < 0$;
- $\frac{\Delta BTC}{BTC} = g\left(\frac{d(w/r)}{w/r} - \frac{d(\alpha/\beta)}{\alpha/\beta}\right)$, with $g' < 0$.

where BTC is the effect of the directed technological change on the TFP; r and w be the capital rental and the labor cost, respectively; and α and β be the output elasticity of capital and labor, respectively.

DATA

- The data are drawn from the Cambridge Econometrics' European Regional Database and from AMECO.
- Unbalanced sample of 278 regions spread over 28 European countries.
- 77% of the regions are observed from 1980 to 2011; 23% from 1990 (1991 for six German regions) to 2011.

Regressions

The structural models take the following forms:

$$BTC_{i,t} = \alpha + \beta \left(\frac{w}{r} - \frac{\alpha}{\beta} \right)_{i,t} + \sum_{k=1}^{K} \gamma_{k,i,t} z_{k,i,t} + \sum_{t=1}^{T} d_t + \sum_{i=1}^{N} \varphi_i + \epsilon_{i,t};$$

$$\left(\frac{dBTC}{BTC} \right)_{i,t} = \alpha + \beta \left(\frac{d(w/r)}{w/r} - \frac{d(\alpha/\beta)}{\alpha/\beta} \right)_{i,t} + \sum_{k=1}^{K} \gamma_{k,i,t} z_{k,i,t} + \sum_{t=1}^{T} d_t + \sum_{i=1}^{N} \varphi_i + \epsilon_{i,t}.$$

$z_{i,t}$ are the control variables for $k = \{population, man\_share\}$; d_t is the time dummy; and φ_i is the region-specific effects.

Definitions and Descriptive Statistics

Variable	Definition	N	Mean	Min	Max	Sd	Skewness	Kurtosis
BTC	Biased component of productivity	8171	11.836	-14.341	177.486	15.064	3.175	22.447
$d(BTC)/BTC$	Rate of change of the biased component	8171	1.031	-73.972	182.357	9.502	7.690	132.307
$w/r - \alpha/\beta$	Technological congruence	8171	0.255	-3.468	63.931	2.776	9.461	137.973
$d(w/r)/(w/r) - d(\alpha/\beta)/(\alpha/\beta)$	Rate of Technological congruence	8171	8.348	-4.512	99.912	6.142	2.193	24.336
Man_share	Log of employment share in manufacturing	8171	-1.741	-4.116	-0.786	0.487	-1.073	4.708
P	Log of Population levels	8171	7.130	3.215	9.382	0.872	-0.741	4.589

Unit Root Tests and Correlation Matrix

Variable	IPS statistics	PP statistics
BTC	-4.2403***	8.8170***
$d(BTC)/BTC$	-14.9431***	6.0082***
$w/r - \alpha/\beta$	-9.2763***	16.9540***
$d(w/r)/(w/r) - d(\alpha/\beta)/(\alpha/\beta)$	-7.3335***	4.0366***
Man_share	-6.4469***	3.4675***
P	12.4169	-0.5422

	BTC	$\frac{d(BTC)}{BTC}$	$w/r - \alpha/\beta$	$\frac{d(w/r)}{w/r} - \frac{d(\alpha/\beta)}{\alpha/\beta}$	Man_share	P
BTC	1					
$\frac{d(BTC)}{BTC}$	0.3373*	1				
$w/r - \alpha/\beta$	-0.2720*	-0.3715*	1			
$\frac{d(w/r)}{w/r} - \frac{d(\alpha/\beta)}{\alpha/\beta}$	0.1641*	0.1952*	-0.0904*	1		
Man_share	-0.3279*	0.0057	-0.0921*	-0.1634*	1	
P	-0.7588*	-0.1069*	-0.1698*	-0.0154	0.2296*	1

Asymptotically standard normal distributed test statistics. Starred statistics are significant at the 1% level. Automatic selection of lags based on AIC criteria for the IPS statistics. 3 lags included for the calculation of the PP statistics.

Econometric Results I

	(1)	(2)	(3)	(4)
$w/r - \alpha/\beta$	-0.6817***		-0.6531***	
	(0.0173)		(0.0175)	
$(w/r - \alpha/\beta)_{t-1}$		-0.6100***		-0.5757***
		(0.0175)		(0.0173)
Man_share_{t-1}			1.4896***	1.2351***
			(0.4237)	(0.4310)
P_{t-1}			-20.9968***	-21.8090***
			(1.3951)	(1.4173)
_cons	17.2527***	14.9979***	171.3672***	175.9390***
	(0.3885)	(0.3989)	(10.0044)	(10.1671)
N	8171	7895	7895	7895
R^2	0.190	0.161	0.214	0.188
adj. R^2	0.159	0.127	0.182	0.155
AIC	50479.8856	48462.4887	47953.0692	48211.5933
BIC	50711.1611	48685.6562	48190.1847	48448.7088

Dependent variable: BTC.
Standard errors in parentheses.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Econometric Results II

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\frac{d(w/r)}{w/r} - \frac{d(\alpha/\beta)}{\alpha/\beta}$	-0.1245***		-0.1101***					
	(0.0244)		(0.0227)					
$\left[\frac{d(w/r)}{w/r} - \frac{d(\alpha/\beta)}{\alpha/\beta}\right]_{t-1}$		-0.1070***		-0.1048***				
		(0.0227)		(0.0228)				
$w/r - \alpha/\beta$					-0.1052***		-0.0980***	
					(0.0124)		(0.0119)	
$(w/r - \alpha/\beta)_{t-1}$						-0.0950***		-0.0926***
						(0.0115)		(0.0116)
Man_share$_{t-1}$			0.7570***	0.7514***			0.7993***	0.7536***
			(0.2890)	(0.2893)			(0.2874)	(0.2877)
P_{t-1}			-1.7084*	-1.6934*			-0.4373	-0.4999
			(0.9446)	(0.9448)			(0.9464)	(0.9462)
_cons	0.8797***	0.4582*	15.3388**	15.2132**	1.5868***	1.3214***	7.1085	7.4117
	(0.2675)	(0.2408)	(6.7833)	(6.7843)	(0.2782)	(0.2621)	(6.7871)	(6.7872)
N	8171	7895	7895	7895	8171	7895	7895	7895
R^2	0.013	0.013	0.014	0.014	0.019	0.019	0.020	0.020
adj. R^2	-0.025	-0.027	-0.026	-0.026	-0.019	-0.021	-0.020	-0.020
AIC	45069.3974	41882.0192	41872.5877	41875.1288	45021.7610	41834.1745	41826.4222	41830.6219
BIC	45300.6728	42105.1868	42109.7032	42112.2442	45253.0364	42057.3420	42063.5377	42067.7374

Dependent variable: $d(BTC)/BTC$.
Standard errors in parentheses.
$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$.

Conclusion

- Technological relatedness and technological congruence are the drivers of the smart specialization strategy.
- It is possible to measure with standard databases the smart specialization strategy and its drivers.
- In Europe the levels and the changes in technological congruence have significant effects on the levels and the changes of TFP.

The technological congruence

- The rate of technological congruence at time t:

$$\frac{dY_t}{Y_t} = \ln\left(\frac{\alpha_t}{\beta_t}\frac{w_t}{r_t}\right) d\alpha_t.$$

- The technological congruence over time $[0, T]$:

$$TC = \int_0^T \ln\left(\frac{\alpha_t}{\beta_t}\frac{w_t}{r_t}\right) d\alpha_t dt$$