An assessment of the impact of innovation policy on the regional economies of Europe

Pablo Casas[a] **Tryfonas Christou**[a] Abián García Rodríguez[a] Nicholas Lazarou[a] Patrizio Lecca[b] Philippe Monfort[c] Simone Salotti[a]

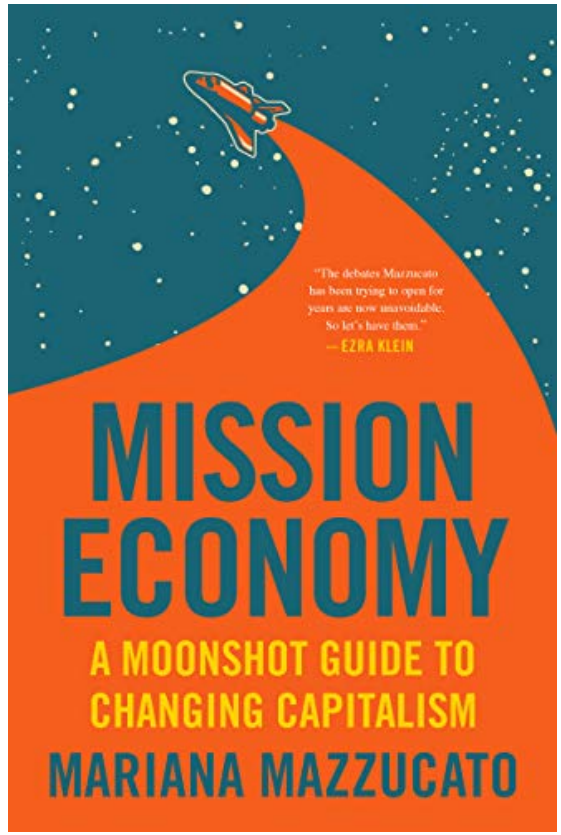
[a]European Commission - JRC Seville, Spain[1]
[b]ICADE, Universidad Pontificia Comillas, Spain
[c]European Commission - DG REGIO, Belgium

University of Crete
Department of Economics Research Seminars

[1]The views expressed in this presentation solely belong to the authors and do not necessarily reflect the opinions or positions of the European Commission.

In a nutshell

- We aim to evaluate the economic impact of the EU Horizon 2020 policy funding from 2014 to 2022.
- To do so, we incorporate R&D-based semi-endogenous growth in a spatial dynamic general equilibrium model with 235 EU regions.
- We find that the policy has a positive impact on GDP, with considerable territorial heterogeneity.
- GDP gains are expected to remain significant after the program ends due to the process and product innovations of H2020 funds.
- Regression analysis reveals the importance of regional initial conditions to explain GDP and competitiveness effects.
- Our results suggest that innovation policy is *key to promote regional development*, and highlight the essential role of the *entrepreneurial state as a creator of the knowledge economy*.



- NASA's Apollo program: a huge, gov-led moonshot project
- U.S. government has been the orchestrator of the groundbreaking innovation needed to put a man on the moon.

Entrepreneurial state and innovation policy

- State-promoting innovation policy is crucial for funding basic research (Mazzucato, 2011), whereas the risk-averse private sector focuses on applied research (Castelnovo & Florio, 2020).
- **"Entrepreneurial state"** (Mazzucato, 2011 & 2015)
  More active role of the state driving innovation (and growth).
- Entrepreneurship as a spillover mechanism (Audretsch and Feldman (2004)).
- Shift of the focus of innovation policy: *from market failures to national innovation issues and now to societal problems (Schot & Stenimueller, 2016).*
- Tackling societal challenges requires supranational cooperation, with innovation policies considering regional diversity and the role of regional economies (Calignano (2022)).
- In EU: European innovation policy through Horizon programmes.

The European innovation policy - Horizon 2020

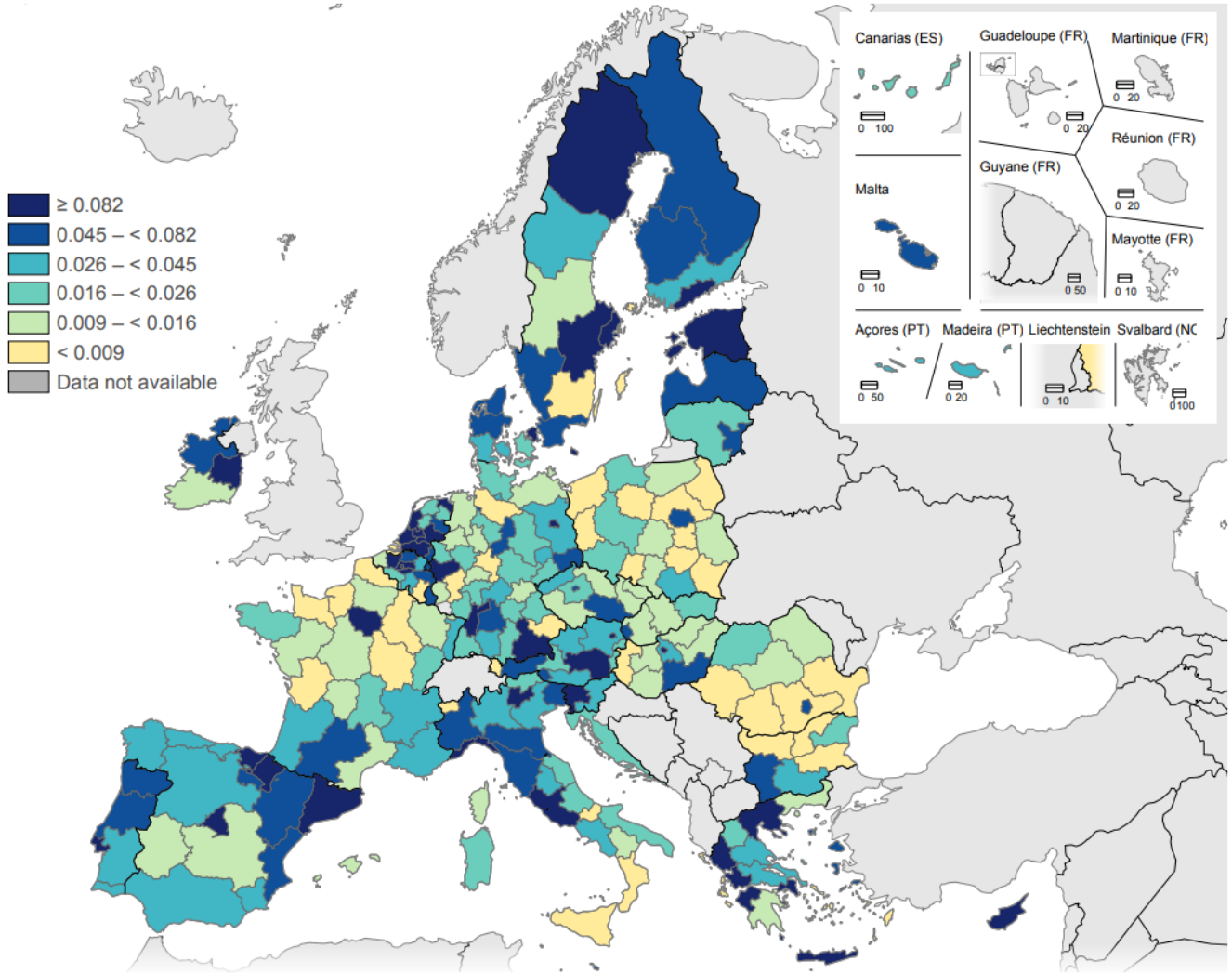
- **EU Horizon 2020 (H2020)** research and innovation programme is one of the largest funds under a single political authority (Mazzucato, 2018); budget of almost €74 billion.
- Designed to drive economic growth and job creation, focusing on scientific excellence and addressing societal challenges.
- Societal challenges include, among others: *inclusive, innovative and reflective societies; smart, green and integrated transport, climated action and environment*.
- EU Horizon 2020 is well studied in the literature:
  - Impact on innovation (Veugelers et al. (2015)), firm growth (Mulier and Samarin (2021)) and GDP growth (Pollex and Lenschow (2018)).
  - Creation of collaborative networks (Kosztyan et al. (2024)).
  - Motivation to participate (Enger (2018)).

EU H2020: Characteristics and throwbacks

- Competitive Funding: Financial support through proposal calls.
- Inclusivity: Open to EU and international participants (researchers, businesses and innovators)
- Collaboration: Promoted partnerships among universities, industry, and research centers.
- Lack of Mission Alignment: No missions to link projects to broader challenges; but should be addressed to make the mission concept stronger and more effective (Larsson (2022)).
- Insufficient Monitoring: Monitoring focused only on individual project evaluations.

Territorial distribution of the H2020 funds in EU regions

2014-2021 annual average, % of 2017 GDP



- Funds are concentrated in Central Europe and in most developed regions of EU Member States.

RHOMOLO model

- **RHOMOLO** is the European Commission's spatial computable general equilibrium model developed and maintained by TEDAM team and DG REGIO.
- Used to study RRF (Barbero et al. 2024), Cohesion policy (Crucitti et al. 2023), and policy governance (Gianelle et al. 2024), among other things.
- The model covers the EU NUTS 2 regions and disaggregate their economies into 10 NACE Rev. 2 sectors; RoW is modelled as an exogenous external aggregated region.
- Main blocks
  - Households: consume final goods and services.
  - Firms: goods/services production under monopolistic competition.
  - Reg. governments: collect tax & provide public goods/transfers.
  - Trade: costly and modelled using iceberg transport costs.

RHOMOLO RnD
A spatial model of semi-endogenous growth

- We incorporate **R&D-based semi-endogenous growth** in RHOMOLO, a spatial dynamic general equilibrium model.
  - Integration of R&D-driven endogenous growth and interregional technological spillovers, using a modified discrete-time R&D model originally developed by Jones (1995, 2005).
  - Similar approach as in Butler and Pakko (1998), Diao et al. (1999), and the EC's DSGE model QUEST (2022).
- When the policy takes place, each region finances its contribution (according to its GDP share), with distortionary labour taxation.
- The policy can affect regional economies through channels affecting public investment and firm productivity.

RHOMOLO RnD: New capital varieties

- Firms engage in R&D activity to produce a new design using existing stock, skilled labour, and taking into account regional spillovers:

$$\underbrace{\Delta H_r}_{\textit{Blueprints}} = -\delta^H H_r + \nu \cdot \underbrace{Z_r^{\zeta}}_{\textit{R\&D spillovers}} \cdot \underbrace{H_r^{\phi}}_{\textit{R\&D stock}} \cdot \underbrace{J_r^{\gamma}}_{\textit{Skilled labour}} \quad (1)$$

- ν: efficiency of R&D process
- δ^H: depreciation rate of knowledge
- γ: elasticity of R&D production to the number of researchers
- ζ: spillover effects coming from the rest of the other EU regions.
- ϕ: elasticity of the common stock of knowledge to the production of new designs
  - $\phi < 0$: rate of innovation **decreases** with the level of knowledge
  - $\phi > 0$: rate of innovation **increases** with the level of knowledge

  $\phi = 1$: full endogenous growth

RHOMOLO RnD: Modeling regional spillovers

- Following Coe and Helpman (1995), we model reg. spillovers as:

$$Z_{r'} = \rho_{r'} \cdot \left[\sum_{r} H_r \cdot V_{r,r'} \right] \tag{2}$$

- $V_{r,r'}$: share of goods of region r imported from region r'.
- ρ: regions have partial capacity to capture R&D developed elsewhere.
- In brief, regional spillovers Z_r are modeled based on the *import share of goods from other regions* and the *regions' capacity to capture external R&D*.
- Thus, regions able to stimulate their own R&D policies can become a growth factor for other regions, through knowledge spillovers.

RHOMOLO RnD: Production function

Value added output is produced in a CES combination of public capital (KG_r^d), private capital ($K_{r,i}$) and labour ($L_{r,i}$):

$$Y_{r,i} = \left(KG_r^d\right)^{\psi} \left[\zeta_{r,i}^{K} \left(H_r K_{r,i}\right)^{\frac{\sigma-1}{\sigma}} + \zeta_{r,i}^{L} L_{r,i}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{3}$$

where we assume that:

- Accumulated knowledge, H_r, enters the production function as a form of capital-augmenting technological change.
- Effective public capital KG_r^d is an unpaid production factor (Barro (1990), Baxter and King, (1993)).
- ψ: elasticity of value added to public capital.
- σ: elasticity of substitution of private capital and labour inputs.
- ζ^K, ζ^L: share parameters of private capital and labour inputs respectively.

Calibration

- 235 NUTS2 EU regions and 10 sector economies.
- 2017 data using social accounting matrices (SAMs) - García Rodríguez et al. 2023.
- Bilateral transport costs (Persyn et al. (2022)).
- Unemployment rates, employment by skills, fixed costs are calibrated on the basis of the annual European Regional Economic Accounts data, the EU Labour Force Survey, the European Structural Business Statistics.
- Structural and behavioural parameters of the model are common across regions and based as standard in the literature.

How we work

- The model is solved following a recursive dynamic approach, starting from a **baseline initial equilibrium** calibrated for 2017.
- The model remains in a steady state unless an exogenous shock occurs, such as public investment increase or firm productivity policies.
- Our simulations include the model with distortionary labour taxation or lump sump taxation.
- We present general equilibirum effects on GDP and welfare.
- Then, we examine how regional characteristics affect the impact of the policy by running regressions on simulated data.

Economic channels to model innovation policy

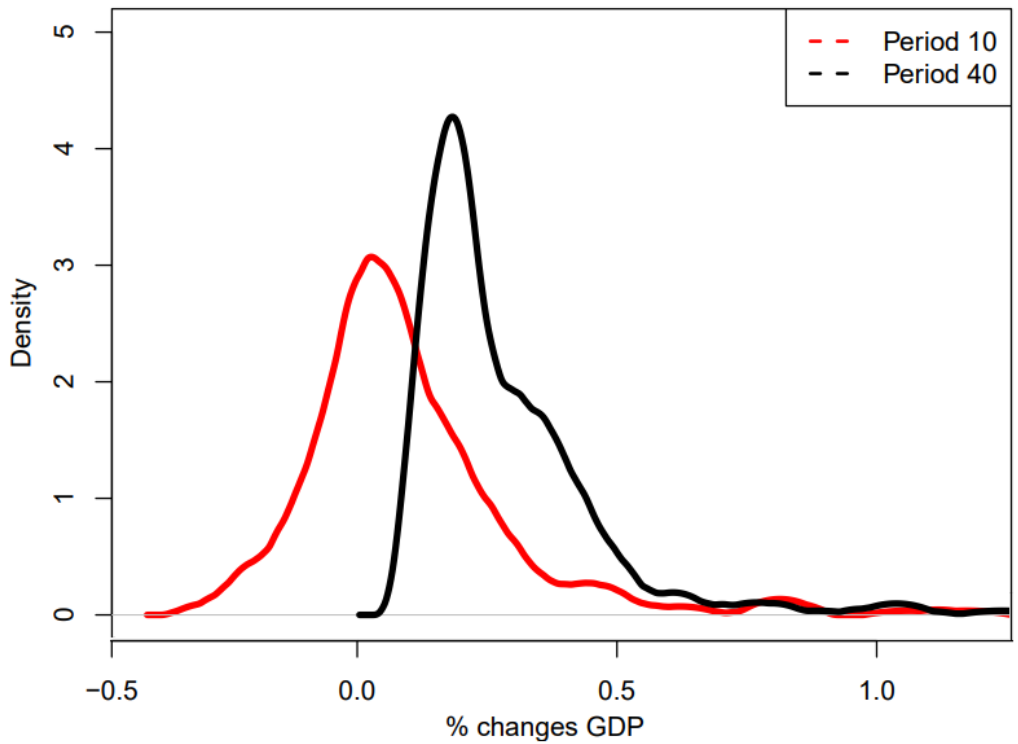
According to official impact assessment (EC, 2024):

- 40% of the H2020 funding are allocated to basic research.
- 60% to applied research.

1. Basic research funding occurs via public investment increase:
   - Public investment
   - temporary increase in regional public capital stock benefiting all firms (supply-side effect of the policy).
2. Applied research funding is assumed to:
   - Reduce the user cost of capital $\Rightarrow$ increase private investment.
   - Subsidise R&D workers: $\Rightarrow$ reduction of R&D labour cost positively affects capital productivity via the accumulation equation.

Results: Macroeconomic impact of EU H2020

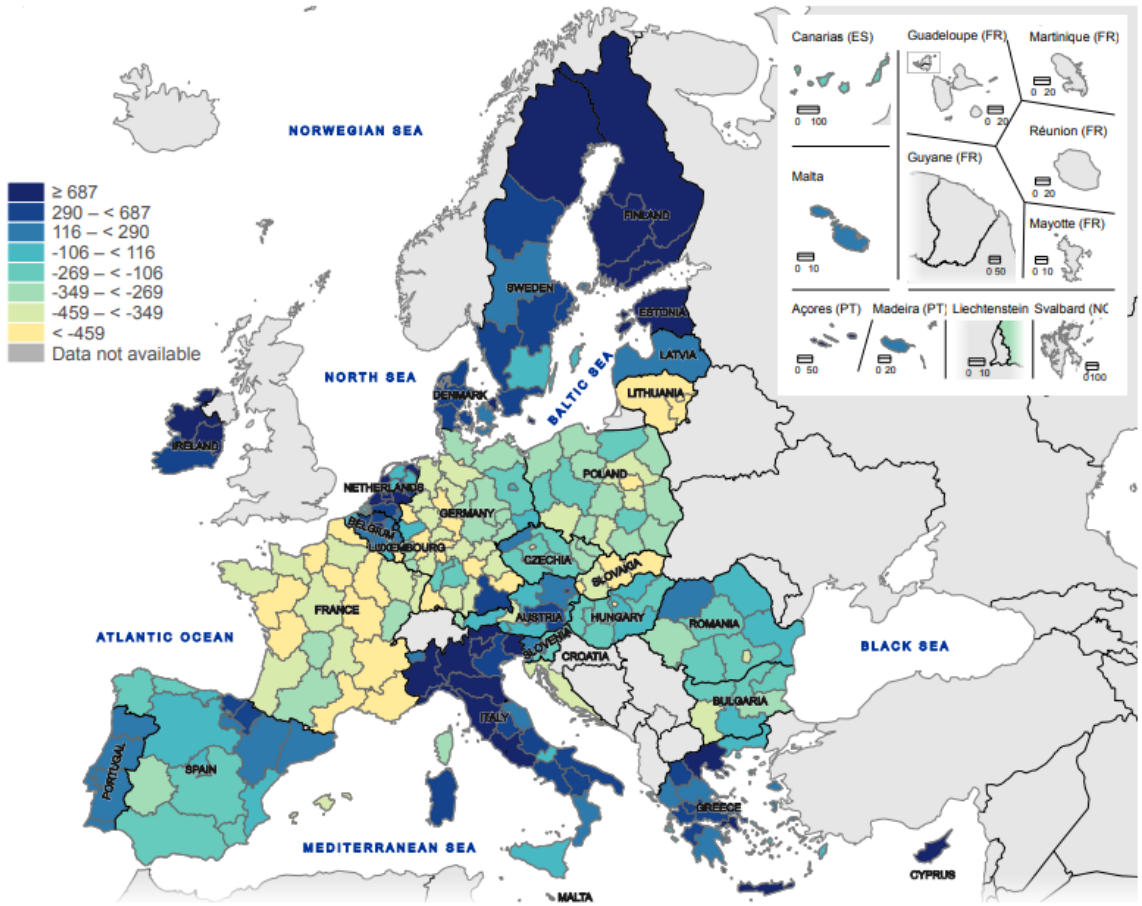
GDP impact regional distribution (% dev. from steady state GDP), periods 10 and 40



- Period 10: Distortionary taxation $\Rightarrow$ short/medium-run negative effects.
- Period 40: All regions have *positive GDP impact in the long-run*.

Results: Welfare impact of EU H2020

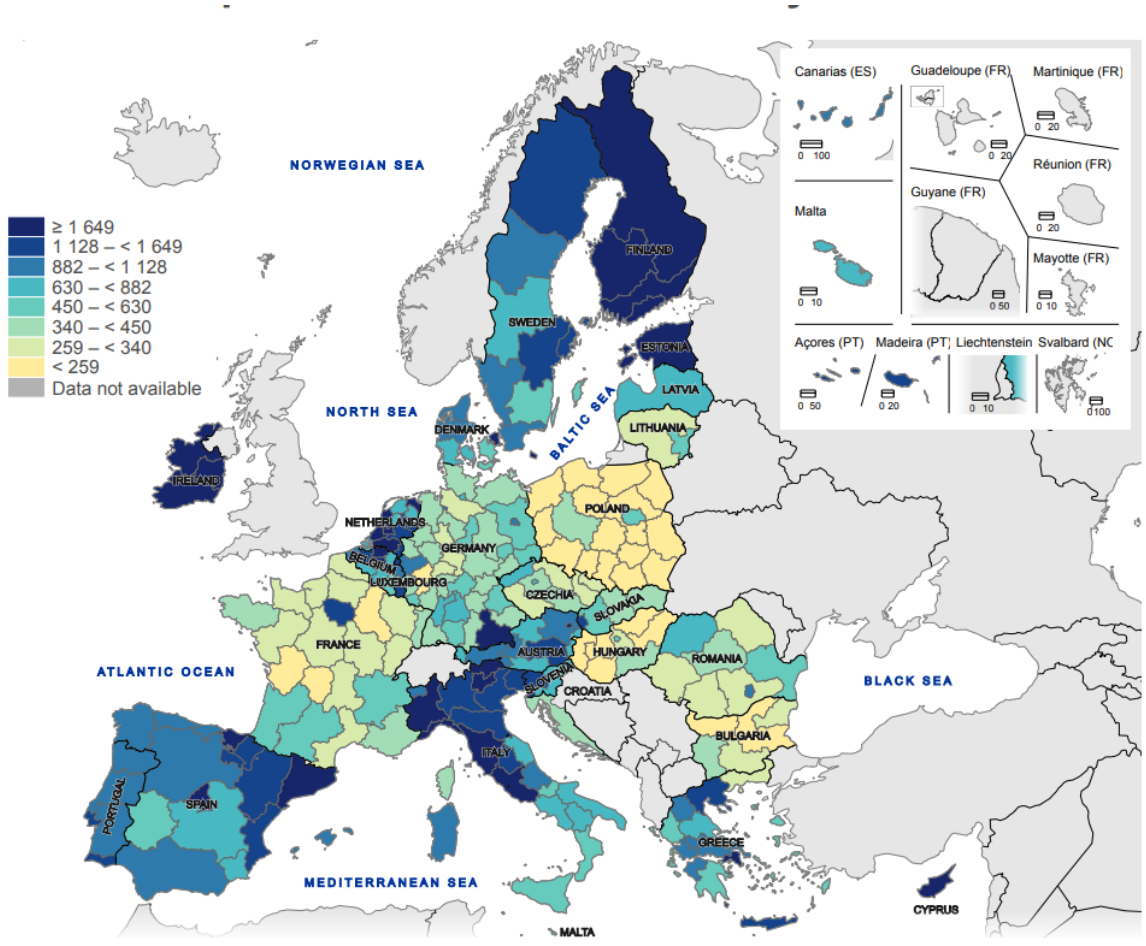
Compensating variation of consumption, Distortionary taxation, period 40



- Negative effects in several Central European regions. Northern European regions as well as regions in Italy and Greece have high welfare impacts.

Results: Welfare impact of EU H2020

Non-distortionary taxation, period 40



- With non-distortionary taxation results are milder.

Results: The importance of initial conditions

Regional cross-sectional regression analysis on **simulated changes GDP** in periods 10 and 40, using pre-shock economic variables as explanatory variables:

- Initial value of capital share of total income (Tamura et al. (2019))
- Measure of backward/input-output linkages (Miller and Blair (2009))
- Regional openness (Zachariadis (2004))
- Initial level of unemployment rate

We also perform regression analysis at the regional level on the **simulated change in exports** using as explanatory variables additionally:

- Initial share of exports to trading partners benefiting directly from H2020 funds.
- Initial share of exports to regions with higher R&D intensity.

Results: Determinants of the impact on regional GDP

	Dependent variable: Percentage changes in GDP			
	T=10		T=40	
	(1)	(2)	(3)	(4)
Shock	39.660***	40.682***	27.840***	23.992***
	(2.346)	(2.271)	(2.618)	(2.263)
Sh. Kap		0.651***		1.229***
		(0.149)		(0.148)
IO Linkages		0.015		0.053***
		(0.015)		(0.015)
Open H20		0.058***		0.066***
		(0.022)		(0.021)
Open R&D		0.062***		0.003
		(0.020)		(0.020)
Unemp. rate		-0.335**		0.618***
		(0.158)		(0.157)
Constant	-0.137***	-0.692***	0.095***	-0.802***
	(0.012)	(0.102)	(0.014)	(0.102)
Observations	235	235	235	235
R^2	0.551	0.649	0.327	0.581
Adjusted R^2	0.549	0.640	0.324	0.570
Note:			*p<0.1; **p<0.05; ***p<0.01	

Results: Determinants of the impact on regional GDP

- The exogenous H2020 shock explains more than 50% of the variability in short-run GDP deviations from the steady state.
- Moving from the short run to the long run the importance of the exogenous shock diminishes (32.7% R^2, H2020 is deployed over 8 years).
- Introducing the calibrated shares as explanatory variables:
  - Initial conditions play a much more important role in the long-run where they contribute in explaining an additional 30% of variability.
  - Regions with **higher capital share and trade openness** to trading partners receiving substantial H2020 funding are more prone to a larger GDP impact in the long-run.
  - Regions with **stronger backward linkages** benefit from the increased demand generated by the policy.
  - Unemployment rate is negative in the short-run but positive in the long-run; distortionary taxation effects.

Results: Determinants of the impact on regional GDP

	Dependent variable: Percentage changes in exports			
	T=10		T=40	
	(1)	(2)	(3)	(4)
Shock	33.447***	33.920***	22.858***	21.318***
	(2.142)	(1.891)	(2.404)	(1.791)
Sh. Kap		0.525***		1.061***
		(0.128)		(0.121)
Sh. ExpH20		0.084**		0.084**
		(0.039)		(0.037)
Sh. ExpR&D		0.140***		-0.004
		(0.037)		(0.035)
Unemp. rate		-0.042		0.984***
		(0.137)		(0.130)
Constant	-0.110***	-0.569***	0.122***	-0.561***
	(0.011)	(0.075)	(0.013)	(0.071)
Observations	235	235	235	235
R^2	0.511	0.631	0.280	0.612
Adjusted R^2	0.509	0.622	0.276	0.603
Note:				*p<0.1; **p<0.05; ***p<0.01

Results: Determinants of the impact on regional exports

- EU H2020 innovation policy aims to boost regional productivity, increase competitiveness (place competitiveness as in Storper (1997)) and stimulate exports of goods and services.
- The exogenous H2020 shock can explain the regional distribution of exports at 51.1% in the short-run but only at 28% in the long-run.
- Introducing the calibrated shares as explanatory variables:
  - Initial conditions are crucial to exploiting H2020 funding: R^2 increases in both periods.
  - Regions with **strong capital shares and trade patterns** can better leverage funding benefits.
  - Unemployment rate is positively significant in the long-run: a larger pool of available labour exerts less downward pressure on wages. Thus, competitiveness is improved through lower commodity prices.

Conclusion

- We evaluated the economic impact of the EU Horizon 2020 policy funding from 2014 to 2022.
- To do so, we introduced R&D-based semi-endogenous growth in a spatial dynamic general equilibrium model with 235 EU regions.
- We find that the policy has a positive impact on GDP, with considerable territorial heterogeneity.
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Thank you for your attention!

Get in touch
Email: tryfonas.christou@ec.europa.eu
Personal website: https://sites.google.com/view/tryfonaschristou/

Appendix: Robustness and sensitivity analysis

Distortionary taxation vs lump-sum taxation

	Baseline parametrization				Alternative parametrization			
	Dist. tax		Non-Dist. tax		(a)		(b)	
	t = 10	t = 40	t = 10	t = 40	t = 10	t = 40	t = 10	t = 40
Q1	-0.11	0.07	0.08	0.09	-0.05	0.10	-0.02	0.13
Median	-0.04	0.13	0.15	0.15	0.01	0.18	0.04	0.21
Q3	0.07	0.25	0.27	0.29	0.15	0.32	0.20	0.38

- A crucial factor affecting the final outcome of our analysis in the financing of H2020.
- Distortionary taxation introduces negative supply-side effects that counteract the expansionary government stimulus.
- Using lump-sum taxation, the negative impact disappears in the short run: the **supply-side stimulus dominates** the demand-side effect of a reduction in household income.

Appendix: Robustness and sensitivity analysis

Distortionary taxation vs lump-sum taxation

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Median	-0.04	0.13	0.15	0.15	0.01	0.18	0.04	0.21
Q3	0.07	0.25	0.27	0.29	0.15	0.32	0.20	0.38

Sensitivity analysis for key parameters in the model:

- Elasticity of output to public capital (ψ), elasticity of subsitution between capital and labour (σ), R&D spillover parameter (ρ).
- Two sets of parameters: (a):$\{\psi = 0.1; \sigma = 0.8; \rho = 0.2\}$ and (b):$\{\psi = 0.12; \sigma = 1.2; \rho = 0.3\}$
- Median and first quietly improve significantly with the adjusted elasticity.