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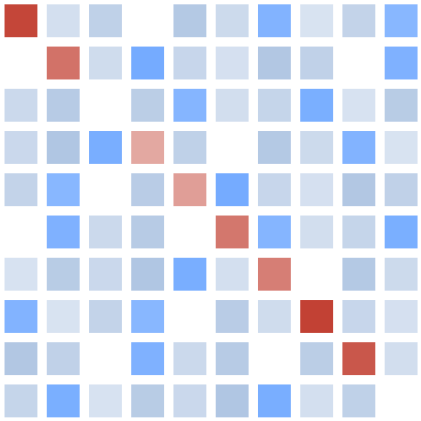
Input-Output Tables as Sufficient Statistics for Short-Run GDP Forecasting and Dynamic Shock Propagation

Multi-country COVID-19 evidence from a Darwinian agent-based simulator and FIGARO data



Martin Jaraiz · Ruth Pinacho
Department of Electronics, University of Valladolid, Spain

Deployers simulator — free binary: doi.org/10.5281/zenodo.18988482 (MIT license)

MOTIVATION

How much macro information is in a single I-O table?

Prevailing view: I-O tables capture production structure at a point in time — they describe, they don't predict. We test that on two tasks, with the table as essentially the only input:

1 Out-of-sample GDP forecasting

Year-N table → year-N+1 growth. Nothing from N+1 enters the model.

2 Dynamic shock propagation

Encode documented COVID shocks → compare GDP path with reality.

THE ENTIRE INPUT

- ✓ FIGARO 64-sector symmetric I-O table (year N)
- ✓ Active population — one public number
- ✓ NAIRU — one public number

NOT USED

- ✗ Time series of any kind
- ✗ Estimated parameters (no ML, Bayesian, GMM)
- ✗ Expectations formation
- ✗ Expert judgement / external forecasts

Spoiler: *it passes both — and that says as much about FIGARO as about the model.*

THE INSTRUMENT

Deployers: the table, animated by natural selection

Variation — workers who observe persistent unmet demand start new firms.

Selection — firms with negative wealth exit. No bailouts, no respawn rules.

Retention — profitable firms survive and grow. Leontief technology, bilateral ±0.5%/month tâtonnement.

Everything is emergent: firm count, sizes, employment, wages and prices are discovered, never imposed.

20–30 min

calibration to convergence — 150–200 simulated months on a desktop

1 self-consistent economy

agents correlated through the I-O network → 12 seeds suffice

CONTEXT

Two opposite routes arrive at the same accuracy

	Deployers (this paper)	Poledna et al. (2023), EER
Agents	≈ 2,000 (w32 scale)	8.8 million (1:1 scale)
Hardware	desktop PC	supercomputer cluster
Ensemble	12 seeds	500 Monte Carlo replications
Estimated parameters	zero	AR(1) behavioural learning, Taylor rule
Expectations	none	adaptive (learning)
Austrian forecast accuracy	**institutional range**	**institutional range**

The one element both share: the I-O table. Convergence from opposite architectures → the table is the binding informational constraint. Structure dominates behavior: whether agents learn (Poledna) or merely survive (Deployers), the production network constrains short-run dynamics so tightly that behavioral detail is secondary.

One table provides everything the model needs

EXTRACTED FROM THE FIGARO TABLE

64×64 intermediate matrix — Leontief coefficients; the production network (Acemoglu et al. 2012).

Factor income L / K per sector — labor–capital split; constrains viable firm sizes.

Household consumption column — demand basket; no utility estimation.

Government accounts — consumption, production & product taxes.

GFCF and trade rows — investment composition; export / import exposure.

Value added per sector — the GDP reference targeted by the forecast.

THE ONLY UNIVERSAL CONSTANTS

0.05	capital → fixed-capital conversion factor
2.5×	input stock target, in avg monthly sales
1.36×	NAIRU unemployment convergence band
±0.5%	price / wage tâtonnement step per month

Same four values for all 37 countries tested and all 9 Austrian years. Nothing is fitted — ever. No maximum likelihood, no Bayesian estimation, no GMM, anywhere in the pipeline.

Each SAM column is a firm recipe

Spain 2008 · 10^6 EUR	P01_AgroPesc	P02_EnerPetro	P03_Indust	P04_Construc	P05_ServVenta	N06_ServNoVenta	F07_GFCF
P01_AgroPesc	1,701	1	24,972	24	2,877	302	811
P02_EnerPetro	1,119	41,384	19,205	2,678	21,061	6,438	292
P03_Indust	8,616	5,037	209,653	64,805	76,816	21,507	65,355
P04_Construc	190	793	1,909	108,372	25,997	3,654	176,136
P05_ServVenta	3,682	10,762	94,805	31,726	244,738	49,376	54,460
N06_ServNoVenta	0	0	0	0	0	0	0
F07_GFCF	0	0	0	0	0	0	0
X08_SectExt	8,742	35,259	238,669	804	60,405	1,085	0
L09_CompEmployees	**4,259**	4,220	62,958	50,681	200,109	88,364	0
K10_GrossOpSurplus	**19,803**	17,740	48,917	46,113	321,169	14,029	0
T11_SSoc	624	1,543	19,007	15,518	53,763	26,223	0
T12_TaxProduction	−244	120	−137	204	1,118	53	0
T13_TaxProducts	−471	307	−1,062	1,555	12,274	4,100	21,578
T14_IRPF	0	0	0	0	0	0	0
G15_Government	0	0	0	0	0	0	0
H16_Households	0	0	0	0	0	0	0
colSUM	**48,021**	117,166	718,896	322,480	1,020,327	215,131	318,632

Intermediate consumption
the sector's input recipe

Wages: 4,259
compensation of employees

Dividends: 19,803
gross operating surplus

Taxes
SSoc, production, products

Gross output: 48,021
column sum

Firms are created following each sector's column pattern: an AgroPesc firm selling 48,021 units pays 4,259 in wages — the column fixes its input recipe and factor split.

Firms act in response to demand

		FINAL CONSUMERS			
Spain 2008 · 10^6 EUR	F07_GFCF	X08_SectExt	G15_Government	H16_Households	rowSUM
P01_AgroPesc	811	7,834	0	9,499	**48,021**
P02_EnerPetro	292	6,740	0	18,249	**117,166**
P03_Indust	65,355	144,645	7,620	114,842	**718,896**
P04_Construc	176,136	144	0	5,285	**322,480**
P05_ServVenta	54,460	70,689	21,238	438,851	**1,020,327**
N06_ServNoVenta	0	0	211,972	3,159	**215,131**
F07_GFCF	0	103,916	12,014	202,702	**318,632**
X08_SectExt	0	0	0	0	**344,964**
L09_CompEmployees	0	0	0	0	**410,591**
K10_GrossOpSurplus	0	0	0	0	**467,771**
T11_SSoc	0	0	136,752	20,074	**136,752**
T12_TaxProduction	0	0	1,114	0	**1,114**
T13_TaxProducts	21,578	−92	92,348	53,758	**92,348**
T14_IRPF	0	0	117,483	117,483	**117,483**
G15_Government	0	0	0	0	**347,697**
H16_Households	0	11,088	94,452	0	**983,902**
colSUM	**318,632**	**344,964**	**347,697**	**983,902**	

Demand reaches firms from two sides: final consumers — households, government, exports — plus investment (GFCF) …

… and other firms, via the intermediate-consumption block (previous slide).

Firms produce to meet observed demand; persistent unmet demand triggers new-firm creation (variation).

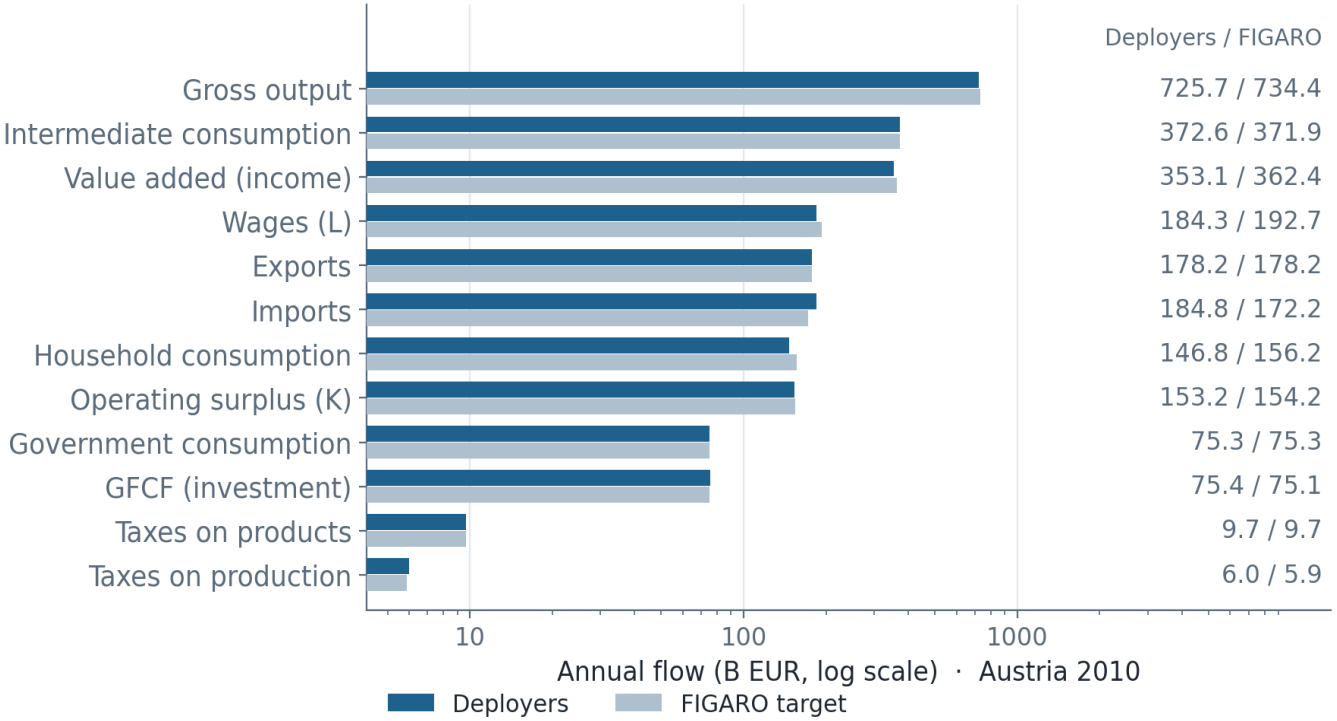
Both sides of every firm — its recipe and its market — come from the SAM.

FOUNDATIONAL CHECK 1

The emergent economy reproduces the FIGARO SAM

Bilateral exchange between ≈2,000 agents — realised annual flows land on the FIGARO targets; none calibrated individually.

Imports largest divergence at +7.33%; all others within ±6.0%. GDP identity closes at 353.13 B EUR (AT 2010).



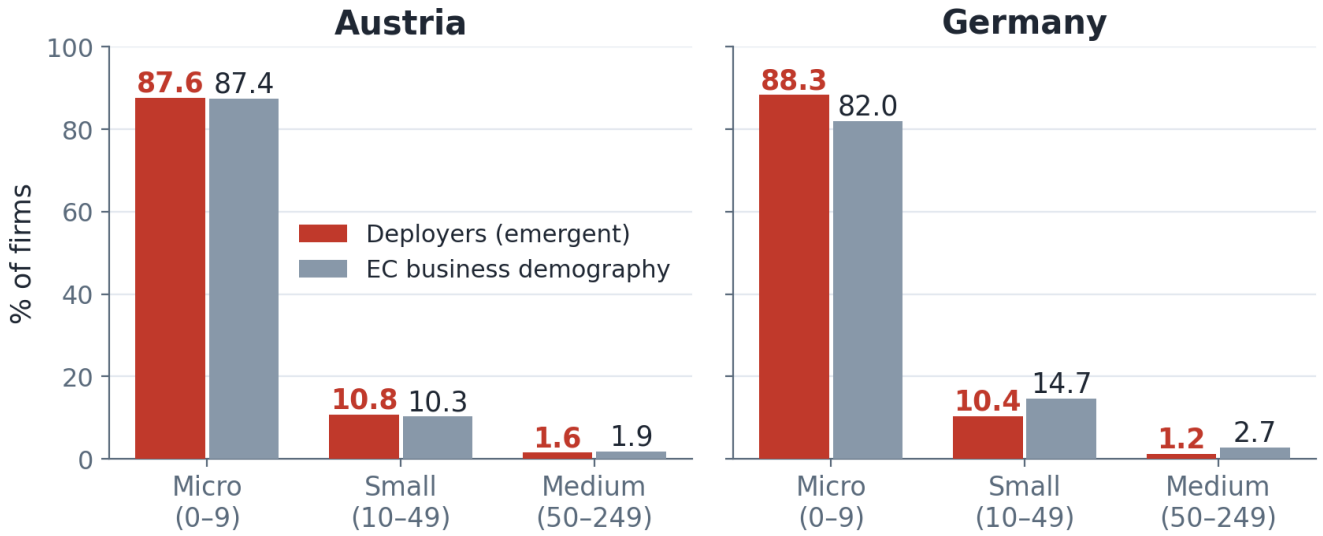
FOUNDATIONAL CHECK 2

Industrial organization emerges — uncalibrated

No business-demography data enters. Firm sizes emerge from Darwinian selection on the 64-sector L/K coefficients.

Austria: micro-firm share matches EC statistics to 0.2 pp (87.6% vs 87.4%). Germany: right shape; w32 scale caps firms above ≈32 workers.

Implication: through its factor-income structure, a 64-sector table implicitly encodes how many firms exist, how large they are, and how employment distributes.



FORECASTING PROTOCOL

Genuinely out-of-sample, by construction

1. **Read FIGARO table, year N** plus population & NAIRU
2. **Calibrate to convergence** unemployment + price-factor stability criteria
3. **Run 12 months free market** no knobs, no interventions
4. **OLS fit on monthly real GDP** ordinary least squares — growth = 12·b/a · 100%
5. **Repeat × 12 seeds** report ensemble mean

No information from year N+1

No nowcasts, no quarterly indicators, no revisions.

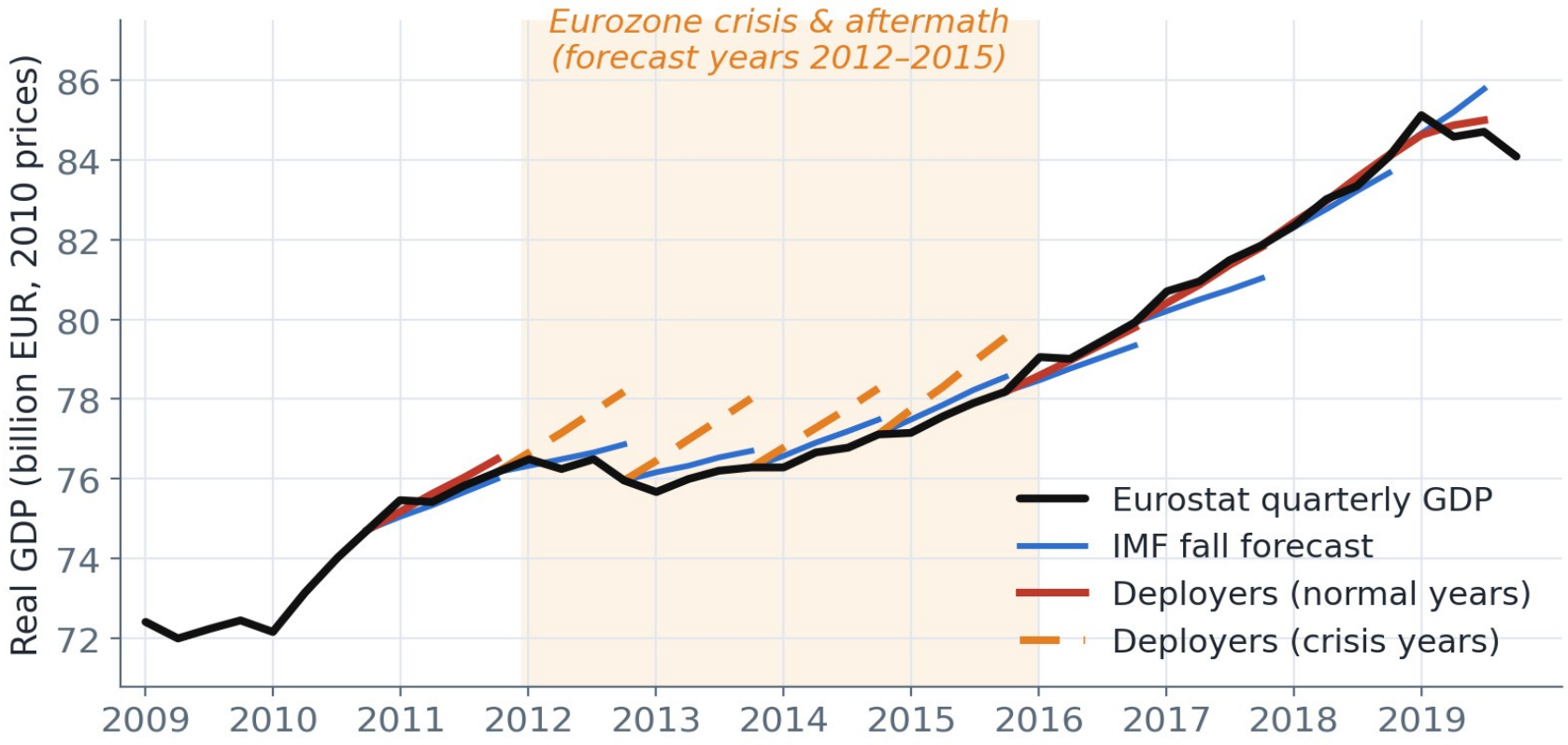
SD 0.7–1.4 → SE 0.2–0.4 pp

12 independent seeds; reported value = ensemble mean.

Portability is trivial

Country switch = two-letter code. Year switch = matrix file.

Austria, nine years out-of-sample (2011–2019)



0.42 pp
MAE, 5 normal years (2011, 2016–2019)

1.22 pp
MAE, all 9 years (incl. Eurozone crisis)

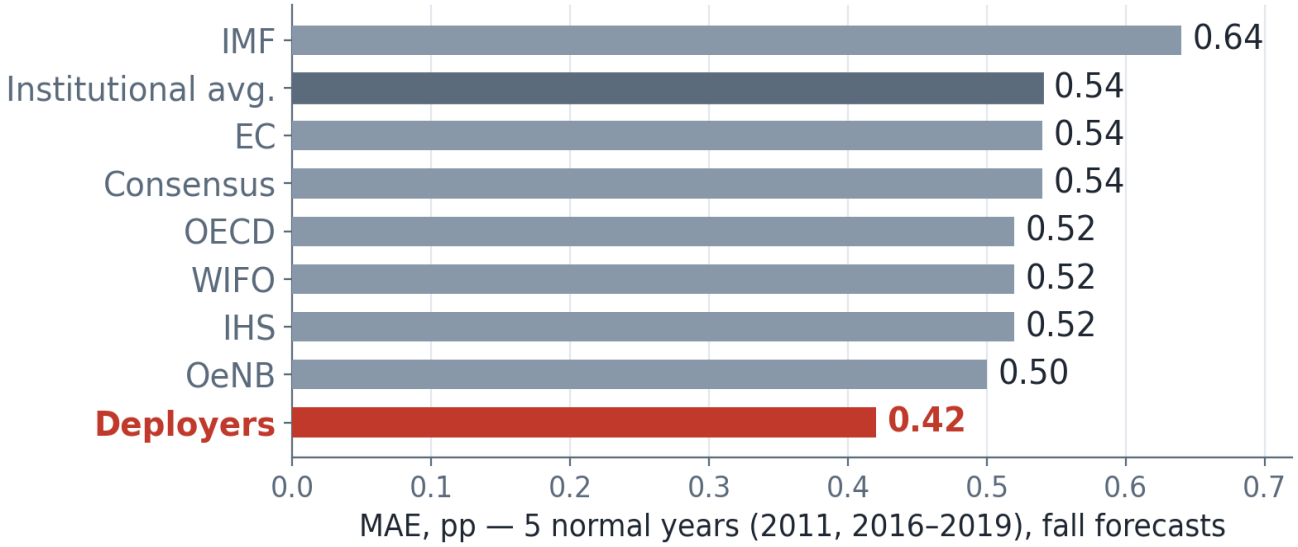
+1.9 to +2.7
crisis-year errors (pp) — all the same sign

RESULT 1 — BENCHMARK

In range with every institutional forecaster of Austria

Seven institutions tracked by Schuster (2021): WIFO 0.52, OeNB 0.50, OECD/IHS 0.52, EC & Consensus 0.54, IMF 0.64 pp. Deployers: 0.42 pp — from the prior-year table, two public scalars and a desktop PC.

Five observations → descriptive, not statistically decisive (a Diebold–Mariano test would lack power). Institutions forecast actual outcomes (incl. anticipated shocks); Deployers forecasts the structural trajectory.



READING THE RESIDUALS

The crisis-year signature is information, not failure

Published protocol	one universal wealth-MPC (marginal propensity to consume out of net wealth) = 0.054, the AT 2019 empirical anchor, for all 9 years
Symptom	crisis years 2012–2015 over-forecast by +1.9 to +2.7 pp — all the same sign
Internal test	re-anchor the MPC to each calibration year's empirical value → residual disappears
Reading	**households in 2012–2015 consumed well below the 2019 reference — precautionary saving in the sovereign-debt crisis**

A CLEAN DIVISION OF LABOR

Task 1 — inertial trajectory: fully automated, from the I-O table alone. **Task 2 — exogenous perturbations:** no I-O table can encode them; the economist identifies and encodes. → Section 4 demonstrates Task 2 on COVID-19.

COVID-19: from forecasting to verification

Different exercise: the shocks are known, documented month-by-month. Question: does the I-O network transmit them correctly?

1 Sector capacity loss

64 per-sector factors 0–1, from AMS unemployment (AT), ONS output (UK), StatCan + CEWS (CA), Destatis production (DE)

2 Trade shocks

multiplicative factors on export / import flows — partner demand collapse, supply-chain breaks

3 Retention schemes

Kurzarbeit · CJRS · CEWS participation rates from official programme statistics; pre-pandemic firms only

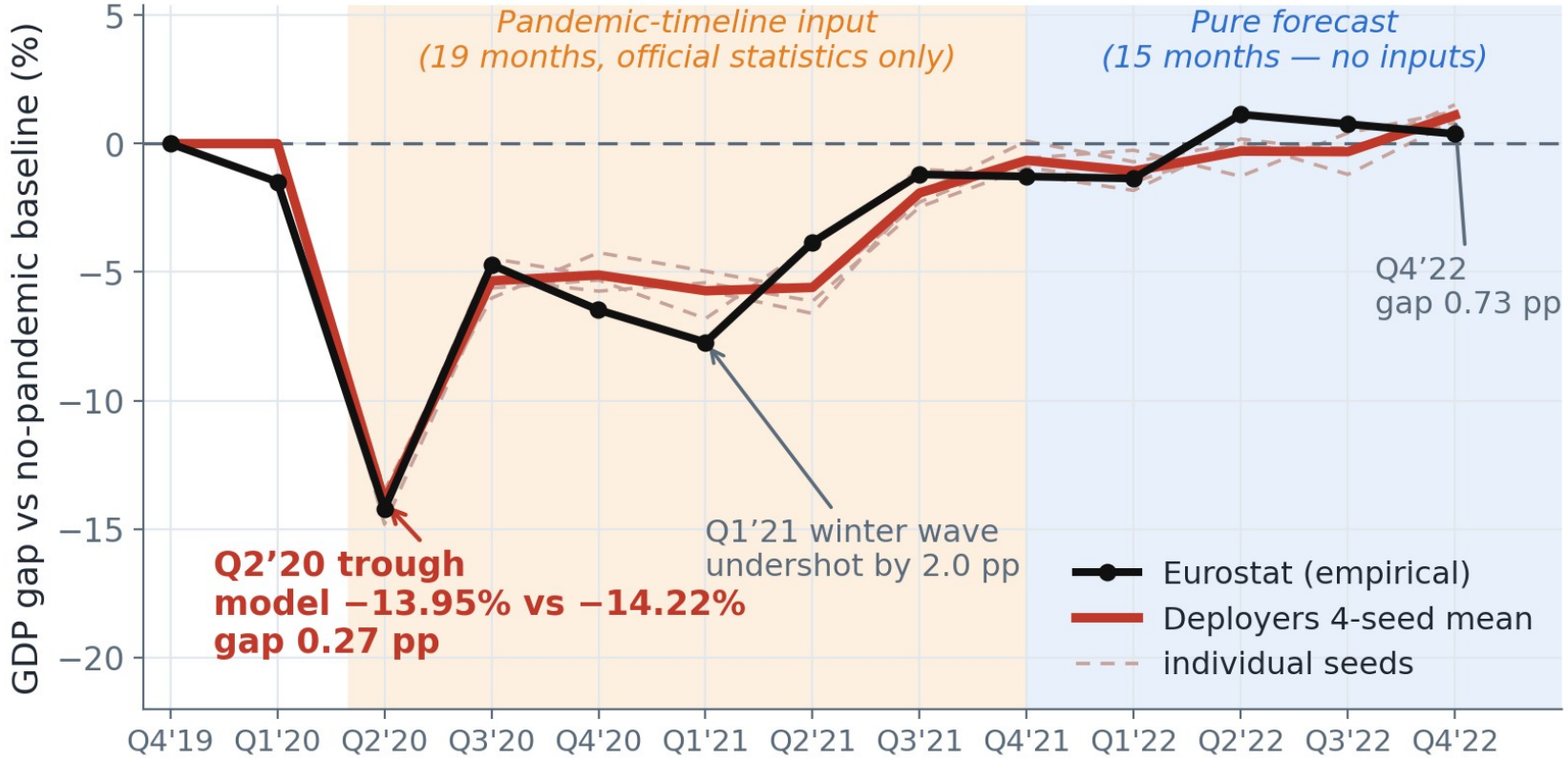
Documented timeline — 19 months (Mar 2020 – Sep 2021)	Pure forecast — 15 months (through Q4 2022)

No GDP data enters the timeline construction — a close match is evidence the I-O linkages are right; a gap means a shock the model was not told about.

One deliberate simplification: all four countries use the Austrian empirical wealth-MPC — marginal propensity to consume out of net wealth — 0.054 per euro per year.

RESULT 2 — AUSTRIA (FULLY GROUNDED)

First-wave trough reproduced to 0.27 pp

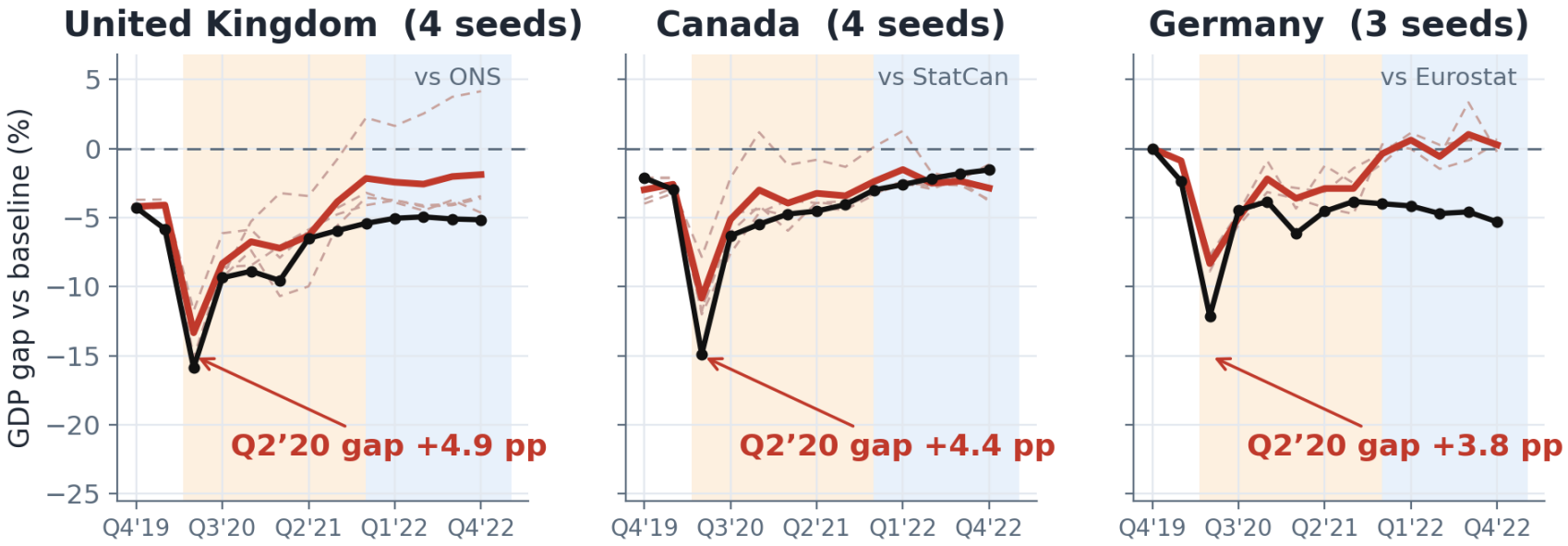


0.27 pp
Q2'20 trough gap (−13.95% vs −14.22%)

2.0 pp
Q1'21 winter wave under-shot — reported honestly

0.73 pp
Q4'22 gap after 15 months of pure forecast

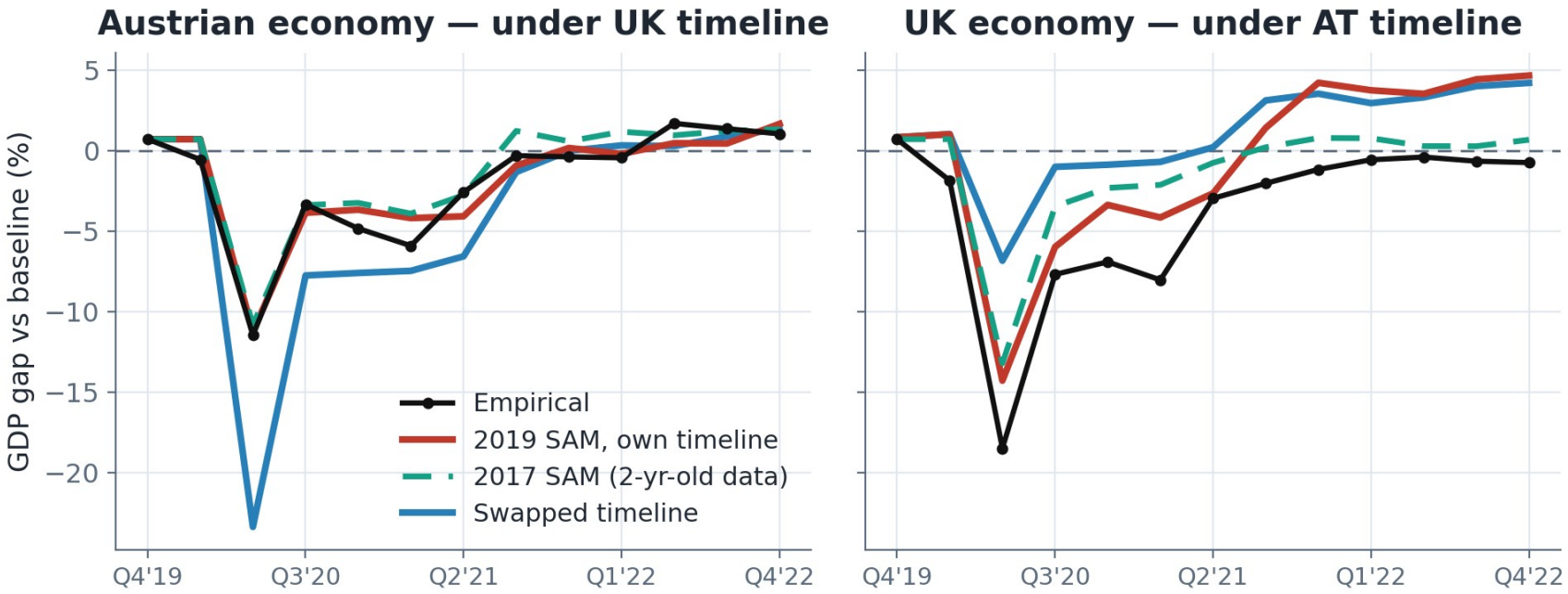
Same code, same constants: UK · Canada · Germany



The I-O transmission mechanism ports: V-shape, timing and recovery reproduce in all three economies with zero parameter changes.

Troughs run 3.8–4.9 pp shallow — two known causes: the Austrian wealth-MPC anchor (0.054) and lockdown depth not yet grounded per country. Country-specific calibration: follow-on study.

The policy timeline dominates the data vintage



±0.5–1.3 pp

2019 SAM → 2017 SAM (2-yr-old data): paths nearly coincide

9–14 pp

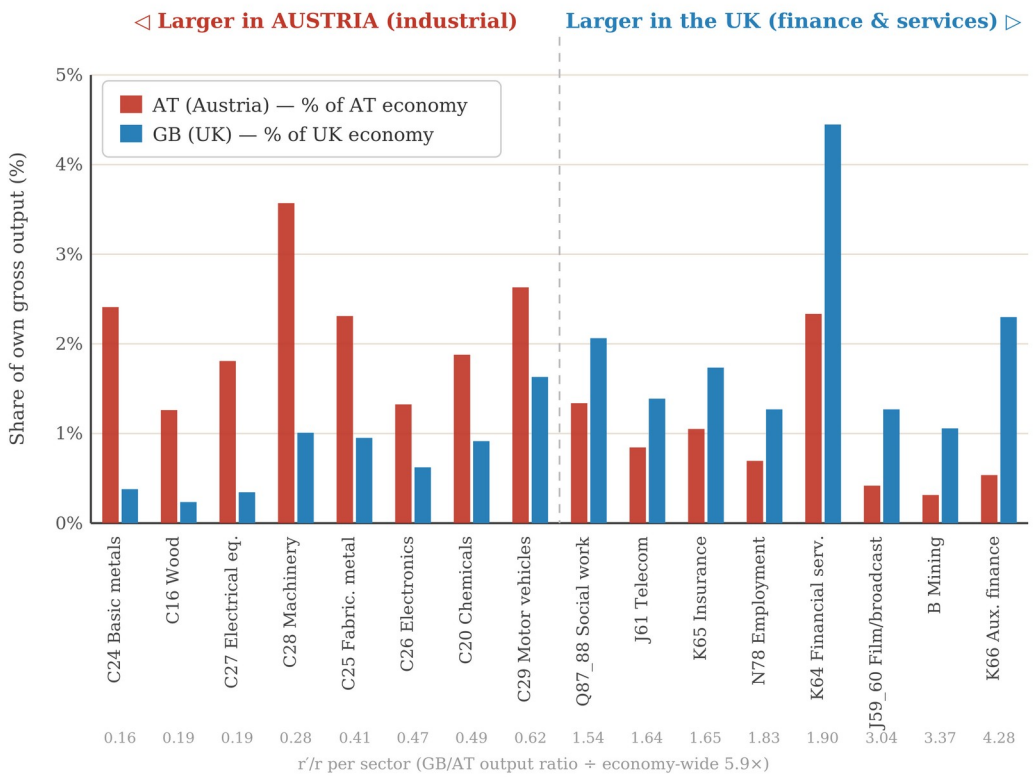
swap the AT/UK lockdown timeline: an order of magnitude larger

Why it matters: I-O tables arrive with a multi-year lag — and that is enough. Crisis tools can run in real time on a 2–3-year-old matrix; lockdown designs can be ranked ex ante.

AT and UK are structurally distinct economies

How the UK and Austrian economies differ in structure (FIGARO 2019)

The 16 sectors whose GB/AT output ratio departs >1.5× from the economy-wide ratio (r ≈ 5.9×), and that exceed 1% of either economy (FIGARO 2019 gross output).



16 sectors where the UK/AT gross-output ratio departs >1.5× from the economy-wide ratio (r ≈ 5.9×), FIGARO 2019.

Austria: metals, machinery, wood, electrical equipment, vehicles, chemicals.

UK: finance, insurance, auxiliary finance, telecom, broadcasting.

So the timeline swap compares genuinely different production networks — a counterfactual, not a rescaling.

FOR THE INPUT-OUTPUT COMMUNITY

Four propositions from one table

1 Informationally rich

One table → GDP forecasts in institutional range on the five Austrian normal years tested.

2 A dynamic shock engine

The same linkages propagate encoded crises — beyond static multiplier analysis.

3 Micro structure encoded

Factor-income coefficients implicitly fix firm demography; Darwinian selection decodes it.

4 Fully reproducible

Public FIGARO + national statistics + free binary. No proprietary microdata, no estimated parameters.

Forecast accuracy is an external validation of FIGARO compilation — a complement to internal consistency checks. Biased linkages would have drifted; nine Austrian tables did not. 46 countries, identical methodology: portable by a two-letter code.

An I-O table is not a snapshot.

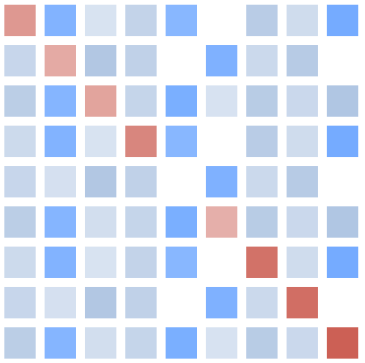
It is a compressed representation of an entire economic ecosystem — production network, industrial organization, and short-run growth trajectory included.

Thank you.

Deployers binary, country files, documentation (MIT): doi.org/10.5281/zenodo.18988482

Paper + reproducibility archive with reference snapshots and bit-identity verification script

mjaraiz@uva.es · Department of Electronics, University of Valladolid



Backup slides

Q&A reference: rules & constants · full panel table · wealth-MPC mechanics · capacity-loss methodology · cross-country convergence · limitations

All behavioral rules — universal, none country-specific

Behavior	Rule	I-O table role
Production	Leontief: min(L, K, IC)	coefficients from intermediate matrix
Input demand	stock target = 2.5 × avg monthly sales	sector sourcing from I-O columns
Pricing	bilateral ±0.5%/month tâtonnement	universal (not from I-O)
Wage setting	hire if offer ≥ asking; both adjust ±0.5%	L/output ratio sets equilibrium wages
Consumption	logit (γ=4), budget = wage income / 12	HH column sets basket weights
Firm entry	start firm when unmet demand observed	demand gaps reflect I-O structure
Investment	K→fixed-capital factor = 0.05	GFCF column sets composition
Firm exit	bankrupt when wealth < 0	K/output ratio sets survivability
Government	collect taxes, pay transfers, consume	tax rates and G row from table
Trade	external sectors buy/sell per I-O	export & import rows directly

Austria 2011–2019: forecasts vs Eurostat

Calib→Forecast	Seeds	Forecast %	Eurostat %	Error pp	SD pp
2010→2011	11	2.37	3.10	**−0.73**	0.85
2011→2012*	12	2.62	0.70	**+1.92**	0.82
2012→2013*	12	2.72	0.00	**+2.72**	0.65
2013→2014*	12	2.57	0.37	**+2.20**	0.94
2014→2015*	12	3.15	1.10	**+2.05**	1.26
2015→2016	12	2.04	2.00	**+0.04**	1.14
2016→2017	12	2.36	2.40	**−0.04**	0.72
2017→2018	12	2.73	2.60	**+0.13**	1.40
2018→2019	12	2.58	1.40	**+1.18**	0.96

0.42 pp
MAE — 5 normal years

1.22 pp
MAE — all 9 years

** Eurozone sovereign-debt crisis years (shaded). 2010 row: one non-converging seed excluded.*

Wealth-side marginal propensity to consume (PtC)

Definition: household consumption demand driven by net wealth — 0.054 = 5.4 cents per euro of net wealth per year.

Empirical anchor: Austrian estimate; developed-economy literature reports 3–5 cents per dollar (Carroll, Slacalek, Tokuoka & White 2017; Paiella & Pistaferri 2017).

Published protocol: one value (0.054) across all 9 panel years and all 4 COVID countries — a deliberate, disclosed simplification.

Consequences: crisis-year over-forecast 2012–2015 (consumption below 2019 reference); UK/CA/DE COVID troughs 3.8–4.9 pp shallow (their wealth-to-income ratios differ from the Austrian anchor).

Internal test: re-anchoring PtC to each calibration year's empirical value eliminates the next-year forecast residual — the published errors are protocol-conditional, not an intrinsic bias.

Capacity loss, not retention-adjusted activity

Deployers has a sector-agnostic labour pool: a laid-off worker enters one unemployment stock; the state "on payroll, at home" (Kurzarbeit/CJRS/CEWS) cannot be represented.

Category error to avoid: feeding retention-net sector activity treats retained workers as fully productive → under-predicts the trough by 5–7 pp.

Correct input: capacity actually lost — regulatory lockdown scope (UK, CA, DE) or per-sector registered-unemployment ratios (AT, AMS Bestand vs pre-pandemic baseline).

Retention layered separately via the subsidy mechanism; the AMS Kurzarbeit overlay only ever reduces a sector factor — it cannot reintroduce the error.

Disclosed openly: a model constraint that becomes an input-selection rule — not a tunable knob optimised against GDP.

Example, first lockdown: accommodation & food ≈ 2–5% capacity under output-based UK/CA/DE factors, ~24% under Austria's AMS+Kurzarbeit factor; manufacturing 70–95%; public administration & health 100%.

Cross-country convergence and seed dispersion

33 / 37

FIGARO countries converge with zero parameter changes

Sub-0.5 pp 2011 forecast errors	
Australia	**+0.03 pp**
United Kingdom	**+0.13 pp**
Austria	**+0.37 pp**
Canada	**−0.39 pp**
Indonesia	**−0.46 pp**

Inter-seed Q2'20 spreads: AT 0.4 · DE 1.1 · CA 2.4 · UK 4.7 pp — an order of magnitude across the panel.

Dispersion ≠ accuracy: DE has the widest trough gap but the second-tightest spread — different mechanisms govern the mean and the variance.

Open question for the follow-on study: seed-sensitivity of firm entry/exit on each country's matrix vs transient timing of the deepest lockdown weeks.

Full 46-country FIGARO sweep in progress (cross-country accuracy is explicitly out of scope for this paper).

What this paper does not claim

Sample sizes: 9 Austrian years; 4 COVID countries; 5 normal-year observations → comparisons are descriptive (Diebold–Mariano under-powered).

Universal PtC protocol: crisis-year errors are conditional on the single 0.054 anchor, not an intrinsic model bias.

Sector-agnostic labour pool: monthly unemployment not comparable to retention-adjusted series; quarterly GDP verification unaffected.

FIGARO 2020–2021 anomalies: pandemic subsidies drove net production taxes deeply negative; 2022–23 high-inflation regimes outside validated range (affects the 46-country sweep, not the COVID panel — it uses 2019 tables).

In progress: systematic 46-country baseline sweep; country-specific wealth-MPC and per-country lockdown grounding for UK/CA/DE.