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Demographic and economic drivers of healthcare system capacity in Italy: A local projection approach

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ABSTRACT

Research in Context

What is already known about the topic? Physician density is influenced by demographic and macroeconomic factors. However, most existing studies analyze these determinants in isolation or focus on short-term correlations, providing limited insight on their dynamic interaction over time.

What does this study add to the literature? This study provides the first long-run analysis of physician density in Italy across distinct institutional regimes: the pre-National Health Service (NHS) period (1953–1978), the centralized NHS era (1979–2001) and the decentralized regional phase (2002–2020). Using Local Projections, we show that structural drivers have *regime-dependent* effects. Importantly, after 2001, demographic aging emerged as a key driver, but its impact has been offset by constraints from rising public debt.

What are the policy implications? Rising demand for healthcare services, driven by population aging, is placing increasing pressure on the Italian healthcare system. In a publicly financed *Beveridge-type* system, addressing these pressures requires adequate fiscal capacity. Yet, in the European context, the scope for expanding public spending is constrained by fiscal rules. This creates a *structural tension* between growing healthcare needs and the resources available to address them. For this reason, physician workforce planning should be shielded from short-term budget pressures through a targeted fiscal mechanism – plausibly framed, within the broader EU fiscal framework, as a "health investment golden rule" – aimed at preserving long-horizon health-system capacity. This should not be interpreted as a general exemption for healthcare spending, but as a safeguard for expenditure related to workforce planning, training capacity, hiring continuity, and measures to reduce territorial imbalances.

Background: Italy has experienced profound demographic, technological and macroeconomic change since 1953, with effects on physician density shaped by changing institutional regimes.

Objective: This study identifies the long-term determinants of physician density in Italy and assesses how their influence varies across three regimes: the pre-National Health Service (NHS) period (1953–1978), the centralized NHS era (1979–2001), and the mature decentralized regional phase (2002–2020).

Methods: We use annual data (1953–2020) on physicians per 1000 inhabitants (a proxy for healthcare system capacity), age composition, a composite innovation index combining medical patents and total factor productivity (TFP), real GDP per capita, and public debt. Impulse responses are estimated using Local Projections, separately by institutional regime.

Results: Before 1978, physician density shows no significant response to aging, GDP or debt shocks. During 1979–2001, a one-standard-deviation (s.d.) shock to GDP growth is associated with a 0.8% increase in physician density over five years. After 2001, a one-s.d. shock to the aging index is associated with a 6% increase in physician density, while a debt shock offsets half of this effect. In the same period, technological innovation is associated with higher physician density.

Conclusions: Institutional design affects the elasticity of physician density. Economic expansion supported physician growth under the centralized NHS, whereas in the decentralized regional phase demographic responsiveness is constrained by fiscal pressures. This points to the need for fiscal arrangements that protect long-run healthcare workforce planning, especially in European Beveridge-type publicly financed systems, where service capacity depends on both public budgeting and institutional coordination.

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1. Background

1.1. Introduction

The sustainability of healthcare systems is a growing concern in advanced economies facing demographic aging and persistent fiscal pressures [1–3]. As populations age and public budgets tighten, understanding how demographic, economic and institutional forces interact is essential to assess the resilience and equity of healthcare provision [4,5]. Italy presents a particularly relevant case due to the severity and simultaneity of these challenges.

Three structural features make Italy a compelling empirical setting. First, it has one of the world's oldest populations, with the share of individuals over 65 more than doubling since the mid-twentieth century [6]. Second, it faces recurrent fiscal constraints and remains among the most indebted countries of the EU [7]. Third, it has undergone major institutional reforms, shifting from a fragmented, insurance-based model to a centralized National Health Service (NHS) in 1978, and then through a gradual decentralizing transformation initiated by the 1992–1993 reform package and later consolidated in the early 2000s through the constitutional reform of Title V [8,9].

This paper examines the long-run impact of demographic, technological and macroeconomic drivers on physician density in Italy from 1953 to 2020. We measure *physician density* as the number of physicians per 1000 inhabitants, using it as a proxy for healthcare system capacity. This indicator, widely used by international organizations such as the WHO and OECD, reflects both labor market dynamics and public investment in health [10–12]. Compared with expenditure-based measures, it offers a more direct view of service capacity.[1]

Our analysis builds on the premise that physician density reflects not only structural drivers but also the institutional and fiscal context in which policy responses occur [13,14]. To this end, we assemble a long-run panel of six variables: physician density (DOC), aging index (AI), life expectancy at birth (LEB), a composite innovation index combining medical patents and total factor productivity (INNOV), GDP per capita (GDP) and public debt-to-GDP ratio (DEBT).

We use the Local Projections (LPs) method of Jordà [15] to estimate impulse responses to structural shocks under minimal parametric assumptions. LPs are well suited for contexts with regime shifts and historical discontinuities. Accordingly, we divide the sample into three institutional periods: pre-NHS (1953–1978), centralized NHS (1979–2001), and decentralized federalism (2002–2020) [9,16–18]. As we show, this periodization is supported by structural-break tests, which indicate significant discontinuities in physician-density dynamics around the main institutional reforms. This regime-sensitive approach enables us to assess how the responsiveness of healthcare supply evolved across different governance models.

Our findings reveal distinct dynamics. Prior to 1978, physician density was largely unresponsive to structural factors, consistent with limited state planning. During the centralized NHS period, economic growth became the main long-run driver of physician expansion. In the post-2001 period, when the decentralized governance model introduced in the early 1990s had become institutionally consolidated, aging emerged as a significant positive determinant, but its effect became increasingly constrained by rising public debt. Technological innovation provided some support, but did not fully offset this broader fiscal constraint. These patterns highlight the growing tension between demographic need and fiscal capacity.

To address this growing structural imbalance, our analysis points to a targeted reform of European fiscal governance. The issue is especially relevant for *Beveridge-type* tax-funded systems, where healthcare is financed mainly through general taxation and the state remains ultimately responsible for ensuring service capacity. This institutional channel differs from *Bismarck-type* social-insurance systems, where financing is mediated through contributory insurance arrangements. In Beveridge-type systems, long-run healthcare capacity depends directly on public budgets, workforce planning, and coordination across levels of government. The policy relevance of our findings therefore extends beyond Italy to other EU countries with similar institutional features. A possible policy instrument would be a "health investment golden rule", designed not to exempt general healthcare spending from fiscal discipline, but to protect expenditure with clear effects on long-run capacity from short-term budget cuts. This includes workforce planning, training capacity, hiring continuity, and measures for underserved areas. By doing so, the rule would help distinguish ordinary current spending from expenditure that preserves future healthcare capacity.

1.2. Literature

A substantial literature has explored how demographic, technological, economic and institutional factors influence healthcare system dynamics. These forces shape not only health outcomes but also the capacity and structure of healthcare provision. Among supply-side indicators, *physician density* has become a widely used proxy for system responsiveness, accessibility and resilience [10,12]. Higher physician density is associated with broader coverage and reduced avoidable mortality, especially under structural pressures [19,20].

Demographic transitions, especially population aging, pose major challenges to health systems. Older cohorts require more complex and long-term care, increasing demand for medical personnel [21,22]. Empirical studies find a positive correlation between aging and healthcare utilization, though the effect on physician density varies by institutional context. In universal systems, aging often leads to workforce expansion [23], while in fiscally constrained or fragmented systems, demographic pressure may result in bottlenecks or increased private provision [24,25]. Life expectancy is another important demographic and health-system metric. However, rather than being a direct determinant of physician density, life expectancy is better framed as a broad outcome of healthcare provision, while also reflecting long-run demographic pressures that shape healthcare needs. Its relationship with physician density is therefore indirect and likely to emerge only gradually, capturing not only healthcare capacity but also wider social and economic conditions [26,27].

Macroeconomic conditions are longstanding determinants of health system capacity. GDP per capita is positively associated with physician density, reflecting both public and private ability to fund medical care [28–30]. For instance, a 1% increase in GDP per capita is linked to a 0.75% rise in physician density [10]. However, *fiscal constraints* weaken this relationship. Rising public debt limits the ability of governments to expand health services, particularly in countries operating under the EU fiscal framework [31]. Austerity measures have been shown to suppress healthcare hiring even amid economic recovery [5,32,33]. Italy illustrates this duality: while economic growth supported physician expansion in earlier decades, debt-driven constraints led to hiring freezes and spending reviews after the 2000s [34].

Innovation is another long-run driver. Technological advances expand treatment capacity and affect labor demand by altering how care is delivered [35,36]. No single time series fully captures healthcare innovation over a long historical horizon. We therefore measure innovation through a composite index that combines medical patents, which proxy codified inventive activity in the medical sector [37], and total factor productivity (TFP), which reflects broader productivity-enhancing and system-wide technological change in healthcare delivery [38]. This allows us to capture both formal inventive output and

[1] Physician density does not fully capture variation in hours worked and therefore may not be a perfect measure of effective service delivery. However, in Italy, this limitation is attenuated by the long-standing role of national collective agreements in regulating working time and by the relative stability of physicians' working hours (see Figure A.3).

wider technological change beyond patenting alone. The relationship with physician density is double-edged: some technologies are labor-augmenting (e.g., diagnostics requiring specialized personnel), while others are labor-saving (e.g., automation, remote care) [39–41]. Institutional and fiscal contexts further mediate the pace of adoption [42].

Institutional design crucially shapes how structural drivers affect healthcare system capacity. Centralized systems respond to demographic or economic shifts through coordinated workforce planning, while decentralized regimes often exhibit uneven capacity across regions [13,43,44]. In Italy, the 1978 NHS reform introduced centralized governance and universal access. The shift toward decentralization, however, began with the 1992–1993 reform package, which expanded regional responsibility and introduced a new fiscal, organizational, and managerial logic into the NHS [9,18,45]. From this perspective, the 2001 constitutional reform did not initiate decentralization. Rather, it consolidated and constitutionalized changes that had already been introduced during the 1990s. The early 2000s should therefore be viewed as the transition to a *mature decentralized regional system* [8,9]. This institutional evolution explains why the Italian healthcare system became more exposed to territorial disparities in physician distribution and service capacity [17].

As such, interpreting trends in physician density requires attention to changing institutional arrangements. Workforce patterns reflect not just macro-structural pressures but also political decisions about hiring, funding and training [46]. While comparative research underscores the importance of regime-sensitive and longitudinal perspectives, much existing work remains focused on individual drivers or short-run effects. An integrated, long-run approach is needed to assess how demographic, economic and technological dynamics interact with evolving governance frameworks to shape the trajectory of healthcare systems like the Italian one.

1.3. Physician density in Italy

Fig. 1 shows the evolution of physician density in Italy from 1953 to 2020, distinguishing between public, private, and total physicians.

Public physician density captures physicians employed within NHS organizations, mainly local health authorities and public hospitals. It is therefore a measure directly shaped by public hiring decisions, regional administration, and budget constraints. Total physician density, by contrast, also includes physicians working in private and accredited private providers (see [9] and [3], for an overview of the organization of public and accredited private healthcare facilities in Italy).

This distinction became increasingly important as the Italian healthcare system evolved across institutional regimes. In the earlier phase of NHS expansion, the growth of physician density was driven mainly by the expansion of public provision. As decentralization matured, however, regional models increasingly diverged in the way they combined direct public provision with accredited private providers, and in some cases assigned a larger role to the latter within the NHS framework [47].

The two series therefore remain closely related, but do not follow the same trajectory over time, especially in the post-2001 period.

Measured as the number of physicians per 1000 inhabitants, physician density serves as a proxy for the healthcare system's capacity to deliver timely and adequate care. Each panel displays the level of physician density (left axis) and its annual growth rate (right axis).

Panel (a) shows the increase in *public-sector* physician density, which rose from 0.43 physicians per 1000 inhabitants in 1953 to 1.74 in 2020. The most rapid expansion occurred prior to the 1978 NHS reform, with an average annual growth rate of 4.3 percent, driven by postwar reconstruction and efforts to expand coverage. Growth slowed to 2.2 percent during the centralized NHS period (1979–2001) and further decelerated to just 0.18 percent annually after 2002, reflecting the effects of tighter fiscal constraints.

Panel (b) illustrates a gradual but steady rise in *private-sector* physician density, from 0.10 to 0.40 per 1000 inhabitants, with growth accelerating after 2001. This pattern indicates an increasing reliance on private provision in the context of stagnating public recruitment.

Finally, panel (c) presents the *aggregate trend*, with total physician density rising from 0.71 in 1953 to 2.14 in 2020. The overall trajectory reflects both the expansion of public-sector employment in earlier decades and the recent growth of private-sector activity, shaped by changing institutional and fiscal conditions [48,49].

Taken together, these patterns show that total physician density does not move one-for-one with public physician density. While public physician density more closely tracks the evolution of public planning and fiscal governance, total physician density also incorporates the changing role of accredited private provision. This distinction becomes clearer when the evidence is read against the three institutional regimes summarized in Table 1.

The *first regime* (1953–1978) was characterized by a mutualistic, occupation-based healthcare system marked by fragmented financing and weak institutional coordination. Health coverage remained incomplete, and substantial disparities across occupational groups persisted.

The *second regime* (1979–2001) began with the establishment of a centralized NHS, which introduced universal coverage and standardized public provision across regions. The period was marked by rapid growth in public health expenditure; however, fiscal imbalances soon emerged, particularly in the 1990s, as regional deficits widened and EU fiscal constraints became increasingly influential.

The *third regime* (2002–2020) followed the reform of Title V of the Constitution (Constitutional Law No. 3/2001), which consolidated an earlier process of NHS regionalization, ushering in a model of "health federalism". This phase coincided with accelerated population aging, rising medical costs and the tightening of fiscal constraints under the EU fiscal framework. While life expectancy remained high, the growth of the physician workforce slowed, and disparities in access, service quality and health outcomes became more pronounced.

Building on these institutional developments and the existing literature, we formulate three guiding hypotheses regarding the structural determinants of physician density in Italy:

Hypothesis 1 (H1). *Population aging has become an increasingly important driver of physician density over time.* We expect a stronger positive relationship in later regimes, particularly under decentralized governance, where demographic pressures are likely to play a more prominent role in workforce planning.

Hypothesis 2 (H1). *The response of physician density to innovation is regime-dependent and may vary across horizons.* Rather than operating uniformly over time, technological change is expected to affect physician density growth differently across institutional settings, depending on how innovation is adopted and integrated into healthcare provision.

Hypothesis 3 (H3). *Fiscal constraints increasingly limit the capacity of the public sector to expand physician density.* While economic growth facilitates expansion across periods, rising public debt and tighter fiscal rules, especially in the decentralized regime, are expected to reduce the responsiveness of physician density to structural demand.

The next section formalizes these hypotheses by introducing a long-run empirical framework to evaluate how demographic, technological and economic forces have influenced physician density across institutional regimes.

2. Methods

2.1. Data

The empirical analysis draws on annual time series data for Italy spanning the period 1953 to 2020 and examines the structural determinants of physician density, interpreted as a proxy for healthcare

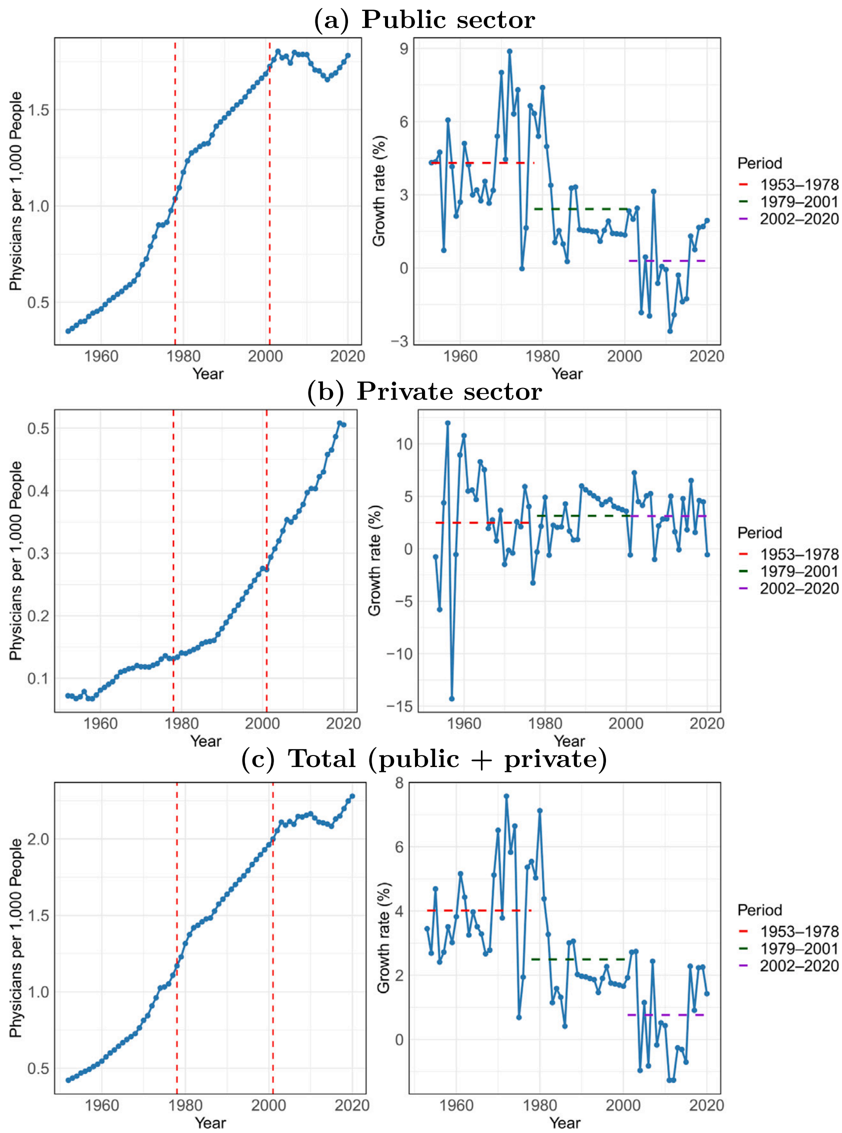

Fig. 1. Physician density levels and growth rates in Italy, 1953–2020.
Note. Each panel presents the number of physicians per 1000 people (left) and their annual growth rate (right) from 1953 to 2020. Panel (a) shows trends for public-sector physicians; panel (b) refers to private-sector physicians; panel (c) displays the total. Dashed red vertical lines in the left-hand plots mark structural breaks. Dashed horizontal lines in the right-hand plots indicate average growth rates for each subperiod.

system capacity. Key explanatory variables include the aging index, life expectancy at birth, a composite innovation index combining medical patents and TFP, GDP per capita and the public debt-to-GDP ratio. Data sources comprise statistics from ISTAT, the OECD, the Bank of Italy, and the Penn World Table.

All series are log-transformed and first-differenced to approximate growth rates. This allows estimation of dynamic responses and avoids spurious regression. Variables are also standardized for comparability. The evolution of growth rates of the key drivers is illustrated in Figure A.2 in the Appendix.

The five structural variables display distinct long-term trajectories, reflecting Italy's evolving demographic profile, macroeconomic conditions and institutional transitions over the study period:

- **Aging Index (AI).** Defined as the ratio of individuals aged 65 and over to those under 15. The index rose steadily across all periods, particularly after 1978, exerting sustained upward pressure on age-related healthcare demand [38].
- **Life Expectancy at Birth (LEB).** Increased from 68 years in 1954 to 83 years in 2020. Most gains occurred before 2000, while progress has slowed in recent decades due to diminishing returns to medical and public health advances [51]. As a broad demographic and health-system indicator, life expectancy is used as an indirect proxy for healthcare needs and system performance, rather than as a direct determinant of physician density.
- **Technological Innovation (INNOV).** Our innovation measure combines medical patents and total factor productivity (TFP). Medical patents capture codified inventive activity in health-related technologies, while TFP captures system-wide technological change. The two components are normalized and aggregated using a Benefit-of-the-Doubt (BoD) approach [52–54]. Its construction is documented in Appendix A.1.
- **GDP per capita (GDP).** Rose rapidly through the late 1970s, then entered a prolonged phase of stagnation marked by macroeconomic instability. Since 2001, sluggish growth has constrained public investment in healthcare and limited households' ability to afford medical services [42].
- **Debt-to-GDP Ratio (DEBT).** Began rising sharply in the 1980s, with peaks in the 1990s and following the 2008 global financial

Table 1
Governance regimes, structural features and health outcomes of the Italian healthcare system.

	1953–1978	1979–2001	2002–2020
Institutional context	Mutualistic, occupation-based system	Centralized National Health Service (NHS)	Decentralized "health federalism" model
Structural features	• Contributory financing via occupational mutual funds • Coverage limited to approximately 75% of the Italian population • Fragmented provision with strong regional disparities	• Universal coverage under centralized NHS (established in 1978) • Rapid increase in public health expenditure • Rising regional fiscal imbalances • 1990s reforms: corporatization and the start of NHS regionalization, introduction of uniform levels of care later formalized as Essential Levels of Assistance (LEAs) • Early adoption of EU fiscal rules	• Constitutional consolidation of regional autonomy in healthcare delivery • Formal definition of LEAs • Enforcement of fiscal rules and periodic spending reviews • Accelerating population aging and chronic disease burden • Cost pressures linked to medical and digital innovation
Health outcomes	• Unequal access and fragmented provision • High infant mortality and prevalence of infectious diseases • Pronounced territorial and socioeconomic disparities	• Major gains in life expectancy • Broad achievement of universal access • Partial reduction of regional and social inequalities	• Continued high life expectancy • Slower growth in public health spending post-2010 • Renewed divergence in regional access, quality and outcomes

Note. Authors' elaboration based on institutional and policy developments discussed in [50]. Key legislative milestones include Law No. 833/1978 (establishing the National Health Service), Legislative Decrees No. 502/1992 and No. 517/1993 (introducing managerial reform and initiating NHS regionalization), Constitutional Law No. 3/2001 (reforming Title V of the Italian Constitution), and the Decree of the President of the Council of Ministers (DPCM) of 29 November 2001 (defining the LEAs).

crisis. High debt levels have increasingly limited public-sector hiring, particularly under the EU fiscal framework [7].

These trends unfolded in tandem with two major institutional transitions in Italy's healthcare system. The first was the creation of the NHS, which coincided with rising life expectancy and the expansion of public provision, marking the beginning of more coordinated national responses to demographic change. The second was the move toward decentralized governance, which took place under mounting debt pressures and economic stagnation, increasingly constraining the fiscal space for workforce investment. At the same time, population aging intensified, placing heavier demands on regional systems, while the pace of medical innovation slowed down.

Taken together, these dynamics underscore the importance of adopting a regime-sensitive analytical framework to capture how structural drivers influence physician density over time. The next subsection details the diagnostic checks and modeling strategy used to estimate these dynamic relationships.

2.2. Stationarity and breaks

Prior to estimation, we assess the time series properties of all variables. Four standard unit root tests – Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), DF-GLS and KPSS – are applied to both levels and first differences, across the three institutional subperiods [55].

Results for variables in levels are mixed (Table A.2). In the 1953–1978 and 1979–2001 regimes, the ADF and PP tests suggest stationarity for several series. However, the DF-GLS and KPSS tests offer more conservative results, warranting caution. In the post-2001 period, most tests fail to reject the null of a unit root, likely reflecting greater persistence and the limited power of these tests in shorter samples.

After log-differencing, the evidence of stationarity improves substantially (Table A.3). Most differenced series reject the presence of a unit root across all regimes. The KPSS test generally supports stationarity. While a few borderline cases remain, the overall results justify using first differences to ensure consistent inference and mitigate the risk of spurious correlations.

To validate the choice of institutional regimes (1953–1978, 1979–2001, and 2002–2020), we perform Chow tests for structural breaks in physician density (DOC) and its public component (DOC_{pub}) around the 1978 and 2001 reforms [56]. Table A.4 shows strong evidence of structural breaks in both the level and log-transformed series, while the differenced series also display significant changes, particularly around 1978.

Appendix Sections A.2 and A.3 complement these exogenously imposed Chow tests with endogenous break detection and a direct comparison between the baseline periodization used in the paper and alternative specifications that introduce 1992 or 1993 as intermediate break years. The results suggest a *layered interpretation*: the early-1990s reforms mark the beginning of the second reform phase, whereas 2001 better captures its mature institutional configuration in the annual data.

Taken together, these findings support the use of log-differenced data and confirm the empirical relevance of the three institutional regimes. Estimating separate models by regime allows us to account for structural heterogeneity in physician-density dynamics, thereby improving both interpretability and consistency with the institutional history.

2.3. Model

To investigate how demographic, technological and economic forces shape physician density, we estimate Local Projections (LPs) *à la* Jordà [15]. LPs allow flexible dynamics, are robust to structural breaks and can be estimated on relatively short macro-historical samples, features that well suit our regime-based study of the Italian healthcare system.

For each structural driver $x \in \{\text{AI, LEB, INNOV, GDP, DEBT}\}$ and horizon $h = 0, \ldots, 5$, we run the horizon-specific regression:

$$\Delta\log(\text{DOC}_{t+h}) \;=\; \alpha_h + \theta_h\, s_{x,t} + \sum_{j=1}^{k} \beta_{j,h}\, s_{x,t-j} + \sum_{j=1}^{k} \phi_{j,h}\, \Delta\log(\text{DOC}_{t-j}) + \varepsilon_{t+h}, \tag{1}$$

where $s_{x,t} \equiv \Delta\log x_t / \sigma_x$ is the *standardized* contemporaneous change in x and σ_x is the sample standard deviation of $\Delta\log x_t$. The lag order is set

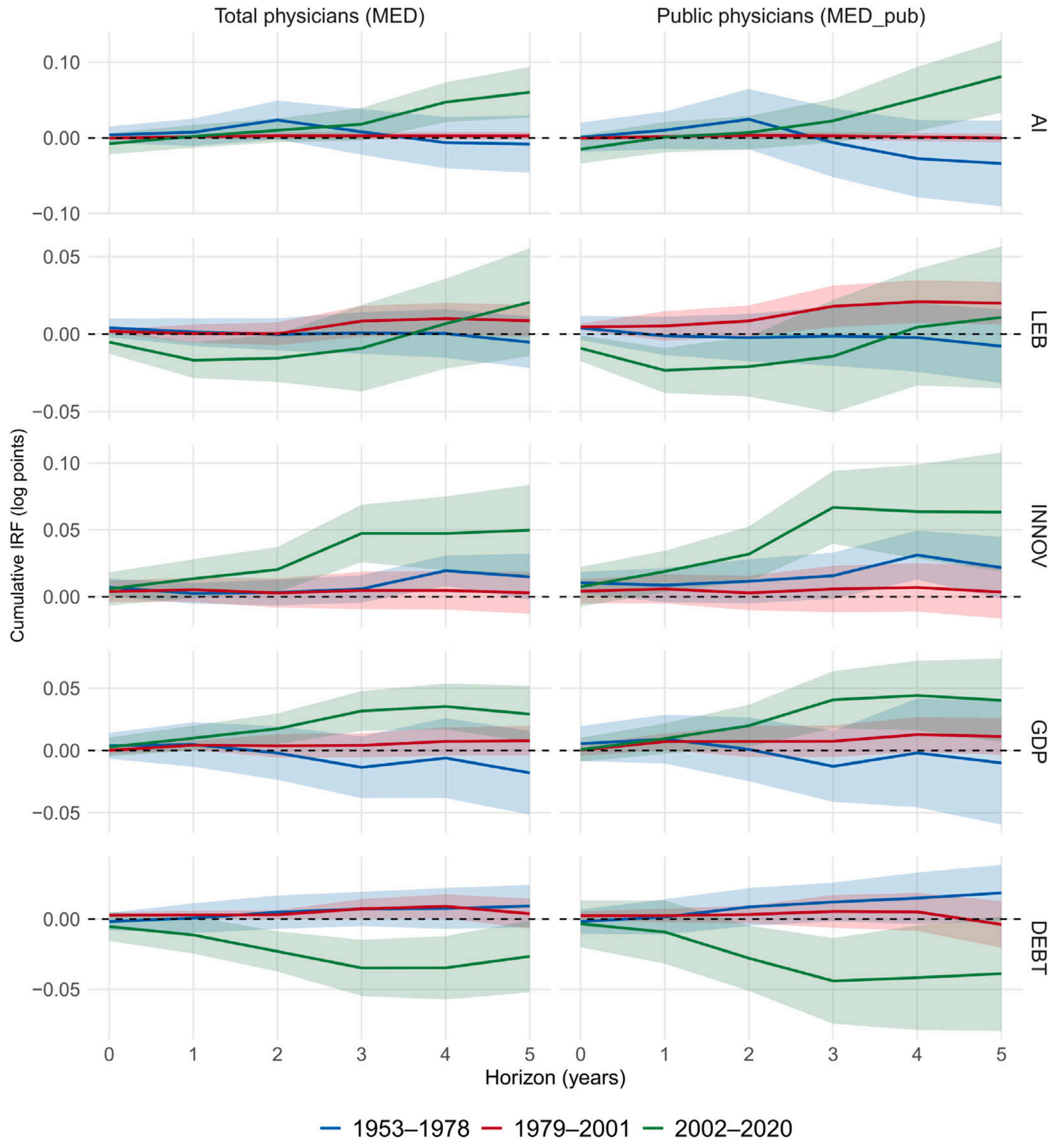

Fig. 2. Cumulative IRFs (1-σ shock) on $\Delta\log(DOC)$ and $\Delta\log(DOC_{\text{pub}})$.
Note. Cumulative impulse response functions for physician density: $\Delta\log(DOC)$ (total) and $\Delta\log(DOC_{\text{pub}})$ (public sector only). Responses are to one-standard-deviation shocks in the annual log changes of five variables: *AI* (aging index), *LEB* (life expectancy at birth), *INNOV* (composite innovation index combining medical patents and TFP), *GDP* (GDP per capita), and *DEBT* (public debt-to-GDP ratio). Estimation is conducted separately for three subperiods (1953–1978, 1979–2001, 2002–2020) using $k = 3$ lags. Confidence intervals are based on heteroskedasticity- and autocorrelation-consistent standard errors computed with the Andrews-Newey–West procedure. Cumulative variance is calculated assuming zero cross-horizon covariance.

to $k = 3$, as indicated by multiple information criteria: AIC, BIC, HQIC and FPE, which generally favor this specification across each subsample (Table A.6).

Because current and lagged changes in x are included on the right-hand side, shocks are interpreted as unexpected one-standard-deviation innovations in $\Delta\log x_t$ conditional on their own and the response's recent history. This "generalized" strategy avoids orthogonalization, ensuring invariance to variable ordering and preserving transparency [57–59].

Heteroskedasticity- and autocorrelation-consistent (HAC) standard errors are computed using the Newey–West estimator, with an automatic, data-dependent bandwidth following Andrews [60]. Confidence bands are constructed from the corresponding HAC/Newey–West statistics using the normal approximation. Cumulative impulse responses are obtained by summing the horizon-specific level responses, with cumulative variance calculated assuming zero cross-horizon covariance.

To account for institutional heterogeneity, Eq. (1) is estimated separately for three regimes: (I) pre-NHS, 1953–1978; (II) centralized NHS,1979–2001; (III) decentralized federalism,2002–2020. Allowing all parameters, including dynamic propagation, to vary by regime improves internal consistency and aligns with documented structural breaks.

We examine both total physician density (DOC) and publicly employed physician density (DOC_{pub}) as dependent variables. The sequence of θ_h coefficients traces the dynamic effect of a one-standard-deviation shock to x on physician density over a five-year horizon, a window that reflects a realistic adjustment period for workforce policy and captures long-run system responses [61,62].

Our approach builds on recent applications of LPs in health systems and public finance [63–65], providing a flexible framework to uncover regime-specific policy dynamics under evolving structural pressures.

3. Results

We estimate Cumulative Impulse Response Functions (CIRFs) from LPs using three lags. Fig. 2 reports the five-year CIRFs of physician

Table 2
Assessment of LP results against guiding hypotheses.

Factor	Empirical Evidence	Interpretation
Demographic structure		
Aging Index (AI)	No detectable association before 2001; strong cumulative response after 2001 (0.060*** at $h = 5$).	**Supports H1:** Aging influences physician density only when demographic pressure becomes significant and institutions are responsive.
Life Expectancy (LEB)	Limited and non-uniform association across regimes, with some evidence during the centralized NHS phase.	**Consistent with H1:** life expectancy does not emerge as a stable or immediate driver of physician density, supporting its interpretation as an indirect demographic and health-system indicator.
Innovation and fiscal capacity		
Innovation Index (INNOV)	Positive association with physician density before 1978 at both $h = 0$ and $h = 5$, weak during the centralized NHS phase, and positive again after 2001, with the strongest cumulative response at $h = 5$ (0.050***).	**Partially supports H2:** innovation is associated with physician density growth in some institutional regimes, but the relationship is not systematic across all settings.
GDP per capita (GDP)	Small cumulative response during the centralized NHS phase (0.008* at $h = 5$), becoming stronger after 2001 (0.029*** at $h = 5$).	**Supports H3:** The association between economic growth and physician expansion strengthens under regimes with greater fiscal autonomy and institutional capacity.
Debt-to-GDP (DEBT)	No detectable association before 2001; negative cumulative response after 2001 (-0.027** at $h = 5$).	**Supports H3:** The negative association between debt and physician density growth emerges only in the decentralized phase, consistent with fiscal constraints becoming more binding.

*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.
Note. All estimates refer to impulse responses from Local Projections (LPs) at horizons $h = 0$ (impact) and $h = 5$ (cumulative).

density ($\Delta \log DOC$) and its public component ($\Delta \log DOC_{pub}$) to one-standard-deviation shocks in each structural driver.

We interpret the results through the lens of the three institutional regimes.

Demographic dynamics. The aging index (AI) has no significant effect in the earlier periods but becomes a predictor of physician growth after 2001. In the federalist regime, a one-standard-deviation (s.d.) shock to the aging index is associated with a 6% cumulative increase in physician density over five years (0.060*** at $h = 5$). *Life expectancy at birth (LEB)* plays a limited and non-uniform role across subperiods. Only during the centralized NHS phase is it positively associated with physician density growth.

Technological innovation. The innovation index (INNOV) shows a discontinuous pattern across institutional regimes. It is positively associated with physician growth before 1978 (both on impact and over the long run), fades during the centralized NHS phase, and becomes relevant again after 2001, when the long-run effect is strongest (0.050*** at $h = 5$).

Fiscal and economic drivers. Fiscal and economic conditions become more relevant in the mature decentralized phase, especially over the long run. After 2001, a one-s.d. shock to the growth rate of GDP per capita is associated with higher physician density growth, while a one-s.d. shock to public debt exerts a negative effect of similar magnitude over five years (0.029*** and −0.027** at $h = 5$, respectively).

To assess whether the post-2001 dynamics reflect increasing regional fragmentation, Appendix A.4 reports a descriptive regional exercise. The results show that physician density differs across Italian regions, but that this dispersion does not display a marked widening over time. This suggests that the pattern is not driven by an increasing fragmentation of regional trajectories.

The public-sector estimates ($\Delta \log DOC_{\text{pub}}$) largely mirror the total physician results. Although some coefficients differ in magnitude, especially for public debt, the broad direction and timing of the estimated effects remain largely consistent, confirming the robustness of the findings and highlighting the central role of the public sector in the adjustment of physician capacity.

4. Discussion

Table 2 summarizes how the empirical patterns align with the guiding hypotheses. The findings confirm that physician density is not uniformly responsive to structural drivers; rather, its responsiveness evolves in tandem with institutional configurations and macroeconomic constraints.

Demographic pressures emerge as a salient determinant only in the most recent period, indicating that aging has become a driver of healthcare demand under the decentralized governance model. The absence of earlier effects may reflect limited institutional responsiveness or, more likely, the lack of targeted workforce planning in centralized regimes. In contrast, life expectancy plays a limited role across regimes. Its association with physician density growth is more evident during the centralized NHS phase, but it does not emerge as a stable structural determinant of physician supply.

The relationship between technological innovation and workforce needs is shaped by institutional and temporal context. When innovation is measured through the composite index combining medical patents and TFP, the results point to regime-dependent effects. Innovation is positively associated with physician growth before 1978, becomes weak during the centralized NHS phase, and re-emerges after 2001, especially over the long run. These results are more consistent with complementarity than with substitution of the medical workforce, although the strength of the association varies.

After 2001, economic and fiscal conditions play an increasingly central role in shaping the system's capacity to expand physician density. The positive association with GDP per capita suggests that physician workforce expansion became increasingly dependent on the availability of economic resources, even as demographic and healthcare needs continued to rise. Conversely, the negative effect of public debt shows that, in Beveridge-type systems operating under the EU fiscal framework, limited budgetary space can constrain hiring capacity. These results reveal a troubling disconnect in the post-2001 regime, since physician density responds to population aging but this response is partly offset by fiscal constraints.

This view is useful for interpreting the changing public–private composition of physician supply. The post-2001 expansion of private physician density in Fig. 1 coincides with the period in which fiscal constraints became more binding for public workforce capacity. This pattern is consistent with a *de facto* shift of part of the demographic adjustment toward private provision. More broadly, the results point to a paradox of Italian health federalism. Decentralization was intended to align healthcare provision with local demographic needs, yet it is precisely in this phase that fiscal constraints have curtailed the system's capacity to respond to population aging.

Taken together, these findings underscore the importance of aligning healthcare workforce policies with evolving pressures. Institutional arrangements mediate the responsiveness to such pressures, but demographic aging, technological transformation and fiscal constraints increasingly define the scope for policy action. Addressing these challenges demands governance frameworks that are both responsive to evolving needs and grounded in long-term economic sustainability.

5. Conclusion

This study investigates the long-run drivers of healthcare system capacity in Italy by estimating regime-specific impulse responses of physician density to structural shocks over the period 1953–2020. Using a Local Projections (LPs) approach, we examine how physician density responds to demographic, technological and fiscal pressures across three institutional regimes: the pre-NHS period (1953–1978), the centralized NHS era (1979–2001) and the decentralized regional system (2002–2020).

Our findings reveal a well-defined pattern of regime-dependent responsiveness. In the pre-NHS period, physician density was largely unresponsive to structural shocks, reflecting limited state involvement and fragmented mutualistic arrangements. During the centralized NHS era, economic growth emerged as the main driver of physician expansion, consistent with state-led investment in public healthcare infrastructure. In the post-2001 period, demographic aging became a significant determinant of physician density, as regional governments took on greater responsibility for workforce planning. However, the positive impact of aging has been increasingly offset by rising public debt, which imposes binding fiscal constraints on healthcare hiring. In this period, technological innovation, captured by our composite index, also emerged as a quantitatively relevant expansionary factor, operating against the drag exerted by rising public debt.

Overall, these dynamics underscore a growing *structural tension*: as the population ages and demand for care increases, the healthcare system's capacity to adapt to evolving needs is increasingly constrained by fiscal pressures. Importantly, the issue is not only the size of the workforce response, but its institutional composition. If fiscal constraints limit public hiring, part of the adjustment to demographic pressure may occur through an increase in private physician density, shifting capacity expansion away from the publicly financed component of the system.

In a *Beveridge-type* healthcare system, this shift has direct equity implications. When public capacity fails to keep pace with need, access to care may become more dependent on households' ability to absorb private costs.

Without coordinated policy intervention, this imbalance risks widening inequalities, thus undermining the equity goals of Italy's universal healthcare system and, more broadly, those of universal healthcare systems across Europe.

To address this challenge at the European level, a possible policy instrument could be the introduction of a "health investment golden rule". Such a rule would not exempt general healthcare spending from fiscal discipline. Its aim would be more specific. It would protect expenditure with clear long-run effects on health-system capacity, particularly investment that strengthens the future supply of medical personnel and helps bridge significant regional infrastructure gaps. This distinction between ordinary healthcare spending and capacity-building investment is particularly important in Beveridge-type healthcare systems, where workforce capacity depends directly on public budgeting, planning, and intergovernmental coordination. In this view, the rule should be understood as a targeted mechanism to protect future supply capacity under fiscal pressure while remaining consistent with budget discipline.

CRediT authorship contribution statement

Alessandro Bellocchi: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Giuseppe Travaglini:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francesco Vidoli:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.healthpol.2026.105701.

Data availability

The raw data used in this study are publicly available from the sources described in the Appendix. The processed dataset and the R code used for the analysis are available from the corresponding author upon request.

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