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Do religious and political stability condition the returns to R&D? evidence from OECD countries

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ABSTRACT

This research re-examines the neo-Schumpeterian prediction linking research and development (R&D) to economic development by asking whether this relationship varies with government and religious stability. Using an unbalanced panel of 23 OECD members and accession candidates over 1998–2018, we estimate country fixed-effects specifications relating log real GDP per capita to R&D intensity, stability indices, their interactions and macroeconomic controls. The marginal association between R&D intensity and income increases with each stability index. A one-standard-deviation increase in R&D intensity is associated with approximately 7.1% higher GDP per capita at the 10th percentile of government stability and 12.0% at the 90th percentile; for religious stability, the corresponding estimates are 3.2%, not statistically distinguishable from zero, and 12.9%. The religious stability interaction is the most robust result: it is positive and significant in all fourteen robustness specifications, including alternative measures of R&D, income and religious stability, labour productivity and patents as outcomes, and a growth equation with lagged income. The government stability interaction is robust in level specifications only. Wild cluster bootstrap inference supports both interactions at the 10% level in the baseline specifications.

KEYWORDS

R&D intensity; economic development; neo-schumpeterian growth; government stability; religious stability

JEL CLASSIFICATION

O30; O40; O43; P16; Z12

I. Introduction

Cross-country differences in productivity and living standards remain a central question in growth economics (Baltgailis 2019). Neo-Schumpeterian endogenous growth theory emphasizes innovation, but the relationship between R&D and economic performance depends on the institutional environment (Rodríguez-Pose 1998, 2013). Political and religious authorities have often been closely intertwined, potentially shaping both innovation incentives and the diffusion of knowledge (Bisin et al. 2024). This research examines whether government and religious stability condition the association between R&D intensity and economic development.

Our sample illustrates the distinction between these institutional dimensions. Finland records the highest religious stability score, while the United States has the highest average government stability score.[1] France and Turkey have below-average religious stability, although Turkey combines this with comparatively high government stability.[2] These contrasts motivate examining the two dimensions separately rather than treating them as interchangeable measures of institutional quality.

The diffusion of printing illustrates the longstanding relationship between innovation, institutions, and religion.[3],[4] Gutenberg's movable type press, developed in Mainz around 1450, spread through

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[1]In our data, Finland records the ceiling value of the ICRG religious stability index throughout 1998–2018 (mean = 6.00, the maximum on a 0–6 scale), and the United States records the highest average government stability score among the 23 countries in the sample (mean = 8.74, ranging from 6.17 in 2007 to 10.83 in 2000).

[2]France and Turkey record religious stability scores below the sample mean (means of 4.46 and 4.09, respectively, against a sample mean of 5.24). Turkey combines this with a comparably high average government stability score (mean = 8.43, the third highest in the sample), while France records a close-to-average government stability score (mean = 7.90) – see Section VI for a discussion of both configurations and of what the ICRG Government Stability construct captures.

[3]In fact, religion forms an integral part of institutional taxonomy: it is an informal institution in North's, (1994) – that is to say, a norm, convention or system of beliefs that structures human interactions outside formal rules and their enforcement mechanisms – and it occupies the first of the four institutional levels defined by Williamson (2000), namely the layer of social anchoring provided by traditions and customs, which evolves only over the course of centuries. We would like to thank an anonymous referee for their comment on this point.

[4]The relationship between innovation and institutional stability may also run in the opposite direction: since Schumpeter (1942), innovation has been seen as disruptive for market equilibria and for political and institutional structures, as the printing press illustrates, and Frimpong (2024) shows that innovation can stimulate economic progress while generating political instability. The innovations able to reshape institutions are, however, rare and radical, and their institutional consequences unfold over decades: in the case of printing, the main institutional reform, the Edict of Nantes (1598), came some 150 years later

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skilled workers and commercial networks, lowering book production costs. Printers and booksellers subsequently helped disseminate Protestantism from 1517 by translating and distributing Luther's writings despite Catholic repression; Luther described printing as 'God's greatest gift' (Audisio 1996). Diffusion proceeded from Germany and neighbouring regions into Italy, then France, the Low Countries, and the Iberian Peninsula. Although Paris adopted printing in 1470, diffusion in France remained slower and more tightly regulated than in German and Italian regions (see Figure Appendix A.1 in Appendix A).

From the 1530s, and particularly after the publication of the Index librorum prohibitorum in 1559, the Sorbonne, monarchy, and Parliament of Paris restricted printing through censorship, bans on Protestant Bibles, and licencing requirements. Political centralization reinforced these controls, unlike the decentralized cities of Germany and Italy. Resistance from established guilds and less favourable commercial conditions also constrained expansion, with Lyon an important exception. Together, these religious, political, and economic restrictions limited the diffusion of an already available technology.[5]

The example motivates our distinction between resources devoted to invention and the institutional conditions governing their productive use. An innovation may exist without diffusing widely when religious authority, political incentives, or incumbent interests restrict adoption. Our empirical analysis considers whether analogous institutional differences are associated with variation in the macroeconomic relationship between R&D intensity and income.

Our results show that the association between R&D intensity and GDP per capita increases with both government and religious stability. The religious stability interaction is the most robust result: it is positive and significant in all fourteen specifications summarized in Appendix K, including alternative measures, alternative outcomes and a growth equation with lagged income. The government stability interaction is robust in level specifications only, and it describes a gradient in an association that is already positive at low government stability. We find no evidence that the two forms of stability must be jointly high.

Section II reviews the literature; Sections III and 4 describe the data and methodology. Section V presents descriptive evidence and preliminary analysis, Section VI reports the results, and Section VII concludes.

II. Literature

In neo-Schumpeterian growth theory, innovation is a central driver of cross-country differences in productivity and income: R&D inputs generate new ideas and technologies that raise total factor productivity (Aghion and Howitt 1992; Grossman and Helpman 1991; Jones 1995a, 1995b; Romer 1990). The empirical literature also shows that the payoff to R&D varies across institutional settings. Our premise is that this payoff depends on whether the political and socio-cultural environment allows inventions to be financed, protected and diffused.

The first strand explains why political instability matters for the R&D–income relationship. R&D investments are irreversible, forward-looking and exposed to appropriation and policy risk. Political instability raises uncertainty and shortens planning horizons, which reduces long-term investment (Alesina et al. 1996), and the literature on institutions and growth stresses the role of property rights, predictable policies and law enforcement for the return on investment (Acemoglu, Johnson, and Robinson 2001; Knack and Keefer 1995; Rodrik, Subramanian, and Trebbi 2004). Applied to R&D, this implies that the return on research effort should increase with political stability.

A second strand concerns religion, cultural conflict and the diffusion of knowledge. The historical link between Protestantism and development has been attributed to human capital formation rather than to a work ethic (Becker and Woessmann 2009), which matters for our question because human capital raises the return to R&D.

Bénabou, Ticchi, and Vindigni (2013) model a different channel: scientific discoveries may threaten religious beliefs or authority, creating incentives for political and religious elites to

and was probably more a consequence of the St Bartholomew's Day Massacre (1572) than of printing itself. Over our twenty-year sample of mostly incremental research effort, we therefore focus on the direction running from institutional stability to the R&D–income association.

[5]Table Appendix A. 1 detailing the main factors affecting the spread of printing in Germany, Italy and France is available in Appendix A.

accommodate innovation, permit secularization, or block diffusion. Religious tension can consequently raise the political costs of adopting new knowledge and reduce the payoff to a given R&D investment. Greater religious stability may ease these constraints, without implying that all barriers to diffusion disappear. Bisin et al. (2024) explain how such conflicts can become embedded in institutional arrangements. When clerical elites hold disproportionate bargaining power, governance may favour religious infrastructure and legitimacy at the expense of secular institutions and civil society. This mechanism connects directly to our institutional measure: the ICRG religious-tensions index identifies domination of society or governance by a single religious group as a source of risk (see Appendix D). Religious stability thus concerns the institutional management of religious tensions, not the prevalence or intensity of religious belief. Read together, these models suggest a possible sequence from concentrated religious authority to restrictions on innovation diffusion and weaker economic performance.

Historical evidence is consistent with this mechanism. In nineteenth-century Prussia, cities with greater religious tolerance and diversity produced more valuable patents (Cinnirella and Streb 2017), and in early modern Berlin, the settlement of persecuted religious minorities was associated with higher textile production (Hornung 2019). At the macroeconomic level, Herzer and Strulik (2020) find that declining religiosity is associated with faster productivity growth in developed economies. Religiosity differs from our concept of religious stability, but this evidence supports the idea that the religious environment shapes the productivity of inventive effort.

The literature reviewed above establishes two complementary arguments. First, the returns to R&D depend on an institutional environment in which political stability, secure property rights and predictable policies reduce uncertainty and appropriation risk. Second, religious institutions can affect the diffusion of scientific knowledge, and the relevant mechanism is not religiosity *per se* but the institutional conditions governing the interaction between political authority, religious groups and the diffusion of knowledge. This is what our religious stability measure captures, since it records the risk that a single religious group dominates society or governance (see Appendix D).

The gap this paper addresses can now be stated precisely. Existing theory and evidence establish that innovation raises income, while a separate literature establishes that political and religious institutions can shape the environment in which innovation is developed and diffused. What has not been tested directly is whether the innovation-growth link is itself conditional on institutional stability, and in particular whether government stability and religious stability systematically moderate the growth payoff to R&D. This is the gap we fill: we show that the baseline neo-Schumpeterian prediction holds only weakly and imprecisely on average in our sample but becomes stronger and more precisely estimated once we allow its magnitude to depend on institutional quality. The results are consistent with the view that stable political and religious environments facilitate the diffusion and productive use of innovation.

III. Data

We use an unbalanced panel of 23 economies over 1998–2018, consisting mainly of OECD members and including 3 OECD accession candidate countries (Argentina, Bulgaria, and Romania).[6] In theory, this represents 483 observations; however, due to missing values for R&D intensity, the final sample includes 468 observations. The countries in the sample are Argentina, Austria, Belgium, Bulgaria, Canada, South Korea, Denmark, Spain, the United States, Finland, France, Hungary, Ireland, Italy, Japan, the Netherlands, Poland, Portugal, Romania, the United Kingdom, Slovenia, the Slovak Republic, and Turkey.

The dependent variable is the logarithm of GDP per capita in constant 2015 US dollars, from the World Bank's World Development Indicators (WDI). Appendix J (Table J.5) reports robustness using PPP-adjusted GDP per capita. The baseline outcome measures the level of economic development rather than its annual growth rate.

The demographic control is working-age population growth, as labelled in the regression tables,

[6]Argentina, Bulgaria, and Romania are not OECD members; accession discussions were opened in 2022.

using World Bank data. This empirical population-based measure is distinguished from the theoretical growth rate of the labour force; total population, working-age population, and the economically active labour force are different concepts.

R&D intensity is measured by the number of researchers in R&D per 100 inhabitants, which reflects the human effort devoted to research, and, as a robustness check, by gross domestic expenditure on R&D as a percentage of GDP (World Bank), which covers all performing sectors, including business enterprise, and not only public expenditure.

Institutional quality is proxied by two variables drawn from the International Country Risk Guide (ICRG) build by the PRS group (2023):

- Government stability assesses the ability of a country to maintain a coherent and durable executive. The indicator is based on three components: government unity, legislative strength, and popular support. Each component is scored from 0 to 4, giving a total possible score of 12. Higher scores indicate stronger political stability.
- 'Religious stability' denotes the ICRG Religious Tensions component, an ordinal risk rating ranging from 0 to 6, with higher scores indicating lower religious-tension risk. It captures tensions associated with religious dominance over society or governance, restrictions on religious freedom, and interreligious conflict pressure. It is not a direct measure of religious homogeneity, pluralism, tolerance, or religiosity. Appendix D reproduces the component definition.

Finally, a set of macroeconomic control variables is obtained from the Global Macroeconomic Database (Müller et al. 2025). These controls include:

- trade openness (exports and imports as a percentage of GDP),
- final consumption (household and government consumption expenditure combined) and gross capital formation (hereafter 'investment'), both as percentages of GDP, which harmonizes national accounts data across official and international sources following SNA 2008 standards:
- government expenditures, revenues, tax revenues, public deficit, and public debt (all expressed as percentages of GDP),
- inflation rate, and unemployment rate.

Appendix D (Table D.2) replaces each ICRG index with an independent-source measure. The religious stability interaction remains positive and significant with the V-Dem Freedom of Religion index (0.230, $p = 0.024$), whereas substituting the WGI Political Stability and Absence of Violence index does not reproduce the government stability interaction (−0.003, $p = 0.987$): the government result relates specifically to the ICRG construct of governing capacity and policy continuity. Appendix F reports the correlations among all variables.

IV. Methodology

We use a framework motivated by neo-Schumpeterian growth theory to examine whether government and religious stability condition the association between R&D intensity and income per capita. The specification builds on the Type III approach described by Herzer (2022), who does not apply it himself, and adds an interaction term between institutional quality and R&D intensity, which represents a novelty relative to the existing literature. Appendix B shows how this specification is motivated by the theoretical framework and reports the theoretical values of the coefficients under the semi-endogenous and Schumpeterian growth models. The model can be written as follows:

$$g_{y,it} = \mu_i + \beta_1 g_{L,it} + \beta_2 \frac{X_{it}}{Q_{it}} + \beta_3 \text{Instit}_{it} + \beta_4 \left(\frac{X_{it}}{Q_{it}} \times \text{Instit}_{it} \right) + \gamma' Z_{it} + \varepsilon_{it} \quad (1)$$

In our model, $g_{y,it}$ denotes the growth rate of output per capita in country $i$at time t. The term $g_{L,it}$represents the theoretical growth rate of the labour force, proxied empirically by working-age population growth, while X_{it}corresponds to an R&D input and $Q_{it}$is the stock of product varieties. Q_{it} is not a directly observed or separately measured variable in the estimated equation; following Herzer (2022), whose Type III specification we follow, Q_{it} is interpreted as a scale variable proportional to the size of the labour force, or equivalently

any variable that grows at the same long-run rate, rather than a literal count of product varieties. The ratio X_{it}/Q_{it} therefore captures R&D intensity and is operationalized in this paper using two proxies that are both standard in the literature: researchers per 100 inhabitants (researchers normalized by population) and R&D expenditure as a percentage of GDP (Herzer 2022). Instit_{it} measures the quality of institutions in each country at time t, and the product of X_{it}/Q_{it} and Instit_{it} represents the interaction between R&D intensity and institutional quality. Z_{it} is a vector of additional control variables that may influence growth. Finally, μ_i captures country-specific fixed effects, accounting for unobserved characteristics that are constant over time, and ε_{it} is the idiosyncratic error term, capturing shocks or factors not included in the model.

As derived in Appendix B (equations A.11a–A.16a), β_3 and β_4 in Equation (1) are motivated by allowing research productivity to depend on institutional quality and adding a direct institutional channel to knowledge accumulation. β_3 captures the direct effect of institutional quality on the growth rate of output, and β_4 is the coefficient of central interest and captures the extent to which institutional quality moderates the growth contribution of R&D intensity. Equation (A.15a) motivates the institutional terms in Equation (1); the latter also includes macroeconomic controls. Both are written as growth-rate relationships, whereas the empirical regressions use log GDP per capita, as discussed below.

Equation (1) is derived, in Appendix B, as a growth-rate relationship: the left-hand side, is the growth rate of output per capita, and the theoretical mapping in equations (A.11)–(A.16) determines how R&D intensity and institutional quality shape this growth rate. The empirical specification estimated throughout the paper, however, uses the log level of GDP per capita as the dependent variable rather than its growth rate. We make this choice deliberately, and explain it here rather than leave it as an unstated departure from the theory.

Our empirical object of interest is the level of economic development associated with R&D intensity and the institutional environment. The growth-rate theory in Appendix B motivates the mechanisms, but integrating a growth equation does not by itself yield the static log-level equation estimated here: the resulting income level also depends on initial conditions and the time path of the regressors. We therefore treat the main specification as a reduced-form level association, rather than as an exact empirical counterpart of the theoretical growth-rate equation. The growth specification with lagged income reported in Appendix E (Table E.9) provides complementary evidence while accounting for conditional convergence.

This choice also matches the object of the paper's central claim. Our hypothesis, developed in Section II, is that political and especially religious instability can lock an economy into a persistently lower development trajectory, not merely slow its growth temporarily, through an institutional channel in which disproportionate religious political power crowds out the secular institutions needed for innovation to diffuse (Bénabou, Ticchi, and Vindigni 2013; Bisin et al. 2024). Testing this hypothesis is naturally a test about the level of development sustained under different institutional configurations, rather than about short-run fluctuations in the growth rate.

A levels regression can be misleading when persistent series reflect unrelated trends. Appendix E reports unit-root tests for log GDP per capita and log R&D intensity and evidence of cointegration between these two series. The PMG and DCCE estimates support a positive unconditional long-run association, while the MG estimate is statistically insignificant (Tables E.3 and E.6). This evidence is relevant to studying long-run R&D-income relationships, as in the related literature discussed by Ang and Madsen (2011). Its scope is nevertheless narrower than the main specifications: the dynamic models use log R&D intensity and omit the institutional interactions, whereas the main tables use R&D intensity in levels. The reported tests therefore do not establish cointegration of the full interaction specification or identify its coefficients as structural growth effects.

Because the main regressions are estimated in levels, their coefficients describe conditional associations motivated by the competing growth frameworks, rather than a test that discriminates between them. If the coefficient β_1 is positive and significant, while β_2 and β_4 are not, the pattern is compatible

with an association dominated by the demographic proxy rather than research intensity.

Conversely, if $\beta_2$is positive and significant while $\beta_1$is not, income is positively associated with R&D intensity at the reference value of the stability index, a pattern motivated by the neo-Schumpeterian framework. Importantly, if $\beta_4$is positive and significant, even when $\beta_1$and $\beta_2$are not, this indicates that the R&D-income association increases with the stability index. Significance of the interaction does not imply that R&D has a positive association only at high stability. In such contexts, R&D efforts are associated with larger income differences, highlighting the crucial role of institutional quality, such as government stability or cultural and religious stability. These results motivate further study of institutional conditions for innovation policy, while remaining conditional associations rather than identified policy effects.

We interpret the estimates as reduced-form associations implied by the theoretical framework, focusing on whether the marginal relationship between R&D intensity and GDP per capita varies systematically with political and religious stability.

V. Descriptive statistics and preliminary analysis

Table 1 reports descriptive statistics. The sample displays substantial heterogeneity in economic development, R&D intensity and institutional stability. R&D intensity ranges from 0.03 researchers per 100 inhabitants in Turkey to 0.80 in Denmark (mean 0.32). Government stability averages 7.96, with a minimum of 4.04 in Hungary in 2009, during a financial and political crisis. Religious stability averages 5.24, with a low of 2.5 in the Netherlands in 2005–2008, following the assassinations of Pim Fortuyn and Theo van Gogh.

This table reports summary statistics for the main variables used in the empirical analysis. P10 and P90 refer to the 10th and 90th percentiles, respectively.

Because government and religious stability are at the core of the analysis, Table 2 decomposes their variance into between- and within-country components, and Appendix D (Table D.3) reports their correlation with alternative institutional indicators.

This table reports overall, between-country, and within-country standard deviations of the two ICRG stability indices. Government stability displays substantial within-country variation (within SD of 1.421, close to the overall SD of 1.467). Religious stability is more persistent: its within-country SD of 0.402 is about 55% of its overall SD of 0.727. This is a ratio of standard deviations; the squared ratio is approximately 31%, not over half of the variance. Tables J.2 and J.3 separately assess sensitivity to excluding the Netherlands.

Government and religious stability are only weakly correlated with each other (0.15), far less than indicators of general governance quality (0.62–0.91), and religious stability correlates at only 0.12–0.28 with rule-of-law indicators (Table D.3). The two indices therefore capture distinct dimensions of institutional stability, and neither is a proxy for the broader rule-of-law environment.

Appendix C presents the trends in GDP per capita, R&D intensity and the two stability indices, together with country maps. Institutional

Table 1. Descriptive statistics of main variables.

	N	Mean	Std. Dev.	P10	Median	P90	Min	Max
Log of GDP per capita	483	10.060	0.706	8.993	10.355	10.775	8.172	11.191
Number of researchers per 100 inhabitants	468	0.318	0.176	0.109	0.295	0.531	0.030	0.801
R&D expenditure (% of GDP)	483	1.663	0.932	0.495	1.575	3.010	0.362	4.516
Growth rate of the working-age population	483	0.004	0.006	−0.003	0.004	0.011	−0.022	0.029
Growth rate of R&D researchers	442	0.040	0.067	−0.025	0.034	0.100	−0.187	0.465
Government stability	483	7.962	1.467	6.167	7.792	10.000	4.042	11.083
Religious stability	483	5.236	0.727	4.000	5.500	6.000	2.500	6.000

Table 2. Between- and within-country variation in the stability indices.

	N	Countries	Mean	SD (overall)	SD (between)	SD (within)
Government stability	483	23	7.962	1.467	0.372	1.421
Religious stability	483	23	5.236	0.727	0.620	0.402

conditions vary both across countries and over time, which is the variation exploited by our fixed-effects estimates.

The next section presents the results of the empirical analysis. Using a specification motivated by the Type III framework of Herzer (2022), we estimate panel regressions with country fixed effects to examine whether the association between R&D intensity and income per capita is conditional on institutional stability. This approach allows us to move beyond descriptive patterns and to document how this association varies with the institutional environment.

VI. Results

Table 3 presents the baseline estimates of the specification motivated by the Type III framework of Herzer (2022), without institutional quality or its interaction with R&D intensity. R&D intensity is positively and significantly associated with income levels, while the association with the growth of the working-age population is not robust. These baseline estimates are consistent with the positive association between R&D intensity and income motivated by the neo-Schumpeterian framework; as level regressions.

We extend the baseline model by interacting R&D intensity with government and religious stability, motivated by the institutional mechanisms discussed by Tebaldi and Elmslie (2008). The estimates describe conditional associations, rather than causal effects of R&D policies. Table 4 first reports the specification without macroeconomic controls.

The results reported in Table 4 show that the association between R&D intensity and income differs across institutional contexts. Working-age population growth is positively and significantly associated with income in all specifications without controls. As for Table 3, we read this as a conditional association in levels.

Without controls, the government stability interaction is positive and significant, while the main R&D coefficient, which measures the association at a government stability score of zero, is not: the R&D–income association is small and insignificant at low government stability and positive and

Table 3. Baseline estimates.

	GDP per capita in log (1)	GDP per capita in log (2)
Growth of working-age population	5.8079**	−1.0328
	(2.5687)	(2.9437)
Number of researchers per 100 inhabitants	1.0487***	0.6213***
	(0.1848)	(0.1823)
Trade openness (% of GDP)		0.2131**
		(0.0980)
Final consumption (% of GDP)		−0.8896**
		(0.3448)
Investment (% of GDP)		−0.2751
		(0.3649)
Government revenues (% of GDP)		−0.4989
		(0.3805)
Government expenditures (% of GDP)		0.3999*
		(0.2320)
Tax revenues (% of GDP)		−0.9395**
		(0.4293)
Government deficit (% of GDP)		−0.2127
		(0.2908)
Government debt (% of GDP)		0.0145
		(0.0515)
Inflation rate (%)		−0.8777***
		(0.1678)
Unemployment rate (%)		−2.5488***
		(0.3258)
Intercept	9.6884***	10.9649***
	(0.0638)	(0.3143)
R-squared	0.32	0.79
Number of observations	468	468
F-statistic	16.12	80.00

Robust standard errors clustered at the country level in parentheses. Country fixed effects included. *, **, *** denote significance at 10%, 5%, and 1% levels.

Table 4. Influence of government and religious stability (log GDP per capita specification).

	GDP per capita in log (1)	GDP per capita in log (2)
Growth of working-age population	6.8586**	5.9295**
	(2.4362)	(2.6131)
Number of researchers per 100 inhabitants	−0.3102	1.7334
	(0.4926)	(1.0894)
Government stability	−0.0698***	
	(0.0227)	
Number of researchers per 100 inhabitants × Government Stability	0.1480**	
	(0.0598)	
Religious Stability		0.0267
		(0.0637)
Number of researchers per 100 inhabitants × Religious Stability		−0.1293
		(0.1928)
Intercept	10.3029***	9.5497***
	(0.1997)	(0.3524)
R-squared	0.43	0.32
Number of observations	468	468
F-statistic	11.87	7.51

Robust standard errors clustered at the country level in parentheses. Country fixed effects included. *, **, *** denote significance at 10%, 5%, and 1% levels.

significant at higher scores (Appendix J, Figure J.1). The religious stability interaction is not significant without controls, which contrasts with the controlled results reported below.

Table 5 adds macroeconomic controls. Working-age population growth is no longer statistically significant. The government-stability interaction remains positive and significant, and the religious-stability interaction changes from negative and insignificant to positive and significant. Table 6 and Figures 1 and 2 present the associated marginal relationships and uncertainty; the government association is significant even at the reported 10th-percentile evaluation point.

Appendix H shows that the uncontrolled estimate is never significantly negative, and that the change in the estimated interaction is consistent with the role of omitted macroeconomic conditions. The positive interaction remains when consumption and investment shares are excluded, including in specifications with year fixed effects (Tables H.1 and H.2).

These results are significant at the 5% level under conventional country-clustered inference, and the wild cluster bootstrap *p*-values of the two interaction terms are 0.054 and 0.096, respectively (Appendix G).

Table 7 evaluates a one-standard-deviation increase in R&D intensity at the 10th percentile, median, mean, and 90th percentile of each stability index. For government stability, the association is approximately 7.1% at the 10th percentile, 9.4% at the mean, and 12.0% at the 90th percentile; it is statistically significant at each reported evaluation point. For religious stability, it is 3.2% and not statistically significant at the 10th percentile, 9.2% at the mean, and 12.9% at the 90th percentile. These are approximate percentage differences derived from a log-level specification.

To check that common time trends in income and research intensity are not loaded onto the interaction terms, Table 7 re-estimates the specifications of Table 5 with year fixed effects in addition to country fixed effects. Both interaction terms remain positive and statistically significant, with magnitudes close to those of Table 5 (0.0696 against 0.0737 for government stability; 0.3542 against 0.2754 for religious stability). The religious stability interaction even becomes larger. The results reported in Table 5 are therefore not driven by common time trends.

Appendix J reports further robustness checks on the preferred specification. Replacing researchers per 100 inhabitants by R&D expenditure as a percentage of GDP yields the same qualitative pattern, with both interactions positive and significant at the 5% level (Table J.1). Both interactions are also essentially unchanged when the Netherlands, whose 2005–2008 episode accounts for a large share of the within-country variation in religious stability, is excluded (0.073 and 0.297), when government revenues are excluded (0.072 and 0.271), when the WGI rule of law is added as a control (0.070 and 0.290, the rule of law itself being insignificant; wild cluster bootstrap *p*-values of 0.066 and 0.069, Table G.1), and when GDP

Table 5. Influence of government and religious stability with controls (log GDP per capita specification).

	GDP per capita in log (1)	GDP per capita in log (2)
Growth of working-age population	−1.3974	−0.5821
	(2.7058)	(2.7977)
Number of researchers per 100 inhabitants	−0.0544	−0.9196*
	(0.3091)	(0.5299)
Government stability	−0.0440***	
	(0.0098)	
Number of researchers per 100 inhabitants × Government stability	0.0737**	
	(0.0329)	
Religious Stability		−0.1039***
		(0.0337)
Number of researchers per 100 inhabitants × Religious stability		0.2754**
		(0.1031)
Trade openness (% of GDP)	0.1707**	0.2266**
	(0.0704)	(0.1012)
Final consumption (% of GDP)	−0.6950**	−0.9715***
	(0.2683)	(0.2979)
Investment (% of GDP)	−0.2367	−0.1893
	(0.3337)	(0.3592)
Government revenues (% of GDP)	−0.7191**	−0.4887
	(0.2974)	(0.3683)
Government expenditures (% of GDP)	0.2507	0.4527**
	(0.2156)	(0.1959)
Tax revenues (% of GDP)	−0.7299**	−0.8055*
	(0.3469)	(0.3906)
Government deficit (% of GDP)	−0.1372	−0.1595
	(0.2206)	(0.2210)
Government debt (% of GDP)	0.0054	0.0214
	(0.0520)	(0.0489)
Inflation rate (%)	−0.8184***	−0.9591***
	(0.1211)	(0.1298)
Unemployment rate (%)	−2.6894***	−2.4463***
	(0.2981)	(0.3310)
Intercept	11.3297***	11.5036***
	(0.2806)	(0.2723)
R-squared	0.83	0.80
Number of observations	468	468
F-statistic	64.95	183.29

Robust standard errors clustered at the country level in parentheses. Country fixed effects included. *, **, *** denote significance at 10%, 5%, and 1% levels.

per capita is measured in PPP terms (0.073 and 0.273) (Tables J.2, J.3 and J.5). Government revenues are excluded in some specifications because they are almost collinear with government expenditures; excluding them brings all variance inflation factors below 2.2 (Table J.4). Both interactions also remain positive and significant when R&D intensity is lagged by one year, which limits concerns about reverse causality within the same year (Appendix E, Tables E.7 and E.8).

Appendix I re-estimates the preferred specification with two outcomes closer to the innovation-

Table 6. Marginal effect of a one-standard-deviation increase in R&D intensity on GDP per capita, by level of institutional stability.

Evaluation point	Marginal effect (%)	Std. error	95% CI	p-value
Panel A. Government stability				
P10 (govstab = 6.17)	7.05	3.58	[0.04; 14.05]	0.049
Median (govstab = 7.73)	9.07	3.55	[2.12; 16.02]	0.010
Mean (govstab = 7.96)	9.38	3.56	[2.40; 16.36]	0.008
P90 (govstab = 10.00)	12.02	3.90	[4.39; 19.66]	0.002
Panel B. Religious stability				
P10 (reltensions = 4.00)	3.20	3.13	[−2.92; 9.33]	0.306
Mean (reltensions = 5.24)	9.19	2.69	[3.93; 14.46]	0.001
Median (reltensions = 5.50)	10.47	2.82	[4.94; 16.01]	0.000
P90 (reltensions = 6.00)	12.90	3.26	[6.50; 19.30]	0.000

Marginal effects computed via the delta method, evaluated at the 10th percentile, median, mean, and 90th percentile of the estimation sample, directly from the specification underlying Table 5. Effects are expressed as the percentage change in GDP per capita associated with a one-standard-deviation increase in R&D intensity (SD = 0.176).

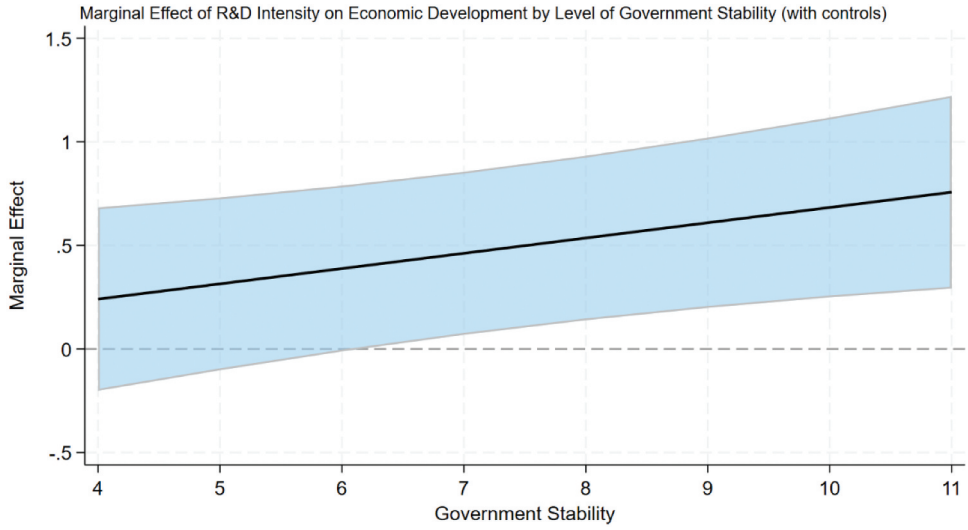


Figure 1. Marginal effect of R&D intensity on economic development by government stability (with controls). The solid line reports the marginal association between R&D intensity and economic development across government-stability scores, estimated with the full controls (Table 5). Shading denotes the confidence interval; the dashed horizontal line denotes zero.

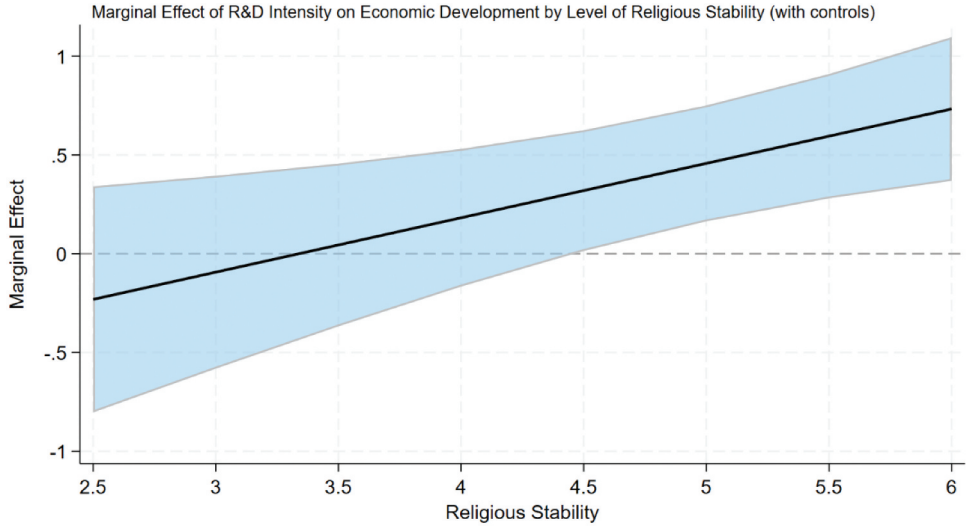


Figure 2. Marginal effect of R&D intensity on economic development by religious stability (with controls). The solid line reports the marginal association between R&D intensity and economic development across religious-stability scores, estimated with the full controls (Table 5). Shading denotes the confidence interval; a band entirely above the dashed zero line indicates a positive, statistically significant association.

diffusion mechanism, labour productivity and resident patent applications. The religious stability interaction is positive and significant for both (0.178, $p < 0.05$, and 0.840, $p < 0.10$), whereas the government stability interaction is insignificant for both, although the marginal effect of R&D intensity remains positive at all levels of government stability. For labour productivity, the marginal effect of a one-standard-deviation increase in R&D intensity rises from 3.9% (not significant) at the 10th percentile of religious stability to 10.2% at the 90th percentile, which reproduces the pattern found for GDP per capita (Table I.2). The patent results should be read with caution, as the patent sample is smaller and less balanced than the main sample.

Appendix E examines slope heterogeneity using panel time-series error-correction models estimated by Mean Group (MG), Pooled Mean Group (PMG), and Dynamic Common Correlated Effects (DCCE) methods. Appendix

Table 7. Influence of government and religious stability with controls and year fixed effects (log GDP per capita specification).

	GDP per capita in log (1)	GDP per capita in log (2)	GDP per capita in log (3)	GDP per capita in log (4)
Growth of working-age population	−1.3974	−2.4277	−0.5821	−2.4922
	(2.7058)	(1.8280)	(2.7977)	(1.6786)
Number of researchers per 100 inhabitants	−0.0544	−0.4250	−0.9196*	−1.9138***
	(0.3091)	(0.3587)	(0.5299)	(0.5940)
Government stability	−0.0440***	−0.0242***		
	(0.0098)	(0.0072)		
Number of researchers per 100 inhabitants × Government stability	0.0737**	0.0696**		
	(0.0329)	(0.0263)		
Religious Stability			−0.1039***	−0.0961**
			(0.0337)	(0.0427)
Number of researchers per 100 inhabitants × Religious stability			0.2754**	0.3542**
			(0.1031)	(0.1363)
Macroeconomic controls	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	Yes
R-squared	0.83	0.88	0.80	0.89
Number of observations	468	468	468	468
F-statistic	64.95	–	183.29	–

Robust standard errors clustered at the country level in parentheses. All columns include country fixed effects and the macroeconomic controls of Table 5, whose coefficients are not reported; columns (2) and (4) also include year fixed effects. Columns (1) and (3) reproduce Table 5. The F-statistic is not reported when year fixed effects are included, as the number of estimated parameters exceeds the number of clusters. *, **, *** denote significance at 10%, 5%, and 1% levels.

E also reports a growth equation with lagged income, which accounts for conditional convergence: the religious stability interaction remains positive and significant (0.048, $p < 0.05$), whereas the government stability interaction is small and insignificant (Table E.9).

Table 8 estimates both stability indices and their interactions with R&D intensity jointly. Because the two indices are only weakly correlated (0.15), this joint model tests whether either interaction merely proxies for the other. Both interactions remain positive: the religious stability interaction is essentially unchanged (0.258 against 0.275 in Table 5, significant at the 5% level), whereas the government stability interaction is attenuated (0.062 against 0.074) and significant at the 10% level. Table 9 reports the corresponding marginal effects of a one-standard-deviation increase in R&D intensity.

Table 8 does not show how the two dimensions of stability combine. We therefore estimate the full triple interaction between R&D intensity, government stability and religious stability, with all lower-order terms (Table 10). The triple

Table 8. Joint specification with both interactions.

	GDP per capita in log (1) Joint specification
Number of researchers per 100 inhabitants	−1.389**
	(0.573)
Government stability	−0.0404***
	(0.0092)
Religious stability	−0.0846**
	(0.0362)
Number of researchers per 100 inhabitants × Government stability	0.0616*
	(0.0310)
Number of researchers per 100 inhabitants × Religious stability	0.2576**
	(0.1176)
Controls	Yes
Country fixed effects	Yes
R-squared (within)	0.84
Number of observations	468
Number of countries	23
F-statistic	146.61

This table reports fixed-effects estimates with the full set of macroeconomic controls (as in Table 5) and country-clustered standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. Both stability indices, both interaction terms, are included jointly in the same specification.

Table 9. Marginal effect of a one-standard-deviation increase in R&D intensity, joint specification.

Evaluation point	Marginal effect (%)	Std. error	p-value
Panel A. Government stability (holding religious stability at its mean)			
P10 (govstab = 6.17)	5.90	2.77	0.033
Median (govstab = 7.73)	7.60	2.63	0.004
Mean (govstab = 7.96)	7.85	2.64	0.003
P90 (govstab = 10.00)	10.06	2.90	0.001
Panel B. Religious stability (holding government stability at its mean)			
P10 (reltensions = 4.00)	2.29	2.66	0.390
Mean (reltensions = 5.24)	7.89	2.65	0.003
Median (reltensions = 5.50)	9.09	2.95	0.002
P90 (reltensions = 6.00)	11.35	3.68	0.002

Marginal effects computed via the delta method from the joint specification (Table 9), evaluated at the 10th percentile, median, mean, and 90th percentile of each index, with the other index held at its mean. The pattern mirrors Table 7: the religious-stability effect is not statistically distinguishable from zero at low levels and rises to a significant effect at high levels; the government-stability effect is significant across the full range, though smaller in magnitude than in the single-index specification.

Table 10. Triple interaction specification.

	GDP per capita in log (1) Triple interaction
Number of researchers per 100 inhabitants	−3.376
	(2.030)
Government stability	−0.1492
	(0.0938)
Religious stability	−0.2514*
	(0.1311)
Number of researchers per 100 inhabitants × Government stability	0.3073
	(0.2783)
Number of researchers per 100 inhabitants × Religious stability	0.6248
	(0.3838)
Government stability × Religious stability	0.0202
	(0.0170)
Number of researchers per 100 inhabitants × Government stability × Religious stability	−0.0449
	(0.0508)
Controls	Yes
Country fixed effects	Yes
R-squared (within)	0.84
Number of observations	468
Number of countries	23
F-statistic	610.67

This table reports fixed-effects estimates with the full set of controls of Table 5 (including the growth of the working-age population) and country-clustered standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. The specification includes the triple interaction and all lower-order terms.

coefficient is small, negative and insignificant (−0.0449, $p = 0.386$), so the data provide no evidence that the two dimensions reinforce each other beyond their separate conditioning effects. Because this coefficient alone does not describe the R&D–income association, Table 11 reports the marginal effect of R&D intensity, with delta-method standard errors, at combinations of the two indices.

Three patterns stand out (Table 11 and Figure 3). First, holding either index fixed, the marginal effect of R&D intensity increases with the other in every row and column of Table 11. Second, it is highest when both dimensions are high (0.792, $p < 0.01$, at a government stability of 11 and a religious stability of 6) and lowest when both are low (−0.638, $p < 0.05$, at 5 and 3). The mixed configurations are asymmetric: with high religious stability, the association remains positive and significant even at low government stability (0.563, $p < 0.05$), whereas with low religious stability it is imprecise even at high government stability (0.398, not significant). Third, the negative triple coefficient reflects diminishing gains from improving one dimension when the other is already high, although this pattern is not statistically significant.

These patterns must be read in light of the support of the data. Figure 4 shows that religious stability is concentrated at the top of its scale: the columns of Table 11 for values 5 and 6 rest on 86% of the sample,

Table 11. Marginal effect of R&D intensity by Government and Religious stability (Delta method).

	Religious stability			
Government stability	3	4	5	6
5	−0.638**	−0.238	0.163	0.563**
	(0.324)	(0.194)	(0.150)	(0.245)
6	−0.466*	−0.110	0.245*	0.601***
	(0.249)	(0.152)	(0.140)	(0.225)
7	−0.293	0.018	0.328**	0.639***
	(0.226)	(0.146)	(0.138)	(0.212)
8	−0.120	0.146	0.411***	0.677***
	(0.270)	(0.178)	(0.146)	(0.204)
9	0.052	0.273	0.494***	0.715***
	(0.357)	(0.234)	(0.161)	(0.204)
10	0.225	0.401	0.577***	0.754***
	(0.463)	(0.300)	(0.182)	(0.211)
11	0.398	0.529	0.660***	0.792***
	(0.578)	(0.371)	(0.208)	(0.225)
Observations at this level of religious stability	6	61	164	237
Share of the sample	1.3%	13.0%	35.0%	50.6%

Each cell reports the marginal effect of R&D intensity (researchers per 100 inhabitants) on log GDP per capita, evaluated at the indicated values of government stability (rows) and religious stability (columns), computed from the triple interaction specification of Table 10, with delta-method standard errors clustered at the country level in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. The last two rows report the number and share of observations whose religious stability index, rounded to the nearest integer, takes the column value; the column for a religious stability of 3 includes the few observations below 3.

whereas only 6 observations have a value of 3 or less, so that the estimates at low religious stability are largely extrapolated. Within the densely populated region, the marginal effect rises from about zero (−0.110, at a government stability of 6 and a religious stability of 4) to 0.754 ($p < 0.01$, at 10 and 6). The triple interaction therefore refines rather than overturns our main results: each dimension strengthens the R&D–income association, the association is largest where both are high, and there is no evidence that both must be jointly high.

Appendix C illustrates these configurations with country maps: Finland and the United States combine high R&D intensity with high stability on both dimensions, whereas France and Turkey have below-average religious stability. France thereby echoes the historical diffusion of printing discussed in the introduction. These comparisons are descriptive.

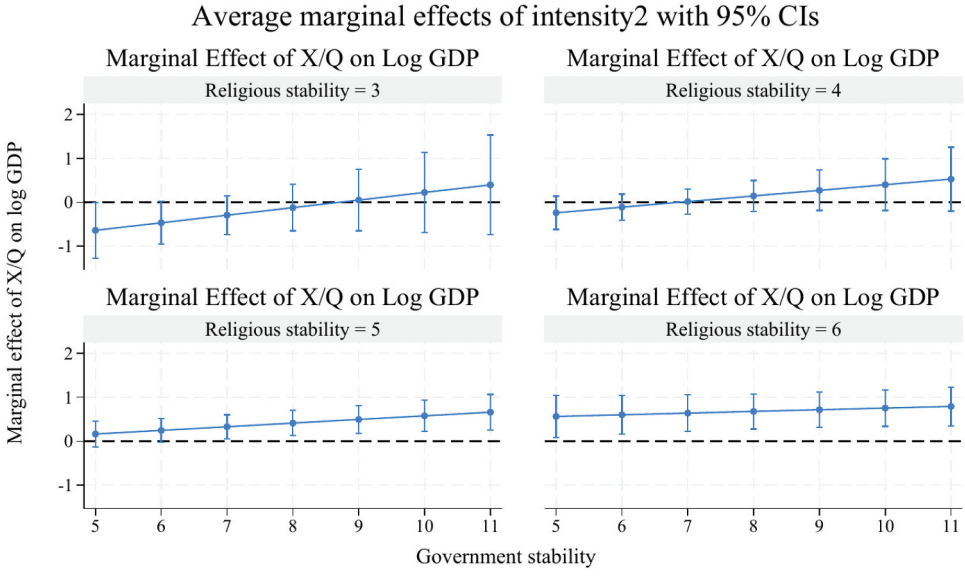


Figure 3. Marginal effect of R&D intensity on economic development by government and religious stability. Each panel plots the estimated marginal effect of R&D intensity on log GDP per capita, with 95% confidence intervals, evaluated at values of government stability from 5 to 11, for a given value of the religious stability index, computed from the triple interaction specification of Table 10 (see Table 11). The horizontal dashed line denotes a zero marginal effect.

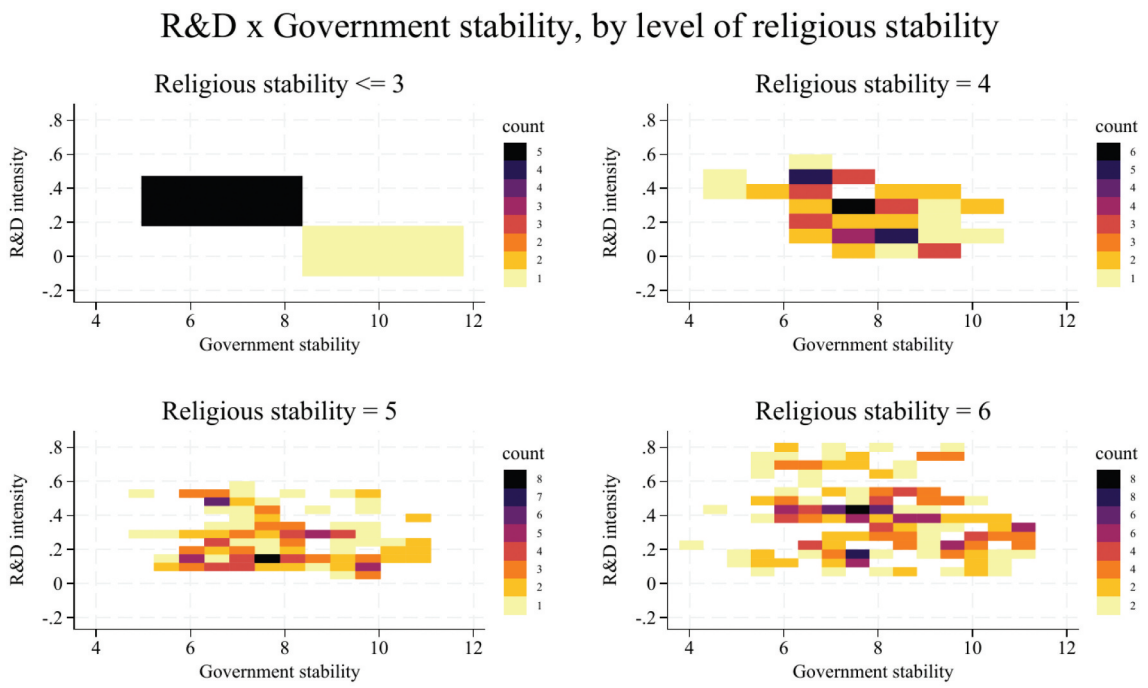


Figure 4. Joint distribution of R&D intensity and government stability, by level of religious stability. Each panel reports the number of country-year observations in each cell of R&D intensity (researchers per 100 inhabitants) and government stability, for a given value of the religious stability index rounded to the nearest integer. The estimation sample contains 6 observations with religious stability of 3 or less, 61 with a value of 4, 164 with a value of 5 and 237 with a value of 6. Blank cells contain no observation.

The controlled R&D-income association is significant at all four reported government-stability evaluation points but insignificant at the 10th percentile of religious stability. In the joint model, government and religious interactions remain positive and significant at 10% and 5%, respectively. These results establish neither a requirement that both indices be high nor empirical complementarity between them.

Appendix K brings together the evidence on the two interaction terms across fourteen specifications (Table K.1) and discusses their interpretation. The religious stability interaction is the most robust result: it is positive and significant in all fourteen specifications, at the 5% level in twelve, with a magnitude between 0.24 and 0.35 in the level of income; it is confirmed with the V-Dem Freedom of Religion index and carries over to labour productivity, patents and the growth equation with lagged income. The government stability interaction is significant at the 5% level in nine specifications, all for the level of income, but not for the alternative outcomes, the growth equation or the WGI Political Stability index. It should therefore be read as a within-country association in levels with a modest gradient, whereas religious stability is the better supported dimension.

This contrast is consistent with the mechanisms discussed in Section II. Government stability matters for research mainly through the investment and policy climate (Alesina et al. 1996; Knack and Keefer 1995); in OECD members and candidates, its fluctuations mostly reflect electoral and coalition dynamics, which rarely threaten the diffusion of knowledge itself. Religious tensions capture a deeper conflict mechanism: the risk that a single religious group dominates society or governance, which Bisin et al. (2024) associate with institutions that favour religious legitimacy over the secular institutions supporting innovation, and of which the Ottoman delay of printing is a historical example (Coşgel, Miceli, and Rubin 2012). Such slow-moving informal institutions (North 1994; Williamson 2000) plausibly condition the diffusion of knowledge itself, consistent with the religious interaction carrying over to productivity, patents and growth.

VII. Conclusion

This paper provides evidence that the association between R&D intensity and economic performance varies with the institutional and religious environment. In the controlled single-index specifications, the marginal association is positive at all reported government-stability evaluation points, while it is not statistically distinguishable from zero at the 10th percentile of religious stability and increases at higher values. In the joint specification, both interactions remain positive, with the government interaction significant at the 10% level and the religious interaction at the 5% level under conventional cluster-robust inference. These findings are consistent with distinct institutional dimensions moderating the R&D–income relationship.

Under wild cluster bootstrap inference, the *p*-values of the two interaction terms in the preferred specifications are significant at the 10% level. The religious stability interaction is positive and significant in all fourteen specifications, whereas the government stability interaction is robust in level specifications only. The association is largest where both forms of stability are high, but we find no evidence that both must be jointly high.

Our results are subject to several limitations. First, they are conditional associations rather than causal effects. Second, the availability of R&D and institutional data restricts the sample to 23 OECD members and accession candidates, and we do not attempt a formal correction for sample selection. Our results may therefore not extend to countries with very different institutional settings; in particular, low levels of religious stability are almost absent from our data. Third, our evidence concerns mainly the level of income: in the growth equation with lagged income, only the religious stability interaction is significant.

From a policy perspective, the evidence suggests that the institutional setting merits attention alongside scientific investment. The estimates are conditional associations from observational data, and do not demonstrate that an intervention increasing government or religious stability would raise the return to R&D. The government-stability finding is specific to the governing-capacity construct measured by the ICRG dataset and is not reproduced by the WGI political-stability substitution.

Future research could test whether government and religious stability are complementary in shaping innovation adoption and long-run economic performance, and identify the mechanisms linking institutions, innovation, and development. One avenue would be to integrate religion into a broader conception of culture.

Author contributions

CRediT: **Nathan Schild:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing; **Jamel Saadaoui:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; **Patrick Rondé:** Investigation, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data used in this study were obtained from the World Bank's World Development Indicators, the International Country Risk Guide, the Global Macroeconomic Database, the Worldwide Governance Indicators, and the Varieties of Democracy project. Data sources and variable definitions are described in Section III and the online appendix. Availability and reuse of the underlying series are subject to the respective data providers' access conditions.

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