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Economics Letters 253 (2025) 112388

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

# From code to creativity: The impact of legal origins on innovation of private enterprises

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ARTICLE INFO

*JEL classification:*
G01
G31
G32

*Keywords:*
Innovation
Products
Services
Processes
Legal origin
Institutions

ABSTRACT

This study explores whether legal origins influence the innovation investments of private enterprises. We hypothesize that enterprises in civil law countries, where legal frameworks are codified and regulations are prescriptive, are more likely to invest in new product/service innovation due to the predictability and stability of their legal environments. Conversely, enterprises in common law countries, with their flexible and adaptive legal systems, are expected to prioritize process innovation, driven by the need to optimize operations and navigate regulatory changes more easily. Using data from the World Bank Enterprise Surveys covering private enterprises in 113 countries between 2010 and 2024, we find strong evidence supporting these hypotheses. Enterprises in civil law countries show a higher propensity for product/service innovation, while those in common law countries focus more on process innovation. These findings highlight the importance of legal and institutional frameworks in shaping innovation strategies, with several important implications.

## 1. Introduction

In their seminal papers, La Porta et al. (1997, 1998) highlighted how a country's historical origins — whether rooted in common law or civil law — profoundly shape its institutions and long-term economic outcomes. Since then, the legal origin theory has been widely applied to various corporate decisions.[1] However, the relationship between legal origins and innovation in private enterprises — which constitute the majority of enterprises and hold more than two-thirds of total assets — remains underexplored.[2] Given the crucial role of innovation in private enterprises for sustainable economic development (Gao et al., 2018; Machokoto et al., 2023; Machokoto, 2024), this paper aims to address this gap by examining the influence of legal origins on enterprise innovation.

Building on the legal origin theory (see La Porta et al., 1997, 1998), we conjecture that innovation strategies may differ between private enterprises in civil law and common law countries due to the distinct legal and institutional frameworks that shape corporate behavior. In civil law countries, where legal systems are more codified and regulations are prescriptive, enterprises operate in a more stable and predictable environment (La Porta et al., 1997, 2008). This stability fosters investment in new products and services, as the codified legal framework provides clear guidelines on intellectual property rights and market entry, mitigating risks associated with new product/service development. Additionally, the structured regulatory environment under civil law offers greater government support and incentives for product/service innovation, further incentivizing enterprises to allocate resources toward developing new market offerings.

In contrast, enterprises in civil law countries may be less inclined to invest significantly in process innovations — such as enhancing operational efficiencies or refining production techniques — due to the regulatory rigidity that hampers the swift adaptation of process changes, particularly when they involve complex contractual arrangements. Additionally, the strong emphasis on stability and adherence to established norms may lead enterprises to prioritize product innovation, which offers more tangible and marketable outcomes, over process innovation that may provide less immediate visibility or competitive advantage.

Conversely, private enterprises in common law systems, characterized by flexibility and case-based legal precedents, may invest more in process innovation. The common law system, with its greater adaptability, responsiveness to changing market conditions, and less prescriptive

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[1] For instance, the effects of the legal origin theory have been reported on debt maturity structure, environmental responsibility, earnings management, and access to external finance (Demirgüç-Kunt and Maksimovic, 1999; Kim et al., 2017; Oz and Yelkenci, 2018).

[2] See, Bigelli et al. (2014) and Brav (2009).

https://doi.org/10.1016/j.econlet.2025.112388
Received 4 February 2025; Received in revised form 19 April 2025; Accepted 11 May 2025
Available online 27 May 2025
0165-1765/© 2025 Elsevier B.V. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

**Table 1**
The effect of legal origin product/service and process innovation.

| Dependent variables | INNOV1 | INNOV1 | INNOV1 | INNOV2 | INNOV2 | INNOV2 |
|---|---|---|---|---|---|---|
| Independent variables | (1) | (2) | (3) | (4) | (5) | (6) |
| ENGLISH | −0.2340*** | −0.1215*** | −0.1510*** | 0.0954*** | 0.2147*** | 0.1460*** |
| | (0.0121) | (0.0133) | (0.0139) | (0.0119) | (0.0132) | (0.0137) |
| Enterprise level controls | × | ✓ | ✓ | × | ✓ | ✓ |
| Country controls effects | × | × | ✓ | × | × | ✓ |
| Industry fixed effects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| # of observations | 64,592 | 64,592 | 64,592 | 64,554 | 64,554 | 64,554 |
| Pseudo.$R^2$ | 0.0253 | 0.1360 | 0.1370 | 0.0309 | 0.1410 | 0.1460 |

The table presents the results from estimating the probit model specified in Eq. (1). The sample, data sources, and variables utilized in this study are detailed in Online Appendix — Table A.1. Robust standard errors reported in parentheses are calculated using the Huber White Sandwich Estimator for the covariance matrix. ***, **, * indicate significance at the one, five, and ten percent levels, respectively, based on robust standard errors.

nature, allows enterprises to experiment with new business models, production techniques, and operational efficiencies, making process innovation a key avenue for gaining a competitive edge (La Porta et al., 2008; Ponzetto and Fernandez, 2008). As legal precedents and case law evolve, common law systems enable enterprises to navigate the uncertainties of process innovation with confidence that the legal system will support and protect their innovative efforts. However, this flexibility may create uncertainty in protecting new products and services, as common law offers less clarity in intellectual property rights compared to civil law systems with codified protections (La Porta et al., 2008; Lerner, 2009), making product innovation riskier and leading enterprises to focus more on process innovation, which provides immediate efficiency gains.

Based on these differences between civil law and common law systems, we hypothesize that enterprises in civil law countries are more likely to engage in product/service innovation, while enterprises in common law countries are more focused on process innovation. Using a large survey dataset of 64,592 enterprises covering 113 countries, we find evidence consistent with this prediction: enterprises in civil law countries are more likely to pursue product/service innovation, while those in common law countries favor process innovation, with these patterns further shaped by institutional development.

The subsequent sections outline the data, methodology, results, and conclusions.

## 2. Methodology and data

### 2.1. Data

The study uses enterprise-level data from the World Bank Enterprise Surveys (WBES), macroeconomic indicators from the World Development Indicators and IMF, institutional quality from the World Governance Indicators, cultural dimensions from Hofstede (2001), and colonial European population shares from Easterly and Levine (2016). The final sample includes 64,592 enterprises across 113 countries from 2010 to 2024 after excluding observations with missing key variables.

### 2.2. Methodology

To explore the impact of legal origin on innovation, we estimate the following probit models:-

$$y_{ijkt} = \alpha_0 + \alpha_1 ENGLISH_k + \boldsymbol{\beta} \boldsymbol{X}_{ijkt} + \boldsymbol{\theta} \boldsymbol{Z}_{kt} + \nu_j + \epsilon_{ijkt} \quad (1)$$

$$y_{ijkt} = \alpha_0 + \alpha_1 ENGLISH_k + \alpha_2 INST_{kt} + \alpha_3 ENGLISH_k \times INST_{kt} + \boldsymbol{\beta} \boldsymbol{X}_{ijkt} + \boldsymbol{\theta} \boldsymbol{Z}_{kt} + \nu_j + \epsilon_{ijkt} \quad (2)$$

where $i$, $j$, $k$, and $t$ indexes individuals, industries, countries, and time, respectively. $y$ is a dummy variable that equals one if an enterprise invests in innovation and zero otherwise. To proxy for innovation, we use two measures: *INNOV1*, dummy=1 if an enterprise has introduced a new product and zero otherwise, and *INNOV2*, dummy=1 if an enterprise has introduced a new process and zero otherwise.[3] *ENGLISH* is a dummy=1 for countries with legal origins rooted in common law and 0 otherwise (see Djankov et al., 2008; La Porta et al., 2008).[4] *INST* is an indicator of institutional development. $\alpha_0$ is a constant. $\alpha_1$, $\alpha_2$, $\alpha_3$, $\boldsymbol{\beta}$, and $\boldsymbol{\theta}$ are the coefficients to be estimated. $\boldsymbol{X}$ and $\boldsymbol{Z}$ represent vectors of individual-specific and country-specific control variables, respectively. $\nu_j$ denotes the industry fixed effects. Finally, $\epsilon_{ijkt}$ denotes the error term. Online Appendix Tables A.1, A.2, A.3, and A.4 report variable definitions, sample distribution, summary statistics, and correlation matrices.

### 2.3. The effect of legal origin on innovation

Table 1 presents the results estimating Eq. (1), with Columns (1) and (4) serving as baseline models without control variables, and Columns (2) to (3) and (5) to (6) progressively introducing enterprise-level and country-level control variables to mitigate omitted variable bias. In Columns (1) to (3), we observe that legal origin, proxied by *ENGLISH*, is significantly and negatively associated with product/service innovation. This finding suggests that enterprises in common law countries may be less inclined to engage in product/service innovation (*INNOV1*). Conversely, in Columns (4) to (6), legal origin, proxied by *ENGLISH*, is significantly and positively associated with process innovation, indicating that enterprises in common law countries are more likely to invest in process innovation (*INNOV2*).

The contrasting findings highlight how legal systems shape innovation strategies: the flexibility of common law reduces the perceived risks of process innovation, encouraging firms to optimize operations, while the stability and protections of civil law make product/service innovation more attractive and rewarding. These findings suggest that each legal system's inherent risks and rewards shape the type of innovation favored by enterprises operating under each of the jurisdictions.

### 2.4. Robustness checks

Next, we implement a battery of robustness tests. First, in Columns (1) of Panels A and B of Table 2, we re-estimate a modified version of Eq. (1), replacing the *ENGLISH* dummy with dummies for French, German, and Scandinavian (SCANDIN) legal origins. This approach allows us to compare whether the associations we have documented

[3] We acknowledge that the repeated cross-sectional design of World Bank Enterprise Surveys (WBES), where enterprises are surveyed only once per wave, limits our innovation measures (*INNOV1* and *INNOV2*) to capturing innovation occurrence within the surveyed period without distinguishing between single and multiple instances of innovation.

[4] To ensure robustness, we further decompose this measure of legal origin into English, French, German, and Scandinavian legal systems.

**Table 2**
Robustness tests.

**Panel A: INNOV1**

| | Alternatives | Controls | WLS1 | WLS2 | PSM1 | PSM2 | ENTROPY | IV-REGRESSIONS | |
|---|---|---|---|---|---|---|---|---|---|
| | PROBIT | PROBIT | PROBIT | PROBIT | PROBIT | PROBIT | PROBIT | SSREG1 | SSREG2 |
| Dependent Variables | INNOV1 | INNOV1 | INNOV1 | INNOV1 | INNOV1 | INNOV1 | INNOV1 | INNOV1 | INNOV1 |
| Independent Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| ENGLISH | | −0.1450*** | −0.0945*** | −0.0812*** | −0.1684*** | −0.1509*** | −0.1510*** | −0.1329** | −0.1378** |
| | | (0.0138) | (0.0162) | (0.0158) | (0.0177) | (0.0139) | (0.0139) | (0.0596) | (0.0618) |
| FRENCH | 0.1200*** | | | | | | | | |
| | (0.0143) | | | | | | | | |
| GERMAN | 0.2269*** | | | | | | | | |
| | (0.0189) | | | | | | | | |
| SCANDIN | 1.0630*** | | | | | | | | |
| | (0.0457) | | | | | | | | |
| CULTURE | | −0.2185*** | | | | | | | |
| | | (0.0072) | | | | | | | |
| RELIGION | | −0.1418*** | | | | | | | |
| | | (0.0262) | | | | | | | |
| FINDEV | | −0.1214*** | | | | | | | |
| | | (0.0322) | | | | | | | |
| Enterprise level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country controls effects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry fixed effects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| # of observations | 64,592 | 64,592 | 64,592 | 64,592 | 30,698 | 64,337 | 64,592 | 35,092 | 35,092 |
| Pseudo.$R^2$ | 0.1440 | 0.1520 | 0.1200 | 0.1200 | 0.1460 | 0.1380 | 0.1370 | | |
| $R^2$ | | | | | | | | 0.0753 | 0.0949 |
| First-Stage F-Statistic | | | | | | | | 3,242.00 | 3,242.00 |

**Panel B: INNOV2**

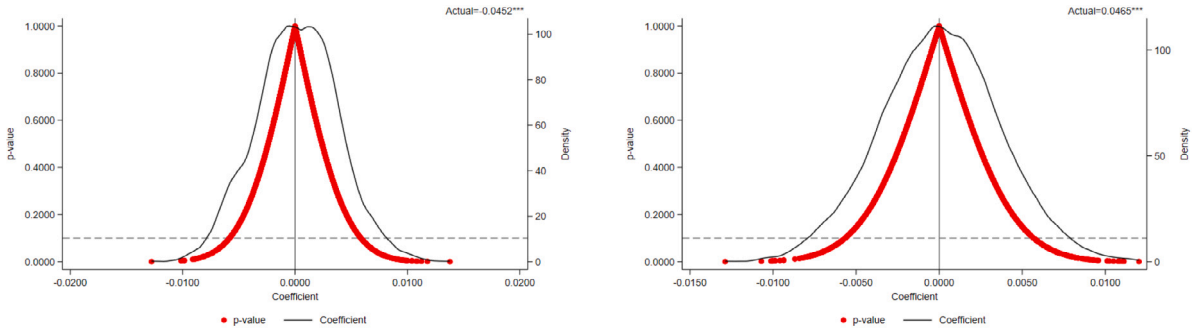
| | Alternatives | Controls | WLS1 | WLS2 | PSM1 | PSM2 | ENTROPY | IV-REGRESSIONS | |
|---|---|---|---|---|---|---|---|---|---|
| | PROBIT | PROBIT | PROBIT | PROBIT | PROBIT | PROBIT | PROBIT | SSREG1 | SSREG2 |
| Dependent Variables | INNOV2 | INNOV2 | INNOV2 | INNOV2 | INNOV2 | INNOV2 | INNOV2 | INNOV2 | INNOV2 |
| Independent Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| ENGLISH | | 0.1316*** | 0.1542*** | 0.1466*** | 0.1202*** | 0.1463*** | 0.1460*** | 0.3412*** | 0.3881*** |
| | | (0.0137) | (0.0157) | (0.0154) | (0.0183) | (0.0138) | (0.0137) | (0.0636) | (0.0659) |
| FRENCH | −0.1778*** | | | | | | | | |
| | (0.0143) | | | | | | | | |
| GERMAN | −0.0642*** | | | | | | | | |
| | (0.0190) | | | | | | | | |
| SCANDIN | 0.8045*** | | | | | | | | |
| | (0.0445) | | | | | | | | |
| CULTURE | | −0.1307*** | | | | | | | |
| | | (0.0074) | | | | | | | |
| RELIGION | | 0.1699*** | | | | | | | |
| | | (0.0266) | | | | | | | |
| FINDEV | | −0.4573*** | | | | | | | |
| | | (0.0337) | | | | | | | |
| Enterprise level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country controls effects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry fixed effects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| # of observations | 64,554 | 64,554 | 64,554 | 64,554 | 30,668 | 64,299 | 64,554 | 35,092 | 35,092 |
| Pseudo.$R^2$ | 0.1540 | 0.1530 | 0.1290 | 0.1300 | 0.1770 | 0.1470 | 0.1460 | | |
| $R^2$ | | | | | | | | 0.0558 | 0.0752 |
| First-Stage F-Statistic | | | | | | | | 3,242.00 | 3,242.00 |

The table presents the results from estimating the probit model specified in Eq. (1). SSREG1 and SSREG2 are estimated using the special regressor method of Lewbel (2000) for binary outcome models with endogeneity, with SSREG1 employing the sorted data density approach and SSREG2 using a standard kernel density approach. The sample, data sources, and variables utilized in this study are detailed in Online Appendix — Table A.1. Robust standard errors reported in parentheses are calculated using the Huber White Sandwich Estimator for the covariance matrix. ***, **, * indicate significance at the one, five, and ten percent levels, respectively, based on robust standard errors.

differ across legal systems more directly. Interestingly, the *FRENCH*, *GERMAN*, and *SCANDIN* coefficients are positive and significant for product/service innovation (*INNOV1*) and negative for process innovation (*INNOV2*) except for *SCANDIN*, confirming that enterprises in civil law countries prioritize product/service innovation over process innovation relative to common law countries.

Next, in Column (2) of Panels A and B of Table 2, we introduce additional controls, namely, culture, religion (data from Dow et al., 2016), and financial development (FINDEV) (see Machokoto et al., 2021, 2023; Machokoto, 2024). In Columns (3) and (4), we re-estimate Eq. (1) using weighted least squares to address uneven distributions of enterprise-year observations across countries (WLS1) and across years (WLS2), given substantial missing data in the time-series dimension.[5] Additionally, we implement propensity score matching (PSM) in Columns (5) and (6) and entropy balancing in Column (7) to ensure a balanced comparison between enterprises in common and civil law

[5] For WLS1, the weight is the inverse of observations in each country; for WLS2, the weight is the square root of the inverse of observations in each country.




(a) INNOV1 (b) INNOV2

**Fig. 1. Falsification tests.**
The figure illustrates the distribution of coefficients and *p-values* for a placebo common law dummy variable (*ENGLISH*) derived from estimating the probit model specified in Eq. (1). The placebo common law dummy variable (*ENGLISH*) was created by randomly assigning enterprises to civil law (control group) or common law (treated group) countries. In this placebo setup, the *ENGLISH* dummy is set to one if an enterprise is randomly assigned to a common law country and zero otherwise. The displayed distribution is based on 2000 iterations of estimating Eq. (1). The sample, data sources, and variables utilized in this study are detailed in Online Appendix — Table A.1.

countries.[6] Across all estimations, we find consistent results, reinforcing our baseline findings.

Additionally, we acknowledge that potential endogeneity might bias our results. However, this is unlikely in our study, as legal origins were established long before the enterprises in our sample were formed and are, therefore, exogenous to enterprise-level decisions.[7] To address any remaining concerns, we instrument legal origin using the proportion of Europeans in the colonial population (Easterly and Levine, 2016). Columns (8) and (9) of Panels A and B of Table 2 show that the results remain consistent.

Finally, we conduct a falsification test to ensure our results are not due to random chance.[8] Fig. 1 shows that the simulated coefficients cluster around zero and differ significantly from actual estimates, confirming that the observed relationship between legal origin and innovation is unlikely to be spurious. Our results also pass the Oster (2019)'s test for omitted variable bias in Online Appendix Table A.6.[9]

### 2.5. Does the institutional environment matter?

Table 3 reports estimates from Eq. (2), showing that higher institutional quality (*INSTQ1* to *INSTQ5*) positively and significantly influences both product/service (*INNOV1*) and process innovation (*INNOV2*). However, the consistently negative and significant interaction terms with *ENGLISH* indicate that the effect of institutional quality varies by legal origin. Specifically, in countries with strong institutions, the negative impact of common law on product/service innovation is more pronounced, likely due to heightened regulatory compliance and competitive pressures. At the same time, the positive effect of common law on process innovation diminishes, as robust institutions already promote efficiency and reduce the marginal value of legal flexibility. These findings suggest that institutional quality moderates the relationship between legal origin and innovation strategies.

## 3. Conclusion

In this short paper, we investigate how legal origins influence product/service and process innovation, using survey-based data from enterprises across 113 countries. We find that firms in civil law countries favor product/service innovation, while those in common law countries focus more on process innovation—patterns that are further shaped by institutional development. These findings highlight the importance of legal and institutional contexts in shaping innovation incentives and economic outcomes. This study has major implications and contributes to explaining why enterprises in different countries engage in different types of innovation strategies. Given the crucial role of innovation in sustainable economic development, policy measures to stimulate innovation could consider the legal and regulatory contexts of different countries.

[6] To implement propensity score matching, we use the covariates in Eq. (1) to estimate propensity scores with the *ENGLISH* dummy as the dependent variable. Enterprises in common law countries (treated group, *ENGLISH*=1) are then matched to similar counterparts in civil law countries (control group, *ENGLISH*=0) based on the estimated propensity scores. The matched samples are used in models PSM1 (observations with non-missing weights) and PSM2 (observations on common support). For entropy balancing, we re-weight observations in common law (treated group) and civil law (treated group) to achieve covariate balance across groups. These methods improve comparability across legal origins by addressing potential confounding issues (see Hainmueller and Xu, 2013). As shown in Online Appendix Table A.5, entropy balancing successfully equalizes mean, variance, and skewness.

[7] This approach follows Acemoglu et al. (2001, 2002), who argue that European settlement patterns played a key role in institutional transplantation. The instrument that we use is based on Easterly and Levine (2016) and captures exogenous variation in the adoption of legal systems, particularly the prevalence of common law in settler colonies, as supported by Beck et al. (2003) and La Porta et al. (1997, 1998, 2008). Estimation is conducted using the special regressor method of Lewbel (2000), suitable for binary outcome models with endogenous regressors and heteroskedasticity of unknown form. Following Mateut (2018), we use the demeaned enterprise age as the special regressor due to its exogeneity, continuous distribution, and relevance to enterprise innovation. The final instrumental variables model we use is just-identified, precluding overidentification tests such as the Hansen J or Sargan test. Introducing additional instruments, while preferable, is challenging, as valid instruments for historical variables like legal origin are scarce and often debated in the literature (see Acemoglu et al., 2001, 2002). At the same time, inappropriate instruments may introduce more bias than they eliminate (Roodman, 2009). The first-stage F-statistic from the model is high, indicating instrument strength (Staiger and Stock, 1997; Machokoto et al., 2021). Although endogeneity cannot be entirely ruled out, legal origin — like language — is a historically determined institutional feature unlikely to be endogenous to contemporary enterprise-level innovation outcomes (see Anderson, 2018; Armour et al., 2009; Klerman and Mahoney, 2007; Klerman et al., 2011; Kim et al., 2017; La Porta et al., 2008).

[8] We randomly assign enterprises to common and civil law subgroups, create a placebo *ENGLISH* dummy, and estimate Eq. (1) with 2000 iterations. We then examine the distribution of placebo coefficients and *p-values*.

[9] Appendix A.6 reports (Oster, 2019)'s test deltas ranging from 3.128 to 12.330, indicating that unobservables would need to be over three to twelve times more influential than observables to eliminate the estimated effect.

**Table 3**
The effect of institutions on innovation-legal origin nexus.

| Dependent variables | INNOV1 | INNOV1 | INNOV1 | INNOV1 | INNOV1 | INNOV2 | INNOV2 | INNOV2 | INNOV2 | INNOV2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Independent variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| ENGLISH | −0.2137*** | −0.2093*** | −0.2038*** | −0.1648*** | −0.2318*** | 0.0399** | 0.0324* | 0.1006*** | 0.0662*** | −0.0323 |
| | (0.0160) | (0.0161) | (0.0149) | (0.0155) | (0.0180) | (0.0163) | (0.0169) | (0.0148) | (0.0162) | (0.0200) |
| INSTQ1 | 0.1087*** | | | | | 0.0431*** | | | | |
| | (0.0042) | | | | | (0.0044) | | | | |
| ENGLISH × INSTQ1 | −0.1879*** | | | | | −0.2581*** | | | | |
| | (0.0106) | | | | | (0.0108) | | | | |
| INSTQ2 | | 0.1393*** | | | | | 0.0629*** | | | |
| | | (0.0057) | | | | | (0.0060) | | | |
| ENGLISH × INSTQ2 | | −0.2629*** | | | | | −0.3820*** | | | |
| | | (0.0151) | | | | | (0.0162) | | | |
| INSTQ3 | | | 0.2048*** | | | | | 0.0852*** | | |
| | | | (0.0095) | | | | | (0.0099) | | |
| ENGLISH × INSTQ3 | | | −0.4205*** | | | | | −0.5508*** | | |
| | | | (0.0244) | | | | | (0.0244) | | |
| INSTQ4 | | | | 0.2407*** | | | | | 0.1039*** | |
| | | | | (0.0103) | | | | | (0.0106) | |
| ENGLISH × INSTQ4 | | | | −0.4575*** | | | | | −0.6334*** | |
| | | | | (0.0233) | | | | | (0.0251) | |
| INSTQ5 | | | | | 0.2332*** | | | | | 0.1189*** |
| | | | | | (0.0091) | | | | | (0.0095) |
| ENGLISH × INSTQ5 | | | | | −0.3903*** | | | | | −0.6394*** |
| | | | | | (0.0268) | | | | | (0.0301) |
| Enterprise level controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country controls effects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry fixed effects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| # of observations | 62,893 | 62,893 | 62,893 | 62,893 | 62,893 | 62,855 | 62,855 | 62,855 | 62,855 | 62,855 |
| Pseudo.$R^2$ | 0.1490 | 0.1480 | 0.1460 | 0.1480 | 0.1480 | 0.1520 | 0.1530 | 0.1500 | 0.1540 | 0.1520 |

The table presents the results from estimating the probit model specified in Eq. (1). The sample, data sources, and variables utilized in this study are detailed in Online Appendix — Table A.1. Robust standard errors reported in parentheses are calculated using the Huber White Sandwich Estimator for the covariance matrix. ***, **, * indicate significance at the one, five, and ten percent levels, respectively, based on robust standard errors.

## Declaration of competing interest

We certify that there are no potential conflicts of interest related to the subject matter discussed in this manuscript. The usual disclaimer applies.

## Acknowledgments

We gratefully acknowledge the helpful comments and suggestions from the editor and anonymous reviewers.

## Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econlet.2025.112388.

## Data availability

Data will be made available on request.

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