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Towards Innovation in West African Business Sophistication: Lessons from the Eurozone

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Abstract:

This paper aims to shed light on the key factors that contribute to improving innovation in West African business sophistication by learning from the experience of the Eurozone. We have used panel data from 2013 to 2022 on 15 West African countries and 20 Eurozone countries. The study opted for non-parametric and semi-parametric modelling, estimated through the Generalized Additive Method. The results show that, first, human development in West Africa has not yet reached the minimum threshold required to positively impact innovation in business sophistication. Second, the relationship between human development and innovation in business sophistication in the Eurozone is non-linear, with 0.861 as the minimum threshold at which the Human Development Index positively influences innovation in business sophistication in the Eurozone. Third, political stability and non-violence positively and linearly influence innovation in business sophistication, whether in West Africa or the Eurozone.

Keywords: Innovation, Business, Sophistication, Non-parametric model, Semi-parametric model

JEL: C51, M21, O32

Statements and Declarations

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1. Introduction

Innovation, seen as an attempt to try out new or improved products, processes or ways of doing things, is a critical aspect of most, if not all, economic activities (Bell & Pavitt, 1993; Fagerberg et al., 2010). For sustained growth and sustainable development, innovation is typically a "first world" activity (Fagerberg et al., 2010; Schumpeter & Swedberg, 2021; Ziemnowicz, 2020). In recent years, a rapidly growing literature has emerged, arguing that increasing the level of sophistication of a country's production is a key component of economic development and the growth process (Spatafora et al., 2012). Countries need to enhance their productive structure to achieve higher levels of economic growth and social welfare (Hidalgo & Hausmann, 2009; Britto et al., 2019; Hartmann et al., 2017; Hartmann et al., 2021).

No economy can claim to be perfectly integrated into the structural transformation pathway without innovating in business sophistication. This paper has been developed to shed light on the key factors that can improve innovation in West African business sophistication by learning from the Eurozone experience.

This objective is motivated by the need to find strategies to enable the structural transformation of West African economies. West African economies are characterised by a low level of industrialisation and an agricultural sector that is dominant in terms of employability but whose contribution to GDP remains lower than the contribution of the services sector, which employs less. Over the last three decades, the path of structural transformation of West African economies shows that, in addition to the fact that the manufacturing sector is less developed in terms of value added to GDP (9.2% of GDP on average) and employability (11.1% of total employment on average), the agricultural sector was the leading sector in terms of employment (53.7% of total employment on average), with an average contribution to GDP of 28%. This is less than the contribution to GDP of the services sector (43.8% of GDP, on average), which employs 35.1% of total employment on average.

At the same time, the path of the Eurozone's structural transformation is in line with the literature, where the weight of the agriculture sector in the economy has been progressively reduced to the benefit of the manufacturing and services sectors, as shown in Fig. 27 in the Appendix. The stylised facts of the path of structural transformation of the West African economies mentioned above can be explained by this region's very low level of business sophistication. Hence, there is a need for such a study to shed light on the factors that can significantly increase innovation in West African business sophistication. To the best of our knowledge, this paper is the first to shed light on the factors that can be used to improve innovation in West African business sophistication efforts. The paper thus contributes to the literature by providing a bridge to this research gap.

In terms of policy implication, there is a need for governments and development partners of West African countries to increase their funding for education in science and technology, advanced health and any other intervention that can improve the experience of life to reach the minimum threshold of human development that would reverse the negative impact that human development has so far had on innovation in West African business sophistication. There is a need to improve the quality of institutions and, above all, maintain political stability and security to ensure sustainable development. While keeping inflation under control, the West African monetary authorities must rethink and improve the conditions under which banks finance the private sector to achieve greater efficiency. Finally, entrepreneurs must make efficient use of the financial resources mobilised to increase investment in

research and development (R&D) and acquire the requisite equipment and infrastructure needed for innovation in business sophistication strategy.

The rest of the paper is structured as follows: Section 2 presents the literature review, Section 3 discusses the data and methodology, Section 4 focuses on the presentation and interpretation of results, and Section 5 concludes the paper.

2. Literature review

Schumpeter pioneered the idea that entrepreneurial innovation is central to economic change and development (Ziemnowicz, 2020). In a dynamic economy, there must be an assumption that a force exists within such an economy that can account for change and development (Schumpeter, 1934; Ziemnowicz, 2020). This force is embodied in the entrepreneur (Schumpeter, 1934). According to Schumpeter (1934), entrepreneurs are the agents of innovation and the pivots on which everything revolves. The quality of the entrepreneurial activities determines the speed of capital growth and whether this growth would involve innovation and change (Schumpeter, 1934; Ziemnowicz, 2020).

Innovation is determined by the level of knowledge twice as much as the level of creativity (Cristescu & Nerișanu, 2021). Knowledge-intensive innovative entrepreneurs are involved in the creation, dissemination and use of knowledge; they introduce new products and technologies, bringing dynamic changes to the economy (Malerba & McKelvey, 2020). According to OECD and Eurostat (2018) and Gault (2023), "innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)." According to Oturakci (2023), countries can gain a competitive advantage because of their innovation activities.

The relationship between innovation and business sophistication is very strong (Razavi et al., 2012; Ceko, 2022). Innovation capacity would need to be expanded in the long run, given that it is positively leading to advanced business sophistication (Kirikkaleli & Ozun, 2019).

Economic sophistication requires specific skills and tacit knowledge embedded in labour (Arif, 2021). Economic sophistication positively impacts labour share in both OECD and non-OECD countries (Arif, 2021). There is a positive relationship between technological readiness and business sophistication (Rahayu, 2020). Analyzing R&D by sector, Kamguia et al. (2024) highlighted the importance of research spending by higher education, business, public sector and private non-profit sectors in improving economic complexity. However, investments in research and development remain associated with higher levels of economic complexity in resource-poor countries in contrast to resource-rich countries, where they have no effect (Kamguia et al., 2024). Economic complexity and human development positively influence economic growth, and these two factors also have a positive interactive effect on economic growth (Zhu & Li, 2017).

Countries that have overcome the gravitational pull towards simple products and completely transformed their economies towards complex products have been able to exploit the opportunities offered by the digital and electronics sectors by adopting intelligent industrial policies that have encouraged endogenous skills and access to international sources of knowledge (Hartmann et al., 2021). High-income economies are more complex than low— and middle-income economies (Zhu & Li, 2017).

The literature presented above highlights the importance of innovation in the development process of an economy in general and, more specifically, the importance of innovation in relation to business sophistication to achieve an economy producing more complex products. Furthermore, studies such as those by Bate et al. (2023) and Coutinho and Au-Yong-Oliveira (2024) have examined the determinants of innovation, finding that human capital, research, infrastructure, and business sophistication are the key pillars determining countries' innovation performance. As innovation in business sophistication is an essential determinant of innovation and crucial in the development process and on the structural transformation path, the existing literature has remained quiet on the factors on which to act to improve innovation in West African business sophistication. To provide tangible answers to this research gap in the literature, our paper proposes to test the following hypotheses:

Hypothesis 1: Human development is essential in accelerating innovation in business sophistication.

Hypothesis 2: Improving institutional quality through political stability and non-violence increases innovation in business sophistication.

3. Data and Methodology

3.1. Data sources

To carry out a comparative analysis between West Africa and the Eurozone, we use two separate panels with the same variables for West African and Eurozone countries. The 15 West African countries and the 20 Eurozone countries covered by the study are presented in Appendix 6. Given the availability of data, the data was collected from 2013 to 2022. Table 1 summarises the descriptive statistics, while Appendix 1 describes the variables and data sources.

Table 1 Descriptive statistics

West African Countries Descriptive Statistics					
Variable	Obs.	Mean	Std. Dev.	Min	Max
Innovation in business sophistication	119	23.56	6.17	12.5	52.2
Innovation in Universities and Industries collaboration in R&D	119	29.42	16.05	0	68.5
Human Development Index	150	0.498	0.069	0.357	.665
Innovation in education	113	33.28	9.59	11.9	54.5
Innovation in infrastructures	116	25.06	7.55	0	42.3
Credit to the private sector by bank	150	18.79	13.28	0.0047	67.87
Political stability	150	-0.62	0.77	-2.48	0.93
Rule of law	150	-0.64	0.46	-1.61	0.66
Regulatory quality	150	-.063	0.35	-1.32	0.27
Eurozone Countries Descriptive Statistics					
Variable	Obs.	Mean	Std. Dev.	Min	Max
Innovation in business sophistication	200	44.65	9.59	25.9	65.1
Innovation in Universities and Industries collaboration in R&D	200	54.39	13.84	25.6	82.8
Human Development Index	200	0.899	0.030	0.839	0.951
Innovation in education	200	58.48	7.99	38	86.3
Innovation in infrastructures	200	54.61	6.35	37.4	66.7
Credit to the private sector by bank	200	81.81	35.28	26.17	254.55
Political stability	200	0.70	0.34	-0.24	1.43
Rule of law	200	1.13	0.53	0.04	2.12
Regulatory quality	200	1.16	0.46	0.14	2.04

Source: authors

3.2. Methodology

The study sought to avoid imposing a functional form between the explanatory and dependent variables. Therefore, the study opts for modelling that will allow it to determine the exact functional form that exists between each explanatory variable and the dependent variable. Non-parametric modelling is the most appropriate way of achieving flexibility in modelling. It does not impose a functional form in advance but lets the nature of the data define the real functional form between the different explanatory variables and the dependent variable (Hastie & Tibshirani, 1986; Kauermann, 2006; Hastie, 2017; Wood, 2017). To this end, the study opts for non-parametric modelling based on the Generalized Additive Models developed by Hastie and Tibshirani (1986) as the starting point for the modelling. With Generalized Additive Models, the dependent variable or the response variable may not be distributed according to the normal distribution. Still, it may be distributed according to an exceptional distribution such as the binomial distribution, the Poisson distribution, etc. (Kauermann, 2006). The following equation generally defines the Generalised Additive Models of Hastie and Tibshirani (1986):

$$\begin{cases} Y = s_0 + \sum_{j=1}^{r} s_j\left(X_j\right) + \varepsilon \\ with \quad E\left[s_j\left(X_j\right)\right] = 0 \end{cases} \tag{1}$$

Where Y represents the dependent variable or the response variable, s_0 is the intercept, $s_j(.)$ are unspecified smooth functions that are estimated using a *scatterplot smoother*, X_j represents the vector of explanatory variables for which the functional relationship between each explanatory variable and Y is initially unknown, ε represents the error term independent of X_j, $E[.]$ represents the mathematical expectancy, and r represents the total number of explanatory variables in X_j.

Estimating equation (1) makes it possible to identify the real functional form between each explanatory variable and the dependent variable Y. From this, we can identify a vector V_j of non-linear explanatory variables associated with the dependent variable Y and a vector W_i associated linearly with the dependent variable Y. To capture both the linearity and non-linearity in the model, the next step is to estimate the semi-parametric model given by equation (2)

$$Y = s_0 + \sum_{j=1}^{p} s_j\left(V_j\right) + \sum_{i=1}^{q} \beta_i W_i + \varepsilon \tag{2}$$

where β_i represents the parameters of the model's linear part to be estimated, p represents the total number of explanatory variables non-linearly associated with Y and q the total number of explanatory variables linearly associated with Y such that $p+q=r$, the rest of the parameters in equation (2) are explained in the same way as in equation (1).

The specification of equation (1) is given by equation (3).

$$IBS_\text{Index} = s_0 + s(\text{IUICRD_Index}) + s(\text{HDI}) + s(\text{InovEduc_Index}) + s(\text{InovInfra_Index}) + s(\text{Credit_PS_Bank}) + s(\text{Pol_Stab}) + s(\text{Rule_of_Law}) + s(\text{Reg_Quality}) + \varepsilon$$

Where s_0, $s(.)$ and ε are explained in the same way as in equation (1). the dependent variable in equation (3) is represented by IBS_Index defined as the innovation in business sophistication index. The explanatory variables are IUICRD_Index defined as innovation in Universities and Industries' collaboration in R&D; HDI is defined as the Human Development Index; InovEduc_Index defined as innovation in education; InovInfra_Index defined as innovation in infrastructure; Credit_PS_Bank defined as credit to the private sector by a bank; Pol_Stab defined as political stability; Rule_of_Law defined as rule of law; Reg_Quality defined as regulatory quality. The description of the variables, their methods of calculation and the source of the data are given in Appendix 1.

4. Results and discussion

Table 2 Non-parametric model results using data from West African countries

	edf	Ref.df	F	p-value
s(Innovation in Ind. and Unv. Collaboration in R&D)	3.157	3.733	6.864	0.0001
s(Human Development Index)	1.000	1.000	19.901	0.0000
s(Innovation in education)	5.926	7.113	2.659	0.0169
s(Innovation dans les infrastructure)	1.000	1.000	0.087	0.7693
s(Credit to private sector by bank)	5.194	6.204	1.508	0.2075
s(Political stability)	1.000	1.000	17.8652	0.0001
s(Rule of law)	5.433	6.531	3.621	0.0023
s(Regulatory quality)	1.000	1.000	9.623	0.0026

Note: edf: effective degrees of freedom; Ref.df: reference degrees of freedom; s(.) is the unspecified smooth function that is estimated using a *scatterplot smoother.*
Source: authors

The non-parametric model results are interpreted according to the significance of the edf values (Hastie & Tibshirani, 1986; Hastie, 2017; Wood, 2017). The results presented in Table 2 show two types of trend—explanatory variables associated non-linearly with innovation in business sophistication (Box 1, from Fig. 1 to 4) and those associated linearly with innovation in business sophistication (Box 2, from Fig. 5 to 8).

For variables whose edf values are significantly greater than one, these variables are non-linearly associated with innovation in business sophistication. The explanatory variables that are non-linearly associated with innovation in business sophistication in West Africa are innovation in industry-university collaboration (edf = 3.2, p-value = 0.0001 < 1%); innovation in education (edf = 5.9, p-value = 0.0169 < 5%) and rule of law (edf = 5.4, p-value =

0.0023 < 1%) (Table 2). Credit to the private sector by banks in West Africa shows a non-significant, non-linear relationship with innovation in business sophistication (Table 2).

The explanatory variables that are linearly associated with innovation in West African business sophistication are those whose edf is significantly equal to one. These are human development (edf = 1, p-value = 0.0000 < 1%), political stability and non-violence (edf = 1, p-value = 0.0001< 1%) and regulatory quality (edf = 1, p-value = 0.0026 < 1%) (Table 2). Innovation in infrastructure shows a non-significant linear relationship with innovation in West African business sophistication (Table 2). The following boxes present the trends of the different explanatory variables about innovation in West African business sophistication obtained from the non-parametric regression.

Box 1 Trend in explanatory variables non-linearly associated with innovation in West African business sophistication

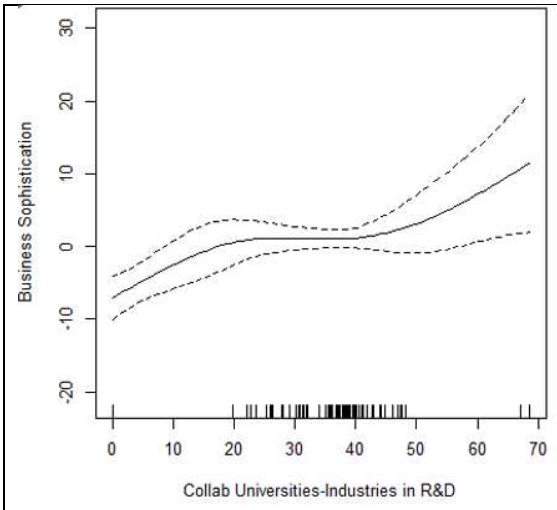


Fig. 1 Non-linear influence of innovation in universities-industries collaboration in research and development on innovation in business sophistication

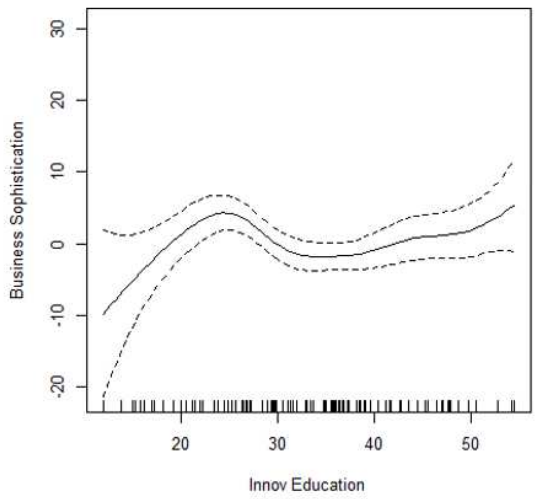


Fig. 2 Non-linear relationship between innovation in education and innovation in business sophistication

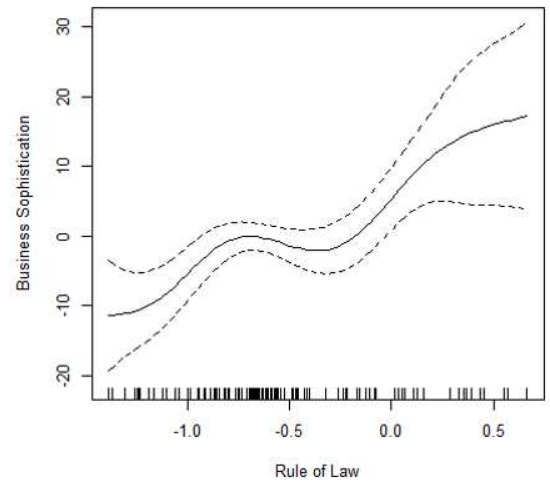


Fig. 3 Non-linear relationship between the rule of law and innovation in business sophistication

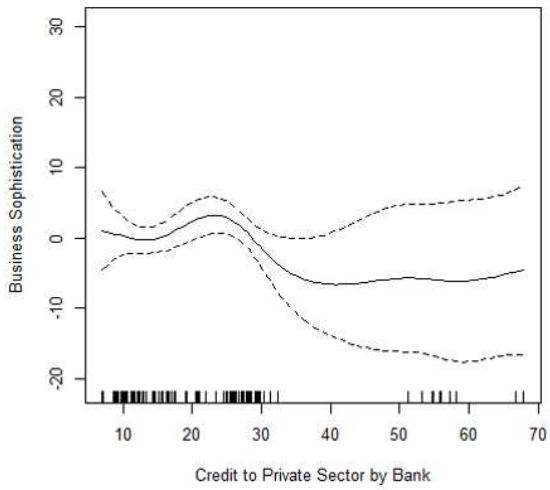


Fig. 4 Non-linear relationship between credit to the private sector by banks and innovation in business sophistication

Source: authors

Box 2 Trend in explanatory variables linearly associated with innovation in West African business sophistication

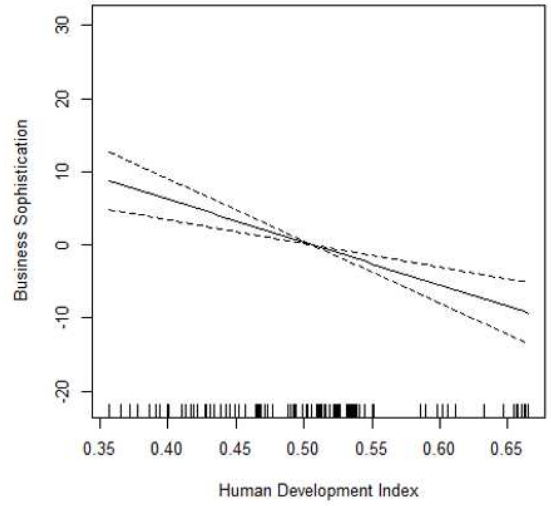


Fig. 5 Linear relationship between human development and innovation in business sophistication

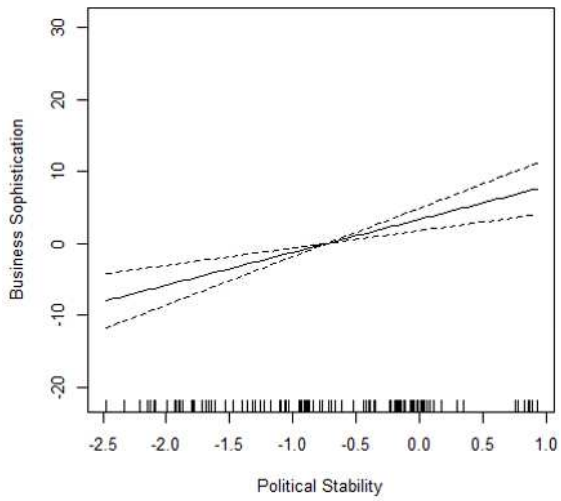


Fig. 6 Linear influence of political stability and non-violence on innovation in business sophistication

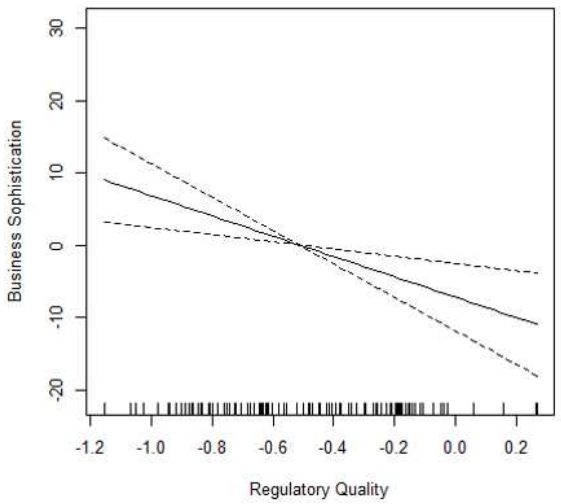


Fig. 7 Linear relationship between quality of regulatory and innovation in business sophistication

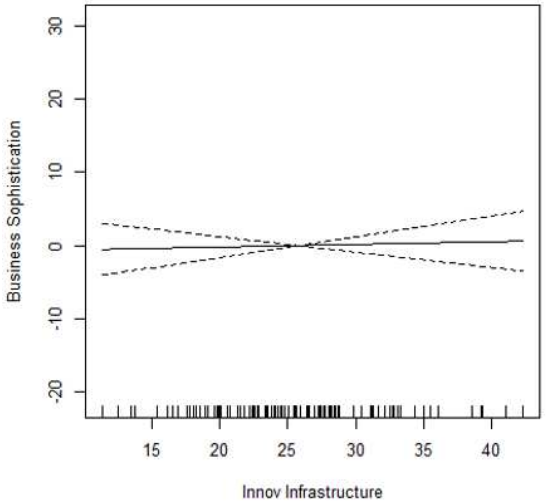


Fig. 8 Linear relationship between innovation in infrastructure and innovation in business sophistication

Source: authors

Our non-parametric model results for the Eurozone are shown in Table 3.

Table 3 Non-parametric model results using data from Eurozone countries

	edf	Ref.df	F	p-value
s(Innovation in Ind. and Unv Collaboration in R&D)	2.768	3.503	2.584	0.0504
s(Human Development Index)	5.954	7.154	13.825	0.0000
s(Innovation in education)	1.024	1.047	3.360	0.0640
s(Innovation in infrastructure)	1.000	1.000	5.918	0.0160
s(Credit to private sector by bank)	2.058	2.529	5.614	0.0024
s(Political stability)	1.000	1.000	23.324	0.0000
s(Rule of law)	6.555	7.644	3.921	0.0005
s(Regulatory quality)	7.291	8.278	5.609	0.0000

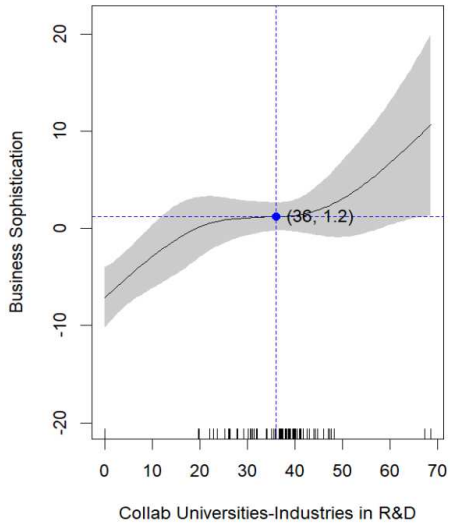
Note: edf: effective degrees of freedom; Ref.df: reference degrees of freedom; s(.) is the unspecified smooth function that is estimated using a *scatterplot smoother.*
Source: authors

The results in Table 3 show that in the Eurozone, the variables associated non-linearly with innovation in business sophistication are innovation in industry-university collaboration in research and development (R&D) (edf = 2.8, p-value = 0. 0504 < 1%); human development (edf = 5.95, p-value = 0.0000 < 1%); credit to the private sector by banks (edf = 2.1, p-value = 0.0024 < 1%); the rule of law (edf = 6.6, p-value = 0.0005 < 1%) and the quality of the regulatory (edf = 7.3, p-value = 0.0000 < 1%). Still in the Eurozone, our results show that innovation in education (edf = 1, p-value = 0.0640 < 10%), innovation in infrastructure (edf = 1, p-value = 0.0160 < 5%) and political stability (edf = 1, p-value = 0.0000 <1%) are linearly associated with innovation in business sophistication (Table 3). The different non-linear and linear trends between each explanatory variable and innovation in business sophistication in the Eurozone are presented in Appendices 2 and 3, respectively.

The non-linear influence of innovation in industry-university collaboration in R&D on innovation in business sophistication in West Africa is an ascending non-linear relationship (Table 2, Fig. 9). This non-linear relationship has an inflexion point where the innovation index in industry-university collaboration in R&D equals 36, and the innovation index in business sophistication equals 1.2 (Fig. 9). While our results also indicate a non-linear influence of innovation in industry-university collaboration in R&D on innovation in business sophistication in the Eurozone, this non-linear relationship is in an inverted U-shape with a threshold when the innovation index in business sophistication is equal to 48 (Fig. 19 in Appendix 2). These results show that an increase in innovation in industry-university collaboration in R&D leads to a rise in innovation in business sophistication in West Africa. In contrast, in the Eurozone, innovation in business sophistication increases up to a threshold before starting to fall slightly.

Innovation in business sophistication requires not only significant investment in R&D but also ongoing collaboration between businesses and universities to leverage the investments made in order to transform these investments into concrete projects to meet the needs for which the investments were made. It is through this mechanism that innovation in industry-university collaboration contributes to improving business sophistication.

The existence of a maximum threshold in the Eurozone calls for efficiency in the financing of collaboration between universities and industries. In the Eurozone, as soon as the value of 48 is reached, equivalent to the value of the index of university-industry collaboration in R&D above which innovation in business sophistication decreases, the funding allocated to the benefit of innovation in university-industry collaboration in R&D should be considerably reduced and reallocated to other areas for greater efficiency. The results provide a clear response to the inability of Power and Malmberg (2008) to explain how universities contribute to regional innovation systems.



Note: The blue point with coordinates (36, 1.2) represents the inflexion point

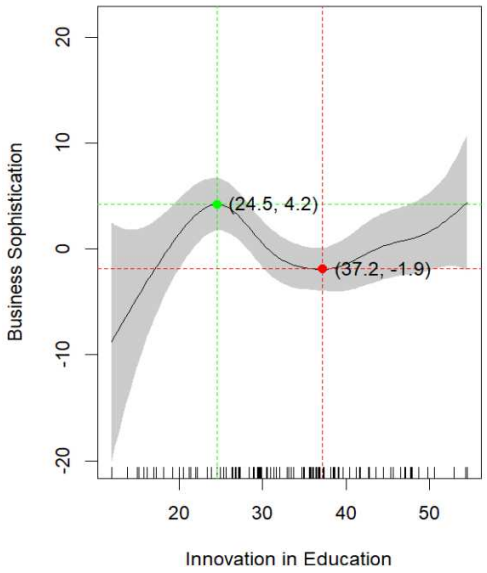
Fig. 9 Non-linear influence of industry-university collaboration in R&D on innovation in the West African business sophistication

Source: authors

According to Fagerberg et al. (2010), innovation is usually seen as carried out by highly educated labour in R&D. Thus, our findings on innovation in university-industry collaboration in R&D in West Africa are reinforced by our findings on innovation in education. Although the relationship between innovation in education and innovation in business sophistication in West Africa is non-linear, this non-linear relationship shows more ascending phases with two extremes (Fig. 2, Fig. 10). This non-linear relationship presents a local maximum (innovation index in business sophistication equal to 4.2) when the innovation index in education is equal to 24.5 and a local minimum (innovation index in business sophistication equal to -1.9) when the innovation index in education is equal to 37.2 (Fig. 10). Apart from the interval described by the innovation index in education between 24.5 and 37.2, where innovation in business sophistication decreases as innovation in education increases, innovation in education positively influences innovation in business sophistication in West Africa.

The dominant positive trend of innovation in education's effect on innovation in business sophistication in West Africa is reinforced by the linear and positive relationship we obtained between innovation in education and innovation in business sophistication in the Eurozone (Fig. 24 in Appendix 3). The combination of these two results describing the influence of innovation in education on innovation in business sophistication, whether in West Africa or the Eurozone, reassures us that innovation in education is an essential factor that positively influences

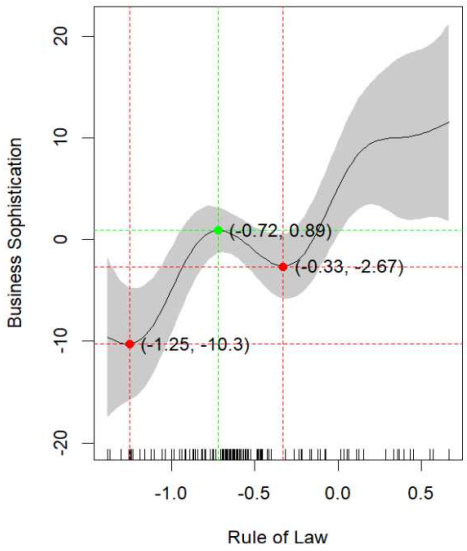
innovation in business sophistication. Innovation in education that considers the labour market's needs by training more in engineering, technological sciences and professional training in specific fields that provide skills for setting up industries can only positively influence innovation in business sophistication. Our results corroborate those of Nielsen (2007), who finds that hiring graduates with engineering backgrounds positively impacts the propensity to introduce new products in the following year.



Note: The green point with coordinates (24.5, 4.2) represents a local maximum. The red point with coordinates (37.2, -1.9) represents a local minimum.

Fig. 10 Non-linear relationship between innovation in education and innovation in West African business sophistication
Source: authors

Whether in West Africa or the Eurozone, our results show a non-linear relationship between the rule of law and innovation in business sophistication. Overall, the non-linear relationship between the rule of law and innovation in business sophistication in West Africa is an ascending non-linear relationship (Fig. 11). Beyond the dominant ascending portions of this non-linear relationship, our results show that when the rule of law index is between -1.61 and -1.25 on the one hand and between -0.72 and -0.33 on the other hand, the rule of law negatively influences innovation in business sophistication (Fig. 11). These results can be explained by the fact that over these portions, the rule of law practices have been very restrictive in West Africa, deteriorating innovation in business sophistication. At the same time, our results indicate that the non-linear relationship between the rule of law and business sophistication in the Eurozone is more complex than that observed in West Africa (Fig. 22 in Appendix 2). From these results, an improvement in the rule of law, with a few exceptions, favours innovation in business sophistication. An improvement in the rule of law, in the form of recognition and protection of private and intellectual property rights, freedom of expression, freedom to practise and entrepreneurial freedom, can only help to stimulate intellectual creation, which in turn helps to consolidate business sophistication. This result is corroborated by those of Zhang and Yang (2016), who found that in developing countries, foreign direct investment and imports play a mediating role in the relationship between intellectual property rights protection and export sophistication; while for developed countries, the corresponding mediating effects rely on R&D and foreign direct investment.



Note: The two red points with coordinates (-1.25, -10.3) and (-0.33, -2.67) represent the two local minimums. The green point with coordinates (-0.72, 0.89) represents the local maximum.

Fig. 11 Non-linear relationship between the rule of law and innovation in West African business sophistication, with indication of inherent extremums
Source: authors

As innovation in education and the rule of law are each non-linearly associated with innovation in business sophistication in West Africa, Fig. 12 shows the combined effect of these two factors on innovation in West African business sophistication.

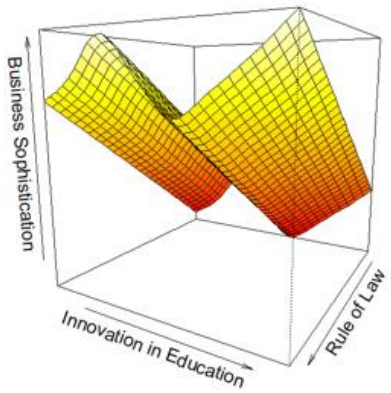


Fig. 12 Influence of the rule of law on innovation in West African business sophistication, including innovation in education
Source: authors

Fig. 12 shows that for the same level of innovation in education, innovation in business sophistication in West Africa increases as the rule of law improves. This result highlights the importance of having solid and reasonable institutions and adopting more innovative educational practices to promote innovation in West African business sophistication.

Given that the non-parametric regressions revealed that some explanatory variables are linearly associated with innovation in business sophistication, we present the semi-parametric regression results to confirm not only the non-linearity of the variables that are non-linearly associated with innovation in business sophistication but also

to confirm the linearity of those that are linearly associated. This approach allows us to estimate the average effect of the influence of each linear variable on innovation in business sophistication.

Table 4 Semi-parametric model results using data from West African countries

term	estimate	std.error	statistic	p.value	edf	ref.df
(Intercept)	52.072	7.747	6.722	0.0000		
Human Development Index	-59.736	13.136	-4.547	0.0000		
Innovation in infrastructures	-0.012	0.118	-0.100	0.9205		
Credit to private sector by bank	-0.015	0.080	-0.191	0.8488		
Political stability	4.458	1.085	4.110	0.0001		
Regulatory quality	-11.636	4.488	-2.593	0.0112		
s(Innovation in Ind. and Unv Collaboration in R&D)			6.698	0.0001	3.012	3.584
s(Innovation in education)			2.763	0.0179	5.373	6.564
s(Rule of law)			4.063	0.0005	6.469	7.616

Note: edf: effective degrees of freedom; Ref.df: reference degrees of freedom; s(.) is the unspecified smooth function that is estimated using a *scatterplot smoother.*
Source: authors

The estimation of the semi-parametric model using West African data reveals that all the explanatory variables that the non-parametric estimation identified as non-linear are indeed non-linear. These are innovation in industry-university collaboration in R&D, innovation in education and the rule of law (Table 4). All the explanatory variables identified by the non-parametric model estimation as significantly linearly associated with innovation in West African business sophistication are confirmed as effectively linearly associated with innovation in business sophistication by the semi-parametric model estimation. These are the human development index, political stability and regulatory quality (Table 4).

Using West African data, our results show a linear and negative relationship between human development and innovation in business sophistication (Fig. 13). At first sight, this result seems counter-intuitive, but a more in-depth analysis provides a better understanding of the West African reality. At the same time, the results for the Eurozone show a non-linear, U-shaped relationship between human development and innovation in business sophistication, with a threshold represented by a local minimum obtained at the point where the development index equals 0.861 (Fig. 14).

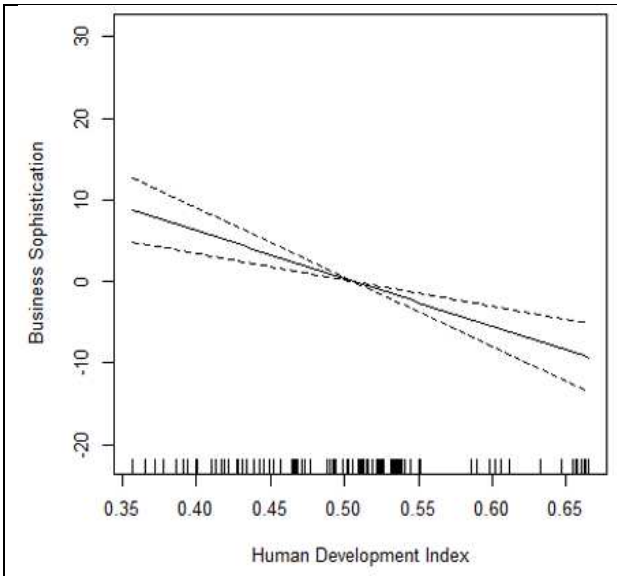


Fig. 13 Linear relationship between human development and innovation in West African business sophistication

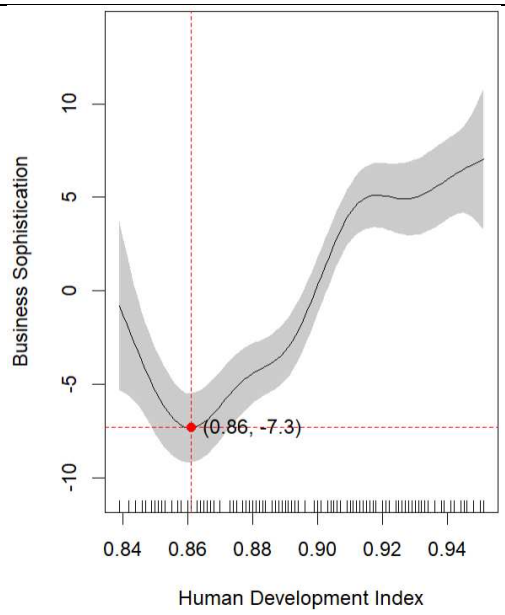


Fig. 14 Non-linear relationship between human development and innovation in business sophistication in the Eurozone

Note. The red point in Fig. 14 with coordinates (0.86, -7.3) is a local minimum
Source: authors

The impact of human development on innovation in business sophistication in the Eurozone can be seen in two phases, as shown in Fig. 14. A first phase in which human development negatively impacts innovation in business sophistication. This is the phase where the human development index is between 0.839 (the lowest level of human development) and 0.861 (the value of human development corresponding to the threshold), and the second phase where this relationship is positive. This is the phase where the human development index is between 0.861 and 0.951 (the highest level of human development). Descriptive statistics of West African data show that the maximum value of the human development index in West Africa is equivalent to 0.665 (Table 1). This would mean that the maximum level of human development in West Africa (0.665) has not yet reached the lowest level in the Eurozone (0.839). Moreover, the Eurozone obtains its local minimum at which human development begins to have a positive impact on innovation in business sophistication when human development is equal to 0.861. This being the case, human development in West Africa has not yet reached the threshold at which human development will begin positively impacting innovation in business sophistication. Thus, human development in West Africa has not yet reached the threshold required for our first hypothesis to be validated in this region. However, our first hypothesis is verified in the Eurozone from a threshold where the human development index equals 0.861. In line with our results obtained on the upward phase of Fig. 14, Ullah et al. (2024) also found that human capital plays a crucial role in the OECD countries' export sophistication.

Political stability and non-violence, whether in West Africa (Fig. 15) or the Eurozone (Fig. 16), positively and linearly impact innovation in business sophistication. Our results show that a one-point improvement in the political stability and non-violence index leads to a 4.5-point increase in the innovation index in business sophistication in West Africa (Table 4) and a 5.7-point increase in the Eurozone (Appendix 4).

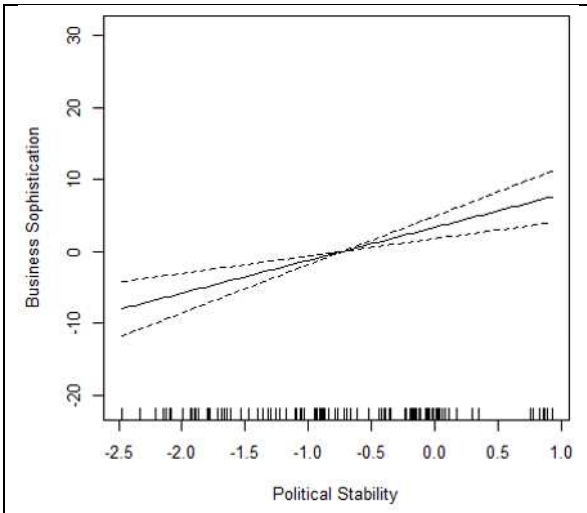


Fig. 15 Positive and linear influence of political stability and non-violence on West African business sophistication

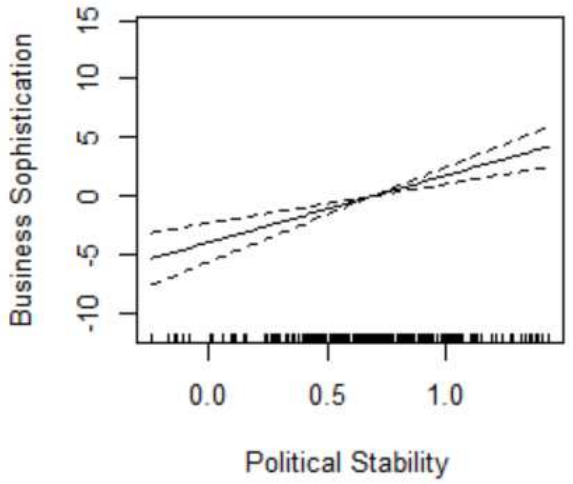


Fig. 16 Positive and linear influence of political stability and non-violence on business sophistication in the Eurozone

Source: authors

Political stability and non-violence are essential in any community and are fundamental prerequisites for developing economic activities and entrepreneurship. Based on the confidence and investment security offered by a politically stable economic environment, political stability and non-violence are essential factors in a country's attractiveness to investors, who often come with innovative business ideas. The emergence of new economic activities, combined with the security of investment driven by a politically stable economic environment, are factors that, in the long term, help to accelerate innovation in business sophistication. These results validate our second hypothesis: that an improvement in institutional quality through political stability and non-violence increases innovation in business sophistication. Our results confirm those of Ullah et al. (2024), who find that institutional quality plays a crucial role in the OECD countries' export sophistication.

Further to the impact that other institutional quality components may have on innovation in business sophistication, our results show that regulatory quality has a linear and negative impact on innovation in West African business sophistication (Fig. 17). At the same time, regulatory quality has a non-linear influence on innovation in business sophistication in the Eurozone (Fig. 18).

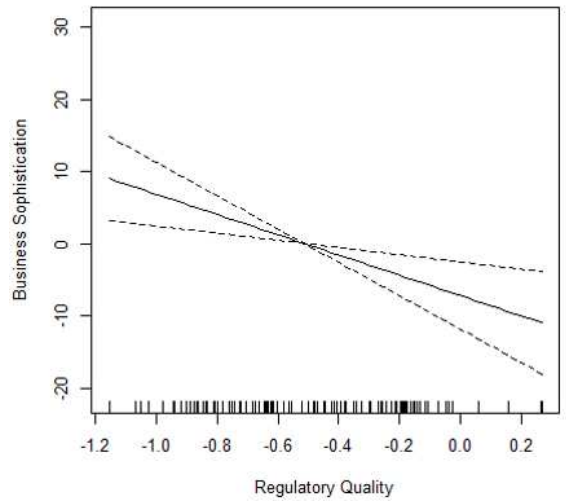


Fig. 17 Negative and linear impact of regulatory quality on innovation in West African business sophistication

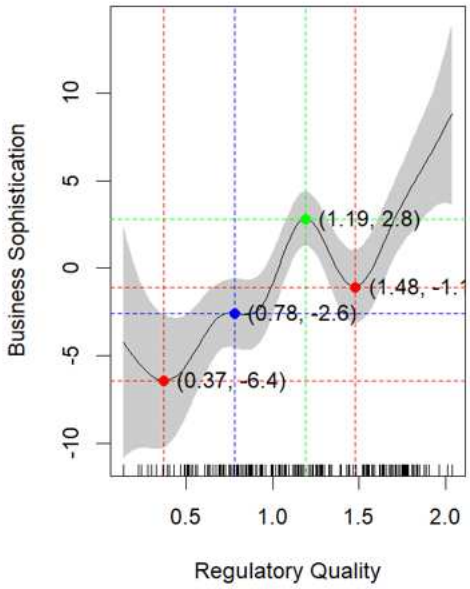


Fig. 18 Non-linear relationship between quality of regulatory framework and innovation in business sophistication in the Eurozone

Note: In Fig. 18, the two red points with coordinates (0.37, -6.4) and (1.48, -1.1) are local minima. The blue point with coordinates (0.78, -2.6) is a local inflexion point. The green point with coordinates (1.19, 2.8) is a local maximum.
Source: authors

The non-linear relationship (Fig. 18) shows that the upward phases in which the quality of regulatory conditions has a positive influence on innovation in business sophistication in the Eurozone are more important than the phases in which the quality of regulatory conditions negatively influences innovation in business sophistication. The two phases (portions of the curve where the index of the quality of regulation is between 0.14 and 0.37 on the one hand and between 1.19 and 1.48 on the other) where the quality of regulation has a negative influence on innovation in business sophistication in the Eurozone can be explained by the inappropriate practice of certain new forms of regulation that are often not adapted to the reality on the ground. Our results for the Eurozone are corroborated by those of Wang et al. (2023), who show that environmental regulation significantly promotes the complexity of export technology for enterprises. However, Wang et al. (2023) add that due to differences in firm heterogeneity, there are significant differences in the impact of environmental regulation on the complexity of export technology.

When we return to the negative linear relationship between the quality of regulation and innovation in business sophistication in West Africa (Fig. 17), we note that in West Africa, the maximum value of the quality of regulation is 0.27, lower than 0.37, the threshold at which innovation in business sophistication in the Eurozone leaves its first downward phase to begin its first upward phase following the evolution of the quality of regulation. This would mean that the quality of regulation in West Africa has not yet reached the threshold required to counterbalance the negative influence of regulation on innovation in business sophistication.

Other best practices that West Africa can learn from the experience of the Eurozone in the process of innovation in business sophistication are the ability of credit to the private sector by banks and innovation in infrastructure to positively and significantly influence innovation in business sophistication. In the Eurozone, our results show that

credit allocated to the private sector by banks (Fig. 21 in Appendix 2) and innovation in infrastructure (Fig. 25 in Appendix 3) positively influence innovation in business sophistication. This is not the case in West Africa. However, a company's ambition to become more sophisticated is not exempt from the rule of financing R&D, the development of infrastructure and innovative equipment, and even less from their acquisition.

The credit allocated to the private sector by banks is one of the essential resources that make it possible not only to finance R&D but also to finance the development of infrastructures and innovative equipment, as well as their acquisition in the business sophistication process. Through this mechanism, credit allocated to the private sector by banks and innovation in infrastructure positively influence innovation in business sophistication in the Eurozone. To achieve such a result, West Africa must improve the efficiency of private sector financing and increase the amount of private sector financing. So far, the average credit allocated to the private sector by banks in West Africa represents only 18.8% of GDP, whereas it amounts to 81.8% of GDP in the Eurozone (Table 1). In the same vein, Ndoya et al. (2024) argue that sound reforms to reduce political, economic and financial risks can leverage financial development to promote the sophistication and complexity of developing economies.

5. Conclusion

Achieving SDG 9 in developing countries, particularly in West Africa, must systematically involve innovation in business sophistication. This study was conducted with this in mind to shed light on the key factors that contribute to improving innovation in West African business sophistication by learning from the experience of the Eurozone.

Using panel data from 2013 to 2022 on 15 West African countries and 20 Eurozone countries, we opted for non-parametric and semi-parametric modelling, estimated using the Generalized Additive Method. Our main results show that, first, human development in West Africa has not yet reached the minimum threshold required to positively impact innovation in business sophistication. Second, the relationship between human development and innovation in business sophistication in the Eurozone is non-linear, with 0.861 as the minimum threshold at which the Human Development Index starts to positively impact innovation in business sophistication in the Eurozone. These two results enabled us to test our first hypothesis: that human development is essential in accelerating innovation in business sophistication. Our results show that West African economies have not yet reached the human development threshold required for our first hypothesis to be validated in West Africa. However, this hypothesis is verified in the Eurozone when the human development threshold equals 0.861 and above.

Our results also show that, whether in West Africa or the Eurozone, political stability and non-violence have a positive and linear impact on innovation in business sophistication. This result validated our second hypothesis, whether in West Africa or the Eurozone. In addition, we show that while banks' credit to the private sector significantly impacts innovation in business sophistication in the Eurozone, with an average credit of 81.8% of GDP, the impact is not significant in West Africa, with an average credit of 18.8% of GDP.

In terms of policy implication, the governments and technical and financial partners of West African countries must increase their funding for science and technology education, advanced health and any other project that can improve the experience of life to reach the minimum threshold of human development that would reverse the negative impact that human development has so far had on innovation in West African business sophistication. Second, public authorities and civil society must continuously improve the quality of institutions and, above all, maintain political stability and non-violence, which guarantees sustainable development. Third, while keeping

inflation under control, the West African monetary authorities must rethink and improve the conditions under which banks finance the private sector to achieve greater efficiency. Fourth, entrepreneurs must improve two critical aspects of their business development strategy. First, they must make efficient use of the credits they receive by investing in research and development and enhancing collaboration between their companies and specialist research centres. Second, entrepreneurs must make good use of the financial resources they mobilise to increase investment in the equipment and infrastructure their companies need to innovate further and become more sophisticated.

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Appendix

Appendix 1 Variables Summary

Variable	Variable description	Source
Innovation in business sophistication	This is the fifth pillar in the calculation of the Global Innovation Index. This index assesses the extent to which companies are conducive to innovation activity. It is calculated on a scale of 0 to 100, using three sub-pillars: knowledge workers, innovation linkages and knowledge absorption. Each of the three sub-pillars mentioned above is calculated based on five other indicators.	World Intellectual Property Organization/ World Bank Group
Innovation in Universities and Industries collaboration in R&D	This indicator is used to calculate the innovation index for business sophistication. This indicator highlights the influence of collaboration between university and industry on the productivity, efficiency and competitiveness of businesses. The index is calculated on a scale from 0 to 100.	World Intellectual Property Organization/ World Bank Group
Human Development Index	The Human Development Index is based on the following three indicators: longevity, as measured by life expectancy at birth; educational attainment, as measured by a combination of adult literacy and combined primary, secondary and tertiary enrollment ratios; and standard of living, as measured by real GDP per capita.	AfDB Socio-Economic Database/UNDP, Human Development Report
Innovation in education	This indicator represents tertiary education, the second sub-pillar used to calculate the Global Innovation Index's second pillar (human capital and research). It captures the coverage rate of tertiary education, the percentage of graduates in science, engineering, manufacturing, and construction, and the inbound and mobility of tertiary students, which plays a crucial role in exchanging ideas and skills necessary for innovation. This index is calculated based on 0 to 100.	World Intellectual Property Organization/ World Bank Group
Innovation in infrastructures	Represents the third pillar in the calculation of the Global Innovation Index. This index is calculated from 0 to 100 and includes Information and communication technologies (ICTs), General infrastructure, and Ecological sustainability.	World Intellectual Property Organization/ World Bank Group
Domestic credit to the private sector by banks	Calculated as a percentage of GDP, domestic credit to private sector refers to financial resources provided to the private sector by other depository corporations (deposit taking corporations except central banks), such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment. This variable is often used as a proxy for financial development.	World Development Indicators
Political stability	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. This indicator varies from -2.5 (weak political stability and presence of violence) to 2.5 (strong political stability and absence of violence) and is used as a proxy for a country's institutional quality.	Worldwide Governance Indicators
Rule of law	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. This indicator varies from -2.5 (weak rule of law) to 2.5 (strong rule of law) and is used as a proxy for a country's institutional quality.	Worldwide Governance Indicators
Regulation quality	Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. This indicator varies from -2.5 (low regulation quality) to 2.5 (strong regulation quality) and is also used as a proxy for a country's institutional quality.	Worldwide Governance Indicators

Source: authors

Appendix 2 Trend in non-linear explanatory variables associated with innovation in business sophistication in the Eurozone

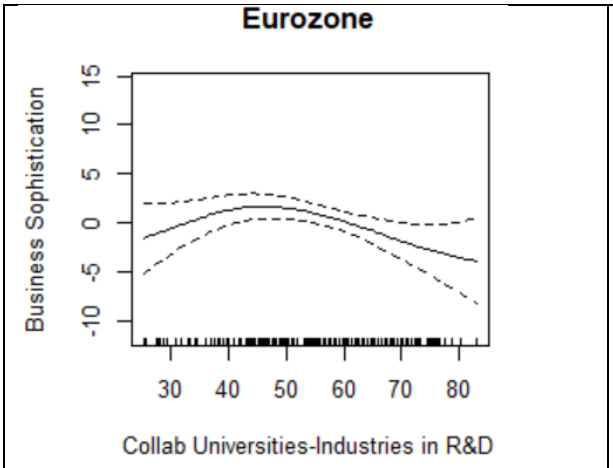


Fig. 19 Non-linear relationship between innovation in university-industry collaboration in R&D and innovation in business sophistication

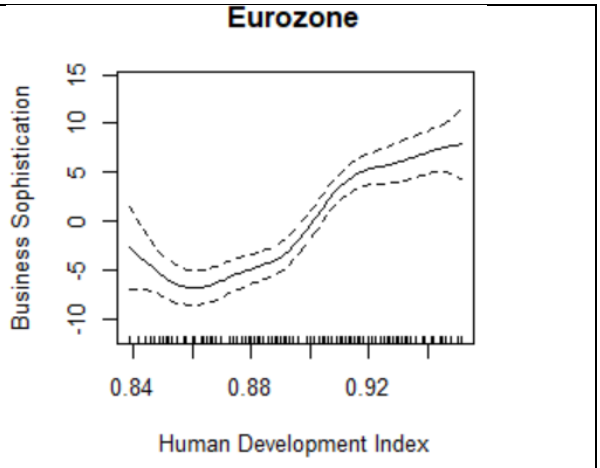


Fig. 20 Non-linear relationship between human development and innovation in business sophistication

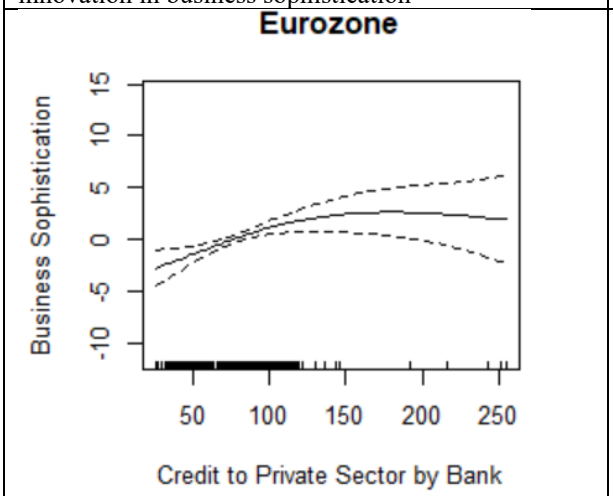


Fig. 21 Non-linear relationship between credit to the private sector by banks and innovation in business sophistication

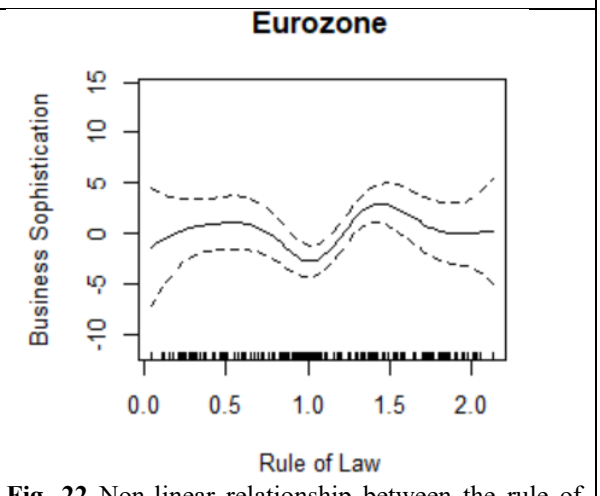


Fig. 22 Non-linear relationship between the rule of law and innovation in business sophistication

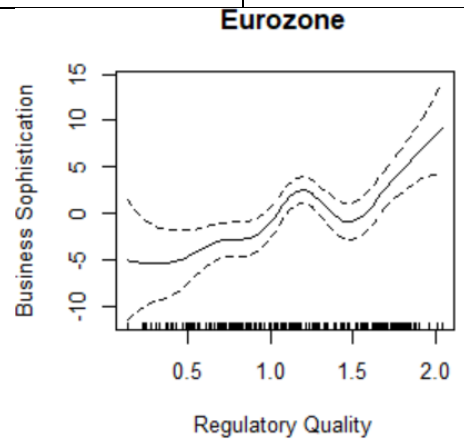


Fig. 23 Non-linear relationship between quality of regulatory and innovation in business sophistication

Source: authors

Appendix 3: Trend in explanatory variables linearly associated with innovation in business sophistication in the Eurozone

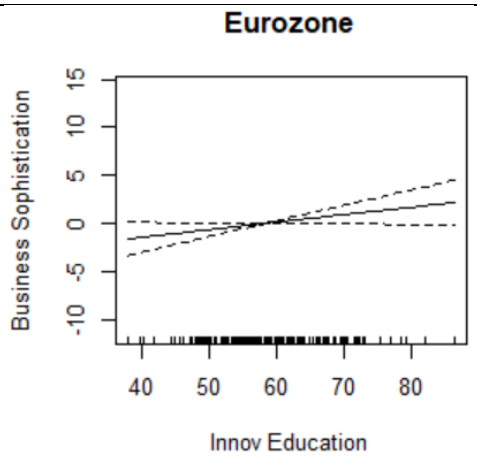


Fig. 24 Linear relationship between innovation in education and innovation in business sophistication

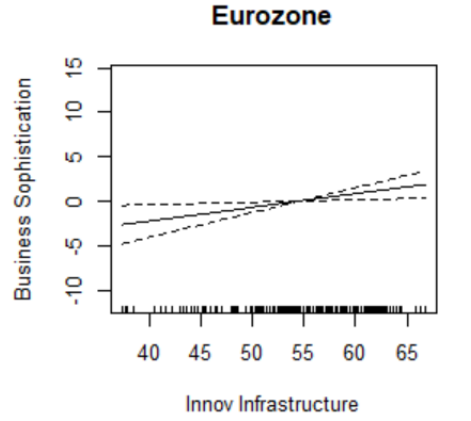


Fig. 25 Linear relationship between innovation in infrastructure and innovation in business sophistication

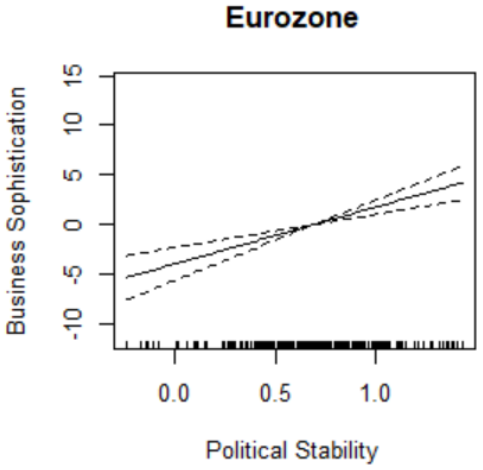


Fig. 26 Linear relationship between political stability and non-violence and innovation in business sophistication

Source: authors

Appendix 4 Semi-parametric model results using data from Eurozone countries

term	estimate	std.error	statistic	p.value	edf	ref.df
(Intercept)	27.693	4.758	5.820	0.0000		
Innovation in education	0.078	0.041	1.891	0.0604		
Innovation dans les infrastructures	0.153	0.063	2.441	0.016		
Political stability	5.733	1.189	4.824	0.0000		
s(Innovation in Ind. and Unv Collaboration in R&D)			2.580	0.051	2.771	3.506
s(Human Development Index)			13.812	0.0000	5.983	7.183
s(Credit to private sector by bank)			5.630	0.0024	2.051	2.520
s(Rule of law)			3.925	0.0005	6.533	7.625
s(Regulatory quality)			5.618	0.0000	7.285	8.274

Note: edf: effective degrees of freedom; Ref.df: reference degrees of freedom; s(.) is the unspecified smooth function that is estimated using a *scatterplot smoother.*
Source: authors

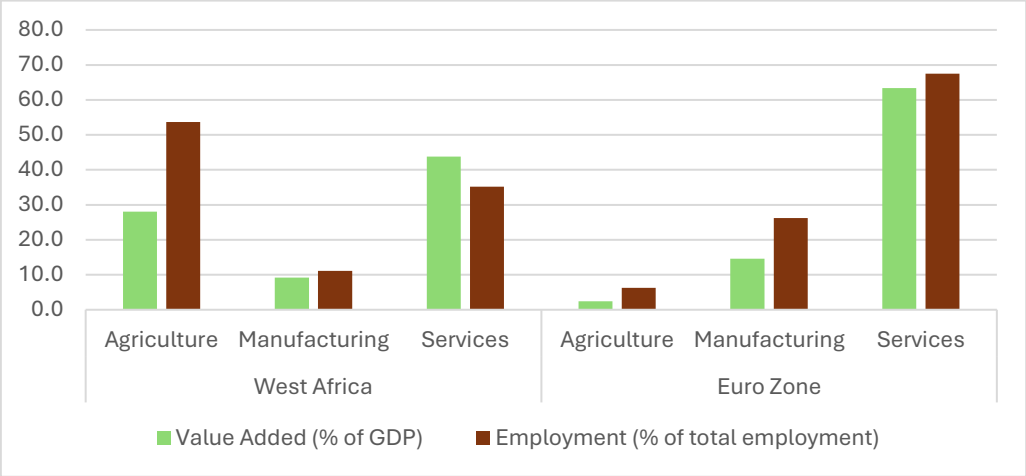


Fig. 27 Structural transformation pathways of the West African economies and the Eurozone over the last three decades
Source: authors

Appendix 6 List of countries covered

West African countries		**Eurozone countries**	
1. Benin	11. Niger	1. Austria	11. Italy
2. Burkina Faso	12. Nigeria	2. Belgium	12. Latvia
3. Cabo Verde	13. Senegal	3. Croatia	13. Lithuania
4. Cote d'Ivoire	14. Sierra Leone	4. Cyprus	14. Luxembourg
5. The Gambia	15. Togo	5. Estonia	15. Malta
6. Ghana		6. Finland	16. Netherlands
7. Guinea		7. France	17. Portugal
8. Guinea-Bissau		8. Germany	18. Slovak Republic
9. Liberia		9. Greece	19. Slovenia
10. Mali		10. Ireland	20. Spain

Source: authors