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Does Intelligence Affect Economic Diversification?

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Abstract

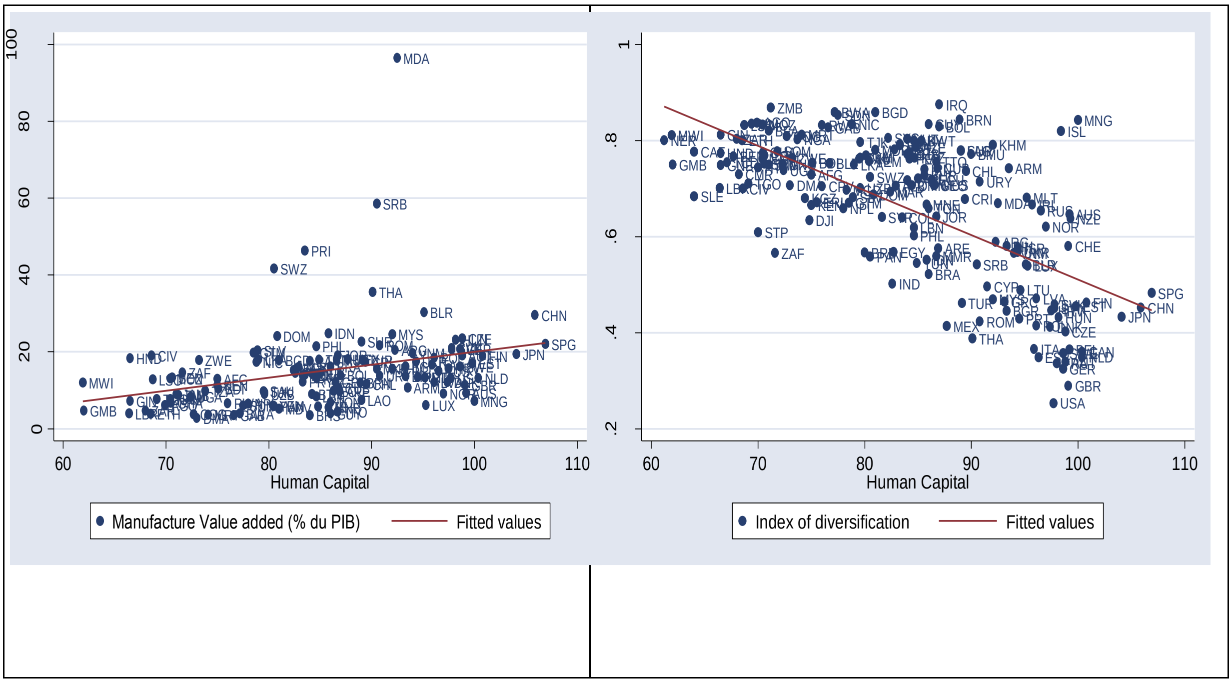
This paper extends the growing literature on knowledge economy by investigating the effect of intelligence on economic diversification. Using a battery of estimation techniques that are robust to endogeneity, we find that human capital has positive correlations with export diversification, manufactured added value and export manufactures. This empirical evidence is based on a world sample for the year 2010. The findings have significant implications for the fight against the Dutch disease. In essence, investing in human capital could bring economic diversity and therefore dampen negative external shocks related to resource-dependence. Other knowledge-economy implications are discussed.

Keywords: Intelligence; Economic Diversification
JEL Codes: O1; O4; O55; I32; I2

1. Introduction

Can economic diversification affect human capital? Most empirical studies have engaged human capital as a control variable in regressions without going further (Hausman et al., 2007; Weldemicael, 2012). Hence, human capital is relegated to the second rank. In one of the cited studies, Hausmann et al. (2007) acknowledge, inter alia, that the link between diversification and human capital is bidirectional. Figure 1 below illustrates this acknowledgement as it is difficult to discern the potential endogeneity.

Figure 1. Human Capital and Economic diversification



As far as we are concerned, the consideration of human capital in a plethora of regressions implies that this underlying variable is useful in economic diversification. In the present exposition, we consider this indicator as an independent variable of interest. Moreover, we are convinced human capital is very useful when considered in an economic structure. Hence, economic sectors should be attracted by more qualified human capital. This could be the basis for labour reallocations from the agricultural to more productive sectors. Externalities resulting from human capital accumulation could result from low economic diversification. Accordingly, an economy that is highly focused on a certain brand reduces interaction among persons and hence increases competition, which could eventually discourage cooperation. Conversely, increasing human capital remains essential for economic sophistication.

As far as we have reviewed, Parketa & Tamberi (2008) and Gullstrand (2008) are some of the few theoretical studies linking human capital to economic diversification. The first-two authors articulate that more human capital facilitates production diversification and hence, increase the rate of new activities in an economy, notably due to product innovation. Gullstrand thinks it enables the differentiations within the framework of intra-industrial commercial models.

Another contribution of the present study is to seriously investigate the issue of endogeneity by taking into account instrumental variables. This provides a more informed opinion on the relationship between the two underlying variables. This knowledge is quite relevant in complementing the literature given the substantial bulk of studies on the importance of diversification in economic development (Piñeres & Ferrantino, 1997 ; Feenstra et al., 1999; Al-Marhubi, 2000; Funke & Ruhwedel, 2005; Herzer & Nowak-Lehnmann, 200; Hausmann et al., 2007; Hess, 2008; Jarreau & Poncet, 2012).

The third contribution of the current exposition to the literature is the measurement of human capital. Economists have traditionally appreciated human capital using quantitative measures and qualitative educational indicators, with the former more exploited (Lutz, 2009). The traditional indicators are predominantly used in growth regressions, inter alia: average years of schooling, life expectancy at school, gross schooling rate in the primary, secondary and tertiary schools (see Barro, 1991; Benhabib & Spiegel, 1994; Barro & Lee, 1993, 2001; Caselli et al., 1996; Mankiw et al., 1992 ; Levine & Renelt, 1992; Sala-i-Martin et al., 2004). The effects of these indicators have not yielded a consensus because of data measurement issues (Cohen & Soto, 2007; De la Fuente & Doménech, 2006). Notably, Weede & Kämpf (2002) have criticised the neglect of output in these human capital indicators, which essentially relies on inputs. This has led to some authors using international academic evaluation tests, notably: Trends in International Mathematics and Science Study (TIMSS) and the Program of International Student Assessment (PISA) (Hanushek & Kimko, 2000; Hanushek &Woessmann, 2008, 2009).

Another strand of authors including the psychologist and Vanhanen (2001,2002, 2006) has compiled data on intellectual quotient (IQ) from many countries. This data has led to many published studies (Lynn & Vanhanen, 2012b). This data is also increasingly being employed by economists (Weede & Kämpf, 2002; Jones & Schneider, 2006; Ram, 2007; Potrafke, 2012; Kodila-Tedika & Kanyama-Kalonda, 2014; Kodila-Tedika, 2014; Rindermann et al., 2014; Kodila-Tedika & Mustacu, 2014; Kodila-Tedika & Bolito-Losembe, 2014). The stream of data from Hanushek and, Lynn & Vanhenen is increasingly being improved and has recently been improved (Rindermann, 2007a, b; Meisenberg & Lynn, 2011). Meisenberg & Lynn, (2012) and Kanyama-Kalonda (2014) have recently employed this new stream of data. In the present study, we also borrow from this new stream.

From cross-sectional data on a number of countries, we establish a weak correlation between economic diversification and human capital. This correlation is generally robust to outliers, a plethora of estimation techniques as well as the inclusion of control variables. We have also considered the hypothesis of causality flowing from human capital to economic diversification. Our estimations suggest a positive effect of this capital on diversification. Hence, more human capital engenders greater economic diversification. This conclusion contributes to the literature on economic diversification in the areas already discussed above.

The rest of the paper is structured as follows. Section 2 discusses the methodology while Section 3 focuses on the data. The main results are presented in Section 4 whereas Section 5 concludes.

2. An Empirical Model Linking Economic Diversification to Human Capital

The main hypothesis of this investigation sustains that Human Capital (HC) has a significant and positive impact on Economic Diversification (EC). As a primary first-step, we estimate the following basic empirical model:

$$ED_i = \beta_0 + \beta_1 HC_i + \delta Z_i + \varepsilon_i, \qquad (1)$$

where ED is economic diversification, HC denotes the human capital, i=1,2... captures the country index, Z = (z_1,… z_k) is the vector of control variables, and ε_i represents the error term that is assumed to be normally and independently distributed. β_0 is the intercept, β_1 captures the effect of human capital and δ=(δ_1, δ_2,.. δ_n) is the parameter denoting the vector for control variables. The control variables used are consistent with those employed by Hausmann et al. (2007). The model is estimated using Ordinary Least Squares (OLS) that are robust to standard errors. As emphasized by Hausmann et al. (2007), if $E(\varepsilon|HC) = E(\varepsilon) \neq 0$ is the cause of the endogeneity and hence, reverse causality, *ED* should be regressed with only the exogenous component of *HC* in order to correct the bias in endogeneity.

The endogeneity issue is corrected by employing a Two-stage-least squares (2SLS) estimation technique. In the first-stage, we regress the endogenous component of HC in an OLS equation as follows:

$$HC_i = \varphi_0 + \varphi_1 \aleph_i + \delta Z_i + \varepsilon_i, \qquad (2)$$

This enables us to extract the exogenous component of HC predicted by, $\aleph_i$:

$$\widehat{HC}_i = \widehat{\varphi_0} + \widehat{\varphi_1} \aleph_i + \delta Z_i + \varepsilon_i, \qquad (3)$$

In the second-stage of the regression, we insert the fitted values from Eq. (3) into Eq. (1). Hence, we replace HC with $\widehat{HC}$ in Eq. (1), to obtain the following OLS equation:

$$ED_i = \omega_0 + \omega_1 \widehat{HC}_i + \delta Z_i + \epsilon_i, \quad (4)$$

The concern arising from Eq. (4) is to investigate if the fitted values are good instruments for human capital. This issue is handled by an overidentification restrictions test in the empirical section of the paper. Moreover, to ensure robustness we shall employ at least two instruments to mitigate the endogeneity concern.

3. Data

We examine a world sample of ……countries for the year 2010.The concept of diversification is employed to emphasise the development of the productive industry which improves the economic structure towards modern economic activities. It is also the source of positive externalities for other sectors. Hence, this concept underlines export diversification. Accordingly, we measure economic diversification with the annual comparative diversification index of export and import of commodities (CNUCED, UNCTADstat). Low values of this variable denote high levels of diversification in a given country. We therefore expect the human capital variable to have a negative effect on this dependent variable. This is contrary to what we expect of two other variables. Our second variable is the added value of the manufacturing sector to GDP from World Development Indicators (WDI) of the World Bank (WB). The third indicator that we employ to measure economic diversification is a binary variable, taking the values of 1 if the country is a major exporter. Major export category: substantial exports are those that account for 50 percent or more of total exports of goods and services from one category, in the period 1988-92. The categories are: nonfuel primary (SITC 0,1,2,4, plus 68), fuels (SITC 3), manufactures (SITC 5 to 9, less 68), and services (factor and nonfactor service receipts plus workers' remittances). If no single category accounts for 50 percent or more of total exports, the economy is classified as diversified. This measurement is consistent with Easterly & Sewadej (2001).

The data on intelligence is from Meisenberg & Lynn (2011) -previous versions with this dataset can be found in Lynn & Vanhanen (2002, 2006). This dataset is a compilation of hundreds of average national IQ tests observed over the 20th and 21st centuries using best practice methods. Average IQ is a measure of general-purpose human capital as well as a measure of the nation's labor quality (Hanushek & Kimko, 2000; Jones & Schneider, 2006).

With regard to institutional quality, we consider IQ as a measure of the ability of a nation's human capital to cooperate in order to produce a nationally efficient outcome in terms of pro-market policies. The advantage of the recent dataset is that it includes more countries as well as a composite measure of intelligence in the form of human capital.

Three measures of intelligence are considered: the IQ measure from Lynn & Vanhanen, a measure where the missing values are filled with school achievement, and a measure of human capital which is a composite measure that accounts for IQ and school achievement. However, since the first measure is a subset of the second, we shall only use the second and the third measures in our analysis.

The measures of institutional quality are obtained from the dataset compiled by Daniel Kaufmann, and Art Kraay and Massimo Mastruzzi at the World Bank (www.govindicators.org). This dataset aggregates indicators of six broad dimensions of governance: voice &accountability, political stability & absence of violence/terrorism, government effectiveness, regulatory quality, rule of law and control of corruption. The six aggregate indicators are based on 30 underlying data sources reporting the perceptions of governance from a large number of survey respondents and expert assessments worldwide. We use only rule of law.

The data on GDP per capita and openness are obtained from Pen World Tables, the 7.1 version. The relevance of the GDP per capita (Imbs & Wacziarg, 2003; De Benedictis et al., 2009; Parteka, 2007; Cadot et al., 2007) and openness indicators have been substantially documented in the literature (Krugman & Venables 1990; Costas et al. 2008).

The data on population and area is from the WDI of World Bank. The works of Hummels & Klenow (2005) and Parteka & Tamberi (2008) have clearly articulated the important role of economic size in economic diversification. Population size here is considered as a measure of this market size. Given that geographic elements (Radelet & Sachs, 1998; Limão & Venables, 2001) can also influence the dependent variable; we have considered the effect of *Area* in the analysis.

Table 1 below which presents the summary statistics of the variables used in the study has a twofold interest. On the one hand, it reveals that the variables are quite comparable. On the other hand, the variations are quite substantial. Hence, we can be confident that some reasonably significant nexuses should emerge from the estimations.

Table 1: Summary Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Index of diversification	182	.66	.15	.25	.88
Manufacture – value added (%GDP)	139	14.64	11.17	2.12	96.58
Exports of manufactures	139	.17	.38	0	1
Human capital	175	84.21	10.85	61.2	106.9
Open	140	95.42	57.16	26.65	446.06
GDP per capita (log)	140	8.873	1.19	5.90	11.17
Rule of law	139	.013	.99	-1.75	1.95
Population	123	16.53	63.11	-13.54	612.36
Area	123	381.13	1020.2	.122	8600.39

Obs : Observations. Std. Dev: Standard Deviation. Min: Minimum. Max: Maximum.

4. Empirical results

4.1 Main results

The main result are based on OLS and Probit estimators that are robust to White's (1980) heteroskedasticity correction, are presented in Table 2 below. The following conclusions are established. First, when the dependent variable is the index of diversification, while *Area* and *Openness* decrease economic diversification, the other variables have the opposite effect, notably: *human capital*, *GDP per capita*, *rule of law* and *population*. Second, when economic diversification is either measured by *Manufacture value* or *Exporters of manufactures added value*, human capital increases economic diversification, consistent with the predictions of economic theory. With the exception of the rule of law which consistently increases economic diversification across all specifications (with the alternative dependent variables), the other control variables for second and third dependent variables consistently display opposite signs. This opposition in signs is expected because one of the dependent variables (or diversification index) is appreciated in decreasing order, such that higher values denote low diversification and vice-versa.

Table 2. Main regressions

	Index of diversification	**Index of diversification**	**Manufacture – value added**	**Manufacture – value added**	**Exporters of manufactures**	**Exporters of manufactures**
Human capital	-.0092695 (0.000)	-.0063527 (0.007)	.3377822 (0.000)	.3047204 (0.018)	.095458 (0.000)	.2330314 (0.000)
Open		.0003624 (0.186)		-.0094717 (0.626)		-.0002127 (0.941)
GDP per capita (log)		-.0197179 (0.355)		.7594738 (0.569)		.5368238 (0.281)
Rule of law		-.0287762 (0.137)		-2.205784 (0.031)		-.9128011 (0.037)
Population		-.0003563 (0.091)		.0219769 (0.000)		.0001544 (0.971)
Area		7.83e-06		-.0012411		-.000017

		(0.505)		(0.002)		(0.910)
Adj R²	0.4356	0.4948	0.0972	0.1951		
Pseudo R2					0.3015	0.4833
Obs	170	112	125	83	173	115
Method	OLS	OLS	OLS	OLS	Probit	Probit

Notes: For OLS regressions, the heteroscedasticity correction is consistent with White. Constants are included in all regressions. P-values in brackets.

4..2 Robustness checks

4.2.1 Additional variables and fixed effects

In this section, three more control variables are added to verify the solidity of estimations in Table 2. In Table 3, additional continental clusters and more control variables are used. The additional control variables include: a dummy variable for the Organisation for Economic Co-operation and Development (OECD) membership, corruption from WDI and shadow economy from Schneider et al. (2010). The effects of human capital on the dependent variables are significant for the most part across specifications and broadly consistent with those of Table 3.

Table 3. Additional variable and clusters

	Index of diversification	**Manufacture – value added**	**Exporters of manufactures**	**Index of diversification**	**Manufacture – value added**	**Exporters of manufactures**
Human capital	-.0040273	.3038859	.3128218	-.0036186	.2555926	.3124921
	(0.069)	(0.019)	(0.002)	(0.241)	(0.044)	(0.000)
ControlVariables	Yes	Yes	Yes	Yes	Yes	Yes
Additional variables	Yes	Yes	Yes	Yes	Yes	Yes
Cluster of continent	No	No	No	Yes	Yes	Yes
Adj R²	0.5806	0.2228		0.6187	0.3409	
Pseudo R2			0.5077			0.5010
Observations	109	81	112		79	108
Method	OLS	OLS	Probit	OLS	OLS	Probit

Notes: For OLS regressions, the heteroscedasticity correction is consistent with White. Constants are included in all regressions. P-values in brackets

In Table 4 below, we use regional dummy variables for Sub-Saharan Africa (SSA), the Middle East & North Africa (MENA), Latin America & the Caribbean, East Asia & the Pacific, East Europe and Central Asia. The signs of the independent variables of interest are consistent with those in Tables 2-3.

Table 4. Using regional dummies

	Index of diversification	Manufacture – value added	Exporters of manufactures
Human capital	-.0050032	.065878	.2854369
	(0.040)	(0.618)	(0.004)
Variables controls	Yes	Yes	Yes
Dummy régional	Yes	Yes	Yes
Adj R²	0.50	0.2762	
Pseudo R2			0.3778
Observations	111	82	52
Method	OLS	OLS	Probit

Note: For OLS regressions, the heteroscedasticity correction is consistent with White. Constants are included in all regressions. P-values in brackets

4.2.2 Outlier variables

In order to further improve the estimations, our empirical approach follows the M-estimators of Huber (1973) by using iteratively reweighted least squares (IRWLS) and MM-estimator proposed by Yohai (1987). As Midi & Talib (2008) have noted, compared to the OLS approach, the advantage of these robust estimators is that they fix simultaneously any issue arising from the existence of outliers and/or heteroskedasticity (non-constant error variances). As far as we know, these regression techniques are not currently available for logistic specifications. Hence, our third dependent variable is not used. We find that the signs and significance of the variables across specifications are consistent with those of the preceding tables.

Table 5. Controlling for Outliers

	Index of diversification	Index of diversification	Index of diversification	Manufacture – value added	Manufacture – value added	Manufacture – value added
Human capital	-.0069176	-.006696	-.0059551	.2900485	.2893021	.2912232
	(0.001)	(0.011)	(0.029)	(0.008)	(0.048)	(0.115)
Open	.0003185	.0003909	.0002443	-.0159217	-.0144367	-.0200911
	(0.270)	(0.175)	(0.367)	(0.304)	(0.462)	(0.476)
GDP per capita (log)	-.01744	-.0165569	-.0206065	.8489403	.8914394	.8822282
	(0.391)	(0.482)	(0.393)	(0.456)	(0.569)	(0.652)
Rule of law	-.028652	-.0328507	-.0276166	-2.163248	-2.20712	-2.189618
	(0.173)	(0.115)	(0.172)	(0.061)	(0.030)	(0.059)
Population	-.0010804	-.0003322	-.0049103	.0210193	.0217959	.0203297
	(0.009)	(0.098)	(0.000)	(0.051)	(0.000)	(0.004)
Area	.000018	8.52e-06	.0000847	-.0012104	-.0012466	-.001209
	(0.198)	(0.503)	(0.000)	(0.091)	(0.002)	(0.004)
Obs	112	112	112	83	83	83
Method	IRWLS	M-estimators	MM-estimator	IRWLS	M-estimators	MM-estimator

Notes: Constants are included in all regressions. P-values in brackets

4.2.3. Endogeneity test

In order to control for endogeneity, we employ instruments of protein and fats per capita daily macronutrients for 2005‑2007 (FAO[1] Statistics Division, 2010), human capital accumulation in the early twentieth century and Historic IQ (Lynn, 2012). Data on students enrolled in primary and secondary schools in the early twentieth century is from Mitchell (2003a, b, c). The first-two instruments are exploited in the first column whereas the first and third are exploited in the other two columns. The sign of the main independent variables remains unchanged while most of the significant control variables have the expected signs.

Table 6. Controlling for endogeneity

	Index of diversification	**Manufacture – value added**	**Exporters of manufactures**
Human capital	-.0259793	.350933	.2126032
	(0.001)	(0.038)	(0.001)
Open	.0002751	.0034992	.0004657
	(0.621)	(0.881)	(0.928)
GDP per capita (log)	.1051149	.769525	.2833632
	(0.076)	(0.660)	(0.622)
Rule of law	.0111592	-2.414453	-.7620715
	(0.718)	(0.015)	(0.087)
Population	.0003614	.0207795	-.0012882
	(0.334)	(0.004)	(0.575)
Area	.0000194	-.0012606	.000026
	(0.467)	(0.002)	(0.872)
Adj R^2	0.1644	0.2122	
Observations	91	72	95
Method	2SLS	2SLS	Probit IV
Test de Sargan	0.4738	0.3924	
Test de Hausmann	0.4926	0.4177	
Wald chi2			31.94
Wald test			0.1336

Notes: Constants are included in all regressions. P-values in brackets. 2SLS: Two-Stage-Least Squares. IV: Instrumental Variable.

The main policy implication is centred on the positive effect of human capital on: export diversification, manufactured added value and export manufactures. Hence, this has a potential to mitigate the Dutch disease in resource-dependent countries. In essence, investing in human capital (especially in least developed countries) would bring economic diversity and therefore dampen negative external shocks related to resource-dependence. As recently shown by Tchamyou (2014) and Asongu (2014ab), South Korea's economic miracle substantially depended on the enhancing of human capital. Two important points emerge here: the need to

[1] Food and Agricultural Organisation.

boost college enrolment and research & development (R&D) on the one hand; and the imperative for workers to adapt to challenging and changing conditions of technology.

First, countries need to adopt very bold moves towards increasing school enrolment rates and allocating more budgets to R&D. Such measures should be implemented hand-in-glove with improvements in other areas like policy and institutional environments. These include, inter alia: capacity building and independence of government agencies. It is expected that education should enhance a country's possibilities of acquiring knowledge, novel know-how and technological abilities. This combination of policies would produce and strengthened blocks is learning activities, human resource development and economic diversification (Suh & Chen, 2007; Lee, 2009; Tchamyou, 2014; Asongu, 2014a).

Second, the policy of education needs to be one of lifelong-learning and should be fully implemented in the workplace to enhance adaptation to changing and evolving technology. Moreover, technical apprenticeship and vocational trainings would substantially boost the possibilities for economic diversification. Continuous trainings at work places should also be encouraged. Nurturing of high calibre engineers and scientists capable of analysing the needs for economic diversification and adapting know-how to existing challenges is crucial for competitive advantage in the global economic environment. This is also true because, as nations grow, technological competence becomes critical to sustaining growth and development. In order to continuously exploit economic diversification opportunities on the boundaries of science and technologies, knowledge-economy based policies should be fundamental to economic policy. As shown by Such & Chen (2007), when educational and industrialisation policies converge within a single strategic umbrella, the effects in enhancing and sustaining development are substantial. Accordingly, education would produce technology-base learning and industrialisation that have positive effects on economic diversification. On the other hand, accelerating industrialisation and economic diversification would promote the demand for more skills. This policy is consistent with the findings of Tchamyou (2014) who has recently established the positive effect of knowledge economy on doing business.

In summary, a knowledge-oriented industrial policy is substantially different from the traditional industrial policy on many fronts (factor inputs; output versus (vs) systematic interactions; firms & industries vs Networks & systematic linkages….etc). Policy options in knowledge-economy diversification strategies on which this study could be extended have been documented by Dobrinsky (2008).

Conclusion

This paper has extended the growing literature on knowledge economy by investigating the effect of intelligence on economic diversification. Using a battery of estimation techniques that are robust to endogeneity, we have found that human capital has positive effects on export diversification, manufactured added value and export manufactures. This empirical evidence is based on a world sample for the period 2010. The findings have significant implications for the fight against the Dutch disease. In essence, investing in human capital could bring economic diversity and therefore dampen negative external shocks related to resource-dependence. Other knowledge-economy implications have been discussed, notably: the need to boost college enrolment and research & development on the one hand; and the imperative for workers to adapt to challenging and changing conditions of technology within a lifelong learning policy framework.

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