Economic Complexity and Green Technology Absorption

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Abstract: The contribution of this paper is twofold: (i) it tests whether the existence of a green technology gap leads to a reduction in GHG emissions (intensity and per capita), following the technology catch-up approach; and (ii) it tests whether an increase in economic complexity leads to a reduction in GHG emissions (intensity and per capita) not only directly but also via an increase in the green technology absorption. The panel data tests reported in the paper suggest that only the second hypothesis is valid. The results indicate that increases in economic complexity predict reductions in emissions (intensity and per capita), while reductions in the green technology gap predict decreases in the emissions (intensity and per capita). Most importantly, the results indica that increases in economic complexity lead to reductions in emission intensntiy and in emissions per capita through green technology absorption.

1. Introduction

In the last couple of years, a number of papers have found evidence of the importance of increasing the economic complexity of nations to reduce the ecological footprint of production. Boleti et al. (2021) and Romero and Gramkow (2021), for instance, provide evidence that economic complexity contributes to improve indicators of environmental performance and to reduce CO_2e emissions. Furthermore, Mealy and Teytelboym (2022) provide evidence that economic complexity is associated with a higher number of green patents.

Considering the recent literature on economic complexity and green growth, the objective of this paper seeks to investigate the impact of economic complexity on the absorption of green technology. According to Romero and Gramkow (2021), the explanation for the negative relationship between economic complexity and greenhouse gas (GHG) emission intensity is twofold: (i) the higher value added of high complexity activities; and (ii) the impact of higher economic complexity on the

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absorption, creation and introduction of greener technologies throughout the different sectors of the economy, since the Economic Complexity Index (ECI) measures the amount of productive knowledge in each economy. Although the first argument is indisputable, the second one still lacks empirical evidence.

The absorption of green technologies is closely linked to the concept of green or ecoinnovation, which is defined as the implementation of a new or significantly improved product (good or service), or process, or a new organisational method in business practice which benefits the environment and contributes to environmental sustainability (Kemp & Pearson, 2007; OECD, 1997; Oltra, 2008). Green innovation (GI) can be either motivated by environmental improvement aims (i.e. this is its intention) or it can be more environmentally friendly than current practice regardless of its intention (ibid.). We sustain that, theoretically, increasing the stock of productive and technological knowledge that is embedded and circulates in an economy is a necessary condition for the development of GI and the absorption of green technologies.

According to Sauter and Watson (2008), absorptive capacity (i.e. the ability to adopt new technologies) is a relatively vague concept that encompasses firm-level absortive capacity and national-level absorptive capacity. Overall, absorptive capacity includes technological capabilities, knowledge and skills as well as supportive institutions (ibid.). The literature (see Oltra, 2008 and Allan et al, 2021 for instance) sustains that the policy determinants of ecoinnovation and absorption of green technologies are not different from the policy determinants of other innovations and technologies. Hence, “classic” innovation and industrial policy mechanisms such as investment, incentives, support and regulation are crucial to drive green technologies absorption. However, the distinctive aspect of green innovation policy is the intent or the goal of the policies rather than the instrument used (Allan et al., 2021).

In this paper emission intensity gap in each country is used as a proxy for the green technology gap, using the technological catch-up literature as reference to investigate the effect of economic complexity on green technology absorption (e.g. Nelson and Phelps, 1966; Abramovitz, 1986; Verspagen, 1991). The existence of an emission intensity gap indicates that there is an opportunity to incorporate foreign technology (or to catch-up by developing one’s own technology by building innovative, technological and productive capabilities) in order to reduce the domestic GHG emission intensity and GHG emissions per capita.

The contribution of this paper, therefore, is twofold: (i) it tests whether the existence of a green technology gap leads to a reduction in GHG emissions (intensity and per capita), following the technology catch-up approach; and (ii) it tests whether increases in economic complexity lead to a reduction in GHG emissions (intensity and per capita) not only directly but also via an increase in the green technology absorption.

The remainder of the paper is divided in four sections. Section 2 presents a literature on technological catch-up and green technology absorption. Section 3 presents the empirical investigation. Section 4 presents the concluding remarks of the paper.

2. Literature Review

2.1. *Technological catch-up*

This paper's investigation takes the large literature on technological absorption as a starting point. Based on the Schumpeterian approach to innovation and growth, the technological catch-up hypothesis was formalised by Nelson and Phelps (1966), who used a technical progress function that considers the impact of the technology gap on productivity growth. The simple relationship between technological absorption and output and productivity growth has been tested in a number of works, which find strong evidence in favour of the hypothesis (see Romero, 2020).

The technological catch-up hypothesis is part of the Schumpeterian tradition of economic development, which emphasises the importance of research intensity for innovation and productivity growth. The simple version of the technological catch-up hypothesis assumes that the existence of a technology gap provides an opportunity for productivity growth through technology absorption for economies not in the technological frontier.

The technological catch-up hypothesis was formalised by Nelson and Phelps (1966) using a technical progress function that considers technology absorption the only source of productivity growth for backward economies:

$$g_A \stackrel{\text{def}}{=} \frac{\dot{A}}{A} = \Phi\left[\frac{T-A}{A}\right] \tag{1}$$

where T is the level of best practice technology, Φ is the function that represents absorptive capacity of the following country and A is its' technology level. Dots above letters denote variation of the variable.

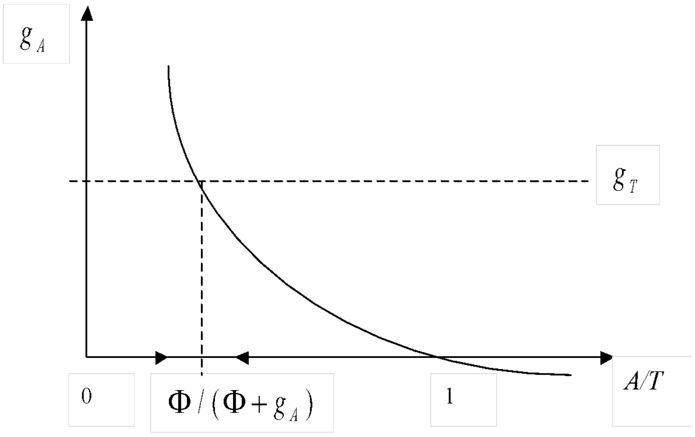
Since the model does not take into account the possibility of technology creation in the follower country, the growth rate of best practice technology in the leading economy (g_T) is assumed exogenous (i.e. $T_t = T_0 e^{gt}$). In the long term, the growth rates of technology in the follower and in the leading economies must be equal (i.e. $g_T = g_A$). Hence, from equation (1), the equilibrium rate of technology growth in the follower country is:

$$\frac{A}{T} = \Phi/(\Phi - \mathrm{g}_A) \tag{2}$$

The equilibrium growth rate from equation (2) is illustrated in Figure 1. Following the technological catch-up hypothesis, countries with a distance to the frontier (*A/T*) lower than the equilibrium level will present higher growth rates than the leading economy. The opposite result holds true for countries with a distance to the frontier above the equilibrium rate. In equilibrium, nonetheless, the level of technology in the following economy (*A*) is always below the level of technology in the leading economy (*T*). This happens because technological growth in the follower economy only takes place through technological absorption in this model, i.e. when there is a gap. The equilibrium rate, however, is determined directly by the magnitudes of the absorptive capacity (Φ) and of the growth rate of technology in the frontier country (g_T).

The model generates three important implications. Fist, if $A=T$, then there is no technology gap and equation (1) becomes zero, indicating that there is no catch-up process. Second, when absorptive capacity (Φ) tends to infinity, as in the hypothesis of perfect knowledge transmission, then the levels of technology will be the same in both countries (as shown in equation (2)) and there will be no technology gap. In this case the model represents the basic neoclassical assumption of technology is a public good, as in the model of Solow (1956) and Swan (1956). Third, and most importantly, the smaller the absorptive capacity is, the larger will be the gap at equilibrium. This means that when absorptive capacity is very low, differences in technology levels must be extremely large to generate equal growth rates of technology in frontier and follower economies. Fourth, if *A* tends to zero, the gap tends to infinity and the follower economy's growth rate will be higher than that of the frontier country, provided that $\Phi>0$.[2]

Figure 1: Simple technological catch-up model



Source: Author's elaboration based on Rogers (2003, p. 49).

The relationship between technological absorption and productivity growth has been tested in several papers. In cross-country tests, productivity in the beginning of the period is used as a proxy for the technology gap or for distance to the technological frontier (e.g. Fagerberg, 1987). In cross-country panels, the technology gap is measured as the ratio of productivity in the country to the productivity of the country with highest productivity, i.e. the one in the technological frontier (e.g. Amable, 1993; Fagerberg & Verspagen, 2002; Griffith et al., 2004). The vast majority of these studies find a negative relationship between productivity growth and the magnitude of the gap, which suggests a connection between growth and technological transfer. In this case, the higher the productivity, the lower the gap, and the lower the rate of growth of productivity.

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[2] The model's production function framework was criticized by Nelson and Winter (1982) and others (e.g. Nelson & Pack, 1999). Yet, since the core ideas of the model are associated with equation (1) and not with the model's initial production function, the macroeconomic ideas represented in the model are compatible with the macro analyses of the evolutionary Schumpeterian tradition.

Moreover, it is interesting to note that the technological catch-up hypothesis is compatible with the empirical evidence of the literature on conditional convergence (e.g. Barro, 1991). In neoclassical growth models, conditional convergence occurs due to transitional dynamics, while technology is assumed to be a public good and therefore the same across countries. Yet, since the assumption of technology homogeneity cannot be tested, the tests of conditional convergence based on neoclassical growth models are in fact compatible with the Schumpeterian hypothesis of convergence due to technological catch-up.

A straightforward form of testing the role of different factors for technological catch-up is to use interaction terms between additional variables and the technology gap. Formally, this means making the technological catch-up parameter dependent on the variable of interest:

$$\Phi = \Omega S \tag{3}$$

where S is the determinant of learning capacity and Ω is a parameter. Thus, substituting equation (3) into (1) yields:

$$g_A = \Omega S G \tag{4}$$

where $G=(T-A)/A$.

Using this strategy, several papers have investigated the factors that might increase technological absorption. Griffith et al. (2004) found that countries with higher research intensity (R&D to GDP ratio) are more capable of exploiting the technology gap, as initially suggested by Cohen and Levinthal (1990). The tests reported by Acemoglu et al. (2006) indicate that high regulation increases technological absorption when countries are far from the frontier. Nonetheless, it slows down technological progress as countries approach the frontier. Vanderbusch et al. (2006), testing Nelson and Phelps' (1966) original insight, found evidence that human capital contributes to technological absorption in countries that are close to the technological frontier.[3] Finally, some works have also found evidence of international R&D spillovers (e.g. Griffith et al., 2006).

In spite of the relatively wide explanatory capacity of the simple technological catch-up model, as a number of authors have stressed, in a more elaborated framework, technological catch-up depends on the institutional factors that create the required capacity for absorbing foreign technology (e.g. Gerschenkron, 1962; Abramovitz 1986; Cohen & Levinthal, 1990; Verspagen, 1991; Lundval, 1992; Nelson, 1993; Griffith et al., 2004; Acemoglu et al,, 2006). Although these factors implicitly determine the value of the technological catch-up parameter (Φ), a number of studies have sought to explicitly formalise and test this hypothesis.

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[3] According to Nelson and Phelps (1966: 75), if Φ is associated with education, then it becomes a crucial factor determining the speed of productivity growth while expanded Solow models (e.g. Mankiw et al., 1992) become "a gross misspecification of the relation between education and the dynamics of production".

Empirical evidence suggests that extremely poor countries might not be able to catch-up (i.e. might not grow at faster rates than developed countries), in spite of the existence of a large technology gap. To formalise the possibility of falling behind, Verspagen (1991) proposed a non-linear function of technological catch-up:

$$\mathrm{g}_A = a\mathrm{G}\mathrm{e}^{-G/\vartheta} \tag{5}$$

where $0 < aG \leq 1$ represents the potential catch-up rate, which is proportional to the size of the technology gap (G) and to the absorptive capacity $\Phi = \mathrm{e}^{-G/\vartheta}$.

In this formulation, absorptive capacity is a function of the gap and the intrinsic learning capacity $\vartheta > 0$. The possibility of falling behind, therefore, is introduced in this model by including the gap in the absorptive capacity function. In other words, countries with high intrinsic learning capacity facing a relatively small technology gap (i.e. $G < \vartheta$) will catch-up, while countries with low learning capacity facing a large gap (i.e. $G > \vartheta$) will fall behind. Hence, equation (7) implies that technological transfer (or imitation) becomes zero when the technology gap is closed and when the gap is too wide (Verspagen, 1991, p. 363).[4]

The most important feature of this model is its capacity to explain both catching-up and falling behind. While the model stresses that the existence of a technology gap might benefit follower countries if they are capable of absorbing foreign technology, it also calls attention to the fact that if this gap is too large and learning capacity is too low, then the country might not be able to explore the gap to catch-up. Nelson and Phelps' (1966) model, therefore, can be interpreted as a particular case of Verspagen's model.

In Verspagen's (1991) empirical investigation, he adopted measures of education and infrastructure as proxies for learning effort. The results he found using this specification were consistent with the theory. However, Amable (1993) found that Verspagen's non-linear specification is not significant when a different sample is used. Thus, the evidence about the validity of this model is mixed.

More recently, many studies have been addressing the determinants of countries' absorptive capacity to understand why some countries have been able to catch-up and others are falling behind. Rodrik (2013) emphasises the importance of industrialization in this absorptive process. According to him, manufacturing presents an unconditional convergence in productivity levels, while service and aggregate productivity do not. Gala et al. (2018) test whether economic complexity is important to explain convergence and divergence among poor and rich countries. They found that countries with high economic complexity index, which indicates a diverse and sophisticated structure of production, tend to converge towards high-income, while countries with low complexity tends to falls behind. Other studies, such as Jia et al. (2020), Di Meglio and Gallego (2022) and Csáfordi et al. (2020) corroborate these findings on the structural determinants of absorptive capacities.

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[4] Verspagen's non-linear model can also be represented in a quadratic formulation: $\frac{\dot{A}}{A} = \Phi(G - cG^2)$ (Rogers, 2003, p. 50).

In sum, despite the considerable progress observed in the literature that investigates the determinants of technological absorption, there seems to be still some room for further research. More specifically, further work is still required to establish whether technological absorption follows a linear or non-linear path. Moreover, further research is also necessary to generate a consensus about the main determinants of technological absorption. In this regard, it would be important to carry out investigations that compare the impacts of different variables on absorptive capacity.

2.2. Green technology absorption

Following the models of technology absorption from the Schumpeterian tradition, in this paper we use a similar specification to test the hypothesis of green technology absorption. Instead of using productivity to capture the level of technology of each country, we use the level of greenhouse gas emission intensity of each country as a proxy for the level of green technology. Formally:

$$g_{EI} \stackrel{\text{def}}{=} \frac{\dot{EI}}{EI} = -\Phi\left[\frac{GA}{GT}\right] \tag{6}$$

where EI is emission intensity, GA denotes the green technology level of the follower economy, and GT denotes the green technology level of the frontier economy.

In the case of emission intensity, the lower it is, the higher the level of green technology. Hence, the technology gap (GAP=GA/GT) in this case, will be equal to one in the frontier economy, and higher than that in the follower economies. Hence, the higher the green technology gap, the higher the potential for green technology growth through green technology absorption, and the lower the growth rate of greenhouse gas emission intensity.

Moreover, since the objective of this paper is to test whether economic complexity increases green technology absorption, then we assume:

$$\Phi = \alpha + \Omega \mathrm{ECI} \tag{7}$$

Hence, substituting equation (7) into equation (6):

$$g_{EI} = -\alpha \mathrm{GAP} - \Omega \mathrm{GAP} * \mathrm{ECI} \tag{8}$$

Equation (8) not only indicates that a higher gap would lead to a reduction in the growth rate of emission intensity, but it also points out that higher economic complexity leads to a high reduction. Finally, it is important to note that it is also possible to use emissions per capita instead of emission intensity as proxy for green technology.

The rationale of the specification above lies in the following. First, emissions intensity can be understood as a proxy for green technology level, since it measures how much greenhouse gas (GHG) a given country emits to produce one unit of GDP (or, in the case of GHG emission per capita, how much GHG per person an economy emits over the course of one year). From a very simplistic standpoint, GHG emission intensity measures indirectly the extent to which green technologies are incorporated into a given economy, because the more green technological capabilities are embedded in the productive system, the less GHG shall be emitted per unit of economic output generated. Indeed, GHG emission intensity has been studied as measure of environmental efficiency, i.e. of the environmental impact of each unit of GDP (Cicea et al., 2014; Peroni, 2012). However, it should be highlighted that GHG emissions intensity and GHG emissions per capita can differ not only due to diverse green technology level, but a myriad of aspects, including countries' specificities such as sectoral composition, GHG emissions profile, among others. As a proxy indicator, it should be interpreted carefully in light of these shortcomings.

Second, the level cumulated technology a given country presents is, according to the literature directly related to the level of productive knowledge accumulated in that economy (e.g. Sciarra et al, 2020). This is the essence of the Economic Complexity Index (ECI), which measures the amount of productive knowledge in each economy (ibid.). Put simply, economic complexity assumes that it is necessary to have the inputs in terms of innovative, technological and productive capabilities in order to be able to produce complex products competitively (particularly in global markets). This conceptual foundation is also true for green technologies. Indeed, the literature has shown that: (i) not only the definition of green innovation relates to any "classical" innovation – the defining element being the reduction of environmental impact, be it intentional or not (see Kemp & Pearson, 2007; OECD, 1997; Oltra, 2008; Sauter & Watson, 2008); but also (ii) the determinants of and the policy framework for green technologies are similar to any other innovation – and, once more, the distinctive aspect of green innovation being the intent or the goal rather than the instrument used (Allan et al., 2021).

In this context, we test in this paper whether increasing the stock of productive and technological knowledge that is embedded and circulates in an economy, captured by the ECI, could be considered a driver of the absorption of green technologies, considering that in order to produce green innovation and technology it would be necessary to develop the productive knowledge base for it. According to Sauter and Watson (2008), absorptive capacity (i.e. the ability to adopt new technologies – be it green or not) is a relatively vague concept that encompasses firm-level absportive capacity and national-level absorptive capacity. Overall, absorptive capacity includes technological capabilities, knowledge and skills as well as supportive institutions (ibid.). In our econometric specification, emissions intensity (and per capita) gap in a given country is understood as a proxy for the green technology gap, using the technological catch-up literature as reference to investigate the effect of economic complexity on green technology absorption (e.g. Nelson and Phelps, 1966; Abramovitz, 1986; Verspagen, 1991).

Should an emissions intensity gap be found, this outcome would suggest that there is an opportunity to either incorporate foreign technology or to catch-up by developing one's own technology by building innovative, technological and productive capabilities in order to reduce the domestic GHG emissions intensity and per capita.

3. Empirical Investigation

3.1. Data Description

The data used in this paper combines information from two databases. The Economic Complexity Index (ECI) was gathered from the Harvard Atlas of Economic Complexity, covering 133 countries over 1995-2021. Data on greenhouse gas emissions (in kt of CO2e), GDP (in constant 2015 US$), population and the R&D to GDP ratio were gathered from the World Development Indicators.

Combining these two databases made it possible to form a balanced panel with 128 countries over the period 1995-2020 when the R&D to GDP ratio was not introduced in the database. A second balanced panel comprising 50 countries over 2000-2019 was formed when R&D to GDP was introduced as a control variable. This second sample is important because a large literature finds that R&D to GDP presents a positive impact on productivity growth through technological progress (e.g. Ha & Howitt, 2007; Madsen, 2008a; Fagerberg, 1987; Fagerberg & Verspagen, 2002) as well as in technology absorption (e.g. Cohen; Levinthal, 1990; Griffith et al., 2004). Hence, it is possible to assume that it should also generate a positive impact on green technology absorption and also, therefore, a negative impact on emission intensity growth.

3.2. Econometric specification

The econometric specification for the tests reported in this paper is based on the seminal tests performed by Grifith et al. (2004) on the importance of R&D for technology absorption, on the one hand, and on the tests performed by Romero and Gramkow (2021) regarding the importance of the ECI for GHG emission intensity. Formally:

$$lnEI_{ct} = \beta_0 - \beta_1 ECI_{ct-1} - \beta_2 EIG_{ct-1} - \beta_3 EIG_{ct-1} * ECI_{ct-1} + u_i + e_t \qquad (9)$$

Where $EI_{ct} = \frac{Emissions_{ct}}{GDP_{ct}}$ denotes emission intensity in country *c* and period *t*. $EIG_{ct-1} = \frac{EI_{ct-1}}{Lowest\ EI_{t-1}}$ is the green technology gap in country *c* and period *t – 1*. βs denote estimated coefficients, u_i are the fixed effects and e_t is the error term.

Hence, according to equation (9), a high emission intensity gap in one period is expected lead to lower emission intensity growth in the next period due to green technology absorption. This effect is expected to be larger in countries with high ECI in the previous period, as indicated by the interaction term between EIG and ECI.

In addition, it is also possible to take GHG emissions per capita as the dependent variable while still using GHG emission intensity to measure the green technology gap:

$$lnEpc_{ct} = \beta_0 - \beta_1 ECI_{ct-1} - \beta_2 EIG_{ct-1} - \beta_3 EIG_{ct-1} * ECI_{ct-1} + u_i + e_t \qquad (10)$$

3.3. Regression Results

Table 1 presents the results of the fixed effects regressions for equation (9), i.e. taking GHG emission intensity as the dependent variable as well as the reference to calculate the green technology gap.

Column (i) presents the results for the basic specification, including GDP per capita, ECI and the emission intensity gap. The first two variables have a negative coefficient, but only the former is significant. The emission intensity gap, however, presents a large positive and highly significant relationship with emission intensity growth in the next period. This result indicates that an increase in the gap does not automatically lead to an increase in green technology absorption.

The interaction term between the emission intensity gap and ECI is introduced in column (ii). The negative relationship of ECI with emission intensity growth becomes significant, while the interaction enters with a negative and significant coefficient. This result suggests the validity of the hypothesis that economic complexity contributes to reduce emission intensity growth via green technology absorption, given an emission intensity gap.

Table 1 – Fixed effects results: Emission Intensity

Model	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Ln. of GDP per capita	0.963***	0.960***	0.957***	0.956***	0.954***	0.952***
	(0.018)	(0.018)	(0.022)	(0.022)	(0.020)	(0.020)
Lag of ECI	-0.013	-0.118***	-0.063**	-0.063**	-0.229**	-0.241**
	(0.018)	(0.033)	(0.030)	(0.030)	(0.089)	(0.090)
Lag of Ln. of E. I. Gap	0.881***	0.902***	0.849***	0.848***	0.898***	0.896***
	(0.025)	(0.025)	(0.024)	(0.022)	(0.034)	(0.033)
Lag of Ln. of E. I. Gap * ECI		-0.058***		-0.095**		-0.102**
		(0.016)		(0.043)		(0.044)
R&D/GDP			-0.002	0.001	-0.0004	0.010
			(0.009)	(0.018)	(0.009)	(0.019)
Lag of Ln. of E. I. Gap * (R&D/GDP)				0.002		0.006
				(0.009)		(0.009)
Constant	-11.407***	-11.350***	-11.657***	-11.654***	-11.565***	-11.545***
	(0.109)	(0.113)	(0.186)	(0.190)	(0.174)	(0.179)
Countries	128	128	50	50	50	50
Period	1995-2020	1995-2020	2000-2019	2000-2019	2000-2019	2000-2019
Observations	3175	3175	945	945	945	945
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.8565	0.8572	0.8639	0.8640	0.8652	0.8654

Notes: Dependent variable: Ln. of GHG Emissions to GDP. Significance: *=10%; **=5%; 1%=***.
Source: Authors' elaboration.

Columns (iii) to (vi) present the results for the reduced sample, used when R&D/GDP is introduced as a control variable. In column (iii), R&D/GDP is introduced separately. It enters no significantly, while GDP per capita and ECI present negative and significant coefficients, and the emission intensity gap presents a positive and significant coefficient. In column (iv) the interaction term between the gap and ECI is introduced. It presents a negative and significant coefficient, while the other variables remain with similar coefficient and significant, except for R&D/GDP. In column (v) the interaction between the gap and ECI is replaced by the interaction between the gap and R&D/GDP. Nonetheless, this interaction is not significant, while the rest of the results remain similar to the previous ones. Finally, in column (vi), both interaction terms are introduced together. Only the interaction between the gap and ECI turns out significant. Hence, these results indicate that while the emission intensity gap is positively related to emission intensity growth, ECI is negatively related to emission intensity growth not only directly, but also indirectly, through its impact on green technology absorption, as captured be the interaction between the gap and ECI.

Table 2 presents the results of the fixed effects regressions for equation (10), i.e. taking GHG emissions per capita as the dependent variable. Column (i) presents the results for the basic specification once again. The coefficient of GDP per capita is positive and significant, while that of ECI is negative but not significant. The emission intensity gap presents a large positive and highly significant relationship with emissions per capita growth in the next period in this specification as well.

The interaction term between the emission intensity gap and ECI is introduced in column (ii). The negative coefficient of ECI becomes significant, while the interaction enters with a negative and significant coefficient as well. This result suggests the validity of the hypothesis that economic complexity contributes to reduce emissions per capita growth via green technology absorption, given an emission intensity gap.

Table 2 – Fixed effects results: Emissions per capita

Model	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Ln. of GDP per capita	0.963***	0.960***	0.957***	0.956***	0.954***	0.952***
	(0.018)	(0.018)	(0.022)	(0.022)	(0.020)	(0.020)
Lag of ECI	-0.013	-0.118***	-0.063**	-0.063**	-0.229**	-0.241**
	(0.018)	(0.033)	(0.030)	(0.030)	(0.089)	(0.090)
Lag of Ln. of E. I. Gap	0.881***	0.902***	0.849***	0.848***	0.898***	0.896***
	(0.025)	(0.025)	(0.024)	(0.022)	(0.034)	(0.033)
Lag of Ln. of E. I. Gap * ECI		-0.058***		-0.095**		-0.102**
		(0.016)		(0.043)		(0.044)
R&D/GDP			-0.002	0.001	-0.0004	0.010
			(0.009)	(0.018)	(0.009)	(0.019)
Lag of Ln. of E. I. Gap * (R&D/GDP)				0.002		0.006
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Constant	-11.407***	-11.350***	-11.657***	-11.654***	-11.565***	-11.545***
	(0.109)	(0.113)	(0.186)	(0.190)	(0.174)	(0.179)
Countries	128	128	50	50	50	50
Period	1995-2020	1995-2020	2000-2019	2000-2019	2000-2019	2000-2019
Observations	3175	3175	945	945	945	945
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.8565	0.8572	0.8639	0.8640	0.8652	0.8654

Notes: Dependent variable: Ln. of GHG Emissions per capita. Significance: *=10%; **=5%; 1%=***.
Source: Authors' elaboration.

Columns (iii) to (vi) present the results for the reduced sample, when R&D/GDP is introduced as a control variable. In all these regressions GDP per capita and the emission intensity gap remain positive and significant while ECI and its interaction with the gap remain negative and significant. R&D/GDP and its interaction with the gap are not significant in any of the regressions.

Taken altogether, therefore, the results reported in Tables 1 and 2 confirm the results found by Romero & Gramkow (2021), showing that economic complexity contributes to reduce both emission intensity and emissions per capita. Most importantly, the results of both specifications suggest that ECI contributes to green technology absorption.

4. Concluding remarks

The results reported in this paper show that an increase in the emission intensity gap leads to increases in emissions (intensity and per capita). This indicates that green technology absorption is not automatic (to some extent) as several papers find in terms of technology absorption for productivity growth. Hence, this suggests that green technology absorption requires more effort that general technology absorption.

Moreover, the panel data tests reported in the paper indicate that increases in economic complexity predict reductions in emission intensity and in emissions per capita, as already found in the literature.

Most importantly, the tests show that green technology absorption increases with economic complexity, since the interaction term between the emission intensity gap and economic complexity is negative and significant in all specifications. Furthermore, These results apply to both to reductions in emission intensity and in emissions per capita. Hence, the panel data tests reported in the paper suggest the validity of the main hypothesis under investigation: that increases in economic complexity lead to green technology absorption, presenting both direct and indirect effects on reductions in GHG emission intensity and in GHG emissions per capita.

The results reported in this paper reinforce the importance of fostering increases in economic complexity in order not only to boost GDP per capita growth, but also to reduce greenhouse gas emissions.

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