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Investment dynamics and its contribution to a differentiated regional growth (1995-2022): the case of Portugal

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Masters (MSc) in Economics and Public Policies

Supervisor:
PhD Sofia Vale, Associate Professor with Aggregation,
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CIÊNCIAS SOCIAIS
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Department of Political Economy

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Abstract

This study analyses the impact of investment on the economic growth of Portuguese NUTS III regions, considering its direct impact and the externalities of investment from neighbouring regions. To this end, the impact of public and private investment is explored, as well as the different types of investment by sector of activity. The aim is to understand how investment contributes to the country's differentiated growth. Data from the 25 NUTS III in Portugal between 1995 and 2022 is used, collected from Ardeco and divided into seven time periods. The regressions are estimated using Bootstrap-based Bias-Corrected Fixed Effects (BCFE), which corrects problems of endogeneity and reverse causality. To robusten the analysis, net investment is also taken into account. The results suggest that public and private investment have a positive and significant impact on regional growth, with the impact of private investment being eight times higher than that of public investment. On the other hand, the externalities of neighbourhood investment are only relevant to private investment. This trend is more pronounced in the regions with the highest levels of investment, while the less developed regions don't benefit from externalities. Investments in industry, information and communication, and cultural activities have a bigger direct impact, but only investment in information and communication has positive externalities. In net terms, only private investment in the neighbourhood is relevant and contributes positively to growth, especially investment in real estate.

Keywords: Investment, economic growth, Portugal, regional development.

JEL Classification: E22, O16, R11, R12, R58.

Resumo

Este estudo analisa o impacto do investimento no crescimento económico das regiões NUTS III portuguesas, considerando o seu impacto direto e as externalidades do investimento das regiões vizinhas. Para tal, é explorado o impacto do investimento público e privado, e dos diferentes tipos de investimento por ramo de atividade. O objetivo é perceber em que medida é que o investimento contribui para um crescimento diferenciado do país. São usados dados das 25 NUTS III existentes em Portugal entre 1995 e 2022, recolhidos do Ardeco e divididos em sete períodos temporais. As regressões são estimadas com o Bootstrap-based Bias-Corrected Fixed Effects (BCFE), que permite corrigir problemas de endogeneidade e causalidade reversa. Para robustecer a análise, é considerado também o investimento líquido. Os resultados obtidos sugerem que o investimento público e o privado têm impacto positivo e significativo no crescimento regional, sendo que o impacto do investimento privado é oito vezes superior ao público. Já as externalidades do investimento da vizinhança apenas são relevantes no investimento privado. Essa tendência ganha expressão nas regiões com níveis mais elevados de investimento, enquanto as regiões menos desenvolvidas não beneficiam de externalidades. Os investimentos da indústria, informação e comunicação, e atividades culturais têm maior impacto direto, mas só o investimento em informação e comunicação tem externalidades positivas. Em termos líquidos, apenas o investimento privado da vizinhança é relevante e contribui positivamente para o crescimento, com destaque para o investimento das atividades imobiliárias.

Palavras-chave: Investimento, crescimento económico, Portugal, desenvolvimento regional.

Classificação JEL: E22, O16, R11, R12, R58.

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1. Introduction

Investment, understood as gross fixed capital formation (GFCF), is an important "engine" of economic growth and its contribution to wealth creation is a phenomenon that has been widely studied in the literature (e.g. Deleidi et al., 2019; Abiad et al., 2015; Krugman, 2005; Solow, 2005). However, academics have paid less attention to the spatial dimension of this phenomenon, even though there is a regional interdependence in terms of investment and growth. In other words, the growth of a region is also influenced by the investment of neighbouring regions (López-Bazo, et al., 2004; Rodríguez-Pose et al, 2012) and these externalities are not always taken into account.

In Portugal, the way in which investment, both public and private, has supported the growth of different regions is a topic that still needs to be researched. In recent years, some studies have been carried out on the impact of investment on regional gross domestic product (GDP), but they have focused on public investment (Modesto, 2015; Quirino et al., 2014), revealing a positive impact on the growth of Portuguese regions. However, private investment also has an impact on growth at a national level and tends to be even greater than public investment (Afonso & Aubyn, 2008). The issue of regional externalities is also considered by Modesto (2015), but the results revealed that neighbourhood investment has a negative impact on the growth of regions, which contradicts economic theory and several international studies (Rodríguez-Pose et al, 2012; Baumont et al. 2000). In addition, studies on investment in Portugal consider aggregate data, making it impossible to understand the contribution of each type of investment to growth (Silva, 2022). This is no small factor, given that an investment in dwellings has a lower economic return than an investment in research and development (BdP, 2018).

This study contributes to filling this gap in the literature by presenting an analysis of the economic impact at regional level of both public and private investment, without forgetting the importance of the externalities of investment in neighbouring regions. To strengthen this analysis, the net values of this investment are also considered, i.e. discounting the levels of capital deterioration over the years. The aim is therefore to see how investment, both gross and net, at regional level has contributed to differentiated growth in the country. To this end, this study aims to answer the following questions: (1) To what extent has public and private investment had an impact on the per capita growth of the different Portuguese regions? (2) To what degree does regional growth reflect the externalities of investments in neighbouring regions? (3) How has investment in different types of investment contributed to differentiated growth potential between regions?

The empirical analysis focuses on the 25 Portuguese NUTS III, between the years 1995 and 2022 – divided into seven periods of four years each (n=25, t=7) –, going through two distinct phases in the evolution of investment flows in Portugal: a period until the early 2000s marked by high levels of GFCF (Ligthart, 2000), due to the boost generated by Portugal's entry into the then European Economic Community (EEC) in 1986, and another of decreasing levels of GFCF accentuated by the financial crisis of 2008 (Garcia, 2020). In addition, the impact of different types of investment on regional growth is explored, based on the sectors of activity defined by the statistical classification of economic activities (NACE), which allows for international comparisons in subsequent studies. Innovatively, the Bootstrap-based Bias-Corrected Fixed Effects (BCFE) estimator is used, which corrects problems of endogeneity and reverse causality – which have been criticized in various studies of the impact of investment on GDP (Pereira & Andraz, 2012) – and which is suitable for samples with short time periods (Vos et al., 2015), as is the case here.

Firstly, the impact of investment on the 25 Portuguese regions as a whole is analysed. Then, in a second phase, the regions are divided into six different sub-groups, in order to understand whether investment has a different impact on the regions according to their levels of development, population density and investment. The results indicate that GFCF contributes to economic growth in Portuguese regions and that the biggest boost comes from private investment. They also show that there are positive externalities in investment made in neighbouring regions and that, in some cases, this investment is more significant than that made in the regions themselves. Investment in industry is the most consistent in terms of wealth creation and the most developed regions and those with more investment tend to benefit more from the investment made, in gross and net terms. The high level of capital deterioration means that, in some regions, the economic return on investment is non-existent, as it doesn't compensate for the losses associated with capital deterioration.

The next section presents a review of the literature on the importance of investment and its dynamics and impact on regional growth, with an emphasis on developments in Portugal. Section 3 describes the methodology used, regarding the econometric specification and the treatment of the data collected. Section 4 presents and analyses the empirical results and section 5 sets out concluding remarks and the practical and/or political implications that can be drawn.

2. Literature review

2.1 Theoretical considerations on investment

According to economic theory, investment is a factor of production and therefore affects the economic growth of a country or region, as a function of its marginal return (Fournier, 2016; Aschauer, 1989b). However, growth on a regional scale is asymmetrical, which means that the same country can grow at different speeds.

According to the neoclassical approach, this asymmetry between regions is explained by market failures and is only transitory. As more developed regions make intensive use of productive factors, they grow more slowly than less developed regions, given that capital accumulation has diminishing returns to scale (Solow, 1956). As a result, over time, there would be a regional rebalancing due to investment saturation, with similar GFCF rates implying greater growth in the less developed regions than in the more developed ones.

Nevertheless, this view is contested by endogenous growth theories, which argue that investment can have constant or increasing returns to scale, given that the accumulation of physical and human capital influences economic growth in the long term and can result in continuous gains in efficiency and productivity (Lucas, 1987; Romer, 1990; López-Bazo et al., 2004). The possibility of transmitting acquired knowledge and replicating developed innovations, leading to a reduction in unit production costs, is an example of these constant or increasing returns to scale, even with constant physical capital. This theory emphasises the importance of internal factors – such as innovation, improving professional qualifications and the accumulation of knowledge and fixed assets – as a way of increasing the development potential of a country or region, unlike the neoclassicals who argue that long-term economic growth depends mainly on exogenous factors, such as technological progress (Solow, 2005). Focusing on accumulated capital and its long-term implications, proponents of endogenous growth theories argue that if investment levels are insufficient to compensate for the deterioration of the capital stock, the GDP of a country or region could be jeopardised. On the other hand, levels of GFCF that compensate for the deterioration of the stock allow a country or region to achieve more significant and continuous growth rates in the long term.

The distribution of investment at regional level has privileged wealthier regions with a higher concentration of economic activity (Pereira & Andraz, 2004; Lopes, 2001), as well as more densely populated regions. These regions tend to be a magnet for investment in the majority of sectors of activity (Krugman, 1991), which, in turn, attracts new investment and allows these regions to benefit from the complementarities of interregional investment. This

concentration of investment has exacerbated regional disparities in Portugal, a trend also observed at European level.

To correct these regional disparities that hinder growth, the European Union (EU) advocates state intervention (McCann & Rodríguez-Pose, 2011; Barca, 2011), in a redistributive approach (Barca, 2011) to respond to market failures resulting from the agglomeration of capital and to compensate disadvantaged regions. Therefore, EU regional policy seeks to redistribute European funds to less developed regions to promote their convergence with richer regions. These European funds are used to finance investment projects, and the projects supported are mainly investments in infrastructure, such as roads and other transport equipment (Crescenzi & Rodríguez-Pose, 2012; Pereira & Andraz, 2012), which are considered to induce greater economic growth (EPRS, 2016). More recently, efforts have been made to move Cohesion Policy towards a more place-based approach (EC, 2024a), i.e. more based on regional development, taking into account the needs of the territory, acting in an integrated manner and promoting innovation and the valorisation of local potential (McCann & Rodríguez-Pose, 2011). However, there is still a long way to go in this regard (Petit & Fröhlich, 2024).

In recent years, investment support and its impact on growth and territorial cohesion have been on the media agenda. In response to the crisis caused by the Covid-19 pandemic, in 2021 the EU launched an unprecedented joint debt issue to stimulate investment in member states and thereby support economic recovery by expanding or modernising the capital stock (Carvelli, 2024). In addition, the Draghi report defends the need for a considerable increase in investment in order to make the EU more competitive (EC, 2024b), reiterating the idea that GFCF is an indispensable factor for economic growth and a way of overcoming the competitive gap with potential competitors such as China and the United States. In both cases, promoting this increase in investment should have asymmetrical impacts on the growth of the different Portuguese and European regions (Pereira & Andraz, 2004; Carvelli, 2024).

2.2 Need for a regional perspective on the impact of investment on GDP

The lack of consideration of the geographical role of investment has divided the literature on its economic return and led to a polarised discussion between public and private investment (Rodríguez-Pose et al., 2012). It is considered that public investment and private investment can influence each other in opposite directions. On the one hand, public investment can have a crowding-out effect, in other words, it can keep private investment away. This is due to the fact that the public and private sectors may have to compete for the

same resources (Dreger & Reimers, 2016) and it is often necessary to finance public investment by contracting public debt, which raises interest rates and thus the financing costs of the private sector (Cavallo & Daude, 2011; Afonso & Aubyn, 2008; Petrović et al., 2021). On the other hand, public investment can also have a crowding-in effect, where it incentivises private investment. This is because the private sector can work to complement public sector investment (Masten & Gnip, 2019). But private investment can also have a crowding-in effect on public investment, and this effect can even be more significant than in the opposite direction (Afonso & Aubyn, 2008).

Despite this polarisation, studies show that public investment in one region generates externalities (spillovers) in others (Rodríguez-Pose, 2012; Baumont et al. 2000), indicating that there is a spatial complementarity in investments that isn't properly analysed when only national data is considered. The same is true of private investment (Kubo, 1995; Baumont et al. 2000). This means that the impact of investment knows no political or administrative boundaries. These spillovers at regional level have a considerable impact and can even prevent diminishing returns to scale, contrary to the idea of neoclassical economists (López-Bazo et al., 2004; Rodríguez-Pose et al., 2012). According to Pereira & Andraz (2012), the failure to take account of externalities between regions partly explains why the impact of investment on GDP is lower at regional level when compared to data obtained at national level (Elburz et al., 2017). These externalities can also contribute to uneven development between regions (Kubo, 1995; Baumont et al. 2000), since richer regions tend to be neighbours of others that are equally or richer, and poorer regions tend to be surrounded by others in identical circumstances (López-Bazo et al., 2004; Baumont et al. 2000).

But not all investment is productive (Silva, 2022). According to Kneller et al. (1999), investment in areas such as education, transport, research and development (R&D) and health has a greater impact on GDP and is in fact "productive". Rodríguez-Pose et al. (2012) reach similar conclusions in relation to education and R&D, but warn that in some cases, investment in public infrastructure, such as roads, may not have a significant impact on the region where it is made. However, it can have a significant indirect effect on neighbouring regions. On the contrary, investment in recreation, security and economic affairs is considered "non-productive" (Kneller et al., 1999) and investment in dwellings appears to have a negative impact on growth (Rodríguez-Pose et al., 2012).

It should be noted that the impact of investment on GDP varies depending on the economic cycle (Petrović et al., 2021; Abiad et al., 2016), with the strongest effects occurring when there is economic slack and an accommodative monetary policy. In addition, the impact

of some investments at a regional level increases over the years due to so-called "gestation effects", especially when it comes to investments in physical infrastructure (Elburz et al., 2017; Bom & Ligthart, 2014). Furthermore, when formulating public policies to promote investment at regional level, there is a political trade-off in the distribution of investment at regional level between efficient allocation and equitable allocation (Yamano & Ohkawara, 2000; Berg et al., 2015; Modesto, 2015). On the one hand, the return on investment tends to be higher in more developed regions because they can benefit from increasing returns from the agglomeration of activities (Krugman, 1991), which accentuates existing regional asymmetries. On the other hand, the poorest regions need more investment so that they can grow more and converge with the rest, but allocating more resources to these regions penalises the national GDP in the long run.

The choice of where to allocate investment, especially public investment, is mainly the result of political decisions, which aren't always related to economic efficiency or equity. As a rule, public spending often tends to be guided by so-called "pork barrel" policies (Mourão & Cunha, 2011), in which the government in power tends to increase public spending – which includes investment – when elections are approaching and to benefit regions led by leaders of the same political colour. This is particularly relevant since a change of government can be associated with considerable changes in the direction of investment. Furthermore, the quality of the government and the level of regional authority, namely whether regions have greater or lesser financial autonomy, influence the ability of regions to attract investment (Alvarez et al., 2023).

2.3 Investment dynamics in Portugal

With entry into the European Union (EU) in 1986, investment in Portugal reached unprecedented levels of growth – in the region of 6% – until the early 2000s (Ligthart, 2000), largely due to the influx of millions of euros in European funds into the country. However, the arrival of the new millennium brought a decline in national GFCF rates, which was accentuated by the 2008 crisis (Garcia, 2020). The shock caused by the financial crisis meant that Portugal's annual investment rate was one of the lowest among Eurozone countries (Barbiero & Darvas, 2014), since cutting capital expenditure tends to be politically "easier" than cutting current expenditure, such as paying civil service salaries or social contributions (Dreger & Reimers, 2016; Barkbu et al., 2015). And this fall in investment partly explains the weak economic recovery that followed the 2008 crisis and whose marks are still being felt today (Blanchard & Leigh, 2013), with the so-called "secular stagnation" (Teulings &

Baldwin, 2014). Since then, investment levels have struggled to take off (Barkbu et al., 2015), even when monetary policy was accommodative and encouraged borrowing for investment (Matvejevs & Tkacev, 2024; Dreger & Reimers, 2016).

In the case of Portuguese public investment, the Portuguese Public Finance Council (CFP) has warned that the country has been unable to compensate for the deterioration in the capital stock since 2012 (CFP, 2024). Under-budgeting is one of the problems identified (UTAO, 2025), since governments tend to use investment as budgetary "slack" that is managed according to the economic climate. This is because Portugal has to follow European budgetary rules, which aren't very favourable to public investment (Barbiero & Darvas, 2014), because they include capital expenditure in the deficit accounts.

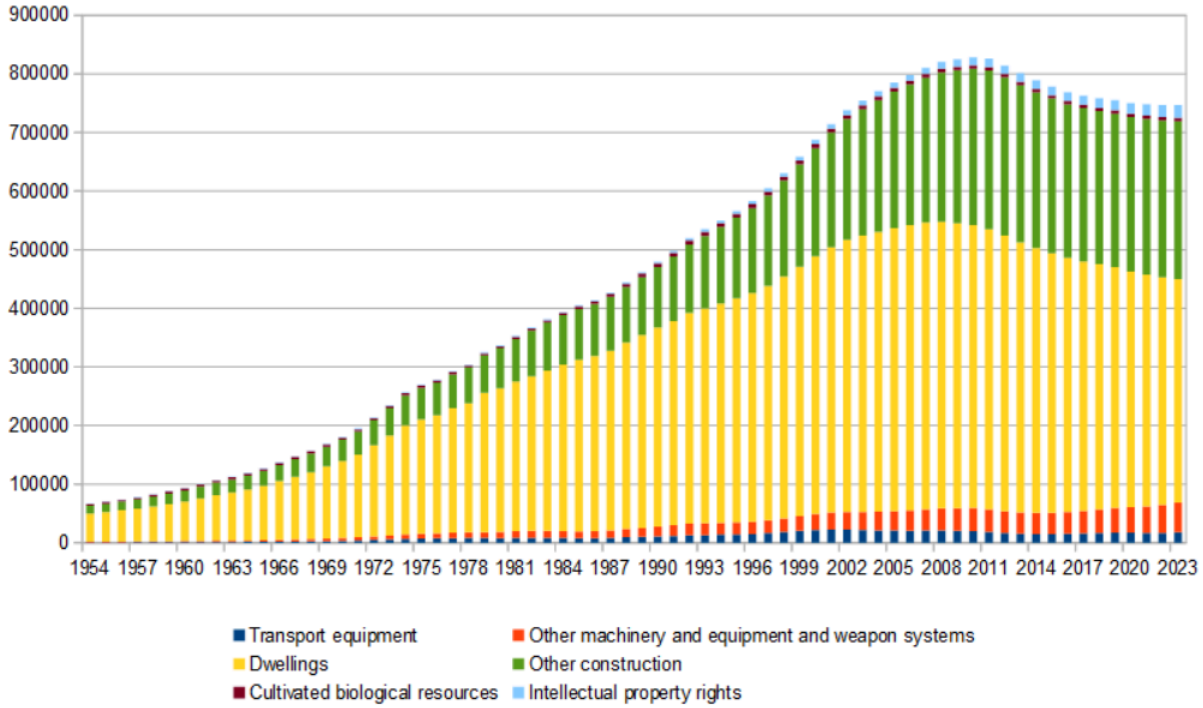
This deterioration in the public capital stock is particularly alarming given that the capital stock is the set of machines, infrastructures and other tangible and intangible assets (such as patents and R&D) that are used repeatedly in production processes. In other words, capital accumulation affects labour productivity (Aschauer, 1989a; Aschauer, 1989b) and when there is no compensation for the deterioration of this stock, it means that there is a loss in a country's potential growth. The capital stock is, in fact, the best indicator for studying the impact of investment on growth (Kamps, 2004), in line with the idea of diminishing returns to scale. Even so, it is the evolution of GFCF that is most often used in studies similar to this one, given the difficulty in accurately calculating the existing capital stock.

The Portuguese capital stock – public and private – was estimated at around 616 billion euros in 2015, corresponding to 343% of GDP at the time (BdP, 2018). In the first 15 years of the new millennium, the Portuguese economy's stock of fixed assets grew by 55.9%, but between 2011 and 2013, annual investment was not enough to compensate for the deterioration in installed capital. At the time, construction was the most common type of asset in the national capital stock, although it had a lower economic return than investment in other assets with more technological incorporation (see figure 1).

Studies on the optimal public capital stock point to the need to guarantee values of between 40% and 80% of GDP (Kamps, 2004; Checherita-Westphal et al., 2014). In the case of countries or regions with a higher stock of public capital, they shouldn't spend so much on investment, as there is a greater risk of betting on inefficient projects (Fournier, 2016). However, this isn't the case in Portugal, where the stock of public capital was below the desired level until 2020 and only improved after joining the EU (Kamps, 2005)

Figure 1

Evolution of the Portuguese capital stock since 1954.



Note. The graph, prepared by the author, was created with data from the National Institute of Statistics (INE). The data presented are in millions of euros.

Until 2018, private investment was showing signs of recovering better from the post-crisis slump than public investment (Garcia, 2020). As in other countries, public investment had a crowding-in effect on private investment in Portugal, especially since Portugal joined the EU (Andrade & Duarte, 2016). However, this effect seems to have diminished over time (Domańska, 2020). Uncertainty has been the main reason for the timid growth in private investment (EIB, 2013). High leverage (Barkbu et al, 2015), loss of competitiveness (Zarchmann, 2012) and the lack of liquidity of many companies across the country are other challenges.

3. Methodology

3.1 Econometric specification

To better understand the impact of investment on the GDP of the different Portuguese regions, this work uses dynamic panel data models (n=25, t=7). These models include lagged values of the dependent variable (the regions' GDP) with the explanatory variables, reducing or eliminating the bias caused by endogeneity. Furthermore, the literature doesn't exclude the existence of reverse causality between GFCF and economic activity (Pereira & Andraz, 2010; Bom & Ligthart, 2014). In other words, an increase in investment leads to GDP growth, but the opposite is also true: more economic growth leads to higher levels of investment. For this reason, we chose to use the Bootstrap-based Bias-Corrected Fixed Effects (BCFE) estimator, as it is suitable for samples with a small T in relation to the number of units, as is the case, and as it allows us to automatically correct for problems of endogeneity, reserve causality and other biases that can compromise the quality of the results.

The BCFE estimator proposed by Vos et al. (2015) works, therefore, as a kind of improved panel data model with fixed effects, since it corrects the estimation bias of the fixed effects of the FE model in data with a small T, caused by the presence of the lagged dependent variable, which is known as Nickell's bias (Nickell, 1981). This bias is controlled using bootstrap resampling techniques, making the results more accurate and reliable. BCFE also makes it possible to take into account different types of heteroscedasticity (dispersion of time-varying error terms) and cross-sectional dependence in panel data (Vos et al., 2015; Everaert and Pozzi, 2007).

The equation used also recognises the possibility of externalities in the investment made by each of the 25 NUTS III regions analysed in neighbouring regions (Rodríguez-Pose et al., 2012) and introduces a lagged GDP per capita variable to control for its persistent nature (Pereira & Andraz, 2010; Bom & Ligthart, 2014). To this end, the following regression is considered:

$$lnGDP_{it} = \beta_0 + \beta_1 lnGDP_{it-1} + \beta_2 lnGFCF_{it} + \beta_3 lnWGFCF_{it} + \beta_4 x_{it} + \varepsilon_{it} \quad (1)$$

Where:

- $lnGDP_{it}$ is the logarithm of GDP per capita in region i in time period t;

- $lnGDP_{it-1}$ is the logarithm of GDP per capita in region i in time period t-1 (lagged measure of GDP);
- $lnGFCF_{it}$ is the logarithm of investment made in region (NUTS 3) i in time period t;
- $lnWGFCF_{it}$ is the logarithm of the average investment made in i's neighbouring regions in time period t;
- x_{it} are the control variables considered in the model (more specifically, the logarithm of population, capital productivity and labour productivity) for region i in time period t;
- ε_{it} is the error term.

To deepen the analysis of the impact of investment in regional terms and guarantee the robustness of equation 1, the impact on GDP of each type of investment, public and private, in each region is also estimated, as well as the externalities of each of these types of investment in the regions. To do this, $lnGFCF_{it}$ is replaced by the logarithm of public investment ($lnPubInv_{it}$) and private investment ($lnPrivInv_{it}$) made in region i in time period t. This change extends to the investment of neighbouring regions, with $lnWGFCF_{it}$ being replaced by the logarithm of the average public investment made by i's neighbouring regions in time period t ($lnWPubInv_{it}$) and the average private investment ($lnWPrivInv_{it}$) of the regions in that period. In addition to this distinction between public and private investment, the impact of investment by sector of activity is also analysed, making it possible to see which types of investment generate the greatest economic return. In this case, the $lnGFCF_{it}$ variable is replaced by the investment made in the different sector of activity considered, taking into account the NACE categories (Eurostat, 2008). The same process is applied to the $lnWGFCF_{it}$. variable.

In addition to these regressions, there is an analysis of the impact of investment, taking into account net investment values, i.e. total investment minus capital depreciation over time. This analysis is crucial to understanding whether the investment that is being made is managing to compensate for the deterioration of capital and how this may be conditioning the growth of Portuguese regions. This analysis takes into account exactly the same variables

mentioned above (total investment and that of neighbouring regions, investment divided by public and private sector, and investment by sector of activity), but in net terms.

Still on the subject of the econometric model, it should be noted that 250 bootstrap samples are used to estimate and correct for bias in the coefficients and 250 bootstrap samples are used to calculate the standard errors and make the statistical inference. With regard to data resampling, a type of non-parametric bootstrap is used that allows for heterogeneity in the error terms, more precisely Monte Carlo Heterogeneous Errors (MCHE). This type of bootstrap is more realistic, taking into account that different regions are being analysed and assuming that the errors are not homoscedastic (with the same variance) between units. In terms of how the estimator is initialised, Analytical Heterogeneous Effects (AHE) is used. It consists of an analytical estimate that is generated to define the first stage of the bias correction process, allowing the fixed effects to vary between units, improving the convergence of the estimator. In order to make the results more robust, non-parametric 95% confidence intervals are considered.

3.2 Data

The vast majority of the data used in this article is taken from Ardeco, the EU's regional statistics portal, and concerns Portugal's 25 sub-regions (NUTS III) over a period of time from 1995 to 2022 (28 years). Only the data on investment in neighbouring regions, capital productivity and labour productivity are the result of our own calculations, using the variables taken from Ardeco. To avoid problems of data stationarity, the sample was divided into seven distinct time periods of four years each, with each one showing the average of the period to which it refers. However, there are some important aspects to bear in mind.

Since 2024, the map with Portugal's division into sub-regions has been changed (EC, 2023), including a new sub-region (Península de Setúbal) as a result of the division of the Área Metropolitana de Lisboa, which is now just called Grande Lisboa. Some changes were also made to the territorial boundaries of some NUTS III regions, namely the Médio Tejo and Beira Baixa. As this study covers a time period up to 2022, these changes to the territorial map are not taken into account. Therefore, the data analysed follows the territorial divisions until 2022 and which came into force in 2013. Therefore, the NUTS III considered are as follows (according to the map in Appendix I): Alto Minho, Cávado, Ave, Área Metropolitana do Porto, Alto Tâmega, Tâmega e Sousa, Douro, Terras de Trás-os-Montes, Região de Aveiro, Região de Coimbra, Região de Leiria, Viseu Dão Lafões, Beira Baixa, Beiras e Serra da Estrela, Oeste, Médio Tejo, Área Metropolitana de Lisboa, Lezíria do Tejo, Alto Alentejo,

Alentejo Litoral, Alentejo Central, Baixo Alentejo, Algarve, Região Autónoma dos Açores, Região Autónoma da Madeira.

Table 1 lists the variables used in this study, as well as their proxies and how they were obtained. In order to ensure better comparability, the data in value (euros) is deflated and in volume chained prices for 2015.

GFCF is the indicator used to measure investment in the different regions, although this is an imprecise measure because it doesn't exclude capital depreciation and leaves out investment made by the state-owned enterprises (Barbiero & Darvas, 2014). Even so, this is the most widely used indicator for measuring investment and is commonly accepted in statistical terms, both at European and international level. In this study, the average GFCF of neighbouring regions will also be analysed, taking into account the 2013 NUTS III map, because, as we have seen, there are positive externalities in the investment of neighbouring regions (Rodríguez-Pose et al., 2012; Baumont et al. 2000). The dependent variable will be the GDP per capita of each of the 25 NUTS III regions considered.

Table 1

Summary of the variables used.

Variable	Definition/Proxy	Details
lGFCF	Investment in region i	The logarithm of the gross fixed capital formation (GFCF) of each of Portugal's 25 NUTS III regions between 1995 and 2022, based on Ardeco, is used.
lWGFCF	Investment in i's neighbouring regions	The logarithm is calculated using the average GFCF of the regions that "border" in geographical terms with each of the Portuguese regions, from 1995 to 2022, based on Ardeco. This indicator makes it possible to determine whether regions benefit from investment in their neighbourhood. For example, if region A shares a "border" with regions B and C, the average GFCF of these two regions is taken into account, according to the following formula, where k is the number of regions with which i shares a border: $$lnWGFCF_{it} = \frac{1}{k_i} \sum_{j \epsilon \upsilon(i)} I_j$$

lGDPpc	GDP per capita in region i	The logarithm of the GDP per capita of each region between 1995 and 2022, based on Ardeco, is used.
lPOP	Population in region i	The logarithm of the total population of the 25 regions from 1995 to 2022, based on Ardeco, is used.
Capproduct	Productivity of capital in region i	This is a ratio that makes it possible to evaluate the efficiency of new investments in production in each of the 25 NUTS III between 1995 and 2022, because not all investments are productive (Kneller et al., 1999). To calculate it, the gross value added (GVA) is divided by the GFCF of each region. The data is taken from Ardeco.
Labproduct	Labour productivity in region i	This is a ratio that gives an idea of how efficiently the workforce is used in production. To calculate it, GVA is divided by the number of hours worked in each of the 25 NUTS III regions between 1995 and 2022, using Ardeco. This indicator is important because, in addition to capital, labour is a crucial factor for economic growth (Romer, 1990; Lucas, 1987).

Note. The indicators used were taken from the Ardeco portal. The calculations referred to are the author's own.

The population, capital productivity and labour productivity of each region over the aforementioned time periods are used as control variables. Table 2 explains how each of these variables affects GDP per capita and what theoretical evidence supports their inclusion in the econometric model.

Table 2

Control variables and their relationship with GDP per capita.

Control variables	**How the variable affects GDP per capita**
lPOP	GDP per capita is calculated by dividing total GDP by the resident population, and so population is a crucial indicator to explain the evolution of this indicator. Any change in population behaviour directly affects GDP per capita, even if GDP remains unchanged. Thus, GDP per capita can increase simply because the population decreases, as it has happened in several Portuguese regions (e.g. Quirino et al., 2014).

Capproduct	Capital productivity is an important indicator to explain the differentiated growth of regions because, according to economic theory, investment is necessary for economic growth (Krugman, 2005; Solow, 2005). But not all investments are productive (Kneller et al., 1999) or are in line with real needs in the territory and, as a result, may not be efficient. That's why not all types of investment have the same impact on GDP per capita. This indicator makes it possible to determine how much wealth is generated by each unit of capital invested. If capital is invested efficiently, GDP increases and, if the population remains unchanged, GDP per capita grows.
Labproduct	Labour productivity is an important variable to explain GDP per capita because it shows how much each worker contributes to economic activity and is therefore a measure of labour "efficiency". The more a worker produces per hour, the higher the GDP will be and, if the population remains unchanged, this will result in an increase in GDP per capita.

Note. The variables are taken from the Ardeco portal, with the exception of capital and labour productivity, which were calculated by the author.

In a second phase, the different types of investment by region are analysed to see which ones have the highest economic return. To do that, the same formula is used, but the GFCF and WGFCF are replaced by the values corresponding to the different types of investment listed in Table 3, based on the different sectors of activities where the investment is made. Investment in 10 different sectors of activities is thus analysed, following the European Union's Nomenclature of Economic Activities (NACE), which serves as a reference in statistical terms in all member states.

In addition, the investment made by the O-Q industries – a category where investment made in public administration and defence, social security, education, health and social support activities is counted together – is used as a proxy for public investment, since the NACE categories don't distinguish by institutional sector. However, it should be noted that there is no NACE category that covers all activities carried out by the public sector (Eurostat, 2008). Although the O-Q sector of activity doesn't correspond exactly to the public sector – since, for example, health and education are services also provided by the private sector – it is still the category that comes closest to the public sector, to compare the economic return generated by public investment. As a proxy for private investment, this study considers the investment made by the other sectors of activities.

Table 3

Different types of investment considered in the analysis and their average annual GFCF.

Variable	Definition/Proxy	Average annual GFCF (1995/2022) in €
GFCFA	Investment in agriculture, forestry and fishing	987 millions
GFCFBE	Investment in industry, energy, water supply and sewerage	6,700 millions
GFCFF	Investment in construction	1,332 millions
GFCFGI	Investment in retail trade; repair of vehicles; transportation and storage; accommodation and food service activities	5,633 millions
GFCFJ	Investment in information and communication	2,152 millions
GFCFK	Investment in financial and insurance activities	508 millions
GFCFL	Investment in real estate activities	8,974 millions
GFCFMN	Investment in professional, scientific and technical activities; administrative and support service activities	2,052 millions
GFCFOQ	Investment in public administration and defence; social security; education; human health and social work activities	5,548 millions
GFCFRU	Investment in cultural activities	666 millions
PubInv	Public investment (= GFCFOQ)	5,548 millions
PrivInv	Private investment (= GFCF-GFCFOQ)	29,004 millions

Note. For each type of investment, investment of the same type in neighbouring regions is also taken into account, as described in table 1. Average annual GFCF is calculated using data collected from Ardeco.

In order to analyse the regional dynamics of investment, the country's 25 NUTS III regions will initially be studied together and then grouped into two distinct groups. Firstly, the sample will be divided based on the logarithm of the regions' GDP per capita, which will make it possible to distinguish between more developed and less developed regions (Table 4), in order to test whether there are significant differences in the economic impact of GFCF in these two groups. Next, an analysis will be made using the population density, an indicator that allows us to see how the population is distributed across the territory, once again dividing the initial sample into two parts: regions with a higher population density and regions with a lower one (Table 5). As it tends to be a concentration of productive activity in regions with more population per square kilometre (Krugman, 1991), this indicator makes it possible to gauge the different dynamics of regional development and is a good starting point for testing the impact of this concentration on regional growth dynamics. Finally, the sample will be

divided into two parts based on the GFCF of the regions (Table 6), analysing whether there are different impacts on GDP per capita between regions that invest more and those that invest less.

Table 4

Division of NUTS III regions according to GDP per capita.

Sub-regions with lowest GDP per capita	Average annual GDP per capita		Sub-regions with higher GDP per capita	Average annual GDP per capita	
	Logarithmic	Absolute (in €)		Logarithmic	Absolute (in €)
Tâmega e Sousa	9.208	10,066	AM de Lisboa	10.075	23,784
Alto Tâmega	9.235	10,388	Alentejo Litoral	9.968	21,464
Beiras e Serra da Estrela	9.275	10,792	Algarve	9.798	18,081
Douro	9.331	11,448	Região de Leiria	9.745	17,115
Terras de Trás-os-Montes	9.410	12,329	Região de Aveiro	9.735	16,941
Alto Minho	9.411	12,336	AM do Porto	9.717	16,621
Viseu Dão Lafões	9.445	12,730	RA da Madeira	9.702	16,485
Alto Alentejo	9.499	13,366	Lezíria do Tejo	9.673	15,900
Ave	9.501	13,436	Alentejo Central	9.653	15,615
Cávado	9.502	13.498	Região de Coimbra	9.650	15,576
Oeste	9.572	14,377	Baixo Alentejo	9.631	15,409
Médio Tejo	9.577	14,458	RA dos Açores	9.611	15,047
Beira Baixa	9.596	14,808	--	--	--

Note. The logarithmic average of the GDP per capita of the 25 regions, calculated using Ardeco data, is used to divide the regions. Absolute values are for comparative purposes only.

Table 5

Division of NUTS III regions according to population density (No./km²) in 2022.

Sub-regions with the lower population density	Population density	Sub-regions with the highest population density	Population density
Baixo Alentejo	13.5	AM Lisboa	968.9
Alto Alentejo	17.1	AM Porto	872
Beira Baixa	17.6	Cávado	340.8
Alentejo Litoral	18.8	RA Madeira	317.2
Terras de Trás-os-Montes	19.3	Ave	289.7

Alentejo Central	20.7	Tâmega e Sousa	223
Alto Tâmega	28.6	Região de Aveiro	222.6
Beiras e Serra de Estrela	33.1	Oeste	170.7
Douro	45.6	Região de Leiria	119.3
Lezíria do Tejo	57.1	Alto Minho	104.9
Médio Tejo	69.3	RA Açores	103.4
Viseu Dão Lafões	78.3	Região de Coimbra	101.8
Algarve	95.8	--	--

Note. The population density data was taken from INE, and as there is no data since 1995 to calculate the average over the 28 years analysed, only the values for 2022 are considered.

Table 6

Division of NUTS III regions according to GFCF.

Sub-regions with less GFCF	**Average annual GFCF**		**Sub-regions with more GFCF**	**Average annual GFCF**	
	Logarithmic	**Absolute (in millions of €)**		**Logarithmic**	**Absolute (in millions of €)**
Alto Tâmega	19.110	200.83	AM de Lisboa	23.209	12,168.40
Beira Baixa	19.385	266.24	AM do Porto	22.424	5,524.76
Terras de Trás-os-Montes	19.508	298.56	Algarve	21.291	1,855.51
Alto Alentejo	19.669	357.94	Região de Coimbra	21.079	1,456.71
Baixo Alentejo	19.932	458.26	Região de Aveiro	20.960	1,287.42
Douro	19.987	481.78	Ave	20.794	1,083.07
Alentejo Litoral	20.005	494.65	RA da Madeira	20.778	1,164.13
Beiras e Serra da Estrela	20.060	525.77	Cávado	20.765	1,054.21
Alentejo Central	20.142	575.36	Oeste	20.740	1,039.15
Alto Minho	20.204	598.14	Região de Leiria	20.688	982.55
Viseu Dão Lafões	20.335	692.29	Lezíria do Tejo	20.565	873.06
Médio Tejo	20.379	724.95	Tâmega e Sousa	20.523	825.37
RA dos Açores	20.485	821.55	--	--	

Note. The logarithm of the average GFCF of the 25 regions is calculated using Ardeco data. It should be noted that the Ave region has a higher logarithmic average than the RA da Madeira, but this isn't the case in absolute terms. This is explained by the fact that there is greater variation in RA da Madeira's FBFC levels over time, with some investment peaks that increase the absolute average but have little impact on the logarithmic average, which is less sensitive to extreme values. The logarithmic average is used to divide the regions. The absolute values are only used for comparative purposes.

Before moving on to the econometric regressions, it is important to give a brief general description of the differences in the investment effort made by the different Portuguese regions, which will be useful when discussing the results obtained. Table 7 shows the proportion of investment (public and private) by sector of activity. The data shows that, in general terms, investment in the 25 regions is mostly carried out by the private sector and is distributed more or less identically by sector of activity among the subsets of regions to be analysed.

Table 7

Proportion of investment by sector of activity in the subsets of regions analysed.

Type of investment	Total	More devel.	Menos devel.	Higher density	Lower density	More invest.	Less invest.
Public Investment	16.06%	14.95%	17.29%	15.10%	16.83%	14.59%	19.26%
Private Investment	83.94%	85.05%	82.71%	84.90%	83.17%	85.41%	80.74%
Inv. Agriculture	2.85%	2.25%	4.47%	1.48%	7.31%	1.84%	6.64%
Inv. Industry	19.39%	17.14%	26.50%	19.09%	19.90%	18.84%	21.07%
Inv. Construction	3.85%	3.68%	3.87%	3.36%	5.01%	3.46%	4.83%
Inv. Retail	16.30%	16.37%	12.65%	15.75%	14.71%	15.66%	14.95%
Inv. Information	6.22%	7.26%	1.78%	7.27%	1.49%	7.05%	1.60%
Inv. Financial sector	1.47%	1.55%	0.96%	1.53%	1.03%	1.53%	0.94%
Inv. Real estate	25.97%	24.83%	25.86%	24.86%	25.79%	25.13%	24.75%
Inv. Sci. and tech. act.	5.94%	6.71%	2.39%	6.50%	2.97%	6.57%	2.15%
Inv. Culture	1.93%	1.94%	1.58%	1.80%	2.07%	1.91%	1.65%

Note. The values highlighted in green refer to the sectors of activity with the highest proportion of investment in each subset of regions analysed, with the values highlighted in darker green being the highest. By contrast, the values in red correspond to the lowest proportion of investment per sector in each subset of regions, with the darker red values highlighting the lowest proportion of investment. The values presented are calculated using data from Ardeco, where public investment is equal to the GFCF of the O-Q sector. To calculate the sum by sectors of activity, it is necessary to include the O-Q sector (public investment). The sum isn't necessarily 100%.

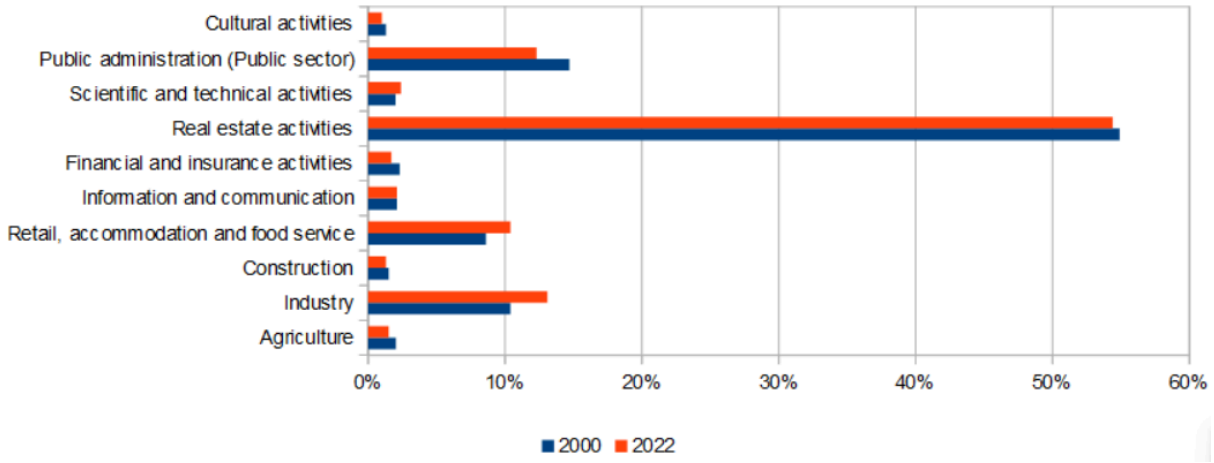
The main investment in the 25 NUTS III is in real estate activities, although the economic return on this type of investment is low when compared to investments in machinery or assets with greater incorporation of technology (BdP, 2018; Garcia, 2020). In all the subsets of regions analysed, GFCF in real estate activities is responsible for around a quarter of all investment, especially in the less developed regions. It should be noted, however, that real estate activities have the largest stock of assets at national level (Figure 2), and real estate is an asset with lower levels of depreciation and which tends to last longer

(BdP, 2018). On the other hand, activities linked to the provision of services have the smallest weight in both the annual change in GFCF and the capital stock (Figure 2).

Industry is the second sector of activity with the greatest weight in the total invested by the regions, especially in the less developed regions. There, the investments made tend to already include some incorporation of technology and a high volume of heavy machinery (Table 7), which justifies the existence of a higher economic return than GFCF in real estate activities, as we will see next.

Figure 2

Weight of the different sectors of activities in the Portuguese capital stock.



Note. The graph was prepared by the author using data taken from the INE on the distribution of the capital stock at national level. There are no values available from before 2000.

Less uniform is the investment effort made in subsequent places. In the most developed regions and those that invest the most, the sector of activity that brings together the retail trade and repair of vehicles, transport and storage, and accommodation and food service activities stands out. In these types of services, the fixed assets associated with them have a shorter useful life than in other sectors, which explains why investment in this sector of activity has a lower economic return. In the less developed regions and regions with less investment, GFCF stands out in the sector of activity that combines public administration and defence, social security, education, health and social support activities, and which is used in this work as a proxy for public investment. In this sector of activity, investment in infrastructures used for education and health is particularly important, and there is also some incorporation of technology, especially in public administration, which explains the economic return of this type of investment in the regions' GDP per capita.

On the other hand, financial and insurance activities are the sector of activity where total investment in the regions is least concentrated, with the exception of the regions with the highest population density. This low volume of investment also explains why GFCF in this type of activity doesn't have a significant impact on GDP per capita, as the investment that has been made is mainly in intellectual property products (Table 8), which have a greater impact on economic activity. In regions with a higher population density, investment is lowest in agriculture, given that in regions with a higher concentration of population per square kilometre, there is generally less space available for agricultural activity. Cultural activities, on the other hand, are the second sector of activity with the least investment in the regions, especially in the regions with the highest population density. This situation is paradoxical given that this type of activity tends to be more dynamic in places with a higher population concentration.

Table 8

Proportion of investment at national level by sector of activity and type of asset.

	Construction			**Transport equipment**			**Other machinery and equipment**			**Cultivated biological resources**			**Intellectual property products**		
	1995 (%)	2022 (%)	Var. (pp)	1995 (%)	2022 (%)	Var. (pp)	1995 (%)	2022 (%)	Var. (pp)	1995 (%)	2022 (%)	Var. (pp)	1995 (%)	2022 (%)	Var. (pp)
Agriculture	8.7	15.6	6.9	2.5	3.9	1.4	31.1	43.3	12.2	57.3	34.3	-23	0.4	2.9	2.5
Industry	30	47.4	17.4	5.8	1.7	-4.1	60.7	39	-21.7	0	0	0	3.9	11.8	7.9
Construction	36.8	33.1	-3.7	13.3	4.9	-8.4	49.2	54.4	5.2	0	0	0	0.7	7.6	6.9
Retail	44.4	57.5	13.1	33.7	19.9	-13.8	20.2	14.6	-5.6	0	0	0	1.8	8.1	6.3
Infor. & Com.	35.1	18.3	-16.8	1.2	0.4	-0.8	43.1	30.3	-12.8	0	0	0	20.6	51	30.4
Financial sector	65.7	-78.2	-12.5	4.1	6.9	2.8	21.3	50.6	29.3	0	0	0	8.9	120.8	111.9
Real estate	99.7	99.1	-0.6	0.2	0.2	0	0.1	0.4	0.3	0	0	0	0	0.3	0.3
Sci. & tec. act.	8.6	22	13.4	42.4	22.7	-19.7	26.8	20.5	-6.3	0	0	0	22.2	34.8	12.6
Public sector	73.6	45.9	-27.7	4.3	3.1	-1.2	12.3	19.5	7.2	0.1	0	-0.1	9.7	31.6	21.9
Culture	34.2	43.1	8.9	35.7	7.6	-28.1	22.7	24.7	2	0	0	0	7.4	24.7	17.3

Note. The values highlighted in green refer to the types of assets with the highest proportion of investment by each sector of activity, with the values highlighted in darker green being the highest. Conversely, the values in red correspond to the lowest proportion of investment by assets in each sector of activity, with the darker red values highlighting the lowest proportion of investment. The values presented are calculated using INE's FBFC data, by sector of activity.

4. Empirical results

4.1 Impact of investment on growth and regional externalities

Table 9 shows the results of the regressions regarding the impact of investment on the growth of the Portuguese regions as a whole. These results show that both investment in the respective regions and investment in neighbouring regions have a positive and statistically significant impact on GDP per capita (see Table 9, column 1). A 1% increase in GFCF increases GDP per capita by 0.559% and a 1% increase in GFCF from neighbouring regions increases the GDP per capita of the region under analysis by 0.125%. These results point to the existence of regional externalities in investment, in line with Rodríguez-Pose et al. (2012) and Modesto (2015). However, this indirect impact is less than that of the investment made in the respective regions.

With regard to the control variables, it can be seen that GDP per capita is persistent over time (Pereira & Andraz, 2010; Bom & Ligthart, 2014), influencing the GDP per capita of the following years. A growth of 1% in GDP per capita in the previous period increases the current GDP per capita by 0.243%. Capital productivity and labour productivity also have a positive and statistically significant relationship with GDP per capita, in line with the literature (Lucas, 1987; Romer, 1990; López-Bazo et al., 2004): an increase of 1 percentage point in capital productivity increases GDP per capita by 0.128%, while an increase of the same size in labour productivity increases GDP per capita by 0.011%. On the other hand, population has a negative and significant relationship with the dependent variable under study, which was expected given that a change in population behaviour directly affects GDP per capita, which has this variable as its denominator. A 1% increase in population reduces GDP per capita by 0.704%.

The same regressions were carried out with the investment variables calculated in net terms (with capital depreciation), but net investment is no longer relevant to explain the regions' GDP per capita (see Table 9, column 2). Although it may seem contradictory, this finding shows that gross investment – which reflects the total size of expenditure and makes it possible to capture indirect effects (externalities) at regional level – is only serving to replace machinery and equipment that has degraded in the meantime, rather than focusing on assets that can generate new net productivity gains (Romer, 1990). Furthermore, it should be kept in mind that these results may also reflect some inefficiency in the investments that have been made by the regions. This issue will be explored when analysing investment data by

sector of activity in the next section, to understand which sectors have the highest returns and compare them with the investment made.

Table 9

Regression of total gross and net investment.

	All regions	
	(1)	(2)
GDP (n-1)	0.243***	0.452***
	(0.055)	(0.059)
Population	-0.704***	-0.474***
	(0.088)	(0.066)
Capital productivity	0.128***	-0.025***
	(0.026)	(0.008)
Labour productivity	0.011***	0.030***
	(0.004)	(0.004)
Investment	0.559***	
	(0.107)	
Investment (neighbours)	0.125***	
	(0.024)	
Net Investment		-0.000
		(0.001)
Net Investment (neighbours)		0.003***
Observations	150	150
Number of id	25	25

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Disaggregating investment by public and private sector, we can see that both have positive and statistically significant coefficients in the correlation with the GDP per capita of the country's regions (see Table 10, columns 3), which is in line with the literature on the impact of investment on growth (e.g. Dreger & Reimers, 2016; Abiad et al., 2016; Matvejevs & Tkacev, 2024). Private investment still tends to contribute more to economic growth, in line with Garcia (2020).

On the other hand, investment by neighbouring regions shows mixed results when divided between public and private. In the case of public investment by neighbouring regions, there is no statistically significant effect on GDP per capita, according to the results. This conclusion contradicts several studies (e.g. Rodríguez-Pose et al, 2012; Quirino et al, 2014; Domańska, 2020), which conclude that there are regional externalities in public investment, as well as Modesto (2015), who concludes that there are externalities in public investment but that they are negative.

Table 10

Regression of total gross and net public and private investment.

	All regions	
	(3)	(4)
GDP (n-1)	0.281***	0.482***
	(0.054)	(0.074)
Population	-0.581***	-0.416***
	(0.099)	(0.071)
Capital productivity	0.099***	-0.024***
	(0.025)	(0.008)
Labour productivity	0.013***	0.026***
	(0.004)	(0.005)
Public Investment	0.046*	
	(0.024)	
Public Investment (neighbours)	-0.009	
	(0.021)	
Private Investment	0.391***	
	(0.095)	
Private Investment (neighbours)	0.143***	
	(0.033)	
Net Public Investment		-0.002*
		(0.001)
Net Public Investment (neighbours)		0.001
		(0.001)
Net Private Investment		0.001
		(0.001)
Net Private Investment (neighbours)		0.003***
		(0.001)
Observations	150	150
Number of id	25	25

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.

In net terms (see Table 10, column 4), the investment made by the public and private sectors isn't relevant in explaining GDP per capita, which can be attributed to the fact that GFCF isn't compensating for capital depreciation in most of the regions analysed. Only private investment made in neighbouring regions has an impact on GDP per capita, which may be due to pendular movements, in the sense that even though a neighbouring region receives a large amount of private investment (for example, to build a factory or shopping centre), the region in question can grow more because that is where the workers in that factory or shopping centre live and make their consumption expenditure, contributing directly to the growth of that region. In addition, the high level of regional integration means that there are positive externalities from this investment.

4.2 Impact of investment by sector of activity on growth

Considering the investment made by the different sectors of activities, it is possible to see that the type of investment made in the regions and in the neighbourhood has a different impact on GDP per capita, as suggested by the literature (Garcia, 2020; Silva, 2022; Matvejevs & Tkacev, 2023). Table 11 shows the results of the regressions carried out for the 10 sectors of activities listed above in Table 3.

From these results, it can be concluded that industry is the sector whose investment has the most direct and positive impact on the regions' GDP per capita (see Table 11, column 5), and that this is one of the sectors of activities with the greatest expression in the total investment of the Portuguese regions (Table 7). This type of investment also has regional externalities, but negative ones. This can be explained by the fact that investment in industry has a "magnet" effect, attracting skilled labour and additional investment to the regions where it is made. Furthermore, industry is one of the sectors of activity that is referred to in the literature as having a crowding-in effect on private investment (Matvejevs & Tkacev, 2023), which can lead to greater concentration in these regions. This will naturally harm the development of the surrounding regions (Krugman, 1991). The same goes for investment in professional, technical and scientific activities, which includes R&D activities that also serve as a "magnet" for the regions where they are carried out.

Also having a direct impact on the region's growth and an indirect impact on neighbouring regions appears the investment in information and communication, which represents less than 10% of total regional investment (Table 7). This is one of the sectors in Portugal that invests the most in research and development (Table 8), an area whose economic return tends to be higher (BdP, 2018). The externalities on the growth of neighbouring regions are also slightly positive.

The results also reveal that although real estate activities are one of the sectors of activities with the highest levels of GFCF in national terms (Table 7), this investment doesn't end up being translated into higher GDP per capita growth in the regions where it is made. This trend is explained by the fact that real estate activities are centred on dwellings services, which have a lower economic return than other sectors that invest more in assets with greater incorporation of technology or machinery (BdP, 2018). Even so, a region's GDP per capita tends to be favoured by investment from real estate activities in neighbouring regions. Investment in cultural activities, many linked to tourism and recreation, also contributes to the growth of GDP per capita.

Table 11

Regression of total gross and net investment by sector of activity.

	All regions	
	(5)	(6)
GDP (n-1)	0.281***	0.516***
	(0.067)	(0.069)
Population	-0.415***	-0.264***
	(0.116)	(0.087)
Investment in Agriculture (A)	0.021	0.005
	(0.025)	(0.006)
Investment in Agriculture (neighbours)	0.041	-0.007
	(0.042)	(0.008)
Investment in Industry (B)	0.100***	0.012***
	(0.023)	(0.003)
Investment in Industry (neighbours)	-0.047*	-0.002
	(0.028)	(0.004)
Investment in Construction (F)	0.015	0.000
	(0.013)	(0.001)
Investment in Construction (neighbours)	0.014	-0.000
	(0.014)	(0.001)
Investment in Retail, accommodation and food services (GI)	0.032	0.001
	(0.026)	(0.002)
Investment in Retail, accommodation and food services (neighbours)	-0.019	0.004**
	(0.028)	(0.001)
Investment in Information and communication (J)	0.028**	-0.001
	(0.013)	(0.001)
Investment in Information and communication (neighbours)	0.029*	0.001
	(0.015)	(0.001)
Investment in Financial and insurance activities (K)	0.003	0.001
	(0.002)	(0.002)
Investment in Financial and insurance activities (neighbours)	-0.001	-0.000
	(0.002)	(0.002)
Investment in Real estate activities (L)	0.036	0.000
	(0.022)	(0.001)
Investment in Real estate activities (neighbours)	0.117***	0.002**
	(0.030)	(0.001)
Investment in Scientific and technical activities (M-N)	0.018	0.001
	(0.021)	(0.001)
Investment in Scientific and technical activities (neighbours)	-0.058*	0.001
	(0.032)	(0.001)
Investment in Cultural activities	0.054*	-0.002
	(0.030)	(0.002)
Investment in Cultural activities (neighbours)	0.044	0.000
	(0.031)	(0.002)
Capital productivity	0.051***	0.021
	(0.012)	(0.015)
Labour productivity	0.014**	0.028***
	(0.006)	(0.005)
Observations	150	150
Number of id	25	25

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

In net terms (see Table 11, column 6), only investment from neighbouring regions in industry, retail and real estate activities is relevant to explain the growth in the regions' GDP per capita. This difference from the gross values is justified by the fact that regional externalities compensate, to a certain point, the levels of capital depreciation, which tend to jeopardise the economic return on investments made.

4.3 Differential impact of investment across the country

A more in-depth analysis of the country's regions leads to the conclusion that there are different dynamics in investment and its impact on GDP per capita. These differences are explained by various factors, including the level of development of the regions – given that the higher the GDP per capita of a region, the greater its capacity to invest (Pereira & Andraz, 2004) – as well as population density (Krugman, 1991) and the intensity with which the regions invest, as we will analyse later.

4.3.1 Impact by level of regional development

In this section, the previous model is estimated taking into account the level of development of the NUTS III regions, separating them into two large groups according to the average GDP per capita over the period analysed (sub-regions with the highest GDP per capita and sub-regions with the lowest GDP per capita, as shown in Table 4). It is concluded that investment has a greater economic impact in less developed regions than in more developed ones (Table 12, columns 7 and 11). This conclusion is in line with the neoclassical theory that in regions where a certain level of development has been reached, there are diminishing returns to scale in the accumulation of capital (Solow, 2005). This impact is greater than that observed when considering all Portuguese regions.

When it comes to investment in neighbouring regions, the results differ: the more developed regions benefit more than the less developed ones. This difference may be explained by the fact that a less developed region is more affected by investments that may "suck" labour and other resources to other regions, thus damaging its economic growth in the long run (Krugman, 1991; Pereira & Andraz, 2004).

In addition, because they are economically – and sometimes even physically – peripheral, these regions tend to be more isolated and less articulated with the productive structures of the neighbourhood. In the more developed regions, this issue doesn't arise as much because they are better able to mobilise complementary investments, as well as attract labour and other investments, and take advantage of economic integration.

Table 12

Regression of gross and net investment by level of development.

	More developed regions				Less developed regions			
	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
GDP (n-1)	0.281***	0.378***	0.334***	0.416***	0.150***	0.532***	0.161***	0.631***
	(0.071)	(0.078)	(0.083)	(0.100)	(0.030)	(0.121)	(0.038)	(0.117)
Population	-0.693***	-0.495***	-0.573***	-0.432***	-0.917***	-0.415***	-0.854***	-0.255**
	(0.137)	(0.114)	(0.178)	(0.146)	(0.064)	(0.124)	(0.064)	(0.120)
Capital productivity	0.127***	-0.023**	0.092**	-0.017	0.160***	-0.034	0.150***	-0.022
	(0.035)	(0.010)	(0.035)	(0.013)	(0.015)	(0.022)	(0.021)	(0.015)
Labour productivity	0.014***	0.030***	0.015***	0.024***	0.005	0.032***	0.006*	0.022***
	(0.005)	(0.005)	(0.005)	(0.007)	(0.003)	(0.006)	(0.004)	(0.008)
Investment	0.562***				0.759***			
	(0.137)				(0.067)			
Investment (neighbours)	0.136***				0.042			
	(0.025)				(0.034)			
Net Investment		-0.001				0.002		
		(0.001)				(0.002)		
Net Investment (neighbours)		0.004***				-0.000		
		(0.001)				(0.002)		
Public Investment			0.037				0.134*	
			(0.030)				(0.071)	
Public Investment (neighbours)			-0.022				-0.018	
			(0.033)				(0.053)	
Private Investment			0.376***				0.606***	
			(0.128)				(0.064)	
Private Investment (neighbours)			0.176***				0.042	
			(0.043)				(0.040)	
Net Public Investment				-0.001				-0.006
				(0.001)				(0.007)
Net Public Investment (neighbours)				0.000				0.004
				(0.002)				(0.006)
Net Private Investment				0.001				0.004***
				(0.001)				(0.001)
Net Private Investment (neighbours)				0.004***				0.001
				(0.001)				(0.002)
Observations	72	72	72	72	78	78	78	78
Number of id	12	12	12	12	13	13	13	13

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 13

Regression of gross and net investment by population density level.

	Regions with higher population density				Regions with lower population density			
	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
GDP (n-1)	0.269***	0.393***	0.278***	0.505***	0.177***	0.529***	0.205***	0.570***
	(0.094)	(0.134)	(0.087)	(0.102)	(0.037)	(0.085)	(0.047)	(0.093)
Population	-0.686***	-0.738***	-0.605***	-0.610***	-0.751***	-0.439***	-0.591***	-0.409***
	(0.139)	(0.213)	(0.146)	(0.206)	(0.079)	(0.113)	(0.119)	(0.138)
Capital productivity	0.105**	-0.012	0.092**	-0.017	0.168***	-0.031**	0.142***	-0.013
	(0.043)	(0.012)	(0.038)	(0.011)	(0.017)	(0.014)	(0.016)	(0.018)
Labour productivity	0.014**	0.038***	0.014**	0.018**	0.007**	0.024***	0.009**	0.026***
	(0.006)	(0.006)	(0.005)	(0.007)	(0.003)	(0.007)	(0.004)	(0.008)
Investment	0.478**				0.724***			
	(0.182)				(0.066)			
Investment (neighbours)	0.152***				0.082***			
	(0.040)				(0.023)			
Net Investment		0.002				-0.002		
		(0.002)				(0.002)		
Net Investment (neighbours)		0.002				0.003**		
		(0.002)				(0.001)		
Public Investment			0.095***				0.045*	
			(0.030)				(0.026)	
Public Investment (neighbours)			-0.072*				-0.002	
			(0.037)				(0.020)	
Private Investment			0.330**				0.578***	
			(0.147)				(0.056)	
Private Investment (neighbours)			0.224***				0.078***	
			(0.058)				(0.025)	
Net Public Investment				-0.003				-0.002
				(0.002)				(0.002)
Net Public Investment (neighbours)				-0.001				0.003
				(0.002)				(0.003)
Net Private Investment				0.001				0.000
				(0.001)				(0.002)
Net Private Investment (neighbours)				0.004***				0.003**
				(0.001)				(0.001)
Observations	72	72	72	72	78	78	78	78
Number of id	12	12	12	12	13	13	13	13

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 14

Regression of gross and net investment by investment level.

	Regions with more investment				Regions with less investment			
	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
GDP (n-1)	0.113*	0.458***	0.169**	0.565***	0.307***	0.518***	0.350***	0.526***
	(0.061)	(0.123)	(0.064)	(0.114)	(0.068)	(0.092)	(0.069)	(0.103)
Population	-0.731***	-0.596**	-0.771***	-0.637***	-0.560***	-0.422***	-0.343	-0.494**
	(0.132)	(0.283)	(0.121)	(0.180)	(0.172)	(0.115)	(0.226)	(0.206)
Capital productivity	0.171***	-0.015	0.144***	-0.015	0.113***	-0.030*	0.085***	-0.028*
	(0.020)	(0.012)	(0.021)	(0.014)	(0.033)	(0.017)	(0.029)	(0.015)
Labour productivity	0.007**	0.034***	0.007**	0.013	0.014**	0.027***	0.017**	0.027***
	(0.003)	(0.006)	(0.003)	(0.008)	(0.006)	(0.007)	(0.007)	(0.007)
Investment	0.736***				0.504***			
	(0.069)				(0.142)			
Investment (neighbours)	0.124***				0.112***			
	(0.020)				(0.033)			
Net Investment		0.000				-0.001		
		(0.002)				(0.003)		
Net Investment (neighbours)		0.004**				0.002		
		(0.001)				(0.002)		
Public Investment			0.074**				0.026	
			(0.032)				(0.044)	
Public Investment (neighbours)			-0.039				-0.005	
			(0.025)				(0.033)	
Private Investment			0.538***				0.361***	
			(0.068)				(0.110)	
Private Investment (neighbours)			0.178***				0.118***	
			(0.034)				(0.044)	
Net Public Investment				-0.003*				-0.002
				(0.001)				(0.002)
Net Public Investment (neighbours)				-0.002				0.003
				(0.002)				(0.002)
Net Private Investment				0.001				0.000
				(0.002)				(0.002)
Net Private Investment (neighbours)				0.005***				0.002
				(0.001)				(0.001)
Observations	72	72	72	72	78	78	78	78
Number of id	12	12	12	12	13	13	13	13

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 15

Regression of gross investment by sub-region and sector of activity.

	More developed	Less developed	With higher population density	With lower population density	With more investment	With less investment
	(31)	(32)	(33)	(34)	(35)	(36)
GDP (n-1)	0.335***	0.012	0.373**	0.359**	0.335**	0.285**
	(0.120)	(0.118)	(0.159)	(0.138)	(0.143)	(0.116)
Population	-0.259	-0.785***	-0.524	-0.441	-0.492**	-0.425
	(0.371)	(0.201)	(0.312)	(0.287)	(0.241)	(0.285)
Investment in Agriculture (A)	0.016	0.027	0.012	0.085	0.019	0.039
	(0.050)	(0.036)	(0.040)	(0.060)	(0.036)	(0.053)
Investment A (neighbours)	0.004	-0.032	-0.016	0.046	-0.028	0.072
	(0.105)	(0.083)	(0.093)	(0.076)	(0.079)	(0.076)
Investment in Industry (BE)	0.077*	0.163***	0.114***	0.097**	0.098*	0.118***
	(0.039)	(0.034)	(0.041)	(0.036)	(0.052)	(0.034)
Investment BE (neighbours)	0.005	-0.126**	0.017	-0.051	0.025	-0.071*
	(0.046)	(0.053)	(0.072)	(0.042)	(0.057)	(0.039)
Investment in Construction (F)	0.009	0.030	0.010	0.051*	0.027	-0.000
	(0.024)	(0.023)	(0.021)	(0.029)	(0.027)	(0.025)
Investment F (neighbours)	-0.011	0.010	-0.002	-0.020	-0.004	0.024
	(0.033)	(0.033)	(0.039)	(0.033)	(0.043)	(0.026)
Investment in Retail (GI)	0.026	0.081	0.010	0.042	0.021	0.056
	(0.066)	(0.061)	(0.046)	(0.048)	(0.046)	(0.045)
Investment GI (neighbours)	-0.012	-0.050	-0.026	0.016	-0.014	-0.027
	(0.058)	(0.075)	(0.070)	(0.052)	(0.058)	(0.055)
Investment in Information (J)	0.027	0.038*	0.020	0.013	0.020	0.010
	(0.033)	(0.020)	(0.027)	(0.020)	(0.023)	(0.017)
Investment J (neighbours)	-0.012	0.035	0.015	0.025	0.010	0.015
	(0.034)	(0.034)	(0.053)	(0.023)	(0.036)	(0.028)
Investment in Financial act. (K)	0.003	0.018	-0.000	0.003	0.002	0.004
	(0.003)	(0.021)	(0.004)	(0.017)	(0.004)	(0.004)
Investment K (neighbours)	-0.001	0.004	0.001	0.006**	0.002	0.002
	(0.004)	(0.003)	(0.006)	(0.003)	(0.005)	(0.005)
Investment in Real estate act. (L)	0.052	-0.027	-0.001	0.067	0.027	-0.003
	(0.047)	(0.103)	(0.065)	(0.043)	(0.051)	(0.054)
Investment L (neighbours)	0.127**	0.147	0.152	0.078	0.112*	0.107
	(0.050)	(0.137)	(0.099)	(0.061)	(0.059)	(0.067)
Investment in Sci. & tec. act. (MN)	0.019	0.047	0.022	-0.024	0.015	0.019
	(0.035)	(0.045)	(0.045)	(0.037)	(0.044)	(0.041)
Investment MN (neighbours)	-0.028	-0.058	-0.052	-0.048	-0.066	-0.025
	(0.056)	(0.053)	(0.062)	(0.034)	(0.061)	(0.043)
Investment in Cultural act. (RU)	0.076	0.004	0.066*	0.037	0.077	0.022
	(0.054)	(0.045)	(0.036)	(0.041)	(0.048)	(0.036)
Investment RU (neighbours)	0.003	0.107	0.069	0.023	0.086*	0.016
	(0.064)	(0.067)	(0.045)	(0.048)	(0.050)	(0.047)
Capital productivity	0.046*	0.076***	0.042**	0.072***	0.061**	0.050***
	(0.025)	(0.024)	(0.019)	(0.020)	(0.027)	(0.018)
Labour productivity	0.019	0.009	-0.006	0.015	-0.011	0.018**
	(0.014)	(0.012)	(0.018)	(0.012)	(0.012)	(0.008)
Observations	72	78	72	78	72	78
Number of id	12	13	12	13	12	13

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 16

Regression of net investment by sub-region and sector of activity.

	More developed	Less developed	With higher population density	With lower population density	With more investment	With less investment
	(37)	(38)	(39)	(40)	(41)	(42)
GDP (n-1)	0.539***	0.524**	0.407***	0.595***	0.521***	0.602***
	(0.127)	(0.214)	(0.121)	(0.159)	(0.126)	(0.154)
Population	-0.399	-0.236	-0.439*	-0.373	-0.348	-0.122
	(0.288)	(0.291)	(0.221)	(0.254)	(0.279)	(0.373)
Investment in Agriculture (A)	0.005	0.004	0.002	0.040	0.004	0.009
	(0.019)	(0.069)	(0.015)	(0.025)	(0.011)	(0.026)
Investment A (neighbours)	-0.005	-0.030	-0.006	-0.011	-0.016	-0.005
	(0.023)	(0.044)	(0.047)	(0.018)	(0.023)	(0.022)
Investment in Industry (BE)	0.012*	0.014	0.014**	0.015	0.012*	0.010
	(0.007)	(0.019)	(0.005)	(0.010)	(0.006)	(0.009)
Investment BE (neighbours)	0.019	-0.007	-0.002	-0.007	0.002	0.002
	(0.019)	(0.018)	(0.007)	(0.010)	(0.012)	(0.009)
Investment in Construction (F)	0.001	0.001	0.000	0.002	0.001	-0.001
	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
Investment F (neighbours)	-0.001	-0.001	0.002	-0.002	0.000	-0.000
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Investment in Retail (GI)	0.000	0.001	0.001	0.002	-0.002	0.004
	(0.004)	(0.007)	(0.003)	(0.003)	(0.003)	(0.003)
Investment GI (neighbours)	0.004	0.004	0.006	0.002	0.008**	0.003
	(0.003)	(0.007)	(0.003)	(0.002)	(0.003)	(0.003)
Investment in Information (J)	-0.000	-0.001	-0.001	-0.002	-0.001	-0.001
	(0.002)	(0.008)	(0.003)	(0.002)	(0.003)	(0.003)
Investment J (neighbours)	0.001	0.000	0.002	0.002	-0.000	0.001
	(0.003)	(0.009)	(0.007)	(0.002)	(0.004)	(0.003)
Investment in Financial act. (K)	0.001	0.009	-0.000	0.011***	-0.001	0.003
	(0.003)	(0.022)	(0.004)	(0.003)	(0.002)	(0.007)
Investment K (neighbours)	0.001	-0.007	0.003	-0.008*	0.002	-0.002
	(0.004)	(0.023)	(0.003)	(0.004)	(0.003)	(0.007)
Investment in Real estate act. (L)	-0.001	0.003	-0.002	0.001	-0.001	0.002
	(0.002)	(0.015)	(0.004)	(0.002)	(0.003)	(0.003)
Investment L (neighbours)	0.002	0.000	-0.000	0.002	0.001	0.003
	(0.003)	(0.009)	(0.004)	(0.002)	(0.003)	(0.003)
Investment in Sci. & tec. act. (MN)	0.002	0.002	0.002	-0.001	0.003	0.000
	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)
Investment MN (neighbours)	0.003	-0.001	0.003	0.002	0.001	0.001
	(0.003)	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)
Investment in Cultural act. (RU)	-0.002	-0.003	-0.002	-0.004	-0.001	-0.004
	(0.003)	(0.008)	(0.003)	(0.004)	(0.004)	(0.004)
Investment RU (neighbours)	-0.002	0.003	-0.000	0.001	-0.000	-0.000
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Capital productivity	0.022	0.028	0.021	0.040	0.022	0.044*
	(0.025)	(0.054)	(0.023)	(0.025)	(0.018)	(0.024)
Labour productivity	0.028**	0.026	0.015	0.032***	0.012	0.034***
	(0.013)	(0.021)	(0.013)	(0.010)	(0.011)	(0.009)
Observations	72	78	72	78	72	78
Number of id	12	13	12	13	12	13

Note. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

In net terms (Table 12, columns 8 and 12), only the GFCF of neighbouring regions has an impact on GDP per capita in the more developed regions, since they are better able to take advantage of the potential of the investment made in the surrounding regions, through complementary investments and the attraction of labour and other resources.

The analysis of the dynamics of public and private investment shows that, in developed regions, only private investment affects GDP per capita, both directly and indirectly. In the less developed regions, only public and private investment in these regions is relevant (see Table 12, columns 9 and 13), which means that these regions don't benefit from the externalities of investment in neighbouring regions. This is a unique case among the regions under analysis, which can be explained by the economic disarticulation between the less developed regions and the neighbourhood (Pereira & Andraz, 2004). In net terms (see Table 12, columns 10 and 14), only private investment from the neighbourhood contributes (but little) to the growth of the developed regions. In the less developed regions, only private GFCF has an impact on GDP per capita, albeit low.

By sector of activity (Table 15, columns 31 and 32), investment in real estate and industry has a direct impact on growth in the most developed regions. These two types of investment are also the ones that the more developed regions invest in the most (Table 7). In the less developed regions, the GFCF that has the biggest impact is industry, but this same investment in neighbouring regions has a negative impact on GDP per capita, which is congruent with the results for the 25 regions. Investment in information and communication also has a positive impact on growth, mainly due to telecommunications, which play an important role in the most disadvantaged regions and peripheral areas. In net terms (Table 16, columns 37 and 38), investment in industry has an impact on GDP per capita in the developed regions. In the remaining regions, none of these investments are relevant.

4.3.2 Impact by region's population density

One of the most important dynamics to explain Portugal's differentiated growth is the concentration of population (Lopes, 2001). A more densely populated region tends to attract more investment, companies, infrastructures and services, which generates the agglomeration economies (Krugman, 1991). In this section, the econometric model is estimated taking population density into account. The subset of 25 regions is divided into two new groups (regions with a higher population concentration and regions with less), as shown in Table 5. This division is based on the population density indicator (number of inhabitants per square kilometre) in 2022, since there is no data since 1995 to calculate the average for the 28 years

analysed. The results show that, in the case of the regions with the highest population density, population is the most relevant variable to explain GDP per capita (Table 13), but the region's investment and that of neighbouring regions remain relevant to explain GDP per capita.

In regions with a high population density, the direct and indirect impact of investment is slightly higher than the average value for all regions. But it is in regions with lower population density that the region's investment has a greater impact on GDP per capita (Table 13, columns 15 and 19), while the investment of neighbouring regions is lower than that observed in a region with higher population density. This difference can be explained by the fact that there are diminishing returns on the investment made by the regions and, in the case of the GFCF of neighbouring regions, the more populated regions are better able to capitalise on the positive externalities of the investment made in the surrounding regions, given that population concentration is associated with a concentration of productive factors and the existence of economies of scale (Lopes, 2001; Krugman, 1991). In net terms (Table 13, columns 16 and 20), the dynamics of investment in the regions with less population per square kilometre is identical to that of the regions as a whole, with only the net investment made by neighbouring regions being relevant and positive in explaining GDP per capita. In the case of regions with more population per square kilometre, investment (from the region or from neighbouring regions) has no relevance for GDP per capita.

When it comes to public and private investment (Table 13, columns 17 and 21), the dynamics are also very similar to those observed in the country's 25 regions as a whole, with public investment having a more relevant and positive coefficient on growth in the regions with the highest population density than in the others. It can also be seen that in the regions with the highest population density, public investment in the neighbourhood has a negative impact on growth, which isn't the case in the 25 national regions as a whole. And although the externalities of public investment in neighbouring regions are not relevant in explaining GDP per capita, private investment in the neighbourhood is significant in explaining the growth of both subsets of regions, especially those with higher population density, which can be explained by the existence of economies of scale and the concentration of productive factors (capital and labour). In net terms (Table 13, columns 18 and 22), only neighbourhood private investment has a positive impact on GDP per capita in the regions with the highest and lowest population concentration, in line with what happens in all Portuguese regions.

By sector of activity (Table 15, columns 33 and 34), in the regions with the highest population density, only investment by industry has a positive effect on GDP per capita, both in gross and net terms. On the other hand, gross GFCF from cultural activities also has a

positive and statistically relevant impact on GDP per capita in regions with more population concentration, despite the fact that investment levels in this sector of the activity in these regions are relatively low (Table 7). This positive impact can, however, be explained by the fact that, in these regions, population concentration generates greater demand for cultural or recreational activities. In regions with lower population concentration, investment in industry and construction also have a significant impact on growth. However, in net terms, these types of investment aren't relevant (Table 16, columns 39 and 40). The investment of neighbouring regions in the financial and insurance activities sector has a positive influence on GDP per capita in gross terms, but in net terms it is harmful. This difference can be explained by the fact that the gains in gross terms from investment in financial activities on GDP per capita, such as improving access to credit and encouraging consumption, don't compensate for the losses because there is no offsetting of the capital lost over the years analysed.

4.3.3 Impact by regional investment levels

In this section, the model is estimated once again, considering the 25 regions divided once again into two groups, according to their average investment levels in the period under analysis (Table 6). The sample is similar to that observed in the more developed regions, which shows that the regions with the highest GDP per capita also tend to invest the most, in line with the literature (Barro, 1990; Krugman, 1991). However, the regions of Cávado, Tâmega e Sousa, Ave and Oeste stand out from the sample. Although they are among the regions with the lowest GDP per capita, they are among those that invest the most. On the other hand, Alentejo Central, Baixo Alentejo and Alentejo Litoral are among the regions that invest the least, despite having a higher GDP per capita.

The results (Table 14) show that in the regions with more investment, the economic return on this investment in GDP per capita is higher than in the 25 regions as a whole and even higher than in the most developed regions. However, when it comes to GFCF made in neighbouring regions, the economic return for the regions that invest the most is slightly lower than the national average and contradicts the more significant gains seen in the more developed regions. This trend can be explained by the fact that the Portuguese regions that invest the most include regions whose level of development, in terms of GDP per capita, is lower than the average and, as we have seen, these regions have less capacity to make investments that are complementary to those in the neighbourhood, which may be having an impact on the joint results. In the regions with less investment, the neighbourhood's GFCF has a positive impact on GDP per capita, but the impact is less than in the regions that invest

more, precisely because they invest less and are underestimating the potential that exists in complementary investments (Table 14, columns 23 and 27). The investment made by the regions with less investment generates, as expected, less economic return and they don't benefit from any significant gain in GDP per capita from public investment, whether made by the regions themselves or by neighbouring regions.

In net terms (Table 14, columns 24 and 28), only the regions that invest the most benefit from the positive externalities of the investment made by their neighbours, and even then this return is relatively small. Meanwhile, the net investment they make isn't significant, which means that although they have higher levels of GFCF, this isn't enough to compensate for capital depreciations over time.

Decomposing this investment by public and private sectors (Table 14, columns 25 and 29), it can be seen that the region's public investment is only relevant to the GDP per capita of the regions that invest the most, with these having an impact above the national average. On the other hand, private investment by the region and its neighbours has a positive impact on the GDP of both sub-groups. In the case of the regions that invest the most, this impact is higher than the national average and that observed in the more developed regions. This higher return is explained, once again, by the fact that these regions invest more and that, with this accumulation of capital, they can make gains in efficiency and productivity (Romer, 1990; López-Bazo et al., 2004). Private investment by the neighbourhood has an impact on the GDP per capita of both the regions that invest the most and the regions that invest the least.

In net terms (Table 14, columns 26 and 30), the region's public investment is slightly harming GDP per capita growth in the regions with more investment, because it isn't offsetting capital depreciations over time, in line with what happens nationally (CFP, 2024). In the opposite direction, net private investment from neighbouring regions has a slight impact on GDP per capita in the regions with more investment, but is still slightly higher than the national average. The regions with less investment have no economic return on these investments, given the level of capital depreciation and the lack of investment.

By sector of activity (Tables 15, columns 35 and 36), only industry investment has an impact on GDP per capita in the regions that invest the most, and this investment generates a higher return in the regions with less investment and above the national average. This may indicate that there are diminishing returns to scale in this type of investment, as in the more developed regions. In regions with less investment, there are also externalities from the same investment made by the neighbourhood, but with a negative impact. It can also be seen that neighbourhood GFCF generates positive externalities in the per capita growth of the regions

which invest the most, when this investment is made by real estate and cultural activities. In net terms (Table 16, columns 41 and 42), the investment made by industry remains positive and statistically significant for the GDP per capita of the regions with the highest allocation to GFCF. Similarly to the 25 regions as a whole, investment in retail in neighbouring regions has an impact on GDP per capita, which is explained by the fact that this sector of activity is managing to compensate for material deterioration over time and is being "useful" for increasing the capital stock and thus generating more productivity. In regions with less investment, the net values of GFCF aren't relevant to explain GDP per capita.

4.4 Summary of the main results

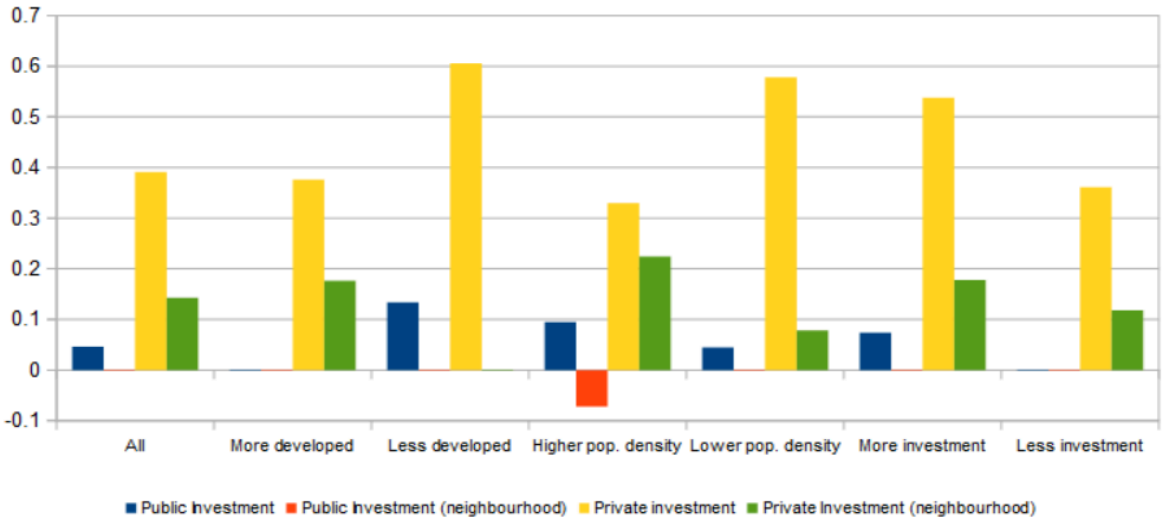
The empirical results are in line with the literature and suggest that investment has a significant and statistically significant impact on the economic growth of Portuguese regions (Modesto, 2015; Quirino et al, 2014), with a 1% increase meaning a growth in GDP per capita of 0.559%. This impact is particularly relevant when it comes to private investment, which has an impact on the GDP per capita of the 25 regions around eight times greater than that of public investment. It can also be seen that private investment made in other regions has a positive impact on GDP per capita, and there is an indirect impact of this investment, as suggested by Rodríguez-Pose et al. (2012). This indirect impact can be explained by complementarities in investments and regional interdependence. These externalities are positive and, on average, contribute to a growth in GDP per capita of 0.125% for every 1% increase in private investment made in the neighbourhood. On the other hand, public investment alone isn't relevant to explain the growth of regions, which contradicts Quirino et al. (2014). When net investment values are taken into account, only private investment in neighbouring regions is relevant and contributes positively to GDP per capita.

These results are more expressive when analysing the regions by sub-categories (more developed and less developed; with more population density and less; with more investment and less), particularly in the regions with more investment. This difference can be seen in Figure 3, which summarises the results obtained from the regressions carried out by sub-regions. On the other hand, the less developed regions don't benefit from the investment externalities of neighbouring regions, which points to an economic disconnection between these regions and the neighbourhood, and limits their per capita growth potential. In the regions with less investment, public investment (direct and indirect) isn't relevant in explaining GDP per capita. In regions with a higher population density, public investment in the neighbourhood has a negative impact on growth. In net terms, it is also interesting to note

that only the less developed regions benefit from the private investment they make, which is related to the fact that this type of investment has a lower level of depreciation than the other regions. The regions with less investment are the ones that benefit less from investment, because the capital is largely degraded and isn't renewed as often as would be desirable, harming GDP per capita. In fact, the regions with less investment don't benefit, in net terms, from any gain in GDP per capita due to the (poor) effort made in terms of investment.

Figure 3

Direct and indirect impact of public and private investment on regions' GDP per capita.



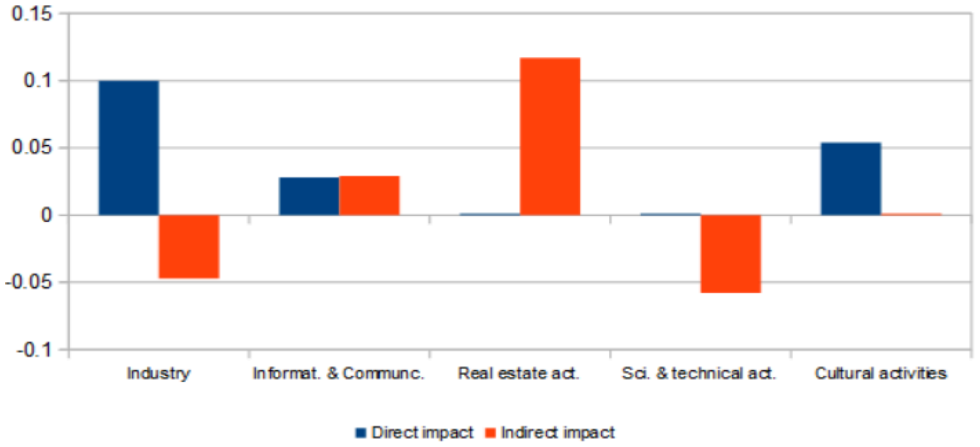
Note. The graph, prepared by the author, summarises the results obtained from the regressions carried out using the BCFE estimator, in order to understand the impact of investment (public and private) on the growth of Portuguese regions (divided into sub-categories) and whether this growth benefits (or not) from regional externalities of the investment made in the neighbourhood. As can be seen in the figure, public investment in the neighbourhood isn't relevant to explain the GDP per capita of any of the subsets of regions analysed, except in regions with a high population density. The direct impact of public investment is also not relevant in the more developed regions and those with less investment.

The results also show that, by type of investment, only GFCF in information and communication has a positive and significant impact on GDP per capita and positive externalities in the neighbourhood, as can be seen in Figure 4, which summarises the results obtained from the regressions referring to GFCF by sector of activity. This impact can be explained by the sector's strong commitment to assets with greater technological incorporation, whose economic return tends to be higher (BdP, 2018). But the strongest positive and direct impact on GDP per capita comes from investment in industry. This also has externalities in neighbouring regions, but these are negative, since investment in the

neighbourhood tends to capture productive resources in neighbouring regions and have a negative impact on the region's per capita growth. It should also be noted that investment in cultural activities has a positive impact on GDP per capita. With regard to investment in neighbouring regions, GFCF in real estate activities has a very significant and positive impact on regional growth, while GFCF in professional, technical and scientific activities and administrative services harms the GDP per capita of the 25 Portuguese regions.

Figure 4

Impact of different types of investment on GDP per capita in Portuguese NUTS III regions.



Note. The graph, prepared by the author, summarizes the results obtained from regressions using the BCFE estimator to quantify the impact of investment by different sectors of activity on the GDP per capita of 25 Portuguese regions as a whole. The graph considers only the types of investment, by sector of activity, whose impact on the regions' GDP per capita is statistically significant. In the case of real estate and scientific and technical activities, GFCF isn't relevant to explain GDP. In cultural activities, it is the indirect impact (spillovers) that isn't relevant.

Only investment in industry is consistent when analysing regional data by sub-category, producing a positive impact across all regions where it occurs. When carried out in neighbouring regions, investment in industry is especially harmful to per capita growth in less developed regions and those with less investment. Investment in real estate in neighbouring regions has a significant and positive indirect impact, especially in more developed regions and those with more investment, and investment in cultural activities has a significant and positive impact in regions with higher population density, where these types of activities have greater demand. On the other hand, investment in information and communication is especially relevant and positive to GDP per capita in less developed regions, particularly the GFCF in telecommunications.

5. Conclusion

This study analysed the impact of public and private investment on GDP per capita in the 25 Portuguese NUTS III regions between 1995 and 2022 (divided into seven periods of four years each), using the Bootstrap-based Bias-Corrected Fixed Effects (BCFE) estimator. The novelty of this study is that it analyses both the economic impact of public and private investment in Portuguese regions over a period of almost three decades and explores the impact of different types of investment, based on the sectors of activity defined at European level with NACE. The main objective was to understand the extent to which investment at regional level has contributed to differentiated growth in the country. The aim was to quantify the direct impact of investment in the regions, the externalities of investments made by neighbouring regions and to understand to what extent the type of investment made makes the growth potential of the regions different.

The empirical results obtained point to a positive and significant impact of investment on the economic growth of Portuguese regions, in line with the literature (Modesto, 2015; Quirino et al., 2014), with the impact of private investment tending to be stronger than that of public investment. The impact of the private sector GFCF is around eight times higher than that observed in the public sector. Investment made in other regions also has a positive impact on GDP per capita, pointing to the existence of positive externalities in investment made in the neighbourhood (Rodríguez-Pose et al, 2012). However, it is only in private investment that these positive externalities occur and are consistent in net terms.

In the regions with more investment, this tendency is even more pronounced, with the GFCF of the region and neighbouring regions having a higher impact on GDP per capita than the average of the 25 regions. On the other hand, the less developed regions don't benefit from externalities. In the regions with less investment, the impact of capital deterioration is notable, since in net terms they don't benefit from any added value on GDP per capita.

Investments in industry, information and communication, and cultural activities have the greatest direct impact on the growth of Portuguese regions. However, only investment in information and communication manages to have positive externalities when made in neighbouring regions. The impact of industry's GFCF on neighbouring regions even has a negative impact, which suggests that this is one of the sectors where neighbourhood investment tends, on average, to capture resources and hinder economic growth. The same goes for scientific and technical activities, which include scientific research and development activities. In net terms, only private investment from the neighbourhood is relevant and contributes positively to GDP per capita, especially in real estate and retail.

Due to the unavailability of data at regional level, one of the limitations of this article is the lack of a detailed analysis of the assets in which investment is made, since the economic return on GFCF depends above all on the type of assets prioritised. For example, in construction, in addition to buildings – which have a low economic return – it also invests in intellectual property assets, which generate a higher return (BdP, 2018). Therefore, an analysis of the distribution of investment by asset on a regional scale would be interesting to enrich the analysis of the investment dynamics of the Portuguese regions. Similarly, the public investment data used in this study should be interpreted with some caution, as it is a proxy that adds together the GFCF of the O-Q sector of activity, which includes public administration, defence, social security, education, health and social support activities. However, this NACE category doesn't coincide 100% with the public institutional sector (Eurostat, 2008). Similarly, private sector GFCF – calculated by subtracting total investment from the public investment proxy – should also be viewed with caution.

Even so, these results reinforce the need for political decision-makers to adopt measures to stimulate investment as a factor in development and regional cohesion, since GFCF has a positive impact on all regions, particularly in the less developed and less densely populated regions. Promoting investment is also important to compensate for the high levels of capital deterioration in Portugal's regions, particularly in those regions where GFCF levels tend to be lower, namely the country's inland regions and the autonomous region of Açores. Reducing taxes for companies that invest in productive sectors is a good measure in this direction, with a focus on industry, information and communication activities (especially telecommunications and IT), and other sectors with technological incorporation, whose economic return tends to be greater. Facilitating the access to financing and creating more tax benefits for regions with net investment deficits are also measures to be taken into account.

The results obtained raise some interesting questions for future studies, namely to determine how the returns on investment, both public and private, can be maximised and to understand, in an analysis of the political trade-off in the distribution of investment at regional level, whether the allocation of GFCF in Portugal has been equitable or whether preference has been given to an efficient allocation (Yamano & Ohkawara, 2000; Berg et al., 2015), favouring the more developed regions that benefit more from increasing returns to scale. Another interesting analysis would be to understand to what extent the 2008 financial crisis and subsequent financial restrictions influenced the potential growth of Portuguese regions, through a reduction in investment (Blanchard & Leigh, 2013; Dreger & Reimers, 2016), and how this impact resulted in differentiated growth in the country.

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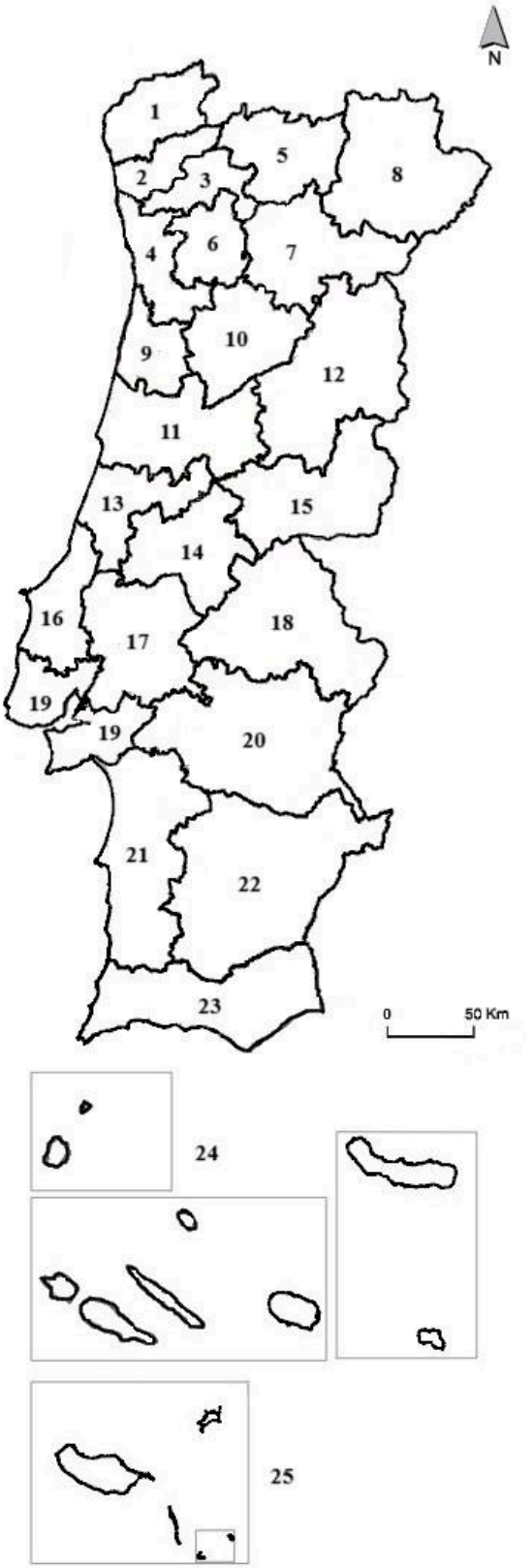
Appendix A

Map of NUTS III regions of Portugal (2013 division).

1. Alto Minho
2. Cávado
3. Ave
4. Área Metropolitana do Porto
5. Alto Tâmega
6. Tâmega e Sousa
7. Douro
8. Trás-os-Montes
9. Região de Aveiro
10. Viseu Dão Lafões
11. Região de Coimbra
12. Beiras e Serra da Estrela
13. Região de Leiria
14. Médio Tejo
15. Beira Baixa
16. Oeste
17. Lezíria do Tejo
18. Alto Alentejo
19. Área Metropolitana de Lisboa
20. Alentejo Central
21. Alentejo Litoral
22. Baixo Alentejo
23. Algarve
24. Região Autónoma dos Açores
25. Região Autónoma da Madeira



Source: INE.

Appendix B

Descriptive statistical analysis of the variables used.

		Mean	Std. dev.	Min.	Max.	Obs.
lGDPpc	Overall	9.580774	.2323638	8.932697	10.12688	175
	Between		.2100561	9.207888	10.07525	
	Within		.106728	9.278697	9.834504	
lGFCF	Overall	20.52061	.8866842	18.97367	23.41494	175
	Between		.881916	19.11008	23.20904	
	Within		.1877577	19.97426	21.11509	
lWGFCF	Overall	19.2107	5.721965	0	22.46582	175
	Between		5.821463	0	22.25236	
	Within		.1416314	18.92011	19.51838	
lPOP	Overall	12.51313	.7956912	11.30555	14.87534	175
	Between		.8083987	11.39831	4.82876	
	Within		.0463764	12.36481	12.62013	
Capproduct	Overall	4.269887	.8809606	1.75418	6.468009	175
	Between		.2567547	3.753296	4.772903	
	Within		.8440626	2.114902	6.828731	
Labproduct	Overall	15.42005	3.160808	8.624909	25.4974	175
	Between		2.729897	11.1735	22.86493	
	Within		1.671929	11.7552	19.37442	
PubInv	Overall	18.72824	.8333198	17.02023	21.36271	175
	Between		.8191764	17.52773	21.21257	
	Within		.2156653	18.173	19.11414	
WPubInv	Overall	17.47419	5.207788	0	20.39951	175
	Between		5.296818	0	20.24679	
	Within		.1795221	16.93796	17.85861	

		Mean	Std. dev.	Min.	Max.	Obs.
PrivInv	Overall	20.32559	.9109577	18.72968	23.28168	175
	Between		.9048581	18.8758	23.05879	
	Within		.198265	19.73685	21.02582	
WPrivInv	Overall	19.0519	5.677368	0	22.33258	175
	Between		5.77595	0	22.10418	
	Within		.1459601	18.74534	19.36338	
lGFCFA	Overall	17.28522	.6311597	15.46827	18.66295	175
	Between		.6092796	16.10053	18.5286	
	Within		.1998541	16.54956	17.96219	
lWGFCFA	Overall	16.09426	4.776892	0	18.39902	175
	Between		4.859585	0	18.16417	
	Within		.1321481	15.74703	16.56424	
lGFCFBE	Overall	18.93845	.9533796	16.54907	21.19062	175
	Between		.9072553	17.30497	21.00509	
	Within		.3379405	17.9774	19.66534	
lWGFCFBE	Overall	17.78892	5.294947	0	20.44045	175
	Between		5.382658	0	20.24135	
	Within		.2500542	17.10538	18.33996	
lGFCFF	Overall	17.17684	1.004489	15.00155	20.07487	175
	Between		.8852693	15.66547	19.46862	
	Within		.5023161	15.7666	18.18229	
lWGFCFF	Overall	16.07067	4.80655	0	19.23537	175
	Between		4.872802	0	18.65332	
	Within		.421288	14.94352	16.95062	
lGFCFGI	Overall	18.51213	1.033847	16.22315	21.58919	175
	Between		.996817	17.01259	21.38897	
	Within		.3308446	17.54135	19.20324	

		Mean	Std. dev.	Min.	Max.	Obs.
lWGFCFGI	Overall	17.34053	5.189144	0	20.62086	175
	Between		5.273594	0	20.43171	
	Within		.2746182	16.42153	17.88243	
lGFCFJ	Overall	16.50855	1.498729	13.65126	21.21886	175
	Between		1.468805	14.49941	21.06083	
	Within		.3941023	15.42145	17.20709	
lWGFCFJ	Overall	15.79453	5.060396	0	20.13225	175
	Between		5.019503	0	19.97972	
	Within		1.131817	2.932892	18.47605	
lGFCFK	Overall	13.8408	3.789836	0	19.52746	175
	Between		1.515441	11.34586	17.81849	
	Within		3.485038	2.128618	19.12952	
lWGFCFK	Overall	13.60171	4.932291	0	18.52714	175
	Between		4.267782	0	16.87145	
	Within		2.596458	4.673458	17.76762	
lGFCFL	Overall	19.01035	1.022883	17.35143	22.23927	175
	Between		.971845	17.83044	21.77315	
	Within		.366572	18.30058	19.83913	
lWGFCFL	Overall	17.80693	5.325054	0	21.27147	175
	Between		5.409531	0	20.78872	
	Within		.3197617	17.23196	18.42517	
lGFCFMN	Overall	16.83115	1.336671	13.75721	21.33989	175
	Between		1.298602	14.51906	20.87872	
	Within		.3980883	15.81557	17.80126	

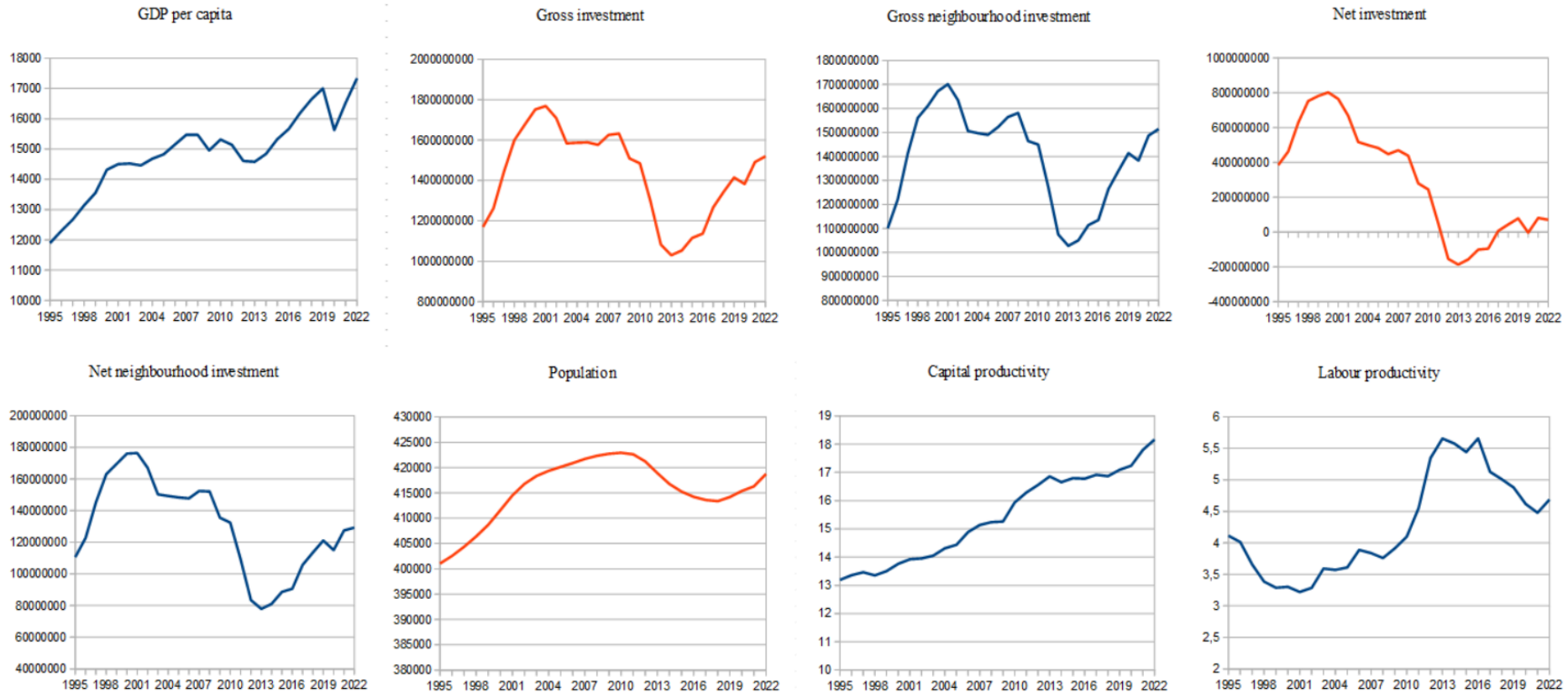
		Mean	Std. dev.	Min.	Max.	Obs.
lWGFCFMN	Overall	16.08427	4.898425	0	20.28589	175
	Between		4.971971	0	19.83694	
	Within		.3556693	15.11489	17.05438	
lGCFRU	Overall	16.29349	1.110934	13.66804	19.7895	175
	Between		1.03479	14.55684	19.28183	
	Within		.4475566	15.40469	17.44661	
lWGCFRU	Overall	15.35671	4.623796	0	18.78936	175
	Between		4.68795	0	18.28085	
	Within		.4005464	14.59913	16.36093	
lnGFCF	Overall	14.30343	7.535784	0	22.37375	175
	Between		2.27235	10.96317	18.28438	
	Within		7.197397	-1.664084	23.23258	
lnWGFCF	Overall	14.16275	7.589404	0	21.49435	175
	Between		4.554795	0	20.94834	
	Within		6.129297	-1.189626	21.85267	
lnPubInv	Overall	10.90283	7.940422	0	20.12915	175
	Between		.9063063	7.038753	12.44023	
	Within		7.890325	-1.537402	23.99323	
lnWPubInv	Overall	9.732145	8.214089	0	19.32284	175
	Between		3.202058	0	12.02518	
	Within		7.587598	-2.293034	21.64452	
lnPrivInv	Overall	15.10361	6.588291	0	22.29434	175
	Between		2.197733	11.78729	18.67623	
	Within		6.224315	-.862215	23.4443	
lnWPrivInv	Overall	14.68273	7.212313	0	21.40475	175
	Between		4.682878	0	20.93247	
	Within		5.553764	-1.434765	21.51553	

		Mean	Std. dev.	Min.	Max.	Obs.
lnGFCFA	Overall	14.39602	4.717604	0	18.06194	175
	Between		4.338785	.4896482	17.64014	
	Within		2.019869	8.016227	26.3381	
lnWGFCFA	Overall	15.02005	4.497126	0	17.65291	175
	Between		4.550371	0	17.15876	
	Within		.4819351	10.87781	16.21245	
lnGFCFBE	Overall	17.2623	2.25263	4.37982	20.34742	175
	Between		1.286594	13.17166	18.91051	
	Within		1.86443	8.470453	22.38276	
lnWGFCFBE	Overall	16.5821	5.010543	0	19.57854	175
	Between		5.034762	0	18.99232	
	Within		.7942369	12.16316	17.73129	
lnGFCFF	Overall	10.79172	6.951541	0	19.39781	175
	Between		3.125602	6.797265	16.24212	
	Within		6.236297	-1.938324	20.59805	
lnWGFCFF	Overall	10.33487	6.92351	0	18.82362	175
	Between		3.579272	0	14.91172	
	Within		5.963687	-3.028671	19.91187	
lnGFCFGI	Overall	13.93533	5.505552	0	20.76008	175
	Between		1.557845	11.72744	17.59988	
	Within		5.288469	.7659683	20.54211	
lnWGFCFGI	Overall	13.15671	6.530363	0	19.86574	175
	Between		4.071346	0	16.21579	
	Within		5.161527	-1.680495	18.48748	
lnGFCFJ	Overall	11.63543	5.866685	0	20.07121	175
	Between		2.479549	8.666296	17.88939	
	Within		5.336838	-4.412831	18.53409	

		Mean	Std. dev.	Min.	Max.	Obs.
lnWGFCJ	Overall	12.08906	6.623505	0	18.97376	175
	Between		4.42643	0	17.46115	
	Within		4.995315	-3.107961	18.61271	
lnGFCFK	Overall	9.589112	7.197084	0	18.67843	175
	Between		.6652339	8.761296	11.54797	
	Within		7.167339	-1.958858	18.76005	
lnWGFCFK	Overall	8.939812	7.423053	0	17.78425	175
	Between		2.753256	0	10.84621	
	Within		6.912502	-1.906397	17.09795	
lnGFCFL	Overall	8.659729	8.688686	0	21.24912	175
	Between		1.903012	5.367972	12.53983	
	Within		8.485086	-3.8801	21.21667	
lnWGFCFL	Overall	8.40169	8.747785	0	20.34615	175
	Between		2.690821	0	10.69338	
	Within		8.338638	-2.291687	20.52759	
lnGFCFMN	Overall	10.04588	5.706569	0	20.15448	175
	Between		3.486898	1.561344	17.21474	
	Within		4.563521	.7563454	20.05022	
lnWGFCFMN	Overall	10.29681	6.406391	0	19.08145	175
	Between		4.511221	0	16.94472	
	Within		4.625203	.6144443	19.62599	
lnGFCFRU	Overall	9.182271	6.196968	0	18.51436	175
	Between		2.940458	5.481649	16.13115	
	Within		5.482177	-1.034961	20.39468	
lnWGFCFRU	Overall	8.804798	6.610112	0	17.63674	175
	Between		3.927852	0	15.49171	
	Within		5.366336	-1.301186	19.37681	

Appendix C

Graphs of variables used.



Note: The study also considers other disaggregated investment variables (public and private, and by sector of activity). For the sake of brevity, the graphs for these variables aren't presented here. A description of these variables can, however, be found in Appendix B.