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ORIGINAL ARTICLE

Export economic growth, social welfare, and economic development: a departmental analysis for Perú, 2005-2019

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Abstract
This thesis exposes the relationship between traditional and non-traditional exports, with social well-being and economic development. Social well-being will be approximated by estimating a Sen well-being index; while economic development is approximated, from a standard perspective, by GDP per capita. The results obtained show that social well-being depend directly on the level of non-traditional exports, while economic development depends directly on both traditional and non-traditional exports. Finally, social well-being and economic development are concomitant but obey different explanatory variables.

Key words: non-traditional exports, traditional exports, Peru, social welfare, economic development.

1. Introduction

In Sunkel's classic text (1979), development is conceived as a process of global change; that is, as a deliberate process of social change with the ultimate goal of equalizing economic and social opportunities in relation to countries with higher levels of wealth and material well-being. Likewise, concerning underdeveloped economies, such as Peru, the fundamental problem of development is conceived as the need to overcome a state of dependence, in order to achieve a transformative process of its productive structure that allows it to obtain a greater capacity for growth of the economic system and an expansion of the production possibility frontier. Thus, under this perspective, the Peruvian economy is characterized as an underdeveloped capitalist economic system, where poverty is massive and income distribution inequality is at a high level (Figueroa, 1992). tabla 1

Table 1. Percentage of departmental salaried EAP, 2017

Department	%Salaried EAP	Department	%Salaried EAP
Ica	61.2 %	Apurímac	33.9 %
Lima	61.0 %	Huánuco	31.9 %
Arequipa	55.8 %	Puno	30.1 %
Moquegua	54.9 %	Cajamarca	29.6 %
Tumbes	50.2 %	Huancavelica	26.4 %

Note. Source National Institute of Statistics and Informatics.

Another relevant characteristic of an underdeveloped economy is the low percentage of the economically active population that is under the condition of wage earners, while the non-wage sector is economically organized around small economic, commercial and agricultural units since the stock of fixed capital is insufficient to employ most of the labor force as wage earners. This is a situation of overpopulation (Figueroa, 1986). This characterization particularizes the nature and functioning of the labor market, leaving the theoretical framework of supply and demand for labor as an insufficient tool to explain its functioning (Figueroa, 1994).

Therefore, this particular structure of the Peruvian economy, as a capitalistically underdeveloped economy is reflected in the low proportion of the economically active population under wage conditions in each department of Peru, a situation that still persisted in 2017, despite the economic growth of the last twenty years, as shown in Table 1. Consequently, in Peru, there has been an export-led growth process in recent years on this productive structure and characterization of the economy's labor market.

Regarding the characterization of recent economic growth in the Peruvian economy and its relationship with poverty, according to García Carpio and Céspedes Reynaga (2011) and Céspedes Reynaga (2017), it is argued that economic growth has allowed poverty levels to be reduced, as well as income distribution inequality. An average annual growth of 5.1%, between 2004 and 2016, has had an impact on the poverty rate, reducing it by 65%, although there is heterogeneity between departments in relation to the impact on poverty and inequality. That is, for some departments such as Moquegua, there has been pro-poor economic growth, while for others such as Cajamarca, it is classified as non-pro-poor. On the other hand, in relation to the effects of inequality, Jaramillo and Saavedra (2011) provide evidence of the existence of a relationship between higher economic growth and the reduction of inequality for early periods of growth. That is, they find a significant reduction in the Gini index of 3.6 points during the growth period from 2001 to 2006 and a decrease of 5 points during the entire period 1997-2006.

To identify the role that exports play in the economy and their relationship with economic growth, the findings of Bello Alfaro (2012) are collected, who shows a remarkable growth in exports for a long period, from 1970 to 2010[1] , with a positive impact on GDP measured with an estimated elasticity of 0.1250. On the other hand, León (2014), evaluating the performance of exports of traditional mining products for the period 1993-2013, using a time series model, estimates an elasticity of exports of these products concerning Chinese GDP for the long term equal to 1.4.

In addition, for more recent periods, Vargas Ruiz (2018), using a VAR model, shows short-term results, estimating lagged effects of exports on GDP with elasticities of 0.0322, 0.1389 and 0.1830 for each lag, respectively, although only significant for the third lag. Also, the econometric treatments with cointegration carried out by Angulo Delgado and Cabello Puelles (2019) are collected, who show, for the period 1980-2016, an empirical positive relationship between economic growth and exports, estimating a long-term elasticity of 0.158. In addition, they estimate a positive elasticity between traditional exports and GDP of around 6.556 and for non-traditional exports of around 0.207.

While Gonzales Fernandez (2018) estimates an elasticity GDP-exports equal to 0.257 for the period 1990-2016 using a time series model. In conclusion, these studies show that there is a significant relationship between economic growth and exports. However, all these studies are limited to evaluating the effect of exports on national GDP, without considering possible structural differences that may exist in the Peruvian economy, at the departmental level, due to the nature of an underdeveloped economy, specifically a labor market that operates with overpopulation. In this sense, to characterize the export-led economic growth of the Peruvian economy in recent years and its effect on social welfare and economic development, we must consider the role played by traditional and non-traditional exports with the intention of capturing heterogeneous effects under a theoretical framework such as the one supported by Boloña Behr (1975), Figueroa (1986) and Almada y Reche (2019).

2. Theoretical Bases

1. Exports for 1970 were 1,034 million dollars, while by 2010 it had a value of 35,310 million dollars.

2.1 Social Welfare

There are various proposals for the conceptualization and operationalization of social welfare from an empirical point of view. Actis Di Pasquele (2008) provides a classification of welfare indexes, where a comparison is made between synthetic indexes, after a discussion of the differences between the operationalization of the concept of social welfare and that of quality of life.

On the other hand, Actis Di Pasquele (2015) points out that Sen recognizes three meanings encompassed in the concept of social welfare under the utilitarian approach. First, as happiness; then, as the satisfaction of desire; and finally, as a choice, and any of them have different implications in relation to the distributive aspects of income. Likewise, another consequence refers to the estimation of social welfare, where collective welfare becomes the algebraic sum of individual utilities, without considering the distributive aspect of income. Therefore, there is a need to introduce corrections to the monetary variable through which the circumstances of people are considered, such as the differentiation in the level of income; therefore, consequently, inequality can be useful to introduce such corrections.

In addition, according to Molpeceres Abella (2008), for the classification of welfare measures, it is pointed out that the main factors that affect welfare can be measured in monetary terms. This methodology should take into account those elements that negatively affect well-being; therefore, monetary values should be added, subtracted, or corrected according to other factors such as, for example, leisure, pollution, and durable goods, respectively.

Additionally, as a reference for the construction of a social welfare indicator for the case of Brazil, Vidigal et al. (2017) point out that GDP per capita is one of the oldest measures of economic well-being; however, it does not collect anything about income distribution, life expectancy or disaggregated expenditure levels, the stock of natural resources, etc. Consequently, it constitutes an aggregate measure that is not free of certain disadvantages by not collecting information on relevant economic variables.

For objective indicators of social welfare, Villar (2017) focuses on the relationship that may exist between distributive inequality and welfare loss (understood as a greater amplitude of welfare inequality), the correspondence that may exist between welfare indexes and social welfare functions. Consistency between inequality indexes and social welfare functions requires that they be of a cardinal type. Then, the strict quasi-concavity of the social welfare function would imply that any convex combination of any two income distributions, of a given total income volume, unequivocally increases social welfare. That is, society will prefer smaller distributions to more unequal distributions; that is, there is an aversion to inequality. In the face of this, Sen (1973) formulates a social welfare function that depends directly on the distribution of income and verifies the properties of symmetry and strict quasi-concavity. Then, given the equivalent egalitarian income:

Definition 1. [Generalized equivalent egalitarian income, Y]

It is the level of per capita income that, if enjoyed by all members of society, would produce the same level of social welfare generated by the current income distribution. In other words, Y is that value of y such that (Equation 1):

$$W(\gamma i) = W(y) \tag{1}$$

where $i = \underbrace{(1, 1, \ldots, 1)}\, n.$

And, given that the welfare function W(y) is symmetric and strictly quasi-concave, the generalized equivalent egalitarian income is less than the mean income. Then, Sen's inequality measure Sen I_s is given by (Equation 2):

$$I_s = 1 - \frac{\gamma}{\mu} \tag{2}$$

next, note that the value of Y effectively depends on the social welfare function W(y). Then, it will be possible to derive Sen's social welfare function, generalizing it for any index that can measure income distribution inequality I, where $0 \leq I \leq 1$. Sen's welfare function would be expressed as (Equation 3):

$$W_s(y) = \mu(1 - I) \tag{3}$$

where $\mu > 0$ *is the mean income of society.*

Thus, Riveros-Gavilanes (2021) estimates Sen's welfare index for Latin America using the Gini index. Then, from Equation 3 we derive the following relationships: the higher the mean income of the income distribution, the higher the level of welfare (Equation 4):

$$\frac{\partial W_s}{\partial \mu} = (1 - I) > 0 \textit{ whenever que } 0 < I < 1 \tag{4}$$

and the lower the income distribution inequality, the higher the level of welfare, that is (Equation 5):

$$\frac{\partial W_s}{\partial I} = -\mu < 0 \textit{ para } \mu > 0 \tag{5}$$

Finally, there is another line of research on social welfare that rests on psychology and has two traditions: a hedonic one that focuses on subjective well-being and a eudaimonic one that focuses on psychological well-being (Blanco y Díaz, 2005). For the purposes of this research, our concept of social welfare does not follow this perspective, since the relationship between subjective well-being and income is not evident in cross-sectional data to compare rich countries with poor countries; moreover, neither is it when comparing longitudinal data (Betalleluz, 2018).

2.2 Economic Development

In the mainstream economic literature, the concept of economic development focuses on GDP per capita. According to Sunkel (1979), regardless of the structural characteristics of economies, classifying countries according to their GDP per capita is a recurrent presentation of the economic growth approach, which refers to the dynamics of the economy and not so much to the structure.

From another perspective, economic development is conceived as a process of economic growth. From the early theoretical developments of economic growth theory with Harrod (1939) and Domar (1946), through the contributions of Solow (1956) to the recent ones of Romer (1986), Romer (1990) and C. I.Jones (1995), a set of variables has been identified that include human capital, in addition to physical capital, as determinants of economic growth.

Regarding this conception of economic development as a process of economic growth, even recognizing its possible limitations and omissions, it was standardized beyond the academic sphere when, starting in 1978, the World Bank published the World Development Report, establishing a ranking and classifying countries according to their GDP per capita level (Uribe Mallarino, 2008). This position, to date, has not changed.

Subsequently, in the light of the new contributions of economic growth theory, such as those of Romer (1986, 1987), Lucas (1988) and Barro (1991), economic growth economists pointed out that economic development theories were based on models of little rigor, which constituted a limitation for empirical treatment, focusing research on the long-term growth rate, since they pointed out that small differences between the growth rates of countries (of 1 percentage point), would translate in the future into a significant difference in the standard of living between countries (Barro and Sala-i-Martin, 2004).

One of the problems addressed by economic growth theory is to explain the determinants of the level of per capita production. Solow (1956), in the article *A contribution to the Theory of economic growth*, presented a model of economic growth in a line different from that of the Keynesian-type models formulated independently by Harrod (1939) and Domar (1946). Solow's (1956) model proposes a per capita production function, where $y = k^{\alpha}$, whose solution proposes (Equation 6):

$$y = K^{\alpha} = \left(\frac{s}{\delta + n}\right)^{\frac{\alpha}{1-\alpha}} \tag{6}$$

where k is the level of physical capital per capita, s is the investment rate, δ is the depreciation rate of physical capital, n is the population growth rate, and y is the output per capita. This model indicates that an economy with a higher level of capital per capita should have a higher level of output per capita.

On the other hand, later developments incorporated human capital in order to account for GDP per capita levels. In an article, Mankiw et al. (1992) made adjustments to the Solow model by incorporating differences in education levels and skills between different countries. The model formulates a level of output per capita (Equation 7):

$$y = (Ah)^{\alpha} K^{1-\alpha} = Ah\left(\frac{s}{\delta + g + n}\right)^{\frac{\alpha}{1-\alpha}} \tag{7}$$

where h denotes the level of human capital per capita. Therefore, according to this model, a higher level of human capital per capita is expected to lead to a higher level of output per capita.

Also, in the model developed by Romer (1990), a backward two-sector economy is assumed: a final goods sector and an intermediate goods sector. In the first two sectors, firms produce goods, taking ideas from the most technologically advanced countries[2] , where for the less developed country, the accumulation of skills indicates that the closer a person's skill level is to the frontier, the greater the accumulation of skills. Thus, the more time people devote to accumulating skills, the closer the backward economy will be to the technological frontier. Then, considering the structure of the model, it is solved (Equation 8):

$$y^{*} = \left(\frac{S_k}{\delta + g + n}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{\mu}{g} e^{\psi\mu}\right)^{\frac{1}{\gamma}} A^{*} \tag{8}$$

where u represents the amount of time that a person devotes to accumulation and g denotes the rate at which the technological frontier expands, which becomes the rate of skill accumulation.

That is, production per worker increases at the rate of the skill level of the labor force. Economies that devote more time to skill accumulation will be closer to the technological frontier and will be richer (technology transfer). On the other hand, the differences in technology levels between countries are because people in countries differ in the levels of skills acquired.

Finally, the Lucas (1988) model assumes an economy where human capital is accumulated according to the time devoted to accumulating skills. Then, the growth of production is explained by that rate, in addition to the factors that explain the growth of k. This is (Equation 9):

$$\hat{y} = \alpha s \left(\frac{h}{k}\right)^{1-\alpha} + (1-\alpha)(1-\mu) \tag{9}$$

Thus, in this model, a government policy that permanently increases the time that people spend acquiring productive skills will generate a permanent increase in the growth of output per worker.

2. In the Peruvian case, the external sector can be identified with the sector through which technological transfer occurs.

In conclusion, from the review of these fundamental models of economic growth theory that explain the level of output per capita, it is expected that the level of physical capital per capita, human capital per capita, and exports per capita (as long as the external sector is a channel for transmitting technological progress) constitute the explanatory variables of the level of economic development.

3. Data

In this work, the variables we take for the estimation of the econometric models and the construction of Sen's social welfare index are presented as part of a panel data type database, where the unit of observation is at the departmental level of Peru for the period 2005 to 2019.

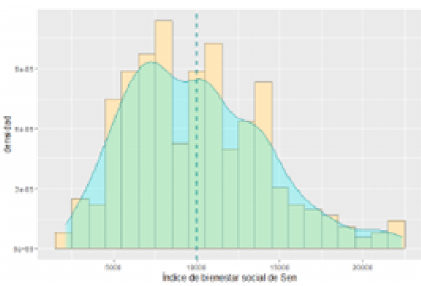
Table 2. Statistical description of the variables

Var	mean	sd	median	min	max	range	skew	Kurtosis
WSSEN	10007	4173	9795	2138	22348	20210	0.58	-0.04
PIBPC	12270	8877	9191	3720	52187	48468	2.62	8.04
XTPC	1333	2613	416	0	15876	15876	3.58	13.77
XNTPC	198	288	72	0	1652	1652	2.27	6.09
KDPC	31929	33839	20647	3240	200157	196917	3.02	10.82
HDPC	5.20	0.64	5.21	3.47	6.72	3.25	-0.09	0.52
LMPM	690	322	734	9	1504	1495	-0.29	-0.49
TPM	979	615	799	138	3343	3205	1.47	2.00

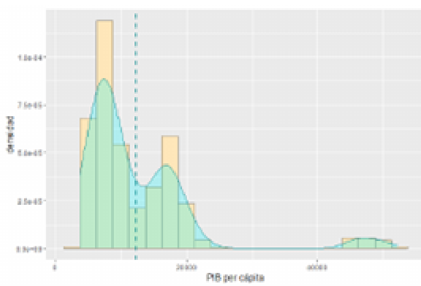
Source: own elaboration.

To construct Sen's social welfare index, the average annual total individual income by department (YTOTP) and the Gini coefficient (GINI) [3] were used. On the other hand, to evaluate the effects under study, Sen's social welfare index (WSSEN) and per capita gross domestic product (PIBPC) are considered as the dependent variables [4] . While the independent variables considered in the research are traditional exports per capita (XTPC), non-traditional exports per capita (XNTPC), fixed capital stock per capita (KDPC) [5], years of schooling per capita (HDPC). Finally, the number of mobile lines per thousand inhabitants (LMPM) and the number of tourists per thousand inhabitants (TPM) are considered as control variables. All variables have as their direct and indirect source the observational data published by the National Institute of Statistics and Informatics of Peru. In Table 2, we present a statistical summary of the variables used.

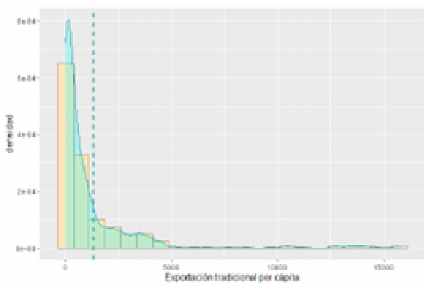
Figure 1. Distributions of the main variables, Peru 2005-2019.



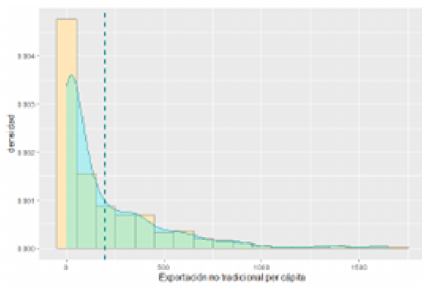
(a) Índice de bienestar social de Sen



(b) PIB per cápita



(c) Exportación tradicional per cápita



(d) Exportación no tradicional per cápita

Source: own elaboration.

3. Both variables estimated following the methodology of Avalos (2023).
4. The results of the WSSEN and GDPPC estimates are graphically represented in Appendix B.1 and C.1, respectively.
5. For the estimation, the methodology of Tello Pacheco (2017) was followed with some modifications.

4. Empirical methodology

The econometric modeling in this research has Sen's social welfare index (WSSEN) and per capita gross domestic product (PIBPC) as dependent variables. As the main explanatory independent variables, we have traditional exports per capita (XTPC), non-traditional exports per capita (XNTPC), physical capital per capita (KDPC), and the number of years of schooling per capita (HDPC). While the independent control variables are the number of mobile lines per thousand inhabitants (LMPM) and the number of tourists per thousand inhabitants (TPM). The specification of the basic econometric models that were estimated is given by (Equation 10):

$$WSSEN_{it} = \beta_0 + \beta_1 XTPC_{it} + \beta_2 XNTP_{it} + \beta_3 KDPC_{it} + \beta_4 HDPC_{it} + \textit{ otros determinantes} \tag{10}$$

And by (Equation 11):

$$PIBPC_{it} = \gamma_0 + \gamma_1 XTPC_{it} + \gamma_2 XNTPC_{it} + \gamma_3 KDPC_{it} + \gamma_4 HDPC_{it} + \textit{ otros determinantes} \tag{11}$$

The other determinants of the models specified in Equation 10 and Equation 11 are the number of mobile lines per thousand inhabitants ($LMPM_{it}$) and the number of tourists per thousand inhabitants (TPM_{it}).

According to the developed theory, it is expected that a higher non-traditional export will increase social welfare, ceteris paribus. That is, in model 10 it is expected to obtain (Equation 12):

$$\frac{\partial WSSEN}{\partial XNTPC} = \beta_2 > 0 \tag{12}$$

Likewise, we expect that more traditional exports will increase GDP per capita, ceteris paribus. So, in model 11 it is expected to obtain (Equation 13):

$$\frac{\partial PIBPC}{\partial XTPC} = \gamma_1 > 0 \tag{13}$$

However, if this result were conditioned by the level of human capital and by unobservable factors that remain constant over time, it is expected to obtain:

1. The impact of non-traditional exports on social well-being is heterogeneous at the departmental level for an average due to unobservable variables. This is (Equation 14):

$$\beta_{01} \neq \beta_{02} \neq \dots \neq \beta_{024} \tag{14}$$

   being β_{0i} ($i = 1, \dots, 24$), they are the parameters that capture the unobserved heterogeneity for each department.
2. The impact of traditional exports on economic development is heterogeneous at the departmental level for an average due to unobservable variables. This is (Equation 15):

$$\gamma_{01} \neq \gamma_{02} \neq \dots \neq \gamma_{024} \tag{15}$$

   being γ_{0i}($i = 1, \dots, 24$), they are the parameters that capture the unobserved heterogeneity for each department.

As for the rest of the determinants, we expect that a higher level of human capital per capita and physical capital per capita will lead to greater social welfare and development. We also expect that the higher the number of mobile lines per capita, the higher the level of social welfare and economic development. Finally, we expect a higher number of tourists per capita to be associated with a higher level of social welfare and economic development.

5. Findings

5.1 The panel data model

To perform the quantitative analysis, eighteen regression models have been estimated, of which the first nine models, from model (i) to model (ix), have as the dependent variable the departmental social welfare, which is approximated by the respective Sen social welfare index (WSSEN). Then, the remaining nine models, from model (x) to model (xviii), have as the dependent variable the departmental level of economic development approximated by the respective per capita GDP (PIBPC). The details and results are presented in Tables 9 and 10.

5.1.1 About the social welfare

According to the results of the estimates carried out, it is found that departmental non-traditional exports are relevant to explain the departmental social welfare. This statement is supported by an exhaustive econometric analysis of panel data. Thus, for the analysis of the effect of exports on social welfare WSSEN, nine regression models are estimated. The first six, from model (i) to (vi), were estimated using the ordinary least squares method. For model (vii) and (ix), the fixed effects between groups least squares method was used. Finally, for model (viii), the random effects least squares method was used.

In light of the results obtained that are presented in Table 9, the models are evaluated according to the estimates of the effects of traditional exports per capita and non-traditional exports per capita on social welfare. First, models (i), (ii), and (iii) are evaluated. According to the discrimination method, model (ii) is chosen over model (i), since with the first one a higher adjusted R2 is obtained than with the second model (0.3665 > 0.0206)[6] . Likewise, according to Mallows' Cp criterion, whose result is presented in Table 3, between model (i) and model (ii), the one that has non-traditional exports per capita as an explanatory variable corresponds to a lower Cp value (718.65 > 339.11). Therefore, there is no statistical basis for the variable traditional exports per capita to be included as an explanatory variable in the model.

This result is corroborated by using the F test discrimination method, since, evaluating models (i) and (iii), it is obtained that the null hypothesis H0: $\beta_1 = 0$ of XNTPC can be rejected for model (iii). Then, evaluating models (ii) and (iii) with the same test, it turns out that the null hypothesis H0: 1 = 0 of XTPC is not rejected. Therefore, the marginal contribution of traditional exports XTPC is not statistically significant in model (iii) [7].

6. The discrimination method allows us, given two or more rival models that have the same return, to choose a model based on goodness-of-fit criteria (Gujarati and Porter, 2009; Wooldridge, 2010).

7. The discernment method is one where, to choose a model, the information provided by other models is taken into account (Gujarati and Porter, 2009).

Table 3. Criteria:R^2, R^2 adj and Cp of Mallows.

Index	N	Predictors	R-Square	Adj. R-Square	Mallow's Cp
1	1	XNTPC	0.3683	0.3665	339.11
2	1	XTPC	0.0234	0.0206	718.65
3	2	XTPC XNTPC	0.3707	0.3672	338.42
4	5	XNTPC HPC KDPC LMPM TPM	0.6783	0.673	8 5.99
5	5	XTPC HPC KDPC LMPM RPM	0.5888	0.5830	104.43
6	6	XTPC XNTPC HPC KDPC LMPM TPM	0.6792	0.6737	7.00

Source: own elaboration.

Then, in the same analytical perspective; that is, under the same procedure to evaluate models (iv) and (v), it is found that model (iv) has a lower value than model (v) for the adjusted R2 (0.5830 < 0.6738). Subsequently, performing the F test for models (iv) and (vi), the null hypothesis H0: 1 = 0 of XNTPC is rejected for model (vi). Next, evaluating models (v) and (vi), it is observed that the null hypothesis for XTPC cannot be rejected in model (vi). In this sense, the marginal contribution of traditional exports per capita (variable XTPC) on social welfare is not statistically significant in model (vi). On the other hand, using other discrimination method criteria, such as Mallows' Cp criterion between models (iv) and (v), it is model (v) that presents a lower Cp value (104.43 > 5.99). Likewise, model (v) presents a relatively lower Cp value than that calculated for model (vi) (7.00 > 5.99) [8] . This result can be visualized in Figure 2. In addition, according to the Akaike (AIC) and Schwarz (BIC) information criteria, a lower value is obtained for model (v) and not for (iv) in both cases. That is, $AIC(iv)$ = 6716.90 > 6628.56 = $AIC(v)$ and $BIC(iv)$ = 6744.10 > 6655.77 = $BIC(v)$. In addition, according to the Cp value, model (v) would be more suitable than model (vi), which is confirmed by the Akaike information criterion, since $AIC(vi)$ = 6629.56 > 6628.56 = $AIC(v)$. This result is ratified under the Schwarz criterion, since$BIC(vi)$ = 6660.65 > 6655.77 = $BIC(v)$. On the other hand, model (v) presents a similar value to model (vi) for the adjusted R2 (0.6738 > 0.6737).

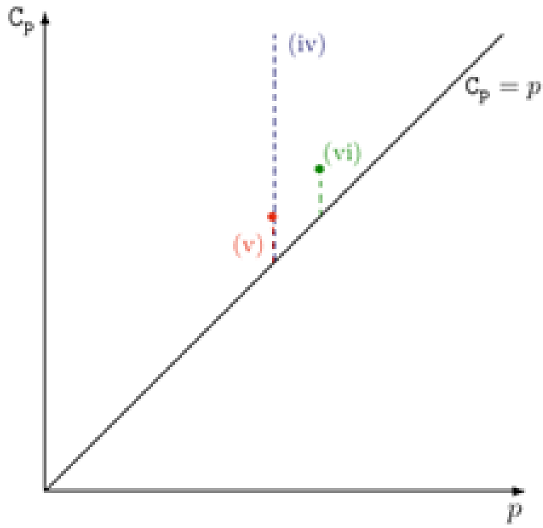
In conclusion, from here on to evaluate the effect on social welfare, the estimates will be worked from model (v), without including traditional exports per capita (XTPC), since they are not statistically significant to explain social welfare.

On the other hand, in model (ii) the sign of the parameter of non-traditional exports is consistent with theoretical expectations: an increase in non-traditional exports is associated with a higher level of social welfare. The same result is also ratified for models (iii), (v), and (vi): an increase in non-traditional exports is associated with a higher level of social welfare, in all of them with a statistical significance of 0.1%. The punctual estimate of the coefficient of non-traditional exports per capita in the model (v) is 4.9866, holding the rest of the variables constant. On average, the marginal effect of non-traditional exports on social welfare is positive.

However, according to the results of the F test presented in Table A.1 (see Appendix A), we must consider possible heterogeneous effects of the impact of non-traditional exports on social welfare for each department. This means that for some departments the magnitude in which non-traditional exports would be impacting social welfare is not the same for all departments. In this sense, we must take the fixed effects model (model vii), whose punctual estimate of the coefficient of non-traditional exports per capita is 2.3103, given the rest of the variables, with a statistical significance of 0.1%.

8. When choosing a model according to the Cp criterion, one should look for a model with a low value of Cp, approximately equal to p, which denotes a number of regressors such that $p \geq k$ (Gujarati and Porter, 2009; Wooldridge, 2010) .

Figure 2. Distributions of the main variables, Peru 2005-2019.



Source: own elaboration.

Concerning the results of the Lagrange multiplier test presented in Table A.2, they indicate that there are random effects that must be taken into account by estimating model (viii), so that an ordinary least squares estimation together (model vi) is not enough. Thus, for the random effects model, the estimated marginal effect of non-traditional exports per capita on social welfare is equal to 4.6498, with a statistical significance of 0.1%. However, according to the Hausman test, which allows us to evaluate whether or not there is endogeneity of the regressors and whose results are presented in Table A.3, the existence of exogeneity between the regressors is rejected. Therefore, it is preferable to use the estimates of the fixed effects model (model vii) rather than those of the random effects model (model viii).

Additionally, evaluating the presence or absence of heteroscedasticity, according to the results presented in Table A.4, it is concluded that there is evidence of heteroscedasticity, so the fixed effects model was re-estimated controlling for the absence of heteroscedasticity by the White method. The new t-values are presented in model (ix), showing that there is a positive effect of non-traditional exports per capita on social welfare with a statistical significance of 0.1%. Therefore, according to model (ix), we formally have (Equation 16):

$$\frac{\partial WSSEN}{\partial XNTPC} = 2.3103 \tag{16}$$

which shows the existence of a positive empirical relationship between non-traditional exports per departmental capita and departmental social well-being.

On the other hand, model (ix) does not consider the traditional exports variable to evaluate its impact on the level of social welfare, since it is not statistically significant. It also shows that the average number of years of study per capita has a positive effect on social welfare ($\hat{\beta}_2$ = 558.18), with a significance level of 10%. While the stock of physical capital per capita also positively affects the level of social welfare, since a coefficient of $\hat{\beta}_3$ = 0.0236 has been estimated, with a significance level of 0.1%. In contrast, the control variables number of mobile lines and number of tourists have a statistically significant effect on social welfare.

Table 4. Estimates of the intercepts for each department

DPTO	AMA	ANC	APU	AR	E AYA	CAJ
β_{0i}	2819.23**	2831.59**	8.83	5527.36***	350.76	1038.66
Pr[>|t|]	(0.0053)	(0.0087)	(0.9937)	(1.58e-06)	(0.7253)	(0.3059)
DPTO	CUS	HCV	HUA	ICA	JUN	LAM
β_{0i}	494.95	-179.57	1545.46	4218.54***	3403.63**	5462.63***
Pr[>|t|]	(0.6685)	(0.8736)	(0.1364)	(0.0005)	(0.0019)	(5.99e-07)
DPTO	LIM	LLI	LOR	MAD	MOQ	PAS
β_{0i}	9378.64***	3855.40***	5084.20***	7375.84***	1025.38	479.78
Pr[>|t|]	(6.27e-14)	(0.0003)	(1.11e-06)	(5.43e-11)	(0.5205)	(0.6829)
DPTO	PIU	PUN	SMA	TAC	TUM	UCA
β_{0i}	3316.93**	-29.68	3321.10***	3927.13***	5262.75***	6513.79***
Pr[<|t|]	(0.0016)	(0.9807)	(0.0009)	(0.0008)	(1.89e-05)	(1.02e-09)

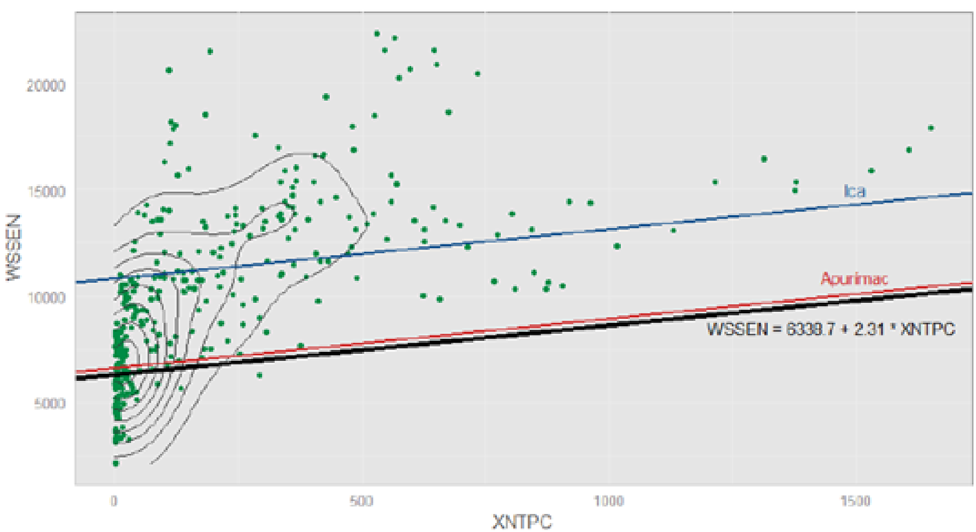
p-values in
† Significance at 10 %. * Significance at 5 %.
** Significance at 1 %. *** Significance at 0.1 %.

Source: own elaboration.

Therefore, the estimates that consider the fixed effects allow us to represent the specific characteristics of each department, but do not allow us to identify these characteristics individually. All heterogeneity characteristics are integrated into the intercept value. Using the least squares model with a fixed effects dummy variable, we obtain the estimates of the intercepts and their statistical significance respectively. See Table 4.

Then, with these parameters and the mean values of the explanatory variables for each department, we can derive the within-group fixed effects estimators for each unit. These results are presented in Appendix D.1.

Figure 3. Estimator within groups: $\widehat{WSSEN} = \hat{\beta}_0 + \hat{\beta}_1 XNTPC + \hat{\beta} X + \mu$ **general, Ica and Apurímac**



Source: own elaboration.

The average estimates allow us to identify the departments whose social welfare is explained to a greater and lesser extent by non-traditional exports per capita. In the first group, we find Ica (16.63%), Piura (14.78%), Tumbes (8.97%), La Libertad (8.01%), and Lima (6.53%). While in the second group we have Cusco (0.34%), Puno (0.34%), Cajamarca (0.28%), Amazonas (0.10%), and Apurímac (0.06%).

Likewise, according to the estimates, although the effect of non-traditional exports per capita on social welfare is statistically significant, in none of them is it the most important explanatory variable. For example, for the following departments, social welfare is mainly explained by human capital per capita: Huancavelica (63.52%), Puno (54.68%), Apurímac (52.29%), Ayacucho (47.81%), Cajamarca (44.64%), Pasco (41.82%), Huánuco (40.93%), and Cusco (38.59%). While only for Moquegua (31.21%) is physical capital per capita the main variable that explains its social welfare. For the rest of the departments, social welfare is explained by unobserved and heterogeneous factors. Among the most important of these cases we have Ucayali (55.02%), Loreto (53.12%), Lambayeque (46.86%), Lima (48.16%), and Madre de Dios (46.03%). In Table 5, we present the proportions of social welfare that are explained by the different variables of the fixed effects model (model ix) and, in Figure 4, we present the proportions of social welfare that are explained by non-traditional exports per capita according to the fixed effects model.

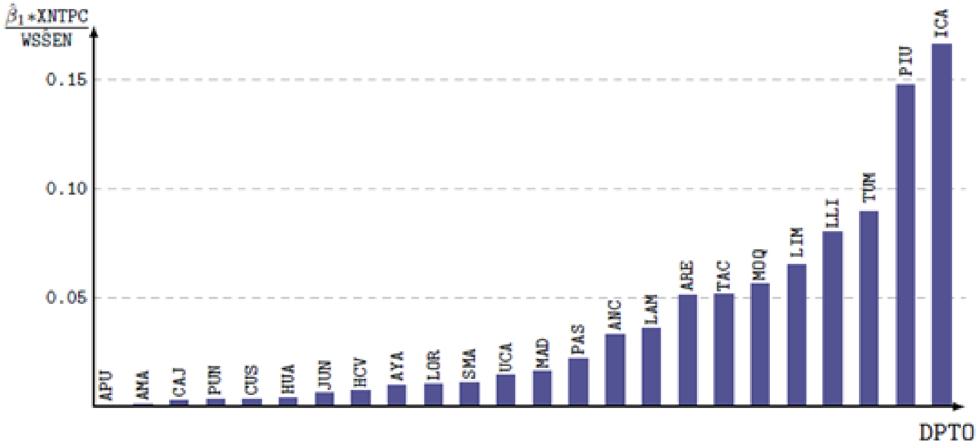
Table 5. Proportion of social well-being that is due to explanatory variables

DPTO	β_{0i}	XNTPC	HHPC	KDPC	LMPM	TPM
AMA	0.3857	0.0010	0.3493	0.0221	0.1489	0.0930
ANC	0.2950	0.0329	0.2950	0.1120	0.1816	0.0835
APU	0.0016	0.0006	0.5229	0.0888	0.2836	0.1475
ARE	0.3878	0.0513	0.2210	0.0834	0.1764	0.0801
AYA	0.0636	0.0100	0.4781	0.0571	0.2989	0.0924
CAJ	0.1722	0.0028	0.4464	0.0613	0.2371	0.0752
CUS	0.0617	0.0034	0.3859	0.1140	0.2141	0.2210
HCV	-0.0408	0.0072	0.6352	0.0994	0.2199	0.0792
HUA	0.2348	0.0042	0.4093	0.0343	0.2066	0.1108
ICA	0.2968	0.1663	0.2085	0.0786	0.1542	0.0956
JUN	0.3644	0.0061	0.3121	0.0505	0.1876	0.0792
LAM	0.4686	0.0360	0.2464	0.0302	0.1655	0.0533
LIM	0.4816	0.0653	0.1697	0.0426	0.1345	0.1064
LLI	0.3575	0.0801	0.2565	0.0584	0.1782	0.0692
LOR	0.5312	0.0107	0.2662	0.0415	0.0962	0.0543
MAD	0.4603	0.0164	0.1886	0.0579	0.1428	0.1341
MOQ	0.0831	0.0562	0.2821	0.3121	0.1994	0.0672
PAS	0.0670	0.0220	0.4182	0.1791	0.2046	0.1091
PIU	0.3376	0.1478	0.2570	0.0533	0.1552	0.0491
PUN	-0.0050	0.0034	0.5468	0.0431	0.3107	0.1010
SMA	0.3878	0.0111	0.3023	0.0196	0.1603	0.1189
TAC	0.2992	0.0514	0.2507	0.0918	0.1998	0.1070
TUM	0.3985	0.0897	0.2413	0.0423	0.1530	0.0753
UCA	0.5502	0.0143	0.2286	0.0274	0.1222	0.0574

Source: own elaboration.

According to the findings, there is evidence that the level of non-traditional exports per capita has a positive impact on social welfare. However, this impact is heterogeneous at the departmental level. This is important for departments such as Ica and Piura and, to a lesser extent, for another group of departments ranging from Arequipa to Tumbes, as shown in Figure 4. Finally, its contribution is insignificant for another group of departments, such as Apurímac, Amazonas, Cajamarca, Puno, Cusco, and Huánuco.

Figure 4. Proportion of WSSEN social welfare explained by the XNTPC.



Source: own elaboration.

5.1.2 Economic development: GDP per capita

According to the results of the estimates made, there is evidence that departmental traditional exports are relevant to explain departmental economic development. To support this statement, a set of models has been econometrically worked on. Thus, to analyze the effect of exports on economic development, the latter approximated by the GDPPC variable, nine regression models are estimated. For the first six, from model (x) to (xv), estimates were made using the ordinary least squares method. Models (xvi) and (xviii) were developed using the pooled fixed effects least squares method; finally, model (xvii) was estimated using the random effects least squares method.

The results of the estimates made are presented in Table 10. Following the same procedure from the previous subsection, the models were evaluated according to the estimates of the effects of traditional exports per capita and non-traditional exports per capita on economic development. In the same way, the evaluation began with models (x), (xi), and (xii). Again, according to the discrimination method, model (xii) is chosen over models (x) and (xi), since with this model a higher adjusted R2 is obtained than with the second and third model (0.7821 > 0.7580 and 0.7821 > 0.0900, respectively). Likewise, applying Mallows' Cp criterion, the result of which is presented in Table 6, among models (x), (xi), and (xii), the one that has traditional and non-traditional exports per capita as explanatory variables is the one that has a lower Cp value (973.14 < 1122.22 and 973.14 < 5201.97, respectively). This means, in the first instance, that the model that is used to explain economic development must incorporate both types of exports as explanatory variables.

Table 6. Criteria: R^2, R^2 adj y Cp of Mallows

Index	N	Predictors	R-Square	Adj. R-Square	Mallow's Cp
1	1	XNTPC	0.7587	0.7580	1122.22
2	1	XTPC	0.0926	0.0900	5201.97
3	2	XTPC XNTPC	0.7833	0.7821	973.14
4	5	XNTPC HPC KDPC LMPM TPM	0.9418	0.9410	8.62
5	5	XTPC HPC KDPC LMPM RPM	0.9174	0.9162	158.17
6	6	XTPC XNTPC HPC KDPC LMPM TPM	0.9424	0.9414	7.00

Fuente: own elaboration.

This result is not credited by using the F test discrimination method, according to which the null hypothesis H0: $\gamma_1 = 0$ of XTPC can be rejected for models (xii) and (xi), which means that the traditional exports per capita variable must be considered as one of the regressors. Then, evaluating models (xii) and (x), with the same test, it turns out that the null hypothesis H0: γ_1 = 0 should not be rejected. That is, the non-traditional exports per capita variable should not be considered as one of the regressors. Therefore, the marginal contribution of non-traditional exports XNTPC is not statistically significant in model (xii). However, this result is not complemented by what was obtained by the discrimination method. Therefore, this situation is re-evaluated when the control variables are incorporated into the model.

In this same methodological effort, the evaluation is carried out with the same procedure for models (xiii), (xiv), and (xv). It is found that model (xv) presents a higher value for the adjusted R2 than that obtained for models (xiii) and (xiv) (0.9414 > 0.9410 and 0.9414 > 0.9162, respectively). Subsequently, we perform the F test between models (xiv) and (xv). According to the results, the null hypothesis H0: γ_1 = 0 is rejected for model (xiii), confirming the importance of the traditional exports per capita variable. Then, evaluating model (xii), we have a result that indicates that the null hypothesis cannot be rejected for model (xv), so the non-traditional exports per capita variable must be omitted. Therefore, the marginal contribution of non-traditional exports per capita (variable XNTPC) is not statistically significant in model (xv).

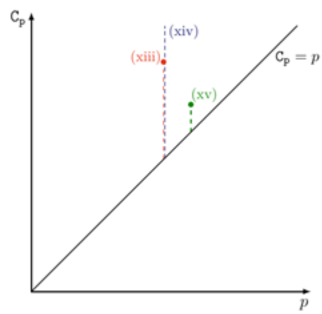
On the other hand, using other criteria of the discrimination method, such as Mallows' Cp criterion between models (xiii) and (xiv), it is model (xiii) that presents the lowest Cp value (8.62 < 158.17). Likewise, model (xiii) presents a relatively higher Cp value than that calculated for model (xv) (8.6 > 7.00), being model (xv) the most suitable for estimating according to this criterion (Table 6). On the other hand, according to the Akaike information criteria (AIC), a lower value is obtained for model (xv) and, according to the Schwarz criterion (BIC), a lower value is obtained for model (xiii). While under both criteria model (xiv) is discarded. See the calculations obtained in Table 7. Guided by the Akaike criteria and Mallows' Cp criteria, in what follows for the study of the change in GDPPC, we work with model (xv). Next, we represent in Figure 5 the differences between models (xiii), (xiv), and (xv) under the Mallows' Cp criterion.

Table 7. Criteria: Akaike (AIC), Schwarz (BIC) and Mallows Cp

Model	df	AIC	BIC	Mallow's Cp
model (xiii)	7	6556.66	6583.87	8.62
model (xiv)	7	6682.74	6709.94	158.17
model (xv)	8	6554.99	6586.08	7.00

Source: own elaboration.

Figure 5. Mallows Cp for models (xiii), (xiv) and (xv).



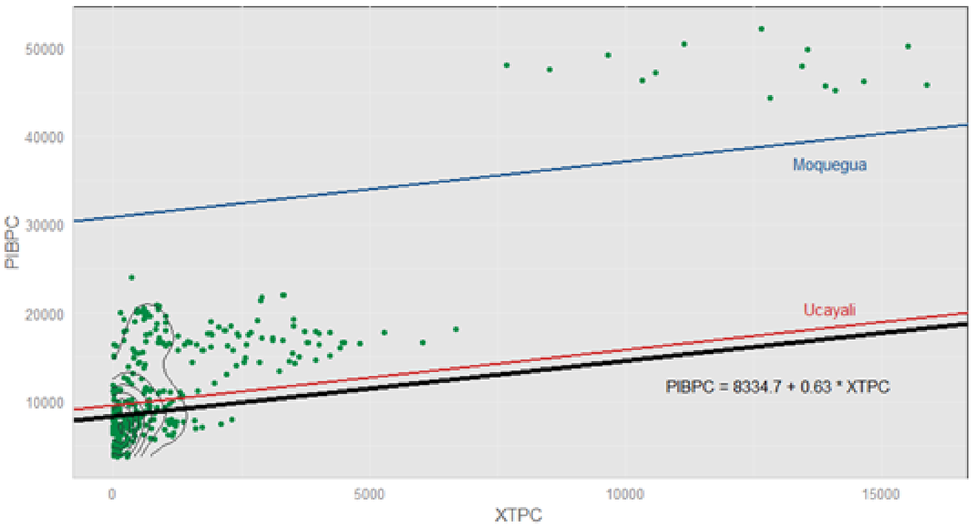
Source: own elaboration.

On the other hand, in models (x), (xii), and (xiii), the sign of the parameter of traditional exports is consistent with theoretical expectations: an increase in traditional exports is associated with a higher level of economic development. The same result is obtained for model (xv), an increase in traditional exports is associated with a higher level of economic development. The point estimate of the traditional export variable coefficient is 1.1435, holding the rest of the variables constant, with a statistical significance of 0.1%[9] . On average, the marginal effect of traditional exports on economic development (GDPPC) is positive and statistically significant.

However, according to the results of the F test (see Table A.5), we must consider possible heterogeneous effects of the impact of traditional exports on economic development for each department. This means that, for some departments, traditional exports would be impacting, to a greater extent, on economic development; while for others, to a lesser extent. In this sense, we should take the fixed effects model (model xvi), whose point estimate of the traditional export per capita coefficient is 0.6291, given the rest of the variables, with a statistical significance of 0.1%[10].

On the other hand, the results of the Lagrange multiplier test (see Table A.6) indicate that there are random effects that we must take into account using model (xvii). Thus, for the random effects model, the estimated marginal effect of traditional exports on economic development is equal to 1.1002, with a statistical significance of 0.1%. However, according to the Hausman test, which allows us to evaluate whether or not there is endogeneity of the regressors, a possible endogeneity between them is obtained with a high statistical significance (see Table A.7). Therefore, it is preferable to use the estimates of the fixed effects model (model xvi) over those of the random effects model (model xvii).

Figure 6. Estimator within groups: *PIBPC* = 0 + 1*XTPC* + *X* + μ **general, Moquegua y Ucayali.**



Source: own elaboration.

Consequently, evaluating the presence or absence of heteroscedasticity, according to the results presented in Table A.8, it is concluded that there is evidence of heteroscedasticity, so we re-estimate the fixed effects model controlling for the absence of heteroscedasticity. The new t-values are presented in model (xviii), indicating that there is a positive effect of traditional exports on economic development, even with a statistical significance of 1%[11] . So, according to model (xviii), we formally obtain (Equation 17):

9. The p-value is less than 0.0010; this is 0.0000.
10. The p-value is less than 0.0010; this is 0.0000.
11. The p-value is less than 0.0100; this is 0.0024.

$$\frac{\partial PIBPC}{\partial XTPC} = 0.6291 \tag{17}$$

This provides evidence of a positive relationship between traditional exports and economic development.

On the other hand, the model shows that the non-traditional exports per capita variable has a positive effect on economic development $\hat{\gamma}_2 = 1.2201$, with a significance level of 10%. It also shows that the average years of study per capita has a positive effect on economic development ($\hat{\gamma}_3 = 862.23$), with a significance level of 10%. While the stock of physical capital per capita also positively affects the level of economic development, since a $\hat{\gamma}_4 = 0.0636$ has been estimated, with a significance level of 10%. Finally, the number of tourists variable also has a statistically significant effect on social welfare of 5%. Finally, the *number of mobile lines variable* does not show evidence of a significant effect on economic development.

Table 8. Estimates of the intercepts for each department

DPTO	AMA	ANC	APU	ARE	AYA	CAJ
γ_{0i}	309.86	4643.68***	-341.91	5692.49***	827.41	612.94
Pr[>|t|)	(0.7478)	(1.19e-05)	(0.7496)	(2.96e-07)	(0.3873)	(0.5289)
DPTO	CUS	HCV	HUA	ICA	JUN	LAM
γ_{0i}	2615.61*	1025.37	-297.93	2783.52*	1427.95	1098.47
Pr[>|t|]	(0.0186)	(0.3435)	(0.7642)	(0.0169)	(0.1721)	(0.2864)
DPTO	LIM	LLI	LOR	MAD	MOQ	PAS
γ_{0i}	5749.46***	1875.15†	2330.19*	4595.52***	22539.40***	7210.50***
Pr[>|t|]	(8.66e-07)	(0.0620)	(0.0182)	(1.42e-05)	(<2e-16)	(6.39e-10)
DPTO	PIU	PUN	SMA	TAC	TUM	UCA
γ_{0i}	1796.03†	-922.84	-655.04	6645.36***	1538.96	1215.22
Pr[<|t|]	(0.0732)	(0.4319)	(0.4913)	(6.53e-09)	(0.1864)	(0.2221)

p-values in parentheses
† Significance at 10 %. * Significance at 5 %.
** Significance at 1 %. *** Significance at 0.1 %.

Sourse: own elaboration.

Therefore, as mentioned above, considering the fixed effects estimates (model xviii), we can represent the specific characteristics of each department, although we cannot identify these characteristics individually. These heterogeneity characteristics are integrated into the intercept value. Using the fixed effects dummy variable least squares model, we obtain the estimates of the intercepts and their statistical significance, respectively (Table 8).

Next, as we did for the case of social welfare, with these parameters and the mean values of the explanatory variables for each department, we derive the within-group fixed effects estimator. These are presented in Appendix E.1.

Table 9. Proportion of economic development (GDPPC) that is due to explanatory variables

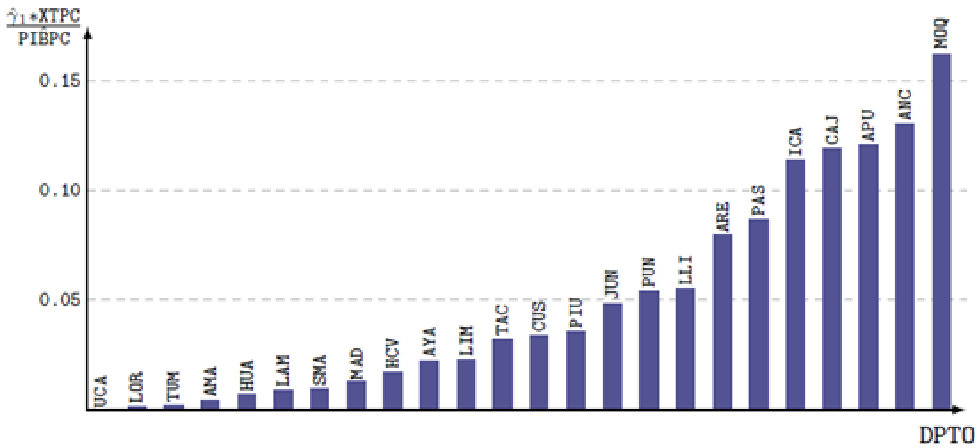
DPTO	γ_{0i}	XTPC	XNTPC	HHPC	KDPC	LMPM	TPM
AMA	0.0526	0.0041	0.007	0.6694	0.0738	-0.0177	0.2170
ANC	0.3007	0.1305	0.0108	0.2833	0.1879	-0.0108	0.0976
APU	-0.0438	0.1208	0.0002	0.5723	0.1699	-0.0162	0.1967
ARE	0.3262	0.0796	0.0221	0.2789	0.1839	-0.0138	0.1231
AYA	0.1229	0.0221	0.0043	0.6053	0.1263	-0.0234	0.1425
CAJ	0.0853	0.1193	0.0012	0.5624	0.1350	-0.0185	0.1154
CUS	0.1935	0.0338	0.0011	0.3541	0.1827	-0.0121	0.2470
HCV	0.1420	0.0170	0.0023	0.5975	0.1633	-0.0128	0.0908
HUA	-0.0516	0.0071	0.0025	0.7211	0.1056	-0.0225	0.2378
ICA	0.1766	0.1138	0.0792	0.2904	0.1912	-0.0133	0.1623
JUN	0.1606	0.0487	0.0034	0.5065	0.1432	-0.0188	0.1565
LAM	0.1415	0.0091	0.0285	0.5715	0.1225	-0.0237	0.1506
LIM	0.3225	0.0231	0.0377	0.2864	0.1255	-0.0140	0.2188
LLI	0.1859	0.0555	0.0452	0.4237	0.1686	-0.0182	0.1392
LOR	0.2809	0.0015	0.0065	0.4745	0.1294	-0.0106	0.1178
MAD	0.2884	0.0128	0.0087	0.2930	0.1571	-0.0137	0.2538
MOQ	0.4722	0.1621	0.0077	0.1126	0.2177	-0.0049	0.0327
PAS	0.3938	0.0870	0.0045	0.2528	0.1891	-0.0077	0.0804
PIU	0.2005	0.0356	0.0856	0.4355	0.1578	-0.0163	0.1013
PUN	-0.1516	0.0545	0.0018	0.8251	0.1136	-0.0290	0.1857
SMA	-0.1152	0.0097	0.0088	0.7032	0.0798	-0.0231	0.3368
TAC	0.3627	0.0324	0.0194	0.2774	0.1775	-0.0137	0.1442
TUM	0.1495	0.0019	0.0608	0.4784	0.1464	-0.0188	0.1818
UCA	0.1620	0.0000	0.0119	0.5574	0.1168	-0.0184	0.1703

Source: own elaboration.

With the average estimates, we identify the departments whose level of economic development (GDP per capita), to a greater and lesser extent, is explained by traditional exports per capita. In the first group, we find Moquegua (16.21%), Ancash (13.05%), Apurímac (12.08%), Cajamarca (11.93%), and Ica (11.38%). While in the second group we have Ucayali (0.00%), Loreto (0.15%), Tumbes (0.19%), Amazonas (0.41%), and Huánuco (0.71%).

Likewise, according to the estimates, although the effect of traditional exports per capita on GDP per capita is statistically significant, in none of the departments is it the most important explanatory variable. For example, for the following departments, GDP per capita is mainly explained by human capital per capita: Puno (82.51%), San Martín (70.32%), Amazonas (66.94%), Ayacucho (60.53%), Huancavelica (59.75%), Apurímac (57.23%), Lambayeque (57.15%), and Cajamarca (56.24%). For the rest of the departments, GDP per capita is explained by unobserved and heterogeneous factors. Among the most important of these cases, we have Moquegua (47.22%), Pasco (39.38%), Tacna (36.27%), Arequipa (32.62%), and Lima (32.25%). In Table 9, we present the proportions of economic development that are explained by the different variables of the fixed effects model (model xviii). In Figure 7, we present the proportions of GDP per capita that are explained by traditional exports per capita according to the fixed effects model.

Figure 7. Proportion of GDPPC economic development explained by the XTPC.



Source: own elaboration.

Therefore, as evidenced, the level of traditional exports per capita has a positive impact on GDP per capita (economic development). However, this impact is heterogeneous at the departmental level. The impact is significant for departments such as Ica, Cajamarca, Apurímac, Ancash, and Moquegua, and to a lesser extent for another group of departments ranging from Junín to Pasco, as shown in Figure 7. Finally, its contribution is insignificant for another group of departments, such as Ucayali, Loreto, Tumbes, Amazonas, Huánuco, Lambayeque, and San Martín.

5.2 Estimates

5.2.1 About social welfare

Table 10 shows the estimates from the fixed-effects and random-effects OLS models, where the regressor is Sen's social well-being index (WSSEN).

Table 10. Econometric results: WSSEN dependent variable

Explicative Variables				Dependent Variable : WSSEN					
	MCO (i)	MCO (ii)	MCO (iii)	MCO (iv)	MCO (v)	MCO (vi)	EF (vii)	EA (viii)	EFCH (ix)
XTPC	0.2442**		0.0802	-0.1179		-0.1017			
	(0.0036)		(0.2396)	(0.3096)		(0.3216)			
XNTPC		8.7936***	8.6687***		4.9866***	4.9788***	2.3103***	2.6647***	2.3103***
		(0.0000)	(0.0000)		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
HPC				−831.35∗	-205.07	-182.24	558.18*	508.23*	558.18
				(0.0243)	(0.5356)	(0.5828)	(0.0200)	(0.0335)	(0.0888)
KDPC				0.0216*	0.0047	0.0120	0.0236***	0.0181**	0.0236*
				(0.0273)	(0.3084)	(0.1677)	(0.0009)	(0.0045)	(0.0160)
LMPM				5.7462***	3.7814***	3.7299***	2.5438***	2.5815***	2.5438***
				(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
TPM				2.9532***	2.7101***	2.5988***	0.9469**	1.1789***	0.9469*
				(0.0000)	(0.0000)	(0.0000)	(0.0011)	(0.0000)	(0.0156)
CONST	9681.2***	8262.2***	8180.0***	6944.5***	4672.9***	4603.1**		3319.7	
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0009)	(0.0011)		(0.0031)	
R^2	0.0234	0.3683	0.3707	0.5888	0.6783	0.6792	0.6050	0.6008	
R^2-adj	0.0206	0.3665	0.3672	0.5830	0.6738	0.6737	0.5716	0.5952	
F	8.57	208.72	105.17	101.40	149.28	124.56	101.41	106.56	
n	360	360	360	360	360	360	360	360	360

p-values in parentheses
† Significance at 10 %. * Significance at 5 %.
** Significance at 1 %. *** Significance at 0.1 %.

Fuente: own elaboration.

5.2.2 About development: GDP per capita

Finally, Table 11 shows the estimates of the fixed-effects and random-effects OLS models, where the regressor is the gross domestic product per capita (GDPPC).

Table 11. Econometric results: GDPPC dependent variable

Explicative Variables	Variable dependiente: PIBPC								
	MCO (x)	MCO (xi)	MCO (xii)	MCO (xiii)	MCO (xiv)	MCO (xv)	EF (xvi)	EA (xvii)	EFCH (xviii)
XTPC	2.9594***		2.8664***	1.1408***		1.1435***	0.6291***	1.1002***	0.6291**
	(0.0000)		(0.0000)	(0.0000)		(0.0000)	(0.0000)	(0.0000)	(0.0024)
XNTPC		9.3773***	4.9138***		0.7688	0.8568†	1.2201*	1.1370*	1.2201†
		(0.0000)	(0.0000)		(0.1541)	(0.0578)	(0.0212)	(0.0499)	(0.0815)
HPC				1146.6***	1514.8***	1258.3***	862.23***	1264.6***	862.23†
				(0.0001)	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0604)
KDPC				0.1595***	0.2397***	0.1578***	0.0636***	0.1126***	0.0636†
				(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0572)
LMPM				–1.4679*	–2.3935***	–1.8149**	–0.2430	–1.3430**	–0.2430
				(0.0114)	(0.0010)	(0.0028)	(0.5501)	(0.0071)	(0.6807)
TPM				1.8748***	0.5630*	1.8139***	1.7819***	1.0572***	1.7819*
				(0.0000)	(0.0477)	(0.0000)	(0.0000)	(0.0004)	(0.0479)
CONST	8323.9***	10409.5***	7473.0***	-1128.2	-2316.6	-1531.1		295.0	
	(0.0000)	(0.0000)	(0.0000)	(0.3675)	(0.1256)	(0.2264)		(0.8103)	
R^2	0.7587	0.0926	0.7833	0.9417	0.9174	0.9424	0.7077	0.8030	
R^2-adj	0.7580	0.0900	0.7821	0.9410	0.9162	0.9414	0.6820	0.7996	
F	1125.34	36.52	645.30	1145.17	785.91	961.98	133.17	239.75	
n	360	360	360	360	360	360	360	360	360

p-values in parentheses
† Significance at 10 %. * Significance at 5 %.
** Significance at 1 %. *** Significance at 0.1 %.

Fuente: own elaboration.

6. Conclusions

According to the econometric results, the conclusions of the research are as follows:

1. The export growth has a differentiated positive effect on social welfare and economic development at the departmental level (Equation 18).

$$\frac{\partial WSSEN}{\partial XNTPC} = 2.31 > 0 \qquad y \qquad \frac{\partial PIBPC}{\partial XTPC} = 0.63 > 0 \tag{18}$$

The direction of the results found on GDPPC coincides with the findings of Angulo Delgado and Cabello Puelles (2019), Bello Alfaro (2012), and Vargas (2017), although in these studies the type of exports is not disaggregated.

2. The departmental-level effect of non-traditional exports on social welfare is positive and heterogeneous due to an unobservable variable. For example (Equation 19):

$$\frac{\hat{\beta}_1 * XNTPC}{\widehat{WSSEN}}(ICA) = 0.1663 > 0.0006 = \frac{\hat{\beta}_1 * XNTPC}{\widehat{WSSEN}}(APU) \tag{19}$$

3. The departmental-level effect of traditional exports on economic development is positive and heterogeneous due to some unobservable variable. For example (Equation 20):

$$\frac{\hat{\gamma}_1 * XTPC}{\widehat{PIBPC}}(MOQ) = 0.1621 > 0.0000 = \frac{\hat{\gamma}_1 * XTPC}{\widehat{PIBPC}}(UCA) \tag{20}$$

REFERENCES

Actis Di Pasquale, E. (2008) *La operacionalización del concepto de Bienestar Social: Un análisis comparado de distintas mediciones.* Observatorio Laboral Revista Venezolana, 1(2), Article 2. http://servicio.bc.uc.edu.ve/faces/revista/lainet/

Actis Di Pasquale, E. (2015) *Hacia una definición conceptual de bienestar social.* El debate desde la economía del bienestar hasta enfoque de las capacidades. VI Encuentro Regional de Estudios del Trabajo, Tandil [ARG], 7-8 septiembre 2015. ISBN 978-950-658-376-7., 1-28. https://nulan.mdp.edu.ar/id/eprint/2342/

Almada, J. A., & Reche, F. H. (2019) *¿Crecimiento, desarrollo o «milagro»? Aportes para un análisis histórico-estructural de la realidad peruana.?* Economía y Desarrollo, 162(2), Article 2. https://revistas.uh.cu/econdesarrollo/article/view/1798

Angulo Delgado, D. K., & Cabello Puelles, K. M. (2019) *Exportaciones y crecimiento económico en Perú: Un análisis de cointegración,1980 – 2016* [Tesis de licenciatura, Universidad Privada del Norte]. https://repositorio.upn.edu.pe/handle/11537/23350

Avalos, E. (2023) *Medición de la desigualdad de ingresos según el ingreso relativo: Fundamentos, simulación y cálculo para el Perú, 2004 – 2017* Revista Economía y Política, 37, 48-75. https://doi.org/10.25097/rep.n37.2023.04

Barro, R. J. (1991) *Economic growth in a cross section of countries.* The Quarterly Journal of Economics, 106(2), 407-443. https://doi.org/10.2307/2937943

Barro, R. J., & Sala-i-Martin, X. (2004) *Economic growth (2nd ed). MIT Press.*

Bello Alfaro, J. L. (2012) *Estudio sobre el impacto de las exportaciones en el crecimiento económico del Perú durante los años 1970—2010* [Tesis de maestría, Universidad Nacional Mayor de San Marcos].

Betalleluz, J. (2018) *Ensayo sobre los constructos de bienestar y felicidad.* Revista Procesos Económicos, 1(1), 1-40. https://doi.org/10.62041/RPE.vol1.n1.2018.6

Blanco, A., & Díaz, D. (2005) *El bienestar social: Su concepto y medición.* Psicothema, 17(4), 582-589. https://www.psicothema.com/pi?pii=3149/1000

Boloña Behr, C. (1975) *Una interpretación matemática del modelo Sunkel sobre subdesarrollo latinoamericano* (Ensayos N° 11; p. 60). Universidad del Pacífico. Centro de Investigación. http://repositorio.up.edu.pe/handle/11354/439

Céspedes Reynaga, N. (2017) *Crecimiento económico y pobreza en las regiones y en los sectores económicos de Perú (Documento de Trabajo 109; p. 23).* Asociación Peruana de Economía. https://ideas.repec.org//p/apc/wpaper/2017-109.html

Domar, E. D. (1946) *Capital expansion, rate of growth, and employment.* Econometrica, 14(2), 137. https://doi.org/10.2307/1905364

Figueroa, A. (1986) *Producción y distribución en el capitalismo subdesarrollado.* Economia, 9(17-18), 63-82. https://doi.org/10.18800/economia.198601.003

Figueroa, A. (1992) *Teorías económicas del capitalismo.* Fondo Editorial de la Pontificia Universidad Católica del Perú. https://ideas.repec.org//b/pcp/puclib/lde-1992-01.html

Figueroa, A. (1994) *La naturaleza del mercado laboral.* El Trimestre Económico, 61(2)(242), 335-360. https://econpapers.repec.org/article/eltjournl/v_3a61_3ay_3a1994_3ai_3a242_3ap_3a335-360.htm

García Carpio, J. M., & Céspedes Reynaga, N. (2011) *Pobreza y crecimiento económico: Tendencias durante la década del 2000 (Documento de Trabajo 21; p. 41).* Banco Central de Reserva del Perú. https://www.bcrp.gob.pe/publicaciones/documentos-de-trabajo/dt-2011-21.html

Gonzales Fernandez, S. A. (2018) *Impacto de las exportaciones en el crecimiento económico del Perú: 1990-2017* [Trabajo de suficiencia profesional, Universidad Nacional del Altiplano]. https://repositorio.unap.edu.pe/handle/20.500.14082/10398

Gujarati, D. N., & Porter, D. C. (2009) *Basic econometri* (5. ed., intern. ed., [Nachdr.]). McGraw-Hill Irwin.

Harrod, R. F. (1939) *An essay in dynamic theory.* The Economic Journal, 49(193), 14-33. https://doi.org/10.2307/2225181

Jaramillo, M., & Saavedra, J. (2011) *Menos desiguales: La distribución del ingreso luego de las reformas estructurales (Documentos de Investigación 59; p. 138).* GRADE. https://www.grade.org.pe/publicaciones/871-menos-desiguales-la-distribucion-del-ingreso-luego-de-las-reformas-estructurales/

Jones, C. I. (1995) *R & D-based models of economic growth.* Journal of Political Economy, 103(4), 759-784. https://doi.org/10.1086/262002

León, J. (2014) *Desempeño de las exportaciones de productos mineros tradicionales, Perú 1993-2013.* Revista de Economía San Marcos, 1(2), 99-113. https://docplayer.es/47385412-Desempeno-de-las-exportaciones-de-productos-mineros-tradicionales-peru.html

Lucas, R. E. B. (1988) *Demand for India's manufactured exports.* Journal of Development Economics, 29(1), 63-75. https://doi.org/10.1016/0304-3878(88)90071-5

Mankiw, N. G., Romer, D., & Weil, D. N. (1992) *A contribution to the empirics of economic growth.* The Quarterly Journal of Economics, 107(2), 407-437. https://doi.org/10.2307/2118477

Molpeceres Abella, M. de las M. (2008) *Métodos de aproximación a la medición del bienestar: Una panorámica.* https://ctinobar.webs.ull.es/1docencia/DESIGUALDAD%20SOCIAL/PANORAMICA.pdf

Riveros-Gavilanes, J. M. (2021) *Estimación de la función de bienestar social de Amartya Sen para América Latina.* Ensayos de Economía, 31(59), 13-40. https://doi.org/10.15446/ede.v31n59.88235

Romer, P. M. (1986) *Increasing returns and long-run growth.* Journal of Political Economy, 94(5), 1002-1037. https://doi.org/10.1086/261420

Romer, P. M. (1987) *Growth based on increasing returns due to specialization.* American Economic Review, 77(2), 56-62. https://econpapers.repec.org/article/aeaaecrev/v_3a77_3ay_3a1987_3ai_3a2_3ap_3a56-62.htm

Romer, P. M. (1990) *Endogenous technological change.* Journal of Political Economy, 98(5, Part 2), S71-S102. https://doi.org/10.1086/261725

Sen, A. (1973) *On economic inequality.* Clarendon Press.

Solow, R. M. (1956) *A contribution to the theory of economic growth.* The Quarterly Journal of Economics, 70(1), 65-94. https://doi.org/10.2307/1884513

Sunkel, O. (1979) *El subdesarrollo latinoamericano y la teoría del desarrollo (12da ed).* Siglo Veintiuno Editores.

Tello Pacheco, M. D. (2017) *La productividad total de factores agregada en el Perú. Nacional y departamental.* Instituto Nacional de Estadística e Informática. https://departamento-economia.pucp.edu.pe/libros/la-productividad-total-de-factores-agregada-en-el-peru-nacional-y-departamental

Uribe Mallarino, C. (2008) *Un modelo para armar: Teorías y conceptos de desarrollo.* Fondo Editorial de la Pontificia Universidad Católica del Perú. https://doi.org/10.18800/9789972428395

Vargas A. P. (2018) *Crecimiento de las exportaciones y el crecimiento económico en Perú: Evidencias de causalidad 1990-2016* [Tesis de licenciatura, Universidad San Ignacio de Loyola]. https://repositorio.usil.edu.pe/entities/publication/f57f1718-75c4-4703-ae88-8899a41ae250

Vidigal, C. B. R., Kassouf, A. L., & Gonçalves Vidigal, V. (2017) *Índice de bem-estar econômico: Uma proposta para os estados brasileiros.* Análise Econômica, 35(68), 199-229. https://doi.org/10.22456/2176-5456.43547

Villar, A. (2017) *Lectures on inequality, poverty and welfare (2da ed., Vol. 685).* Springer International Publishing. https://doi.org/10.1007/978-3-319-45562-4

Wooldridge, J. M. (2010) *Introducción a la econometría. Un enfoque moderno (4ta ed.).* Cengage Learning Editores. https://herioscarlanda.files.wordpress.com/2018/10/wooldridge-2009-introduccic3b3n-a-la-econometrc3ada-un-enfoque-moderno.pdf

Appendix A. Hypothesis Testing

A. 1 *Of the models with WSSEN return*

A. 1.1 F-test for individual effects

We compare the results of the fixed effects model (model vi) and the pooled regression adjustments (model v), testing the null hypothesis H0: there is complete homogeneity, to check whether fixed effects are really necessary. The results of the F test are shown in Table A.1.

Table A.1. Test F

F test for individual effects
$WSSEN \sim XNTPC + HPC + KDPC + LMPM + TPM$
$F = 43.81, df1 = 23, df2 = 331, p - value < 2.2e - 16$
alternative hypothesis: significant effects

Source: own elaboration.

According to the results obtained, the p-value is less than 2.2e-16, so we reject the null hypothesis. That is, there is evidence of the presence of substantial variations between the departments. Therefore, the use of a fixed effects model (model vii) is appropriate.

A. 1.2 Unobserved heterogeneity contrast

Secondly, we carried out the test to see if random effects (model viii) are really necessary. On this occasion, the Breusch-Pagan Lagrange Multiplier test was used. In this test, the null hypothesis H0 is tested: there are no random effects. The results are shown in Table A.2.

Table A.2. Breusch-Pagan Lagrange Multiplier Test

Lagrange Multiplier Test – (Breusch–Pagan)
data: $WSSEN\ XNTPC{+}HPC{+}KDPC{+}LMPM{+}TPM$
$chisq = 1005.9, df1 = 1, p - value < 2.2e - 16$
alternative hypothesis: significant effects

Source: own elaboration.

According to the results of the test, the null hypothesis is rejected with a p-value of less than 2.2e-16. Therefore, there are random effects that must be taken into account with some form of parameter heterogeneity. Then, the pooled regression model (model v) will not be an adequate choice against the random effects model (model viii).

A. 1.3 Test of endogeneity of regressors

Next, we will evaluate the relevance between a fixed effects model (model vii) and a random effects model (model viii). It is known that the random effects model requires the exogeneity of the explanatory variables. According to the standard procedure, the Hausman test will be used to test the null hypothesis H0: the estimators of the fixed effects model and the random effects model do not differ. The results are shown in Table A.3.

Table A. 3. Hausman test

Hausman Test
data: $WSSEN\ XNTPC{+}HPC{+}KDPC{+}LMPM{+}TPM$
$chisq = 22.15, df1 = 5, p - value = 0.005$
alternative hypothesis: one model is inconsistent

Source: own elaboration.

According to the results of the Hausman test, since 0.0005 < 0.05, the null hypothesis is rejected. That is, endogeneity does seem to be a problem. Therefore, the fixed effects model (model vii) is preferred over the random effects model (model viii).

A. 1.4 Heteroscedasticity contrast

Panel data models often exhibit heteroscedasticity between groups, regardless of whether the error term within the cross-sectional units is homoscedastic. To ensure that this is not the case, we use the Breusch-Pagan heteroscedasticity test, testing the null hypothesis H0: there is no homoscedasticity. The results are shown in Table A.4.

Table A. 4. Breusch-Pagan Heteroscedasticity Test

Breusch – Pagan test
data: *WSSEN XNTPC+HPC+KDPC+LMPM+TPM*
$P = 36.074, df1 = 5, p - value = 9.179e - 07$

Source: own elaboration.

Then, according to these results, where p-value = 9.179e-07, the null hypothesis is rejected, since there is evidence of heteroscedasticity. Therefore, according to the result obtained, a robust covariance matrix must be used to control for the absence of homoscedasticity for fixed effects. The new t values are shown in the model (ix).

A. 2 Of the models with GDPPC regression

A. 2.1 F-test for individual effects

Now, the results of the fixed effects model (model xvi) and the pooled regression adjustments (model xv) are compared. We test the null hypothesis H0: there is complete homogeneity to check if fixed effects are really necessary. The results of the F-test are shown in Table A.5.

Table A. 5. Test F

F test for individual effects
PIBPC XTPC + XNTPC + HPC + KDPC + LMPM + TPM
$F = 37.048, df1 = 23, df2 = 330, p - value < 2.2e - 16$
alternative hypothesis: significant effects

Source: own elaboration.

According to the results obtained, p-value is less than 2.2e-16, so we reject the null hypothesis. That is, there is evidence that there are substantial variations between the departments. Therefore, the use of a fixed effects model (model xvi) is appropriate.

A. 2.2 Unobserved heterogeneity contrast

Secondly, we carried out the test to see if random effects (model xvii) are really necessary. On this occasion, the Breusch-Pagan Lagrange Multiplier test was used. In this test, the null hypothesis H0 is tested: there are no random effects. The results are shown in Table A.6.

According to the results of the test, the null hypothesis is rejected with a p-value less than 2.2e-16. Therefore, there are random effects that must be taken into account with some form of parameter heterogeneity. Then, the pooled regression model (model xv) will not be an adequate choice against the random effects model (model xvii).

Table A. 6. Breusch-Pagan Lagrange Multiplier Test

Lagrange Multiplier Test – (Breusch–Pagan)
data: *PIBPC XTPC + XNTPC + HPC + KDPC + LMPM + TPM*
$chisq = 294.25, df1 = 1, p - value < 2.2e - 16$
alternative hypothesis: significant effects

Source: own elaboration.

A. 2.3 Endogeneity contrast of regressors

Finally, the relevance between a fixed effects model (model xvi) and a random effects model (model xviii) is evaluated. It is known that the random effects model requires the exogeneity of the explanatory variables. We use the Hausman test to test the null hypothesis H0: the estimators of the fixed effects model and the random effects model do not differ. The results are shown in Table A.7.

Table A. 7. Hausman Test

Hausman Test
data: *PIBPC XTPC + XNTPC + HPC + KDPC + LMPM + TPM*
$chisq = 221.99, df1 = 6, p - value < 2.2e16$
alternative hypothesis: one model is inconsistent

Source: own elaboration.

According to the results of the Hausman test, the null hypothesis is accepted. That is, endogeneity does seem to be a problem. Therefore, the fixed effects model (model xvi) was preferred over the random effects model (model xvii).

A. 2.4 Heteroscedasticity contrast

As noted above, panel data models often exhibit heteroscedasticity between groups, regardless of whether the error term within the cross-sectional units is homoscedastic. To ensure that this is not the case, the Breusch-Pagan heteroscedasticity test was used, testing the null hypothesis H0: there is no homoscedasticity. The results are shown in Table A.8.

Table A. 8. Breusch-Pagan Heteroscedasticity Test

Breusch-Pagan test
data: *PIBPC XTPC + XNTPC + HPC + KDPC + LMPM + TPM*
$P = 869.53, df1 = 6, p - value < 2.2e - 16$
alternative hypothesis: one model is inconsistent

Source: own elaboration.

Then, according to these results, where p-value = 2.2e-16, the null hypothesis is rejected, since there is evidence of heteroscedasticity. Therefore, we must use a robust covariance matrix to be able to control for the absence of homoscedasticity for fixed effects. The new t values are shown in the model (xviii).

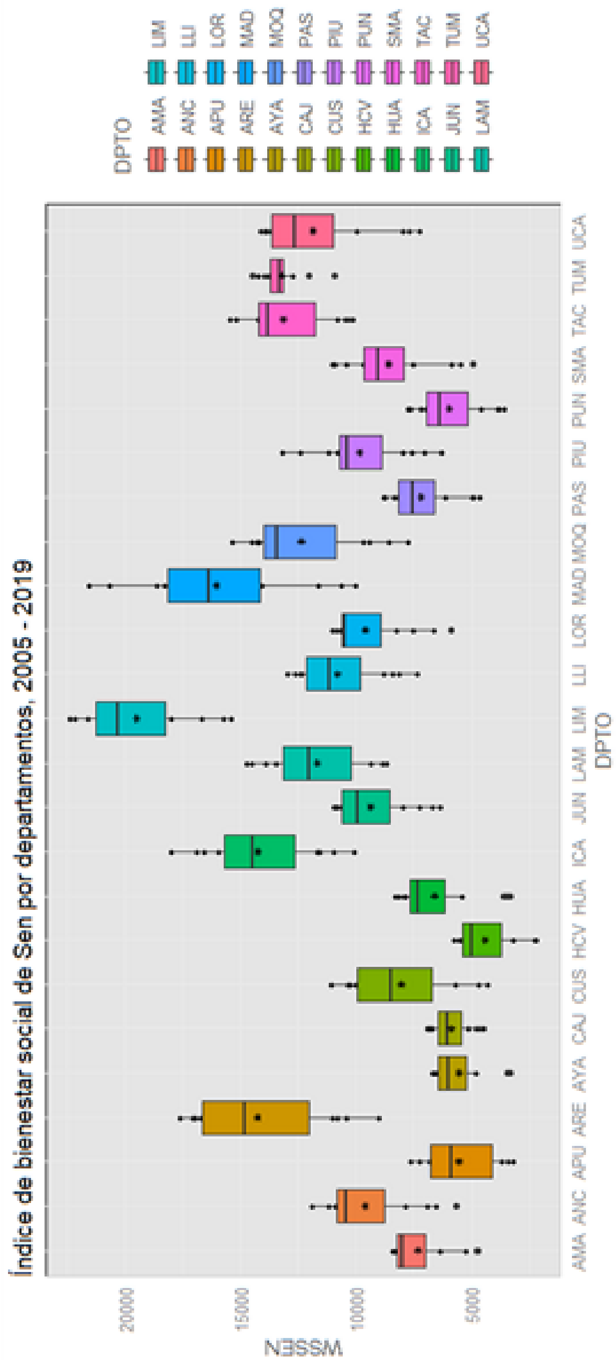
Appendix B. Sen departmental social well-being index

Appendix C. Departmental gross domestic product per capita

Appendix D. Sen's social welfare models estimated for each department

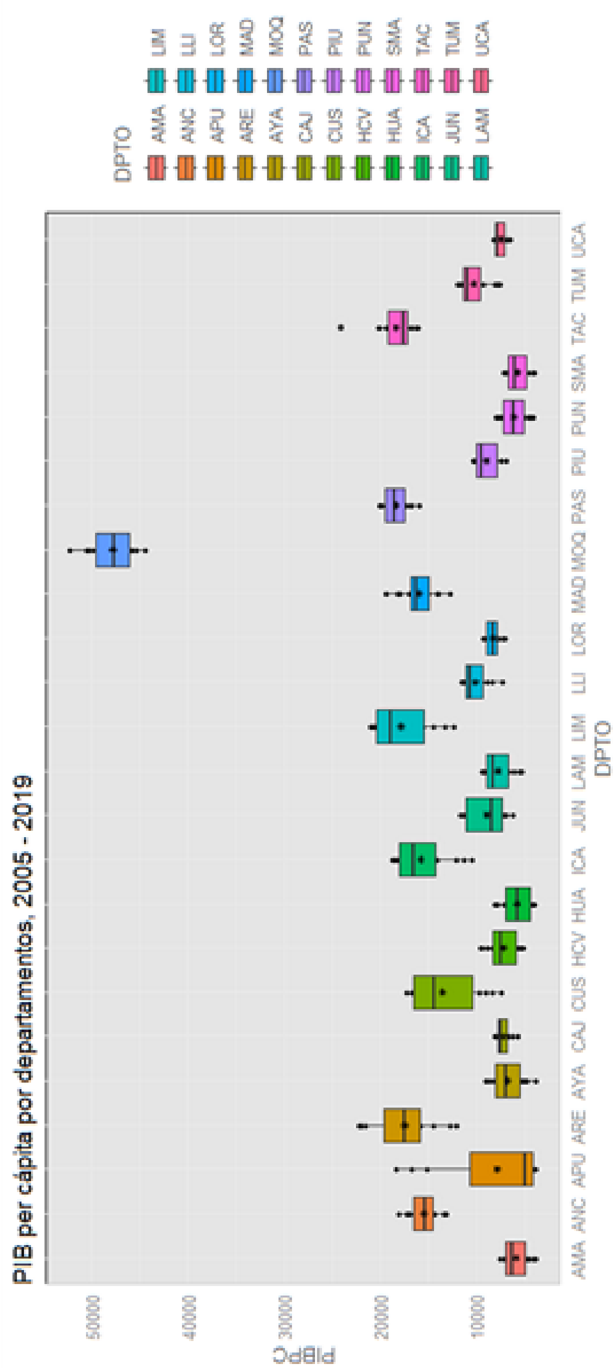
The estimated models of social well-being for each department are estimated from the fixed effects model, model (ix). The results are presented in the following Table D.1.

Figura B. 1. Departmental Sen social well-being index, Peru 2005-2019



Source: Self made.

Figura C. 1. Departmental gross domestic product per capita, Peru 2005–2019



Source: own elaboration.

Appendix E. Estimated economic development models for each department

The estimated economic development models for each department are estimated from the fixed effects model, model (xviii). The results are presented in the following Table E.1.

Table D. 1. Social welfare fixed effects models estimated for each department

DPTO	AMA	ANC	APU
Modelo	$2819.23 + 2.31 * XNTPC + \hat{\beta}X$	$2831.59 + 2.31 * XNTPC + \hat{\beta}X$	$8.83 + 2.31 * XNTPC + \hat{\beta}X$
DPTO	ARE	AYA	CAJ
Modelo	$5527.36 + 2.31 * XNTPC + \hat{\beta}X$	$350.76 + 2.31 * XNTPC + \hat{\beta}X$	$1038.66 + 2.31 * XNTPC + \hat{\beta}X$
DPTO	CUS	HCV	HUA
Modelo	$494.95 + 2.31 * XNTPC + \hat{\beta}X$	$-179.57 + 2.31 * XNTPC + \hat{\beta}X$	$1545.46 + 2.31 * XNTPC + \hat{\beta}X$
DPTO	ICA	JUN	LAM
Modelo	$4218.54 + 2.31 * XNTPC + \hat{\beta}X$	$3403.63 + 2.31 * XNTPC + \hat{\beta}X$	$5462.63 + 2.31 * XNTPC + \hat{\beta}X$
DPTO	LIM	LLI	LOR
Modelo	$9378.64 + 2.31 * XNTPC + \hat{\beta}X$	$3855.40 + 2.31 * XNTPC + \hat{\beta}X$	$5084.20 + 2.31 * XNTPC + \hat{\beta}X$
DPTO	MAD	MOQ	PAS
Modelo	$7375.84 + 2.31 * XNTPC + \hat{\beta}X$	$1025.38 + 2.31 * XNTPC + \hat{\beta}X$	$479.78 + 2.31 * XNTPC + \hat{\beta}X$
DPTO	PIU	PUN	SMA
Modelo	$3316.93 + 2.31 * XNTPC + \hat{\beta}X$	$-29.68 + 2.31 * XNTPC + \hat{\beta}X$	$3321.10 + 2.31 * XNTPC + \hat{\beta}X$
DPTO	TAC	TUM	UCA
Modelo	$3927.13 + 2.31 * XNTPC + \hat{\beta}X$	$5262.75 + 2.31 * XNTPC + \hat{\beta}X$	$6513.79 + 2.31 * XNTPC + \hat{\beta}X$

Source: own elaboration.

Table E. 1. Estimated economic development models for each department

DPTO	AMA	ANC	APU
Modelo	$309.86 + 0.63 * XTPC + \hat{\gamma}X$	$4643.68 + 0.63 * XTPC + \hat{\gamma}X$	$-341.91 + 0.63 * XTPC + \hat{\gamma}X$
DPTO	ARE	AYA	CAJ
Modelo	$5692.49 + 0.63 * XTPC + \hat{\gamma}X$	$827.41 + 0.63 * XTPC + \hat{\gamma}X$	$612.94 + 0.63 * XTPC + \hat{\gamma}X$
DPTO	CUS	HCV	HUA
Modelo	$2615.61 + 0.63 * XTPC + \hat{\gamma}X$	$1025.37 + 0.63 * XTPC + \hat{\gamma}X$	$-297.93 + 0.63 * XTPC + \hat{\gamma}X$
DPTO	ICA	JUN	LAM
Modelo	$2783.52 + 0.63 * XTPC + \hat{\gamma}X$	$1427.95 + 0.63 * XTPC + \hat{\gamma}X$	$1098.47 + 0.63 * XTPC + \hat{\gamma}X$
DPTO	LIM	LLI	LOR
Modelo	$5749.46 + 0.63 * XTPC + \hat{\gamma}X$	$1875.15 + 0.63 * XTPC + \hat{\gamma}X$	$2330.19 + 0.63 * XTPC + \hat{\gamma}X$
DPTO	MAD	MOQ	PAS
Modelo	$4595.52 + 0.63 * XTPC + \hat{\gamma}X$	$22539.40 + 0.63 * XTPC + \hat{\gamma}X$	$7210.50 + 0.63 * XTPC + \hat{\gamma}X$
DPTO	PIU	PUN	SMA
Modelo	$1796.03 + 0.63 * XTPC + \hat{\gamma}X$	$-922.84 + 0.63 * XTPC + \hat{\gamma}X$	$-655.04 + 0.63 * XTPC + \hat{\gamma}X$
DPTO	TAC	TUM	UCA
Modelo	$6645.36 + 0.63 * XTPC + \hat{\gamma}X$	$1538.96 + 0.63 * XTPC + \hat{\gamma}X$	$1215.22 + 0.63 * XTPC + \hat{\gamma}X$

Source: own elaboration.