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Design-based and Model-based Estimation of Poverty Measures at the Provincial Level in the Philippines¹

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ABSTRACT

This paper focused on estimating the Foster-Greer-Thorbecke (FGT) poverty measures (poverty incidence, poverty gap, severity of poverty) at the provincial level in the Philippines. Design-based and model-based estimation techniques were used and the estimates obtained were compared in terms of some measures of accuracy, precision and reliability. The sources of data include 2000 Family Income and Expenditure Survey (FIES) and 2000 Census of Population and Housing (CPH). For estimates of provincial poverty incidence, the model-based estimation technique produced reliable estimates in 71 provinces. The linear model used has an adjusted R^2 of 63.55% with 4 predictors; namely, provincial proportion of the total barangays having (1) street pattern; (2) access to the national highway; (3) surroundings as waste disposal system; and (4) provincial average number of male persons per household. For provincial poverty gap, more than 75% of the provinces have reliable estimates based on model-based estimation technique. The predicting model has an adjusted R^2 of 62.67% and the identified predictors include provincial average number of members aged between 7 and 14; the provincial proportion of the number of housing units with floor area at most 10 sq. m.; and the provincial number of housing units of single type. In estimating provincial poverty severity index, the predicting model has an adjusted R^2 of 51.08% and the predictors include the provincial proportion out of the total count of (1) housing units with floor area at most 10 sq. m.; (2) households with members aged less than 7; and (3) barangays with the surroundings as waste disposal system. Thus, the model-based estimation technique produced reliable estimates of the provincial FGT poverty measures in the Philippines.

Keywords: small area estimation; poverty incidence; poverty gap; severity of poverty

I. Introduction

It is now widely accepted that poverty is multidimensional in nature since there are different conceptualizations of poverty. Poverty is not only material deprivation in terms of having income or consumption levels below a given threshold but also the deprivation arising from illiteracy, malnutrition, bad health, inadequate access to basic services such water and sanitation, unhealthy living conditions, and even lack of political freedom to name a few. Poverty reduction is a worldwide concern. Measurement of poverty is necessary in order to produce essential information for all programs that aim to reduce and alleviate poverty. Poverty estimates and geographic distribution of poverty are vital inputs in the design,

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implementation, and monitoring of antipoverty policies. This leads us to come up with better and up-to-date information about the poor which is essential to assist the government in designing effective policies for attacking poverty (Prescott and Pradham, 1997). Identifying who are the poor, how many are there, how poor they are, and where are the poor are some of the questions that our government agencies need to know in order to succeed in helping the poor.

Today, demand has grown for more frequent estimates of poverty at the sub-national, national, and global levels. Two of the drivers of these demands are the Poverty Reduction Strategy Paper (PRSP) process by the World Bank and International Monetary Fund (IMF) and the attempt to assess progress towards achieving the Millennium Development Goal (MDG) of reducing by one-half the proportion of persons living in poverty by 2015. There are many indices of poverty, each providing different insights into its nature. Income poverty continues to be the leading indicator of poverty levels. In practice, the living standard indicator against the poverty line is compared with income or expenditure collected from household income and/or expenditure surveys. Concerning poverty estimates, the FGT class of poverty measures proposed by Foster, Greer, and Thorbecke (1984) is the most popular and common indicator. This class had several mathematical advantages over other measures because of its simplicity and decomposability. Their main practical advantage is that they highlight different aspects of poverty. The most common of this class is the incidence of poverty or the share of population living in poverty, and two other measurements known as poverty gap index and severity of poverty. The poverty gap index measures the depth of poverty because it is sensitive to changes in the average income of the poor. On the other hand, the severity of poverty measures intensity of poverty because it is sensitive to changes in the inequality of income distribution of the poor.

In the Philippines, the FGT poverty measures are part of the official poverty statistics based on the policies approved by the National Coordination Board (NSCB). In 2000, the incidence of poverty of families in the Philippines was significantly greater in rural areas than in urban areas based on the Family Income and Expenditure Survey. The incidence of poverty of families was 41.4 percent in the rural areas while only 15 percent in the urban areas. This means that almost one-half of the total families living in the rural areas are deemed poor, and that two out of every five families living in the urban areas are poor. Although, it is well documented that poverty is more prevalent in rural areas, very little research examines whether poverty is more severe in these areas. Thus, the poverty gap and severity of poverty indices are important inputs for this kind of researches.

Information on poverty measures at the provincial level is difficult to acquire and often questioned on its reliability. Most poverty analyses of family survey only permit estimates of poverty to be made at the survey stratum level, typically region with urban-rural disaggregation. On the other hand, small-area estimation, a recently developed technique, provides methods to estimate poverty at sublevels. These methods based on a quite number of researches were found useful in giving reliable estimates at these sublevels. In addition, identification of the poor to whom government poverty programs are to be directed is problematic. Geographical targeting of the poor is one method by which such efforts might be implemented more efficiently, targeting poverty reduction projects in those areas that contain disproportionate numbers of the poor (Bigman & Fofack, 2000).

This paper aims to provide poverty estimates, specifically the FGT poverty measures at the provincial level using the design-based estimation and model-based estimation procedures. The paper also evaluated properties of the design-based estimates and further used small-area estimation technique for the observed large standard errors of design-based estimates.

II. Methodology

In generating FGT poverty measures, the data came from the 2000 Family Income and Expenditure Survey (FIES). The Philippine National Statistics Office (PNSO) conducts the survey every three years. In 2000 FIES, provinces and keys cities were used as domains. It adopted the master plan of households that started in 1997. The other data set used was the 2000 Census of Population and Housing (CPH). It was designed to take an inventory of the total population and housing units in the Philippines and to gather information about their characteristics. The census of population was the source of data on the size and distribution of the population as well as data on the demographic, social, economic and cultural characteristics.

Using FIES data, the design-based estimates of FGT measures at the provincial level and its standard errors were obtained and computed considering the sampling design of the survey. The coefficient of variation and mean square errors of the estimates for the FGT poverty measures were evaluated to justify the need for small area estimation procedure.

The aggregate values of the identified variables both in the CPH data and the administrative data at the provincial level were used as part of the auxiliary information for the model building of the FGT poverty measures. A stepwise regression analysis was done for each of the poverty measures using ordinary least squares method. In this paper, the best OLS models were considered as the models with the highest coefficient of determination, all predictors are significant, and all assumptions of regression analysis are satisfied. To account for the survey weights, a regression analysis was done using the weighted least squares method for each of the FGT poverty measures. The same procedure as with the OLS method was done on choosing the best WLS model. On other hand, the estimates from the best WLS formulated models for each of FGT poverty measures were used together with the design-based estimates to produce the small area estimates using empirical best linear unbiased prediction (EBLUP) method. The FGT poverty estimates from the three methods were used as inputs in the generation of poverty maps. The different computations, analyses and mapping were performed using SAS, STATA, and ArcView softwares.

The poverty measures used as variables of interests were the poverty incidence, poverty gap, and severity of poverty also named as FGT poverty measures. Poverty incidence defined as the proportion of the number of poor people in the population. It refers to the percentage of the population whose income level is below the poverty line. On the other hand, poverty gap measures the average distance of the poor below the poverty line across the whole population. This indicator measures the magnitude of poverty as it considers both the number of poor people and how poor they are. Lastly, severity of poverty is an index which is sensitive to the distribution of living standards among the poor. This measure has a value equal to the square of depth of poverty for each individual as it takes into account not only the distance separating the poor from the poverty line(the poverty gap), but also the inequality among the poor.

III. Results And Discussions

Provincial Poverty Incidence (P^0)

Design-based, model-based and EBLUP estimation procedures were the techniques used to produce estimates of the provincial poverty incidence. The distributions of estimates across these three methods are generally the same with some slight differences. Figure 1 show the comparison of the distribution of the estimates of the provincial poverty incidence.

It can be seen that the distribution of estimates is consistent since the three methods produced all high estimates for a particular range and have similar proportion of frequencies in almost all ranges (See Table 1). Majority of the provincial estimates have poverty incidences ranging from 40% to 50% but the model-based estimates has the most number of provincial estimates of poverty incidence falling in this interval. Moreover, model-based estimation method has the least number of provincial estimates with values less than 10%. On the other hand, the design-based estimation has the most number of estimates within the range 50% to 60% while EBLUP estimation produced most number of provincial estimates poverty incidence in the range 60% to 70%.

Table 1. Distribution of provincial estimates of poverty incidence using design-based, model-based and EBLUP methods, 2000.

POVERTY INCIDENCE	DESIGN-BASED	MODEL-BASED	EBLUP
<10	5	3	5
10-20	9	3	7
20-30	4	7	5
30-40	13	22	16
40-50	28	33	29
50-60	17	10	13
60-70	4	3	6
70-80	2	1	1
Total	82	82	82

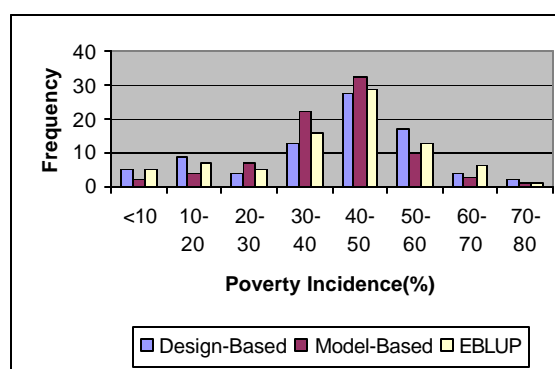


Figure 1. Distribution of provincial estimates of poverty incidence using design-based, model-based and EBLUP methods, 2000.

For the accuracy and precision of the estimates, the model-based estimation procedure produced the most accurate and precise estimates for the provincial poverty incidence among the three techniques as shown in Table 2. Majority of the model-based estimates have mean square errors within the range 0.0001 to 0.0010. On the other hand, the EBLUP estimates are more accurate and precise than the design-based estimates since the latter has the most number of estimates with mean square errors greater than 0.0030 as shown in Figure 2.

Table 2. Distribution of estimates of mean square errors poverty incidence using design-based, model-based and EBLUP methods, 2000.

MSE	DESIGN -BASED	MODEL -BASED	EBLUP
<0.0001	2	0	2
0.0001-0.0010	16	68	18
0.0010-0.0020	21	12	34
0.0020-0.0030	26	0	23
>0.0030	17	2	5
Total	82	82	82

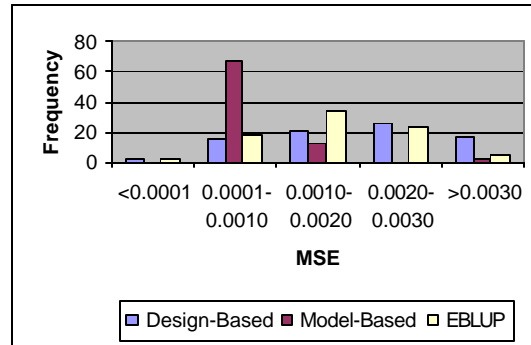


Figure 2. Distribution of the mean square error of the estimates of provincial poverty incidence using the design-based, model-based and EBLUP methods. 2000

For the reliability of the estimates, the model-based estimation procedure produced more reliable estimates because 86.59 percent of its estimates have coefficient of variations less than 10 percent. However, the model based estimation procedure has the highest obtained coefficient of variation at 70.40 percent for the 4th District of NCR while the EBLUP estimation procedure has the lowest at 56.96% for the province of Batanes. Nevertheless, the EBLUP method has the least range of the coefficient of variation among the three set of estimates as shown in Table 3 and Figure 3.

Table 3. Distribution of the coefficient of variation of the provincial estimates of poverty incidence using the design-based, model-based and EBLUP methods. 2000

CV	DESIGN -BASED	MODEL -BASED	EBLUP
<10	28	71	39
10-20	52	6	42
>20	2	5	1
Total	82	82	82

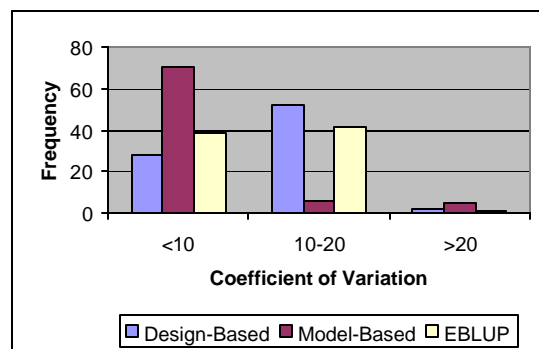


Figure 3. Distribution of the coefficient of variation of the provincial estimates of poverty incidence using the design-based, model-based and EBLUP methods. 2000

For the geographical targeting of the poor, the poverty map for Philippines using the model-based method of estimating the provincial poverty incidence for 2000 is shown in

Appendix Figure 1 at increasing level of resolution. Higher resolution maps reveal that higher incidences of poverty. The province of Lanao del Sur exhibited the highest poverty incidence.

Provincial Poverty Gap (Pⁱ)

The comparison of the three estimation techniques for the provincial poverty gap in the Philippines is shown in Table 4 and Figure 4. The three methods produced almost similar distribution of estimates for provincial poverty gap. Common among the three is that the provincial estimates have ranges from 0 to 30%. High percentages of the estimates in three methods are within 10 percent to 20 percent. The model-based estimation method produced the most number of provincial estimates of poverty gap less than 10% at 31.75 percent. Conversely, model-based and EBLUP estimation methods have the same least number of provincial estimates with values within the range 20% to 30%. On the other hand, the design-based estimation method produced the most number of provincial estimates for poverty gap with values within the range 20% to 30% at 13.41 percent.

Table 4. Distribution of provincial estimates of poverty gap using the design-based, model-based and EBLUP methods. 2000

POVERTY GAP	DESIGN-BASED	MODEL-BASED	EBLUP
<10	25	26	24
10-20	46	49	51
20-30	11	7	7
Total	82	82	82

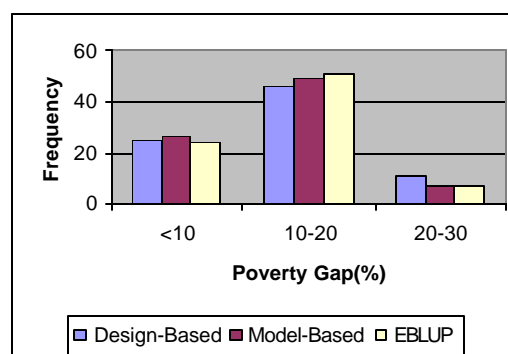


Figure 4. Distribution of provincial estimates of poverty gap using the design-based, model-based and EBLUP methods. 2000

In terms of accuracy and precision, the comparison of the distribution of the mean square errors for the provincial poverty gap among the three methods is shown in Table 5 and Figure 5. The model-based estimation procedure produced the most accurate and precise estimates among the three techniques. Its provincial estimates have 78.05% of mean square errors less than 0.0001. On the other hand, the design-based and EBLUP estimates have almost the same distributions of mean square errors. However, only the design-based estimation method has a mean square error which is greater than 0.0030.

Table 5. Distribution of the mean square error of the provincial estimates of poverty gap using the design-based, model-based and EBLUP methods.

MSE	DESIGN-BASED	MODEL-BASED	EBLUP
<0.0001	14	64	14
0.0001-0.0010	63	18	67
>0.0010	5	0	1
Total	82	82	82

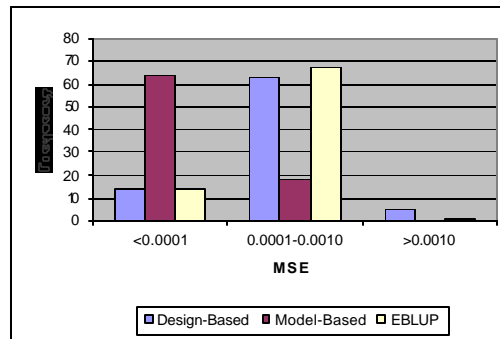


Figure 5. Distribution of the mean square error of the provincial estimates of poverty gap using the design-based, model-based and EBLUP methods.

Table 6 and Figure 6 summarizes the comparison of the coefficient of variations for the provincial poverty gap obtained from the three methods. The model-based estimation procedure again produced more reliable estimates of more than 75% of the provinces in the Philippines have coefficients of variation less than 10%. Unfortunately, the highest coefficient obtained under this estimation procedure is 291.86%. However, the EBLUP estimation method has the lowest observed coefficient of variation at 68.66%. Thus, the EBLUP method has the least range of the coefficient of variation among the three.

Table 6. Distribution of the coefficient of variation of the provincial estimates of poverty gap using the design-based, model-based and EBLUP methods. 2000

CV	DESIGN-BASED	MODEL-BASED	EBLUP
<10	8	65	13
10-20	64	9	63
20-30	9	6	5
>30	1	2	1
Total	82	82	82

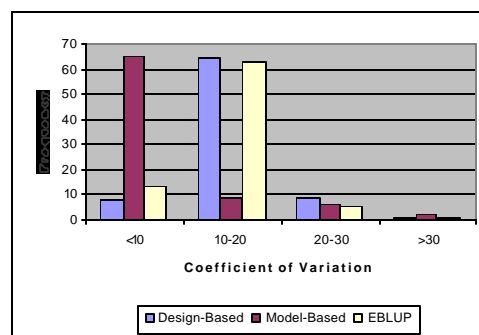


Figure 6. Distribution of the coefficient of variation of the provincial estimates of poverty gap using the design-based, model-based and EBLUP methods. 2000

For the poverty gap mapping in the Philippines, higher resolutions reveal high depth of poverty among provinces in the Mindanao regions were observed consistently in the

estimates derived from the model-based. Poverty map for the provincial poverty gap indicator is shown in Appendix Figure 2.

Provincial Severity of Poverty (P^2)

The estimates of provincial poverty severity index using the three estimation procedures are shown in Table 7 and Figure 7. The distributions of estimates of the methods have come up with consistent range from 0 to 20 percent. Most number of estimates for severity of poverty for the three methods was less than 10 percent. The three methods came up with three different provinces where poverty was most severe. For the design-based, the highest is the province of Romblon at 14%, model-based has Sulu at 10.94% and for EBLUP, Maguindanao at 12.26%. However, among the three, the model-based estimate of poverty severity index for the province of Sulu is the most reliable estimate since it has a coefficient of variation at 9.56%

Table 7. Distribution of the provincial estimates of severity of poverty using the design-based, model-based and EBLUP methods. 2000

Estimates of Severity of Poverty	DESIGN-BASED	MODEL-BASED	EBLUP
<10	74	81	78
10-20	8	1	4
Total	82	82	82

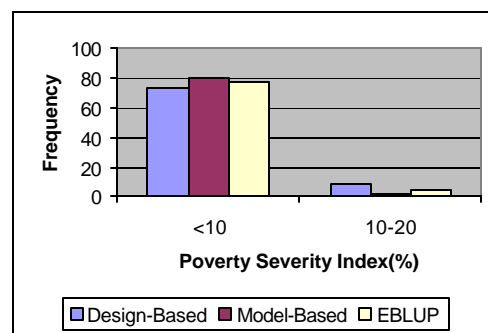


Figure 7. Distribution of the provincial estimates of severity of poverty using the design-based, model-based and EBLUP methods. 2000

Evaluating in terms of accuracy and precision, the model-based estimation procedure produced the most accurate and precise estimates among the three techniques as shown in Table 8 and Figure 8. Although all the estimates from the three methods can be generally considered as precise and accurate since they have all relatively low values for mean square errors. On the other hand, the design-based estimation method came up with an estimate which is greater than 0.0010.

Table 26. Distribution of the mean square errors of the provincial estimates of severity of poverty using the design-based, model-based and EBLUP methods. 2000

MSE	DESIGN-BASED	MODEL-BASED	EBLUP
<0.0001	40	80	46
0.0001-0.0010	41	2	36
>0.0010	1	0	0
Total	82	82	82

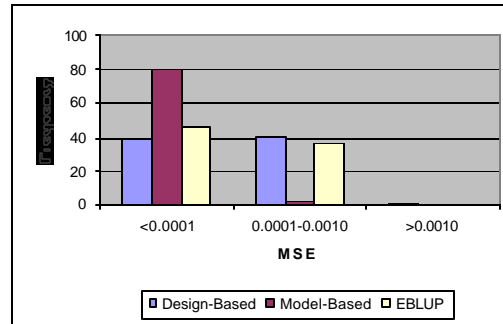


Figure 8. Distribution of the mean square error of the provincial estimates of severity of poverty using the design-based, model-based and EBLUP methods. 2000

Looking at the reliability of the estimates for severity of poverty, Table 9 and Figure 9 show the comparison of the distribution of the coefficient of variation among the three methods. The model-based estimation procedure produced more reliable estimates compared with the two methods. All the distributions of coefficient of variation for severity of poverty for the three methods followed a positively skewed distribution. The highest coefficient obtained among the three estimation procedures is 114.78% coming from model-based method. In addition, the EBLUP procedure came-up with lowest range for coefficient of variation. The province having the highest coefficient of variation is the 2nd District of NCR among the three methods.

Table 9. Distribution of the coefficient of variation of the provincial estimates of severity of poverty using the design-based, model-based and EBLUP methods. 2000

CV	DESIGN-BASED	MODEL-BASED	EBLUP
<10	1	56	1
10-20	47	15	62
20-30	28	4	16
30-40	5	3	2
>40	1	4	1
Total	82	82	82

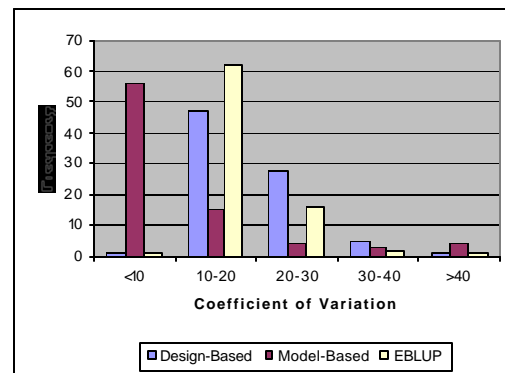


Figure 9. Distribution of the coefficient of variation of the provincial estimates of severity of poverty using the design-based, model-based and EBLUP methods. 2000

For the mapping of estimates where poverty is most severe, the maps are shown in Figures 3 in Appendix B at varying level of resolutions. In the maps, the provinces of

Romblon, Sulu, and Maguindanao have the darkest resolutions for severity of poverty. Common among the three methods of estimation for provincial poverty severity index is that high resolutions in some provinces in Cordillera Autonomous Region (Region 14) in Luzon.

IV. Lessons Learned

Based on the three methods used in estimating the FGT poverty measures, the model-based estimator for FGT poverty measures at the provincial level was found to be the “best” based on our set criteria for choosing. Majority of the estimates produced using model-based estimation method were reliable as measured by the coefficient of variation and were accurate and precise. The model-based approach on estimating poverty measures has a potential to obtain reliable estimates compared to the design-based approach especially for small domains. On the other hand, the EBLUP estimation procedure seemed to preserve the distribution of the design-based estimates but with more reliable estimates.

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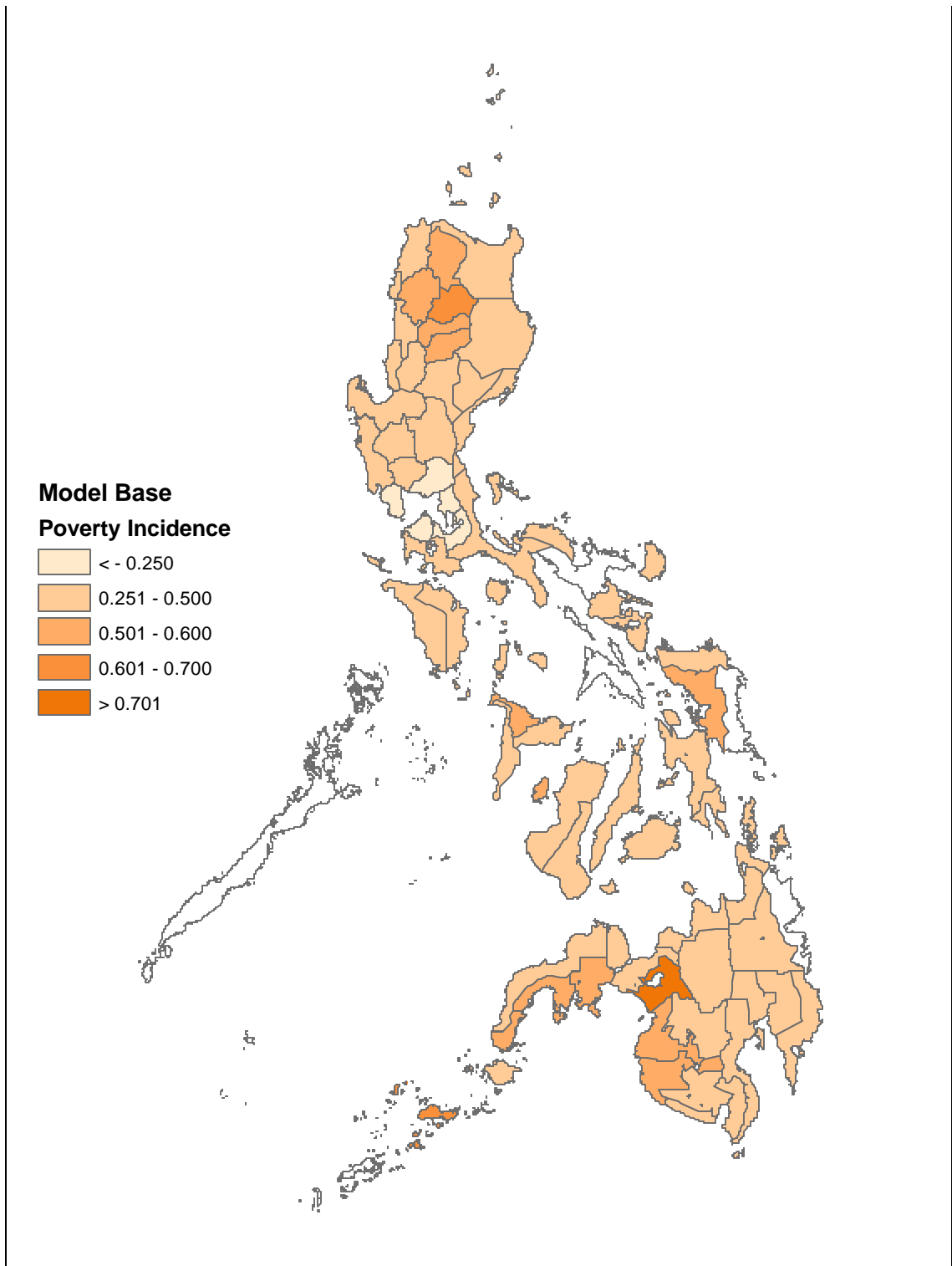
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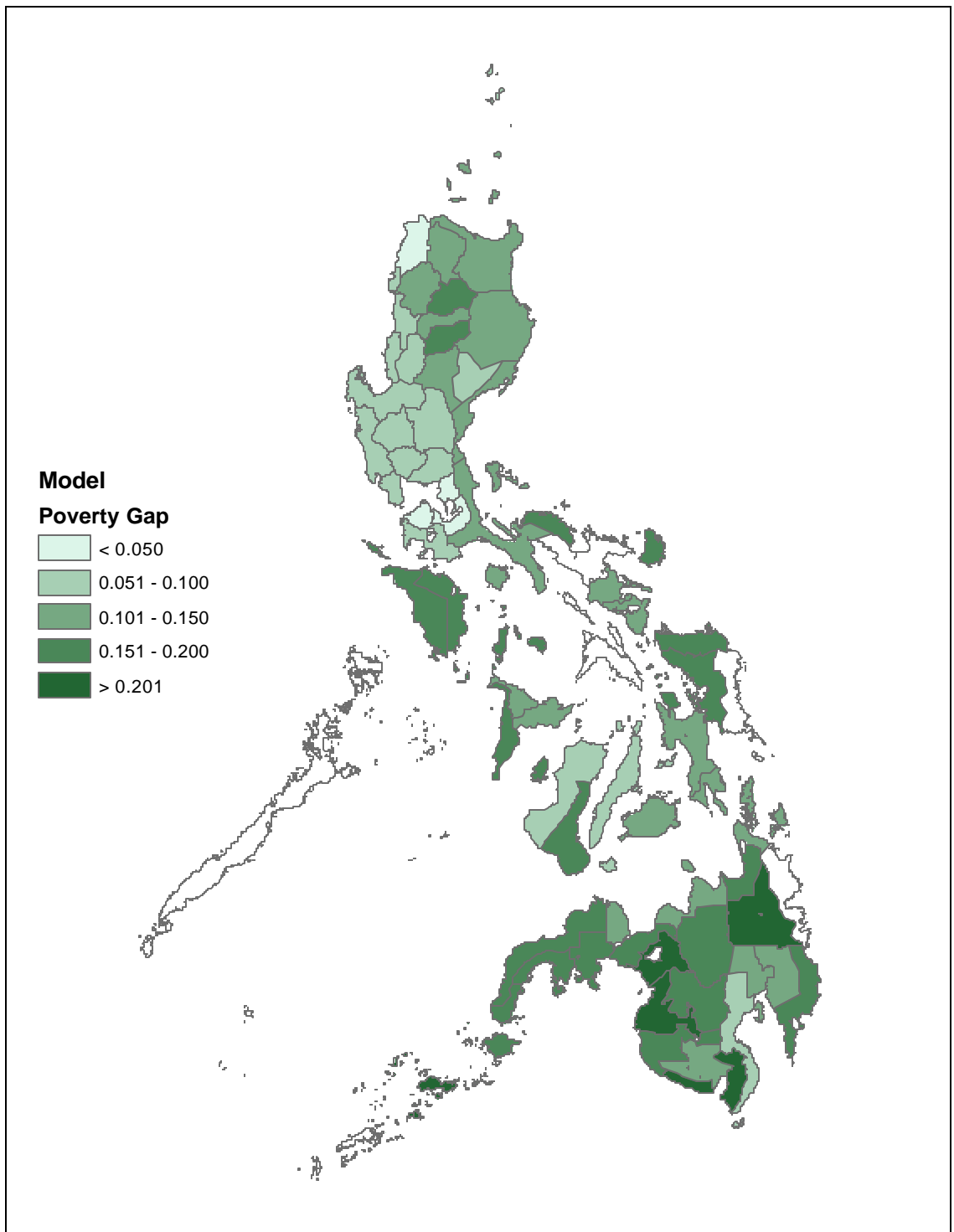
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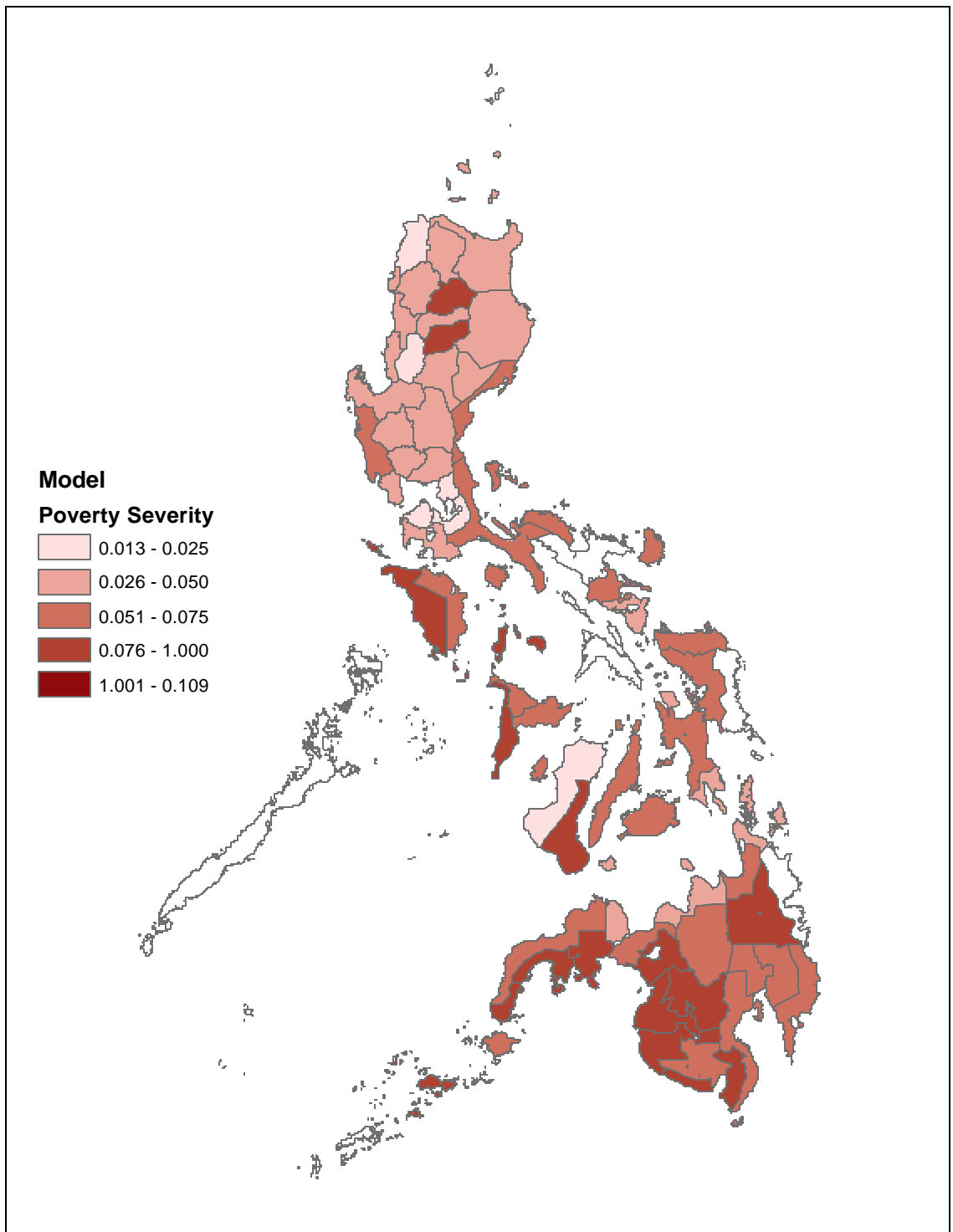
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Appendix Figure 1. Poverty Map of Philippines – Model-based Poverty Incidence by Province.



Appendix Figure 2. Poverty Map of Philippines – Model-based Poverty Gap by Province.



Appendix Figure 3. Poverty Map of Philippines – Model-based Poverty Severity by Province.