DETERMINANTS OF THE NUMBER OF CATHOLIC PRIESTS TO CATHOLICS IN EUROPE—AN ECONOMIC EXPLANATION

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This paper takes a new approach to studying the significant factors that determined the number of Catholic priests in Europe between 1950 and 2006. Using panel data analysis, we found a quadratic relation between the number of Catholic priests per Catholic population and real income per capita. We also identified other factors that are related to the historical role of Catholicism in the country: the fertility rate, the proportion of urban residents, and the proportion immigrant population.

Over the past twenty years, the *Statistical Yearbook of the Church*, published by the Vatican, has confirmed that the number of Catholic priests in most industrialized countries is decreasing. Various hypotheses have been proposed to explain this decrease: changes in demographics, changes in family structure, the existence of virtual religious monopolies, and economic growth. Secularization theory suggests that economic growth is the most important determinant of changes in religiosity. However, previous analyses of this phenomenon have failed to systematize and evaluate the question empirically.[2]

The overall decline in the number of Catholic priests may be a result of the changing lifestyle patterns among European youth, specifically their aversion to lifelong commitments. However, given the diverse historical influences that Christianity has had in most European countries, it is surprising to see the number of Catholic priests per member of the Catholic Church declining in both predominantly non-Catholic and Catholic nations. Therefore, as Barro and McCleary (2002) suggested, there may be a significant statistical relationship between economic development and religious change.

According to the most recent statistics, Europe, more than any other region, has witnessed a significant decline in the number of Catholic priests. In 1999, there were only five priests for every 10,000 European residents. In contrast, in 1950, there were 10 priests for every 10,000 residents, and in three countries (Luxembourg, Ireland, and Belgium) there were more than 15. By 1999, only Malta had more than 15 priests for every 10,000 residents (according to the *Statistical Yearbook of the Church*). These decreasing numbers are the result of a long-term demographic transition towards aging societies, which all European countries are experiencing, but other social and economic developments have also contributed to the declining number of priests.

As a country experiences economic growth, its occupational structures change in important ways. However, these changes are conditioned by each country's specific circumstances. For example, as the *Statistical Yearbook of the Church* notes, the most significant decline in the number of priests between 1970 and 1980 occurred in Denmark, Hungary, and Finland; each saw a decrease of about 20% in the number of Catholic priests. In the following

decade, Lithuania, Luxembourg, and Latvia experienced the greatest decline, and, between 1990 and 2000 the most significant decreases were in Luxembourg, the Netherlands, and Cyprus. During the same decades, the number of priests increased most significantly in Slovenia, Bosnia, and Poland (1970-1980); Yugoslavia, Macedonia, Iceland, and Poland (1980-1990); and the Slovak Republic, Poland, and Sweden (1990-2000). Therefore, we can conclude that the number of priests in a country is determined by factors other than the political regime (e.g., in some Eastern European countries the Church was considered a countervailing power to the state) or the level of economic development. This study will expand on previous research (especially Mourão 2006) to identify a robust set of social and economic factors that determined these changes in the priesthood.

Today, there is a lively discussion about the social changes that might have caused the number of Catholic priests to diminish in the most industrialized countries in recent years. For instance, in Australia, a recent issue (edition 28) of the review *OnLine Catholics* discussed national statistics on the declining number of priests in the context of Catholic seminaries. Across the United States, a substantial number of dioceses have specific departments whose main objective is to monitor the annual progress of priests in each parish.[3] Condon (2002) empirically tested whether the monopolistic character of the Catholic Church, the single employer of Catholic ministerial graduates, is to blame for the decreasing number of ministerial students in the U.S. Azevedo (2003) also provided a general framework for the current decline in the number of Catholic priests.

The previous literature on these issues explains different vocational choices as the result of social, economic or geographical factors. Over the past century, authors such as Bowdern (1936), Fichter (1961), Poeisz (1963), and Suaud (1975) posed the problem of vocational choice as a central issue for academic research. Building on this focus on vocational choice, researchers have tested numerous hypotheses and variables to understand the international distribution of Catholic priests relative to the Catholic population. Based on our survey of the literature, we group these numerous hypotheses into four main categories.

Hypothesis 1 argues that economic growth influences religiosity (Lindenthal 1968; Franco Infante 1970; Stark and Bainbridge 1985). As the frequently cited works of Anaya (1999) and Borjas (2005) show, an increasing level of social welfare might have strong substitution effects (*i.e.*, alternative occupational opportunities) on the supply of individual labor. Barro and McCleary (2003) defined secularization theory as the tendency for an increased level of income in a society to accompany a decline in the vigor of religious practice, for which leisure activities are substituted. Alternatively, a young man may find it less socially and economically attractive to choose a ministerial vocation when he sees a higher chance of success in a secular, professional career that is more valued in his socio-economic context.[4] Here we combine these arguments and test the secularization hypothesis using per capita Gross Domestic Product (GDP) as an independent variable.

Hypothesis 2 suggests that a nation's fertility rate is a key factor; families with one child (or at most two) tend to prefer that their children pursue secular, professional careers (*Message of the 13th Synod of the Cistercian Order* 2002; Sander 1992). This hypothesis also suggests that today's relatively small families may, in the long-term, influence children's choices to enter religious or secular vocations (previously described by Fichter 1967 and Curcione 1970). Families with a small number of children usually prepare them to pursue secular activities, particularly those related to the *status quo* of the parents. Conversely, in large families, the children may feel that they have more freedom in their vocational

choices. Thus, children from larger families may be more likely to enter the priesthood. To test Hypothesis 2, we studied the Total Fertility Rate and the proportion of resident young people as our variables.

Hypothesis 3 proposes that young men avoid the priesthood because they fear lifelong commitments. According to modern youth, being a Catholic priest (or even being married) has a high opportunity cost (*Final Document of the Congress on Vocations to the Priesthood* 1997). When a young man considers becoming a priest in the Latin Rite, he knows that he will face lifelong social restrictions, including the impossibility of being married as a priest.[5] According to the document cited above, the "crisis of marriage" in many developed countries also arises from the fears that cause young people to avoid long-term commitments. Consequently, we expected a strong correlation between the variables related to such fears, such as the increased number of divorces or the postponement of marriage, and the diminishing number of new priests (see also Hoffman 1998; Garelli 2007). The variable that researchers often choose to test this hypothesis is the total female divorce rate.[6]

Finally, Hypothesis 4 suggests that a religious monopoly is responsible for the declining number of priests; as competition decreases, there are fewer priests (see Stark and Finke 2000:200). This hypothesis suggests that the number of self-professed Catholic residents in society is a potential explanatory variable. However, this variable could be endogenous to our main dependent variable, which is the number of Catholic priests per Catholic residents. To avoid this problem, we tested Hypothesis 4 with a dummy variable that indicates which countries are predominantly Catholic ("1") and which countries are not currently identified as Catholic ("0"). We controlled this variable with the percentage of immigrants in the population because, as McCarrick (1960) and an anonymous referee suggested, immigrants tend to be young and male, which may affect the supply of priests. Additionally, highly developed countries have been accused, in recent years, of "poaching" well-respected priests from less developed countries.[7] Following Schmidt (1969), we also controlled our dummy variable for the percentage of the population residing in urban areas because a higher urban percentage is associated with more diverse religious beliefs.

Following Stark (1997), we focused on the relationship between the total number of Catholic priests and the possible causes of that number. Equation One describes the panel data:

$$CP_{st} = \alpha_{st} + \beta_1 * Y_{st} + \beta_2 * Y_{st}^2 + \gamma * Z_{st} + \mu_s + \nu_t + \varepsilon_{st}$$

where CP_{si} denotes the log of the proportion of Catholic priests to the total number of Catholic residents in country s and year t. We examined the years 1950, 1960, 1970, 1980, 1990, 2000, and 2006. Y_{si} is the log of real GDP per capita. Y^2_{si} is the squared log of real GDP per capita to test for a nonlinear function. Z_{si} is a vector of the logs of the characteristics that, according to the literature, affect men's decisions to enter the priesthood: the national fertility rate, the divorce rate, and the proportions of the population that are urban residents, youth, and immigrants relative to the overall population.[8] The regressions also include fixed effects for country and year. The country fixed effects (μ_s) control for permanent differences across nations, and the year fixed effects (ν_i) control for the changes in the dependent variable, common to all states, in a given year.

We used logged variables because this practice allows us to identify estimates with elasticities. (For the benefit of readers, *elasticity* is defined as the ratio between the proportional

Table 1 – Descriptive statistics

	Variables	Observations	Mean raw [Mean log]	Standard Deviation (raw)	Minimum (raw)	Maximum (raw)
All countries	Cath. Priests per 100,000 Catholic	388	0.845 [-0.320]	0.865	0.001	3.235
	GDP per capita	455	12476.4 [9.040]	12087	261.7	54285.4
	Fertility rate	517	1.966 [0.603]	0.969	1.06	6.57
	Per cent Urban	495	0.582 [-0.591]	0.234	0.137	0.928
	Proportion young	451	38.5 [3.661]	9.719	22.3	60.4
	Divorce rate	484	5.437 [1.296]	9.45	0.79	30.33
	Proportion immigrants	418	19.87 [4.839]	14.56	3.4	48.6
	Catholic country (dummy)	440	0.45	0.498	0	1
Catholic countries	Cath. Priests per 100,000 Catholic	213	0.918 [-0.315]	0.627	0.001	3.235
	GDP per capita	242	14803.7 [9.005]	10883.7	381.8	50672
	Fertility rate	242	1.783 [0.664]	0.469	1.14	3.85
	Per cent Urban	242	0.581 [-0.594]	0.185	0.146	0.877
	Proportion young	231	37.472 [3.669]	5.354	26.1	52.6
	Divorce rate	242	5.643 [1.238]	11.666	0.79	25.7
	Proportion immigrants	209	15.7 [4.835]	11.87	3.4	48.6
Non-Catholic countries	Cath. Priests per 100,000 Catholic	175	0.748 [-0.326]	0.583	0.001	2.453
	GDP per capita	180	11981.84 [9.231]	9245.46	261.7	54285.4
	Fertility rate	198	2.065 [0.548]	0.851	1.06	6.57
	Per cent Urban	198	0.584 [-0.607]	0.178	0.137	0.928
	Proportion young	187	39.91 [3.613]	7.775	22.3	60.4
	Divorce rate	176	5.088 [1.272]	4.768	0.87	30.33
	Proportion immigrants	176	21.5 [4.753]	10.48	4.3	34

change of a dependent variable and the proportional change of an independent variable. After calculations, it is possible to demonstrate that, in Equation 1, the elasticity of each independent variable is equivalent to the estimated coefficient.) This technique is very common in studies of cause-and-effect relationships. For instance, if the estimate for a certain coefficient of a logged linear variable is x, then a 1% increase in that variable is expected to raise the logged dependent variable by $x\%$ (e.g., see Greene 2003).

We used the *Statistical Yearbook of the Church* as the source for the dependent variable, the total number of Catholic priests, and for the percentage of Catholic residents in a given country. We chose this source for several reasons. The *Statistical Yearbook* is an official church document and, as far as we know, is the only compilation of these data from around the world. Additionally, the *Statistical Yearbook* covers a span of more than fifty years. However, from 1950 to 1990, values are often given as the average of each decade.

Other data sources include the following:

- For real GDP per capita, we used the Penn World Tables from Heston, Summers and Aten (2007);
- For the fertility rate and the divorce rate, we used the *Annuaire Demographique* (2004);
- For the urban population, the immigrant population, and the percentage of young people, we used the 2007 *Revision Population Database* (2007).

Table 1 shows the descriptive values of our variables for the 38 countries we studied for the years 1950, 1960, 1970, 1980, 1990, 2000, and 2006.[9] These descriptive statistics are shown separately for the entire population, shown by country in the first eight rows, and for the countries grouped by common patterns in their historical relations to Catholicism. As the literature suggests (see Smith and Sikkink 2003), cultural differences in European countries affect the social restrictions on the ministry and the overall number of priests differently. To describe these group patterns, we present two group panels with the overall report. The two groups are Catholic countries, in which most citizens self-identify as Catholics, and non-Catholic countries (*i.e.*, all other European countries).[10]

Table 2 shows our main results. The panel is short because N, the number of countries, was large in comparison to T, the number of periods observed. Therefore, we used the Generalized Method of Moments with robust statistics to estimate regressions, as Arellano (2003) and Hsiao (2005) advise. For an explanation of why this estimator is the most appropriate method, please refer to the Appendix.

We estimated Equation 1 using six specifications. Specification 1 tests only the Secularization Hypothesis without including the variables for our other hypotheses. Specification 2 adds the variable for *fertility rate*, which is related to Hypothesis 2. Specification 3 includes the variables for all four hypotheses. Specification 4 adds a dummy variable that identifies which countries in the sample are Catholic and which are not. This dummy had a significant effect, and thus we drew on Brender and Drazen's (2004)[11] method of splitting the sample into Catholic countries (Specification 5) and non-Catholic countries (Specification 6).

Table 2 also shows the number of observations and the number of countries that composed the panel data for each specification. The last two rows of each specification show the values for the joint significance (Wald-Chi^2) tests and for the Arellano-Bond test for autocorrelation of the second order. All the values in these last two rows show that the included variables were jointly significant for each specification and that there was no evidence of autocorrelation in any of the specifications.

Table 2 – Results (Dependent variable: Catholic priests per Catholic population)

	All	All	All	All	Catholic countries	Non-Catholic countries
	GMM	GMM	GMM	GMM	GMM	GMM
	(1)	(2)	(3)	(4)	(5)	(6)
Catholic Priests	-0.550a	-0.555a	-0.286a	-0.285a	-0.391a	-0.278a
per Catholic Population	(0.134)	(0.136)	(0.077)	(0.077)	(0.062)	(0.113)
(lagged value at one period)						
GDP per capita	6.702a	5.496a	4.025a	4.069a	2.829a	5.527a
	(1.926)	(1.532)	(1.044)	(1.040)	(0.532)	(1.018)
(GDP per capita)^2	-0.414a	-0.345a	-0.242a	-0.245a	-0.172a	-0.327a
	(0.118)	(0.093)	(0.061)	(0.061)	(0.037)	(0.063)
Fertility rate		-0.319	-0.243	-0.252	0.467c	-0.020
		(0.198)	(0.215)	(0.215)	(0.250)	(0.222)
Proportion of young (<15 years)			-0.051	-0.033	0.150	-0.685
in population			(0.330)	(0.330)	(0.294)	(0.587)
Divorce rate			-0.078	-0.079	-0.034	-0.112
			(0.052)	(0.052)	(0.062)	(0.106)
Proportion of immigrants			0.101	0.101	0.186a	0.035
in population			(0.076)	(0.076)	(0.068)	(0.102)
Per cent Urban			0.069	0.081	-0.381c	-0.530
			(0.265)	(0.265)	(0.220)	(0.501)
Catholic country				0.069a		
				(0.018)		
constant	0.139a	0.149a	-0.019	0.069a	0.055c	0.049a
	(0,041)	(0.047)	(0.012)	(0.018)	(0.030)	(0.016)
Observations	297	288	246	246	105	125
Countries	38	38	38	38	16	22
Wald-chi^2	17.53	77.68	99.69	100.47	1296.14	120.52
Arellano-Bond Order 2	1.26	1.64	0.27	0.26	-0.54	-0.13

Significance: a $p < 1\%$; b $p < 5\%$; c $p < 10\%$

In parentheses, standard errors

GMM: Generalized Method of Moments

In all the specifications, the most significant effect was produced by GDP per capita. In Specification 1, we observed that the estimated income elasticity in the quadratic model[12] (suggested by Equation 1) is 6.7-0.8*lgdp (In this case, dCP/dY=6.7+2*(-0.4)*Y), which forms an inverted U-shaped curve[13] for the log of the number of Catholic priests per Catholic population (Greene 2003: 126-27). For Catholic countries (Specification 5), the estimated income elasticity is 2.83-0.34*lgdp (In this case, dCP/dY=2.83+2*(-0.17)*Y); for non-Catholic countries (Specification 6), the estimated income elasticity is 5.53-0.6*lgdp (In this case, dCP/dY=5.53+2*(-0.3)*Y). These findings show that the supply of priests per Catholic population is more inelastic in Catholic countries than in non-Catholic countries because, for the same level of GDP log, the income elasticity is lower in Catholic countries than it is in non-Catholic countries.

These results support the economic growth hypothesis for the European countries included in the study. With economic growth, the ratio of Catholic priests to the Catholic population dropped; this result is also suggested by the inverted U-shaped curves.

We also found that the relationship between the dependent variable and the fertility rate differs across Catholic and non-Catholic countries. In Catholic countries, the total number of priests per Catholic population is positively related to the fertility rate. In non-Catholic countries, there is no significant relationship between the number of priests and the fertility rate.

When we focused on Specifications 4, 5, and 6 in countries with a history of strong Catholic influence, we observed that the fertility rate, the proportion of immigrants, and the proportion of urban residency all exerted a significant influence on the dependent variable. In the Catholic countries, a higher fertility rate resulted in a greater ratio of Catholic priests to the Catholic population. In contrast, in both non-Catholic countries and the whole sample (seen in Specifications 3 and 4), we observed no significant effects from the fertility rate. Indeed, in the non-Catholic countries, we only found strong estimated effects from the variables related to real GDP per capita.

In Catholic countries, the growing urban population caused a reduction in our dependent variable. In this case (Specification 5, with a significance level of .10), we can draw on Schmidt's (1969) recognition that the concentrated population in large cities promotes agglomeration effects that lead to heterogeneous preferences for religious beliefs. Thus, people's adherence to traditional religions tends to diminish. However, the rise in the proportion of immigrants tends to increase the ratio of priests to the Catholic population (Specification 5). This trend validates the claim that well-regarded priests from less developed countries are "poached" by European Catholic countries. In addition to these results, we found no evidence to support Hypothesis 4, which is "fear of lifelong commitments."

In summary, our results clearly show that economic growth influences the number of Catholic priests per Catholic population in European countries. These findings support the secularization hypothesis. Furthermore, our results indicate that urbanization, migration, and changing fertility rates affect the number of priests in Catholic countries, as Hoge (1987) and Fishman and Jones (2007) also recognized.

This research used a new scientific approach to test the different explanations for the changing rates of entry into the Catholic priesthood in Europe. Our work discussed this trend using a model of vocational supply and identified four types of hypotheses that were suggested in the literature: economic growth, changes in family structure, young people's fear of lifelong commitment, and a crisis of religiosity.

When we combined the empirical evidence, we found that the log of the number of Catholic priests per Catholic population forms an inverted U-shaped curve when compared to income per capita. As income per capita rose due to economic growth, the ratio of priests per Catholic population tended to diminish in the 38 countries we studied. This result supports secularization theory, which claims that economic growth changes individuals' religious behavior. We also found that Catholic European countries (such as Spain, Italy, and Ireland) are particularly affected by their fertility rates, the proportion of immigrants in the population, and the relative size of their urban populations.

We interpreted these variables as explanatory factors for the relative inelasticity between the number of Catholic priests per Catholic population and income per capita in Catholic countries. This inelasticity generates a relatively low reactivity of religious vocations to changes in per capita income and thus leaves more room for other institutional factors to influence the ratio of priests to Catholics. Thus, we argue that national institutions have significant effects on the number of priests when Catholicism is the predominant religion. The links between these institutions and the number of Catholic priests merit further research; for instance, questions such as "How do Catholic institutions stimulate fertility rates?" or "How might these institutions interfere with the proportion of immigrants in the population?" might be posed in future studies.

Although this paper offers some answers to the questions it sets forth, it would also benefit from further development. For instance, researchers might use micro data to improve the estimates we discussed here. We also think that aggregate relationships might pick up the effect of numerous factors that were not suggested here. Further research might also substitute our dependent variable with other variables, such as priests under the age of 50 per 10,000 Catholics or major seminarians per 10,000 Catholics. However, the data currently available do not include such variables. Another possible extension of this research would include more detailed information about the priests. For example, researchers could study contemplative priests, whose communities tend to ordain fewer priests and have a higher share of clergy, or the priests who teach other priests. Unfortunately, the current data do not provide this information for every country in our study nor do they cover a sufficient time period.

In spite of these challenges, we believe that the findings in this paper provide new insight into the relationships between the religiosity of populations, the number of people entering religious orders within those populations, and the deep economic and sociological changes that are occurring around the world.

NOTES

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[2] Kumar (2008) is a theoretical attempt to fill this need.

[3] For a detailed example, see the Archdiocese of Detroit (http://www.aodonline.org/AODOnline/Together+In+Faith+12019/Charts+and+Graphs+14016/Archdiocesan+Priests+By+the+Numbers.htm).

[4] An anonymous referee made a curious observation – priests can be more productive because of technological changes that accompany economic growth. If this assumption holds, then a fewer number of priests can supply the same amount of services previously supplied by a higher number of priests. Consequently, this can help in explaining the negative effect that GDP may have on the number of priests.

[5] The oriental rites in Roman Catholicism have married priests, but the very existence of those rites has a low profile in many countries.

[6] We also tested this hypothesis using the ratio of female first marriage rate and the divorce rate. However, as noted by a referee, "Many nations have experienced a population expansion after World War II, followed by smaller cohorts. For some years, this results in a small rate of first marriages to a large rate of divorces." In fact, our results with the ratio of female first marriage rate and the divorce rate were not significantly different than the results obtained with the Total Female Divorce Rate (which we commented in the text). We preferred to use the Total Female Divorce Rate because it avoids problems with different cohorts (for instances, in the ratio of female first marriage rate and the divorce rate, the number of new marriages in a given cohort is placed in a ratio with the number of divorces of a larger cohort)

[7] There are clear parallels here to other professions and quasi-professions—such as nursing—that have experienced supply-side shortages in industrialized countries.

[8] We ran the Hausman-endogeneity test on these right hand side variables of Equation 1. The respective F statistics are fertility rate (0.29), proportion of urban population (1.29), percentage of young people (2.36), the divorce rate (1.32), and the share of immigrant population (1.22). In all of these cases, we do not reject the null hypothesis of exogenous regressors. More details can be provided upon request.

[9] For some sources, like the religious ones, not all the countries had observations, especially for the most remote years. In those cases, the observations of the closest available years were used (for instance, 1951 for 1950). The 38 European countries that have been studied are Albania, Austria, Byelorussia, Belgium, Bosnia, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Yugoslavia (Serbia and Montenegro), Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom.

[10] Sixteen Catholic countries: Austria, Belgium, Croatia, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Malta, Poland, Portugal, Slovakia, Slovenia, Spain, and Switzerland. Twenty-two Non-Catholic countries: Albania, Byelorussia, Bosnia, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Yugoslavia (Serbia and Montenegro), Germany, Greece, Iceland, Latvia, Moldova, Netherlands, Norway, Romania, Russia, Sweden, Ukraine, and the United Kingdom.

[11] The methods for this study follow those described by Brender and Drazen (2004), who suggested dividing the estimation by sub-samples. This procedure is more convenient because it allows different estimations for different groups of countries, and it is also more reliable when comparing the number of priests in countries such as Finland, Denmark, and Norway (where the percentage of Catholics is negligible) with Italy or Spain ("traditionally" Catholic nations). When there is a single estimation (using the entire sample), even with interaction terms between geographical dummies and explicative variables, a set of common coefficients estimates remains for the other explicative variables that have been reached under the imposed assumption of homogeneous institutional patterns.

[12] Equation 1 follows a quadratic model (Greene, 2003, 126-127). In quadratic models, at least one of our explicative variables appears twice: firstly, as a linear variable and, secondly, as a squared variable. If the model were a linear model with logged variables, then the elasticity for each explicative variable would be identified to the estimated coefficient for that variable. With quadratic models (such as Equation 1), the elasticity is given by $dCPsi/dY_{si}=\beta_1+2*\beta_2 Y_{si}$.

[13] The relation between real GDP per capita and the log of the number of Catholic Priests per Catholics would be a U-shaped function if $d^2CP_{si}/d^2Y_{si}>0$. In all of our cases, $d^2CP_{si}/d^2Y_{si}<0$; for instance, take specification 1 as an illustration: $d^2CO_{si}/d^2Y_{si}=$—0.8, suggesting an inverted U-shaped function.

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External links:

http://www.aodonline.org/AODOnline/Together+In+Faith+12019/Charts+and+Graphs+14016/Archdiocesan+Priests+By+the+Numbers.htm

APPENDIX

Why use the Generalized Method of Moments?

Let panel data (i countries, t periods) be described by the following (Greene 2002: 307):

$$y_{it} = w'_{it}\beta + \alpha_i + \varepsilon_{it}$$

In this case, w_{it} represents the set of right-hand side variables, including the lagged dependent variable y_{it-1}. It can be proven that for a finite value for T (for instance, for a small number of periods observed), there is a finite sample bias of 1/T in the estimator. This problem arises when we estimate our panel data by an ordinary fixed-effects regression with a lagged dependent variable. The variance of this estimator does not go to zero as *i* increases. As Greene (2002: 308) noted, this problem is even more severe when we estimate our panel data by random-effects.

A very common method for handling with the problem of heteroskedasticity is differentiating each side of the panel data model.

$$y_{it} - y_{it-1} = \delta(y_{it-1} - y_{it-2}) + (x_{it} - x_{it-1})'\beta + (\varepsilon_{it} - \varepsilon_{it-1})$$

However, it also can be shown that this model has problems of autocorrelation between the lagged dependent variable and by first-order moving average disturbance.

Then, besides the traditional instrumental variable estimators LSDV or FGLS (discussed in Roodman 2006), other techniques have been developed more recently to produce the

Generalized Method of Moments (GMM) estimator (Arellano and Bond, 1991; Arellano and Bover, 1995).

With this estimator, and given a short time series, we use the difference ($y_{it-2} - y_{it-3}$) or y_{it-2} *and* y_{it-3} as instruments for ($y_{it} - y_{it-1}$).

As Greene (2002: 309-312) demonstrates (reverting to formal algebra), the empirical moments condition constructed using these steps can generate a GMM estimator that is a robust estimator for short panels.