Detecting Peaks and Valleys in the Number of Births in Portugal

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DETECTING PEAKS AND VALLEYS IN THE NUMBER OF BIRTHS IN PORTUGAL*

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Abstract

Portugal is characterised by a noteworthy decline in fertility, which is a phenomenon that requires some intervention given the costs, namely economic and political, associated with it. Notwithstanding the downward trend in fertility, a careful observation of the data on the number of births in Portugal indicates that there months where the number of births is clearly higher as well as others where the number of births seems to be smaller. This impression is confirmed by a time series analysis of the data, which shows that, in general, May and September are, indeed, months where more babies are born and that December and February are months where fewer babies are born. This fact is also evident from a prevision of the number of births throughout a whole year. Of particular importance is the detection of the factors explaining those two peaks in births as they may be manipulated by a demographic policy leading to an increase in fertility.

Keywords: Births, Fertility, Peaks Detection, Portugal, Seasonality, Time Series.

JEL Codes: C22, J11, J13.

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1. Introduction and motivation

Portugal is characterised by a noteworthy decline in fertility, which is a phenomenon that requires some intervention given the costs, namely economic and political, associated with it. Notwithstanding the downward trend in fertility, a careful observation of the data on the number of births in Portugal indicates that there months where the number of births is apparently much higher as well as others where the number of births seems to be much smaller.

As a matter of fact, the seasonality in the number of births is an issue that has deserved some attention from the literature since a long time ago. In a seminal work, Huntington (1938) called the attention for the fact that the seasonal variations of births could be explained essentially by reasons related with the climate/weather. In accordance with this natural selection viewpoint, a higher number of conceptions should occur in a season such that consequent births take place in a season such that its temperature guarantees a higher probability of survival. This physical explanation of seasonality in births entails a rational choice by humans, which have been enriched by authors that proposed other explanatory factors for the existence of seasons where (much) more/less babies are born. In fact, the assumption of rationality by humans makes it possible to include in those factors the alleged physical and/or intellectual characteristics of babies that are born in a particular season. Huntington (1938: *v-vi*) himself pointed out "the curious relation of low temperature not only to mental activity but also to the conception of persons who later display unusual intellectual ability."

That being said, it is worth to mention that the literature on the matter has a lengthy strand where, indeed, have been studied the consequences of being born in a particular season, such as the likelihood of certain types of diseases, notably of mental origin [see Castrogiovanni et al. (1998) for a review of some relevant issues in psychiatry related with the season of birth]. As examples of studies relating the seasonality of births with the occurrence of some diseases, Rezaul et al. (1996)

consider the case of eating disorders, Torrey et al. (1997) survey the literature about that relationship with schizophrenia and bipolar disorders, Salib (2002) for considers the case of suicide, and Pjrek et al. (2004) analyse that relationship with seasonal affective disorder. Assuming a broader perspective, Kihlbom & Johansson (2004) also show that, at least for young Swedish men, the results of intelligence tests, psychologists' ratings of psychological function and school achievement, among other factors, are related with the month of birth.[1]

Plainly, if a relationship between the season of birth and the occurrence of diseases and provoked deaths do exist, it is expectable that some effect on life expectation is detectable. Among others, Doblhammer (1999) analyses the relationship between the month of birth and the longevity, which are shown to be correlated for Austria and Denmark [see also Doblhammer & Vaupel (2001)]. Furthermore, Kihlbom & Johansson (2004) present some evidence that, for Swedish young men, body height, weight and self-reported health during childhood, are correlated with the month of birth.

Clearly, the relationship between the season of birth and the several factors identified by the literature, from which we highlighted those above mentioned studies, do not necessarily require that in some months or seasons a significantly higher/smaller number of births do occur. This requisite would only gain relevance in case of assuming that the decision of conceiving babies in a particular month/season is made in such a way leading to births in a season/month associated with better aspects of babies, such as smaller likelihood of diseases. That would require an amount of information that seems not to be accessible to the majority of future parents. Still, there are some factors that may be causal for the occurrence of much more/less births in particular months/seasons. One of those factors is the alleged propensity to have children born in the same month of one of the parents, leading to some differences in the number of births by months, given the concentration that would be observed,

[1] In fact, one should mention that fathers' socioeconomic background was shown to be more decisive than month of birth for the aspects under consideration in Kihlbom & Johansson (2004).

after a long run time period. In fact, this characteristic of the time period may not be that required if, by some reason, parents, in particular women, reveal to be more fecund in some months/seasons. Smits et al. (1997), considering The Netherlands, report that women born in September revealed to be more fecund whereas childless women showed a birth distribution that was best represented with a bimodal curve with zeniths in January and July. In accordance to the authors, the tentative explanation for the existence of differences in fecundability by month of birth may lie in a melatonin-dependent circannual variability of the quality of the oocyte.

The results of Smits et al. (1997) are interesting in the sense that they call the attention for the fact that peaks and valleys in the number of births in some months may be explained by the fact that there are physiological factors in women and men that potentiate conceptions in some particular months of the year, possibly conjugated with higher frequencies of sexual intercourses [nevertheless, Udry & Morris (1967) present some evidence that the seasonality of sexual activity do not explain the seasonality in births]. This fact could be a partial explanation for a peak or a valley if the particular season/month propitiates sexual intercourses during the part of the day where the quality of semen is higher/smaller [Cagnacci et al. (1999) report that the human male semen presents some diurnal variation in what concerns its quality.]

In some sense related to that view, we start with a basic question, i.e. the verification of the existence of peaks and valleys in the number of births in Portugal, as they higher/smaller number may be mere artefacts of the data. In case of their existence, we then want to identify the months where those peaks and valleys occur in order to shed some light to the factors that may explain those peaks and valleys. This is important for a policy point of view, given that it may lead to manipulable factors.

Given the objectives of this paper, it is thus more important to us the analysis of the factors that reveal to be explanatory of peaks and valleys in the number of births. Since some time ago, authors have been proposing the climate/weather or, more specifically temperature as an explanatory factor, despite being true that other factors are needed to explain the observed seasonal patterns on births. The most consistent results seems to be that extreme temperatures [especially summer heats, in accordance to Lam & Miron (1991),(1996)] suppress fecundity. This may partly explain the September peak on births for some north-hemisphere countries, such as the USA but, even after controlling for temperature, some peaks in births, such as the persistent spring peak in births in northern Europe are not completely explainable by temperature. Still considering the USA, in particular women from Texas, Mancuso et al. (2004) find no evidence that the number of naturally occurred births is related with the day of the week but do report that most of the births take place in the fall (i.e. between September and November) and that less births occur in the winter (i.e. between December and February).

Closely related with those aspects is the importance of photoperiod, i.e. the day length on reproduction [Roenneberg (2004) and a contra-argument in Bronson (2004), whose impression is that some individuals do respond to photoperiod but others do not.]. See also Bronson (1995) for a review of the way environmental factors like nutrition, temperature and photoperiod contribute to seasonal patterns of births by acting directly on the reproductive axis.

Both temperature and photoperiod, which are somehow related, would affect sexual activity and, plausibly, hormonal concentration and sperm quality and therefore the seasonal distribution of conceptions and births. If so, seasonality of births should depend upon geographic latitude, by that meaning that the localization on the north or south hemisphere should be important. Barber (2002) support the hypothesis that indeed these factors are important, even after controlling for societal variables, as total fertility rate in countries below 33° latitude is much higher than it is in at higher latitudes, and also that fertility peaks at mild winter temperatures and falls for warm winters and cold ones. To sum up, the data support the hypothesis that human reproduction is suppressed by short photoperiods and low temperatures.

From the previous studies one may conclude that climate/weather may be important but do not explain all the seasonal variations in the number of births For the CEC Republic, Bobak & Gjonca (2001) show that socio-demographic factors are more important than temperature or photoperiod. One of the remaining factors that may be important is the occurrence of marriage, especially in more traditional communities [Grech et al. (2003), considering the case of Malta, conclude that the seasonality in births is, indeed, closely related with the seasonality of marriages].

Given the evolution of socio-demographic factors during a demographic transition, some structural aspects of fertility such as geography and climate are supposed to loose most or, ate least, part of its influence in fertility. As a consequence it is supposed that, from a long run point of view, birth distribution reflect some changes, allegedly from the existence of (strong) seasonality to its diminishment or even disappearance. For instance, when in the past agriculture played a dominant role in the life of many communities, birth seasonality could reflect seasonal variation in agricultural, but disappear as workers, particularly women, became more integrated in other labour markets. This dynamic/temporal view was also explored in some studies, such as Condon (1991), who identifies a significant shift from pronounced seasonality of births in the 1970s to nonseasonality in the 1980s, in a Canadian Inuit community located 300 miles north of the Arctic Circle. This kind shift is also documented by Doblhammer et al. (1999), considering the case of Austria and two periods: 1881-1912 and 1947-1959.

To finalise it is important to refer that there are also some studies which do not detect the presence of significant seasonality in births [see Arcury et al. (1990) for the case of a rural U.S. county over the period 1911-1979, after Clark & Thomson (1987) positive result for another rural community in the US, and/or Pascual et al. (2000) for the case of Tierra del Fuego, in Chile].

In what concerns Portugal, seasonality in births seems to exist. This impression is confirmed by our results, based upon a time series analysis of the data, which shows that, in general, May and September are, indeed, months where more babies are born and that December and February are months where fewer babies are born. This fact is also evident from a prevision of the number of births throughout a whole year. Of particular importance is the detection of the factors explaining those two peaks in births as they may be manipulated by a demographic policy leading to an increase in fertility.

The remaining part of the paper is structured as follows. Section 2 describes the data. Section 3 introduces and applies the specific time series methodology that is used in this study. Section 4 concludes.

2. The data

The source of the data, which is monthly and covers the period January 1969 until December 2006, is the Eurostat. We retrieved data for the number of live births in Portugal throughout that period, which means 456 observations. Figure 1 plots this data.

[**Insert Figure 1 around here**]

Roughly speaking, Figure 1 shows that, from 1969 until around 1977, the number of births followed a U-shaped trajectory. After 1977 a general decline started, which was halted around 1996 when a tentative increase until 2001 could be observed.

Plainly, given the distinct duration of months in what concerns the number of days, a better figure can be obtained when dividing the total number of births in each month by the number of days of that month. Figure 2 thus plots the daily averages of live births by months (henceforth, births).

[**Insert Figure 2 around here**]

Unexpectedly, the trajectory of the daily averages of live births, as shown by Figure 2, is in perfect agreement with the one about the monthly data as mentioned above. In a visually clearer way, Figure 3 adds up Figure 2 with the trend of the data obtained by the use of the Hodrick-Prescott (HP) filter.[2]

[**Insert Figure 3 around here**]

Clearly, besides confirming the u-shape, downward, inverted u-shape pattern, the trend also shows that – as it clearly should be – there are positive and negative cyclical components. These components can be associated with a seasonal effect if, indeed, the above-trend values tend to occur in the same months, the same happening for the below-trend values. In fact, from a closer look at Figures 2 or 3 it results an impression of seasonality in the data. A correlogram, as shown in Figure 4, confirms that, indeed, the number of births presents evidence of seasonality.[3] The most significant spikes at Autocorrelation Functions (ACFs) as well as the Partial Autocorrelation Functions (PACFs) indicate a 12-month seasonality.[4]

[**Insert Figure 4 around here**]

3. The application of the methodology

The observation of the pattern exhibited by the number of births, in accordance with the evidence of seasonality, brings about a crucial question: if there are months that are characterised by a number of births that is significantly distinct from the rest, in which there are peaks and in which there are valleys in the number of births? Plainly, the identification of peaks and valeys in the number of births may serve as an

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[2] The HP filter defines the trend or mean, g_t, of a time series, f_t, as the solution to the minimisation problem: min $\{\Sigma\,(f_t - g_t)^2 + \lambda\,\Sigma\,[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2\}$, i.e. the HP-filter seeks to minimise the cyclical component subject to a smoothness condition reflected in the second term.

[3] This correlogram was produced for the first differences of the series, given the non-stationarity of the original series.

[4] The ACFs contain serial correlation coefficients for consecutive lags in a specified range of lags. In PACFs, the dependence of the elements within the lag is partialled out, i.e. removed.

instrument for a demographic policy based upon the manipulation of the factors that may explain the decisions behind that established fact. In particular, it seems obviously important to understand what may lead couples to have more babies at some particular months of the year, which indeed may result from planned or unexpected pregnancies.

Having said that, one way to proceed is by detecting the peaks and valleys in the number of births. A simple approach to this problem consists on the following.

An observation, b_t, is considered to be a peak with tolerance w if it assumes a value higher than the assumed by the previous w observations and by the subsequent w observations.[5] Plainly this means that, within the width tolerance parameter, there are no higher peaks but it may exist lower peaks. As a consequence, the higher is the tolerance parameter the less peaks (but higher) exist. Table 1 shows the results after applying this methodology.

[**Insert Table 1 around here**]

From the observation of Table 1 it is immediate to acknowledge the regular existence of peaks in the number of births associated with the months of May and notably September.[6] In fact, in 15 of the 38 years of data, September is considered to be a peak even with tolerance 11. This happens in 6 years in the case of May. In what concerns all the tolerances, September is not considered to be a peak in only 4 of those 38 years whereas this happens 6 times for May. January seems also to be a month where much more babies are born but, in fact, this is an apparent result that occurs given that January is surrounded by months of fewer births.

[5] Note the strictness on this definition. In fact, a looser definition of a peak just considers the previous w observations. Plainly, in this case it is (much) easier to consider an observation to be a peak, especially when in the case of an upward trend.

[6] In fact, the number of births in (each) September presents the least correlation with the births that took place in the year.

In what concerns the valleys, an observation, b_t, is considered to be a valley with tolerance w if it assumes a value smaller than the assumed by the previous w observations and by the subsequent w observations.[7] Plainly this means that, within the width tolerance parameter, there are no smaller valleys but it may exist higher valleys. As a consequence, the higher is the tolerance parameter the less valleys (but smaller) exist. Table 2 shows the results after applying this methodology.

[**Insert Table 2 around here**]

From the observation of Table 2 it seems conciliatory to accept the existence of valleys in the number of births associated with the months of November, at the beginning of the period, December and February, throughout most of the period, and March/April more recently.

It is interesting to note that whereas in the case of the peaks, May and especially September seem to be robust all over the long period of the data, in what concerns the valleys, the months show some variety all over the period. Moreover, it is also of interest to note that May, being a month where more babies are born happens immediately after some months characterized by valleys but this is not the case of September, which appears separated from the rest of the valleys and peaks.

Undoubtedly the robustness of the above presented results must be checked. One way of attaining this goal is by the consideration of some sort of statistical approach. In fact, the counting of peaks and troughs as done above requires that a reasonable tolerance width w must be considered in order not to make an error in the classification of peaks. This procedure, yet, tends to exclude other potential candidates with a tolerance near w. Moreover, the issues related with the variance of the

[7] Again, note that this definition of a valley is (much) more demanding than another where only the previous w observations are taken into account. In our case, the existence of a downward trend would certainly result in the detection of much more valleys if this looser definition would have been considered.

observations are completely ignored. Therefore we propose another approach, which serves as a complement to that used above.

The proposal consists on considering an observation, b_t, to be an *annual* peak with confidence (90% or 95%) if it assumes a value higher than the average of the twelve last observations plus (1.645 or 1.960) times the standard error of those twelve observations.[8] In accordance to this procedure, an observation b_t, is considered to be an *annual* valley with confidence (90% and 95%) if it assumes a value smaller than the average of the twelve last observations minus (1.645 or 1.960) times the standard error of those twelve observations.

Following the procedure described above, Table 3 shows the results in what concerns the peaks in the number of births. Roughly speaking, the results are in accordance to the previous ones, being evidenced September where more babies are born in Portugal.

[**Insert Table 3 around here**]

Concerning the valleys, Table 4 shows the results, which, again, are in accordance to the previously pointed out. November and December, as well as February can, indeed, be associated with months were less babies are born in Portugal.

[**Insert Table 4 around here**]

Finally, we would like to further confirm those results by the use of the well-known ARIMA methodology. First of all, in what concerns the series for the number of births a problem seems to be in place, given that the series must be stationary in order to implement the ARIMA methodology. From the line graph, you can see that the time series of births is likely to have a downward trend and seasonal spikes, which

[8] Clearly, without loss of generality, we are assuming the year as the reference period as well as a normal distribution.

implies level non-stationary. Therefore we decided to use the methodology behind the SEATS/TRAMO approach as it handles, in a correct way, with all the problems that the original series seems to present [see Gómez & Maravall (1996)].

Given the objectives of our study, the detection of seasonal factors, within the ARIMA methodology, is obviously crucial. Table 5, which presents the seasonal factors, confirms the importance of September as a month where, in a regular way, (much) more babies are born.

[**Insert Table 5 around here**]

A 1 year forecast of the number of births, i.e. until December 2007, is particularly appropriate as it confirms in a condensed way, all the results. Figure 5 shows the forecasts.

[**Insert Figure 5 around here**]

3. Conclusions and directions for further research

This paper is about an eventual existence of a month effect, understood as a seasonality effect, in the number of births in Portugal. This issue is assumed to be relevant because, as we know, Portugal has been characterized by a remarkable decline in fertility [roughly speaking, at the beginning of the 1970s, about 500 babies were born by day, while this number is around 300 at nowadays] and this is, obviously, a serious problem that one has to attack. This is so, given the costs of this phenomenon, which include some (well-known) consequences, such as the pressure on the social security systems, but also some other, (not so well-known), consequences such as the fact the ageing of population makes more important the pensioners from an electoral point of view. Of interest is also to note that, it seems possible to reduce this problem, as the moderate increase in the number of births from 1995 to 2001 seems to indicate.

If there exists that possibility then the needed intervention gains opportunity. As, obviously, the success of the demographic policies depends on the understanding of the reality, one should not ignore why (if so!) there are months where more (or less) babies are born, in order to use the factors explaining those peaks or valleys. That being said, the main objective is therefore the determination of the months associated with a significantly higher/smaller number of births. In order to achieve this objective we use some standard time-series analysis techniques.

The first part of the paper thus considers the detection of peaks and valleys in the trajectory of births. This is done in two ways: first, by a standard approach where, for instance, an observation is considered to be a peak with tolerance w if it assumes a value higher than the assumed by the previous w observations and by the subsequent w observations; second, an observation is considered to be an annual peak with confidence (90% or 95%) if it assumes a value higher than the average of the twelve last observations plus (1.645 or 1.960) times the standard error of those twelve observations. The second part of the paper intends to confirm the previous results thorough an ARMA model, namely by the forecast of seasonal (in this case, monthly) factors.

In what concerns the results we have that May and September are months associated with peaks. In what concerns the valleys, the months of November, at the beginning of the period, March more recently and particularly December and February are months where less babies are born. In what concerns the second part of the detection of peaks and valleys, basically the previous results were confirmed. In particular, September is even more associated with a peak and December with a valley. In what concerns the use of an ARMA model to confirm the previous results, a one-year forecast by months indicates that September is a month where much more babies are born whereas December performs that role for the case of valleys.

To conclude, we would like to acknowledge that the paper is missing a component, that is the analysis of the factors that explain why May and September are months where much more babies are born. This analysis, which we would like to continue in other works, will certainly take into account that summer holidays pregnancies, i.e. those leading to births in May may be explained essentially by physiological factors whereas start-of-the-year pregnancies, i.e. those leading to births in September may be explained essentially by psychological factors. In particular, we would like to explore a possible link between births and marriages as a partial explanation for the peak in May, and to consider economic-related variables, such as confidence or even happiness in order to explain the peak in September [for instance, Merrigan & St.-Pierre (1998) use economic factors to explain the timing and spacing of births (in Canada), whereas Gutiérrez-Domènech (20??) analyses how the labour market, education and other characteristics affect the individual decision to marry and have children in Spain].

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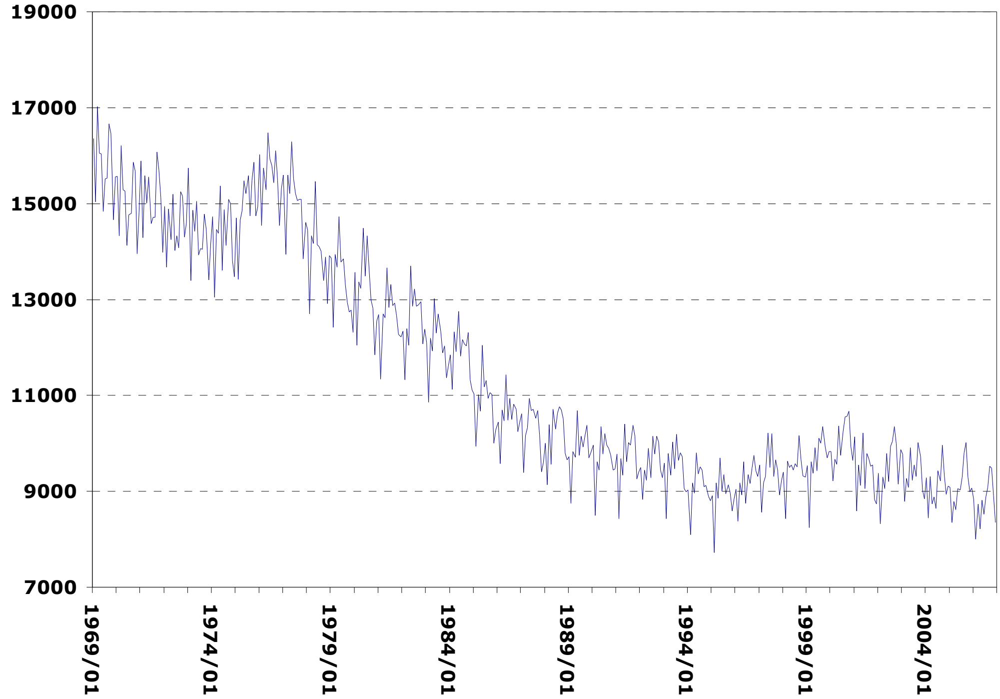

Figure 1: The number of live births by months in Portugal

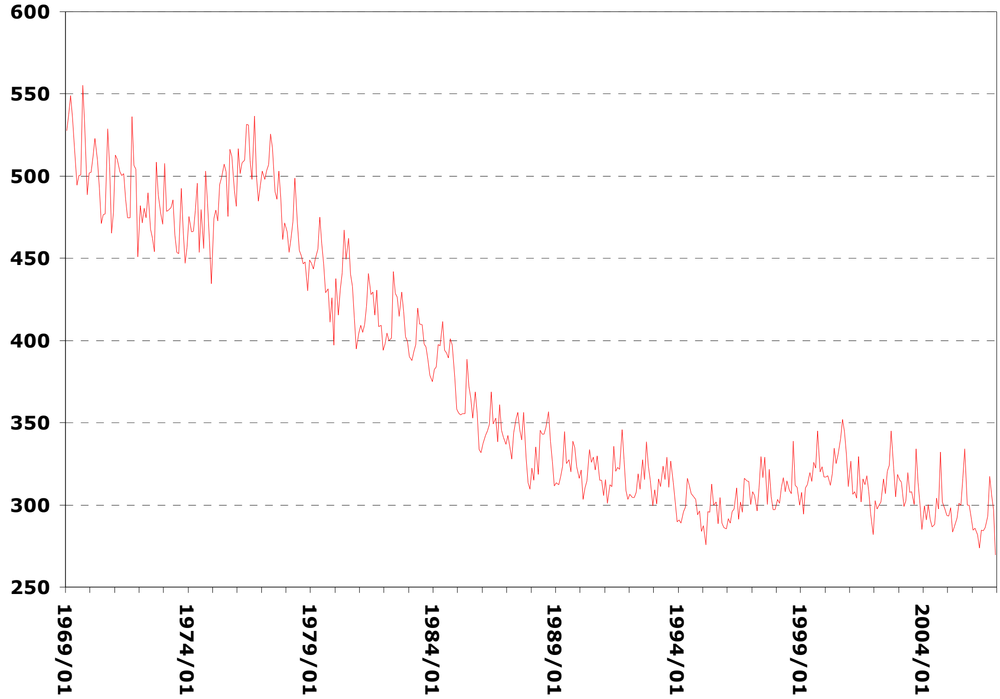

Figure 2: The daily average of live births in Portugal

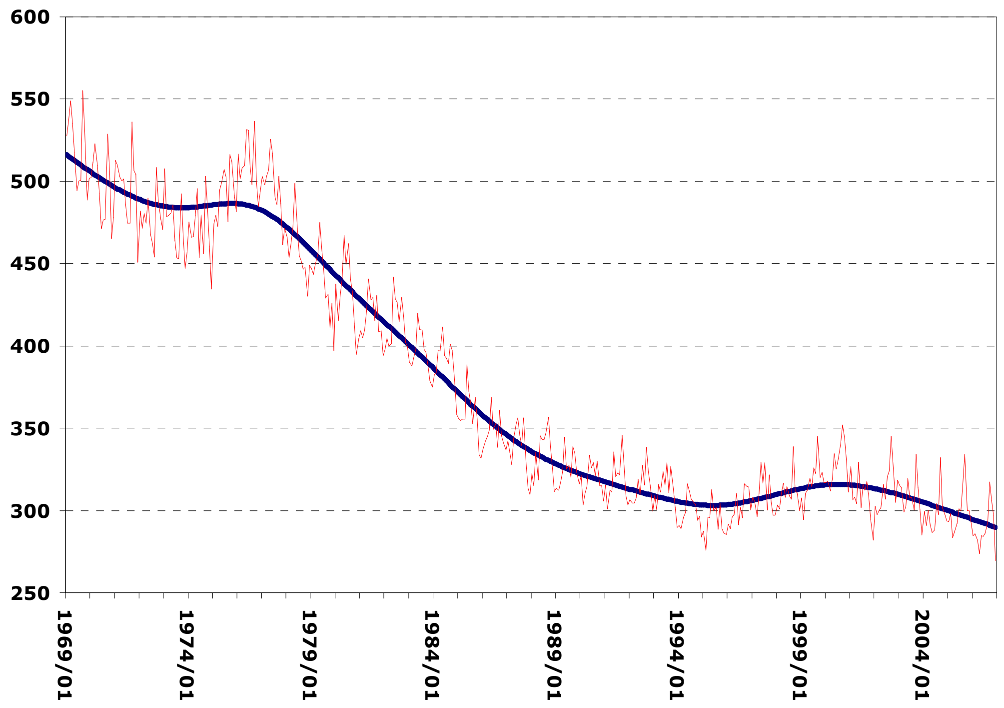

Figure 3: The HP trend of the daily average of live births in Portugal

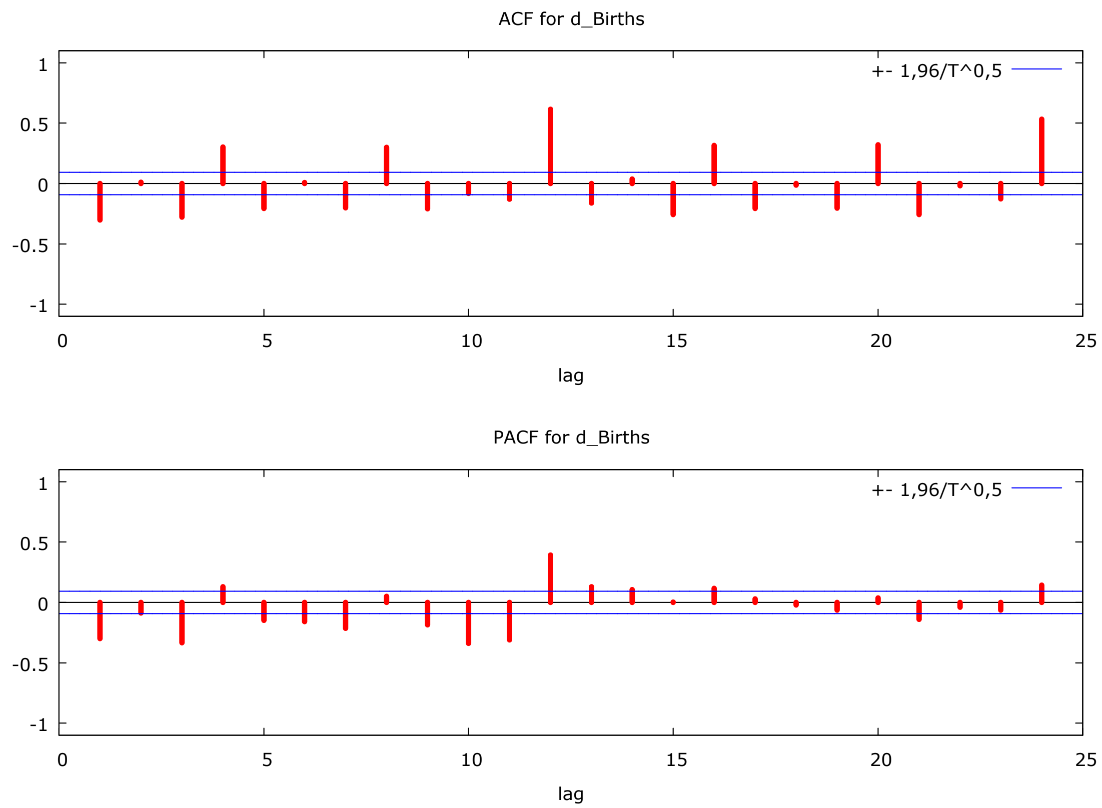

Figure 4: The correlogram for the first differences of births in Portugal

Table 1: The maximum width tolerance of the peaks

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1969			5						11			
1970			4						10			
1971	3				1				11			
1972	1		1		3				11			
1973	3				3				7			
1974	2				3		1		8			
1975		1				2			3			
1976	3				3				11			
1977	1				7				2			1
1978					7					1		2
1979					11				1		1	
1980	2				11		1					
1981	1				9		1		3		1	
1982		2			11				3			
1983					7							
1984			1		11				3			
1985					6				2			
1986					10		1		3			
1987	2					8			2			
1988	1		1		2				11			
1989	1				7		1		3			
1990	1				6		1		3			
1991	3		1		3		1		11			
1992	1				1		1		11			
1993	1		1		1		9		1			
1994	1				7						1	
1995	1		1		11		1		3			
1996	1				3		1		7			
1997	1				11		1		1			
1998	1			4		1			11			
1999	1				1		1		11		1	
2000		1			2				11			
2001	1		1		5		1		3			
2002	2				1				11			1
2003					3		1		11			
2004	1		3				1		11			
2005		3			1				11			
2006		1			1				11			

Table 2: The maximum width tolerance of the valleys

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1969			3			4					6	
1970						4					11	
1971				1			4					11
1972		1		1				7				3
1973		1						2			11	
1974		1				5		1				11
1975			2					4				3
1976		1						2			10	
1977		1						2			2	
1978		5							1		8	
1979		2						1		1		10
1980		1				1					11	
1981		1				1		1		1		11
1982			1					2				
1983		8										11
1984				1				2				
1985		5						2				11
1986						1		3				1
1987			7					1				11
1988		1		1			2					11
1989		1				1		3				1
1990		11				1		1				1
1991		11		1		1		1				9
1992		1				1		1				11
1993		1		1		1		2				1
1994		9								1		1
1995		11		1		1		2				9
1996		1				3		1				2
1997			6			1		2			7	
1998		1			2			3				1
1999		11				1		1		1		
2000	1		8			1						1
2001		1		1		4		1				11
2002		1				1					3	
2003			8			1		3				11
2004		1			4			1				
2005	1		11			1						
2006	1			7		1						11

Table 3: The identified peaks at 95% and 90%

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1969												
1970												
1971									95%			
1972												
1973	95%											
1974					95%				95%			
1975												
1976					95%	90%			90%			
1977												
1978												
1979												
1980												
1981												
1982					90%							
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991					90%				95%			
1992									90%			
1993												
1994												
1995												
1996					90%				95%	95%		
1997					95%		95%					
1998									95%			
1999									95%			
2000								90%	95%			
2001												
2002								90%	95%			
2003												
2004									95%			
2005									95%			
2006									90%			

Note: Plainly, a peak identified at 95% is also a peak identified at 90%.

Table 4: The identified valleys at 95% and 90%

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1969												
1970						95%					90%	
1971												95%
1972												
1973											90%	
1974												95%
1975												
1976												
1977											95%	
1978	90%	95%									95%	
1979								95%		95%		95%
1980											95%	
1981												95%
1982												
1983											95%	95%
1984												95%
1985	95%	95%									95%	95%
1986												
1987			90%							90%	95%	95%
1988												
1989												
1990		95%										
1991		90%										
1992												
1993												95%
1994	90%	90%										90%
1995		95%										
1996												
1997												
1998												
1999		90%										
2000												
2001		90%									95%	95%
2002												
2003												95%
2004												
2005												
2006												90%

Note: Plainly, a valley identified at 95% is also a valley identified at 90%.

Table 5: The forecast of seasonal factors

Period	Seasonal Factors	
	Forecasts	S.E.
1	98.26	1.155
2	97.67	1.157
3	96.75	1.154
4	96.17	1.148
5	99.24	1.184
6	98.78	1.179
7	100.6	1.204
8	101.9	1.223
9	110.0	1.328
10	103.1	1.255
11	100.9	1.241
12	96.57	1.204

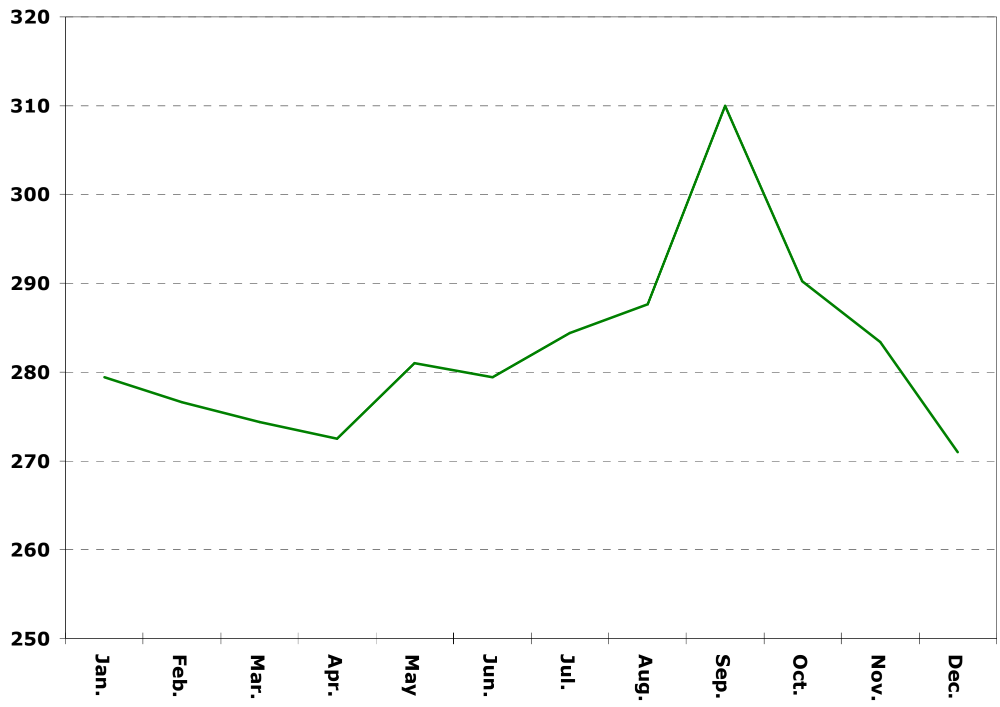

Figure 5: The forecast of the number of births in 2007