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Policy Interventions Affecting Illegitimacy in Preindustrial Austria: A Structural Change Analysis

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Abstract: Reproduction is of inherent interest to anthropologists as fertility and human procreative decisions are influenced by environmental, biological, cultural and social decisions. Due to sanctions by the catholic church and the legal system the majority of reproductive behaviour in preindustrial Austria was confined to marital unions. Nevertheless, illegitimate births, i.e., births conceived outside wedlock, happened although seignorial or state institutions tried to avoid this by interventions such as moral regulations and marriage restrictions.

This paper analyzes the development of illegitimacy in the Austrian village Großarl during 1700–1900 in a policy intervention context. Therefore, two approaches from the structural change analysis framework are employed: evaluating the effect of exogenously known (from historical knowledge) breakpoints and estimating the breakpoints without using further knowledge. Both methods are shown to lead to similar results for the data considered and to produce models that describe the data equally well.

1 Introduction

Reproduction is of inherent interest to anthropologists because of the diversity of environmental, biological, cultural and social constraints which serve to influence fertility and to affect human procreative decisions. The term illegitimacy denotes the condition of children born out of wedlock. The causes, rates and trends of illegitimate births have been the subject of considerable study, aiming at their demographic significance at large, their implications for individual social life, but also for their impact on communities' modes of production or kinship systems (see e.g., Mitterauer, 1983; Becker, 1990; Low, 1989; Scott and Duncan, 1997). Sanctioned by the catholic church and the legal system, the majority of reproductive behaviour in preindustrial Austria was confined to marital unions, nevertheless births conceived outside wedlock happened. Studying this reproductive behaviour deviating from cultural norms is able to illuminate moral standards as well as population policy interventions aiming at regulation of procreative processes in a very special way.

In this paper the development of illigitimacy over time (1700–1900) in Großarl, a village in the Alpine region of Salzburg, is analyzed with methods from the structural change analysis framework. Looking for population patterns over time means to us to specify the linkages between demography, anthropology and history. In this case study we used a mix of qualitative and quantitative approaches to analyze demographical time series data focusing upon the effectiveness of government bio-policies and institutional changes during the period of investigation. Changing normative regimes due changing policy regimes are thought to form a social context for individual and collective strategies within demographic behaviour. Theoretically, the engagement of immaterialistic culture (the sum of institutions, values and mental norms) in this context is substantial, because it explicates human agency and the relevance of cultural interventions into demographic behaviour.

While the theory about structural changes, in particular testing (Kuan and Hornik, 1995; Andrews, 1993; Andrews and Ploberger, 1994) and dating (Bai, 1997a; Bai and Perron, 2002) structural changes, has received much attention in the econometrics literature it is not common in the analysis of demographical time series. This papers considers two different approaches to the analysis of such demographical data in a policy evaluation context and compares their results. The first approach focuses on finding a descriptive model for the time series based on breakpoints derived from historical background knowledge, thus determining the breakpoints exogenously. The second approach tries to estimate the structural changes from the data.

The methodology used in this paper is implemented in a package called `strucchange` in the R system[1] for statistical computing, the GNU implementation of the S language, and is available from the Comprehensive R Archive Network (CRAN) `http://cran.R-project.org/`. A detailed description of the ideas and features of the `strucchange` package is given in Zeileis et al. (2002), but we describe the core functions briefly and illustrate how they can easily be used in the context of policy evaluation.

This paper is organized as follows: After providing information about the origin of the data and the history of Großarl in Section 2 we will outline the theoretical background for the structural change methodology in Section 3. In Section 4 the two approaches with exogenous and estimated breakpoints are applied to the data from Großarl and also compared. A brief summary is given in Section 5.

2 Policy Interventions in Großarl

The data analyzed in this paper is historical demographical data from Großarl, a village in the Alpine region of Salzburg, Austria, during the 18th and 19th century. Parish registers provide the basic demographic series of baptisms, burials and marriages. In the study area, baptism and burial registers provide a good indication of births and deaths in the community until the 20th century. This is because baptisms and burials appear to have taken place 1 to 2 days after birth and death, and

[1] `http://www.R-project.org/`

parish registers covered most of the population. During the period 1700–1900, total population did not vary much on the whole, with the very exception of the period of the protestant emigrations in 1731/32.

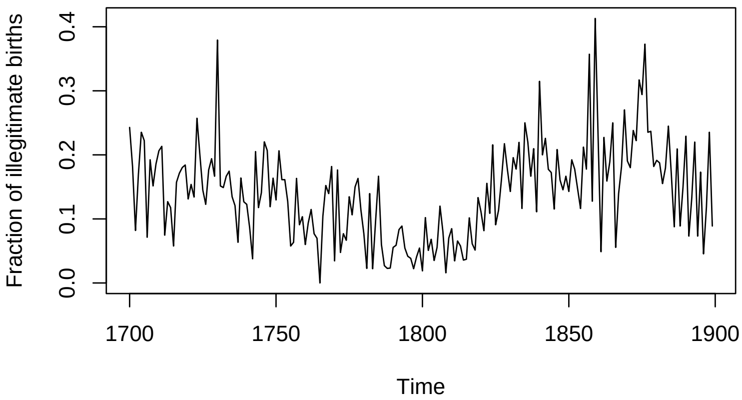

Figure 1: Fraction of illegitimate births in Großarl

Veichtlbauer et al. (2002) analyze the time series of births and deaths per month and the marriages and fraction of illegitimate births per year. We focus on the latter: illegitimate births are those of unmarried parents, which were of course undesirable from a catholic viewpoint. There were between 33 and 82 births per year with a mean of 51.67 and a mean proportion of illegitimate births of 14.11%. The whole time series of the fraction of illegitimate births per year can be seen in Figure 1. We will investigate changes in the mean of this series in Section 4.

Of Austria's nine present-day provinces, Salzburg is the only one ever to have been under the rule of a prince-archbishop as an independent state. Until the late 18th century the archbishops ruled as absolute royal sovereigns. A short overview of the changing political regimes and the common style of the ruler until the end of the 18th century is given in Table 1.

Table 1: Changing political regimes in Großarl

798	Archbishopric of Salzburg (Erzstift Salzburg)
1278	The archbishop becomes prince-archbishop (Fürsterzbischof)
1803	Salzburg is secularized as Duchy of Salzburg
1803 - 1805	The duke is made an elector of the Holy Roman Empire (Kurfürst des Heiligen Römischen Reichs)
1805	Habsburg-Lothringen dynasty established
1810	Incorporated into Bavaria
1816	Restored to the Austrian empire

For our model with exogenously given breakpoints we code the (potential) breakpoints that are induced by political changes in a factor called `politics` defining four segments:

- archbishopric (until 1803),
- chequered period with multiple changes (1803–1816),
- fifth district of the Austrian archduchy above the Enns (1816–1850),
- autonomous crown-land within Habsburg Austria (since 1850).

Additionally to these general political changes, we consider breakpoints induced by political interventions that aimed explicitly at avoiding unwanted forms of sexuality: moral regulations and marriage restrictions. These were an important form of politics and governance in which seignorial or state institutions problematize the conduct and behaviour of their population and impose regulation upon them (Hunt, 1999). In Salzburg, the governmentalisation of issues impinging on the sexuality of the whole population had already resulted in a set of interventions by the 17th century (Salzburger Landesarchiv), when several moral laws were enacted. The close linkage between religiosity and morality and between church and state led to a policy of moral suasion and social disciplining, especially concerning unwanted forms of sexuality. We will briefly illustrate these regulations: Sexual contacts resulting in illicit pregnancy were punished by the regional court. Beginning in the 1770s the judgments were designed to achieve a broad publicity. Stigmatizing corrections ("Schandstrafen") using the pillory ("Prechl") were carried out on Sundays or on celebration days. Corporal punishment ("Ruten- oder Karbatschstreiche") or compulsory labour on fortifications were applied to small offences, such as double fornication. Male adulterers usually were sentenced to one hour in the pillory, women were allocated sentences of two years workhouse-prison, and had even to leave the court district afterwards (repetition danger). Moral laws of this kind were abolished after secularization. The partition implied by the moral regulations is coded in the factor `morals` in the following way:

- "unchastity" regulation 1 (until 1736),
- regulation 2 (1736–1753),
- regulation 3 (1753–1771),
- regulation 4 (1771–1803),
- secularized (since 1803).

As another policy instrument to regulate a population's size and structure, demographically relevant marriage obstacles in Salzburg got their legal and communal basis in the 17th century (Siegel and Tomaschek, 1870). Since the year 1667 a marriage consent ("Ehekonsens") was obligatory to be allowed to marry. Bound to possession, the marriage grant became one special privilege of the higher social strata. After Salzburg was restored to the Austrian empire in 1816, legislation focused upon liberalization of the marriage law despite resistance by parts of the establishment and local political authorities. The following list gives again the coding of the segmentation caused by marriage restrictions which were coded in the factor `nuptiality`:

- matrimonial consent during archbishopric (until 1803),
- after the secularization the Catholic church lost its monopolistic position regarding marriage law. Nevertheless, the legal situation remained unchanged. (1803–1810),
- fundamental change under Bavarian rule: restrictive control concerning marriages of journeymen, day workers, menials (1810–1816),
- political marriage consent - community councils decide upon wedding licenses and pass judgment on petitions (1816–1883),
- none: abolition of political marriage consent in Salzburg (since 1883).

3 Statistical Methodology

3.1 The Linear Regression Model

Consider the standard linear regression model

$$y_i = x_i^\top \beta_i + u_i \qquad (i = 1, \dots, n), \tag{1}$$

where at time i, y_i is the observation of the dependent variable, x_i is a $k \times 1$ vector of regressors and β_i is the $k \times 1$ vector of regression coefficients, which may vary over time.

Tests for structural change are concerned with testing the hypothesis that the regression coefficients remain stable throughout the sample

$$H_0: \quad \beta_i \quad = \quad \beta_0 \qquad (i = 1, \dots, n) \tag{2}$$

against the alternative that they vary over time. In many applications it is reasonable to assume that there are m breakpoints, where the coefficients shift from one stable regression relationship to a different one. Thus, there are $m+1$ segments in which the regression coefficients are constant. Then we can rewrite the model as (1) as

$$y_i = x_i^\top \beta_j + u_i \qquad (i = i_{j-1} + 1, \dots, i_j), \tag{3}$$

where $j = 1, \dots, m+1$ gives the segment, $i_1, \dots, i_m$ denote the breakpoints and by convention $i_0 = 0$ and $i_{m+1} = n$. If these breakpoints are not given exogenously they have to be estimated from the data, which is also known as dating breaks.

The methods presented in this paper are valid under fairly general conditions, see e.g. Krämer et al. (1988) or Bai (1997b). Basically, they have to be such that a functional central limit theorem holds. This is for example satisfied if $\{u_i\}$ is a martingale difference and the regressors $\{x_i\}$ are (almost) stationary, which allows for lagged dependent variables among the regressors.

All procedures in this paper are based on (potentially segmented) ordinary least squares (OLS) estimation.

3.2 Testing Structural Changes

The most important classes of tests for structural change are the generalized fluctuation test framework (Kuan and Hornik, 1995) on the one hand and and the F statistics framework (Andrews, 1993; Andrews and Ploberger, 1994) on the other. The first class includes in particular the CUSUM and MOSUM tests and the fluctuation test, while the Chow and the sup$F$ test belong to the latter.

The generalized fluctuation tests are not to designed to have high power against certain patterns of structural changes—the main idea is to visualize deviations from the null hypothesis to gain insights about the structure of the data. The model (1) is fitted to the data and an empirical fluctuation process is derived that captures the fluctuation in residuals or in coefficient estimates. Under the null hypothesis these processes are governed by a functional central limit theorem, such that boundaries can be computed that are crossed with fixed probability α. But if the empirical process path crosses these boundaries, the fluctuation is improbably large and hence the null hypothesis should be rejected (at significance level α).

In this paper we use the OLS-based MOSUM test introduced by Chu et al. (1995). They suggested to base a structural change test on moving sums of the common OLS residuals $\hat{u}_i$

$$M_n^0(t|h) \quad = \quad \frac{1}{\hat{\sigma}\sqrt{n}} \sum_{i=\lfloor N_n t\rfloor+1}^{\lfloor N_n t\rfloor+\lfloor nh\rfloor} \hat{u}_i \qquad (0 \le t \le 1-h), \tag{4}$$

where h determines the size of the data window relative to the sample size (in this paper $h = 0.1$ is used) and $N_n = (n - \lfloor nh\rfloor)/(1-h)$. This process should reveal systematic departures from the theoretical zero mean of the residuals. Under a multiple shift alternative the process should have a shift around the breakpoints. This and other empirical fluctuation processes from the generalized fluctuation test framework can be fitted in R using the function

```
efp(formula, data, type, ...)
```

from the package `strucchange`, where `formula` specifies the regression model (1) to be tested, e.g., `y ~ x`. This is a version of the notation introduced by Wilkinson and Rogers (1973), which has been adapted for S (Chambers and Hastie, 1992). `data` is a data frame that might contain the variables `y` and `x` and `type` specifies the type of fluctuation process to be fitted, e.g., `"OLS-MOSUM"` to fit the OLS-based MOSUM process from (4). With the function `plot` such a fitted empirical fluctuation process can then be plotted together with its boundaries or with `sctest` the corresponding structural change test can be carried out.

F statistics are designed for the alternative of a single shift model with $m = 1$ breakpoint and have certain optimality properties for this alternative (Andrews and Ploberger, 1994). The basic idea is to compute F statistics (for the alternative that the regression can be segmented at a certain breakpoint) for a sequence of potential breakpoints and reject if a suitable functional of these is improbably large. They are available in `struccange` via the function

```
Fstats(formula, data, from = 0.15, ...)
```

where `from` specifies a trimming parameter h for the minimum segment size similar to the parameter h of the MOSUM test. A fitted `"Fstats"` object can again be plotted together with its boundaries and formal significance tests can be performed with `sctest`.

3.3 Dating Structural Changes

Given a certain m-partition for n observations $\{i_{m,n}\} = i_1, \dots, i_m$, it is easy to estimate the coefficients β_j by OLS. The resulting minimal residual sum of squares is given by

$$RSS(i_1, \dots, i_m) \quad = \quad \sum_{j=1}^{m+1} rss(i_{j-1} + 1, i_j), \tag{5}$$

where $rss(i_{j-1} + 1, i_j)$ is just the usual minimal residual sum of squares in the jth segment. To obtain the optimal m-partition with breakpoints $\hat{\imath}_1, \dots, \hat{\imath}_m$ the following objective function

$$(\hat{\imath}_1, \dots, \hat{\imath}_m) \quad = \quad \text{argmin}_{(i_1, \dots, i_m)} RSS(i_1, \dots, i_m) \tag{6}$$

has to be minimized over all partitions $(i_1, \dots, i_m)$ with $i_j - i_{j-1} \geq nh$. Thus, the minimum segment size is determined by the trimming parameter h and nh should at least be greater or equal to k, the number of regressors that have to be estimated on this subsample.

Solving the minimization problem (6) by an extensive grid search is of order $O(n^m)$ and usually computationally infeasible for $m > 2$. To avoid this many hierarchical algorithms have been proposed in the literature, see e.g. Bai (1997b) or Sullivan (2002), but in general these will not give the global minimizers. However, Bai and Perron (2002) discuss an algorithm based on dynamic programming which is of order $O(n^2)$, which is able to solve (6). The underlying idea is that of Bellmann's principle of optimality: the optimal segmentation satisfies the recursion

$$RSS(\{i_{m,n}\}) \quad = \quad \min_{mn_h \leq i \leq n - n_h} [RSS(\{i_{m-1,i}\}) + rss(i + 1, n)]. \tag{7}$$

Thus, if i is the last breakpoint in an m-partition one needs to find only the optimal $m - 1$-partition for the observations $1, \dots, i$ and so on. For closer details see Bai and Perron (2002). This algorithm is implemented in `strucchange` in the function

```
breakpoints(formula, data, breaks, h = 0.15, ...)
```

where the parameter `breaks` is the number of breakpoints m, that is by default chosen as the largest number allowed by the trimming parameter h. From the fitted `breakpoints` object any other number m of breakpoints can be extracted, which is demonstrated in the following section. Furthermore, the specified can be easily visualized.

4 Statistical Analysis

In this section we investigate changes in the mean of the time series of the fraction of illegitimate births in Großarl. As we are only interested in changes in the mean over time we use a model like (1) with only a constant regressor $x_i = 1$. In the S language this model is denoted `fraction ~ 1`, where `fraction` is a time series containing the data.

Firstly, the segmented models like (3) with exogenously given breakpoints as described in the previous section are fitted. Secondly, we estimate the breakpoints in the segmentation of (3) from the data without using further historical knowledge. Finally, the results are compared.

4.1 Exogenous Breakpoints

To show that the changes in the time series of the proportion of illegitimate births can not be explained by the breakpoints induced by the changes in the political system alone a minimal model will be fitted at first. This segmented regression model can be written in formula notation as `fraction ~ politics`. As will be shown below this model still contains structural changes and therefore further explanation of the changes in the mean of the series is required. Hence, an extended model is fitted that is additionally segmented according to the breakpoints induced by moral regulations and marriage restrictions as explained in the previous section. This model can be denoted as `fraction ~ politics + morals + nuptiality` and it leads to a much better fit without evidence of further structural changes.

The code below fits OLS-based MOSUM processes for both models and plots them together with their boundary at a 5% significance level. The resulting plot is shown in Figure 2.

The solid line MOSUM process for the model that contains only the political interventions has a strong significant shift in the second half of the 18th century, indicating that there are changes that are not explained by that model. It can be seen that adding the moral and marriage interventions this shift disappears in the dashed line MOSUM process of the extended model. In particular, adding the breakpoints for the moral regulation interventions in the 18th century leads to a much better fit to the data that has no further significant changes. The fitted extended model is also depicted in the solid line of Figure 4. In this model all factors are highly significant: `politics` ($p < 0.002$), `morals` ($p < 0.0001$), `nuptiality` ($p < 0.005$). Note that the marginal p values given in parentheses can be derived by an ordinary

```
R> mos.min <- efp(fraction ~ politics, type = "OLS-MOSUM", h = 0.1)
R> plot(mos.min)
R> mos.ext <- efp(fraction ~ politics + morals + nuptiality, type =
   "OLS-MOSUM", h = 0.1)
R> lines(mos.ext, lty = "dashed")
```

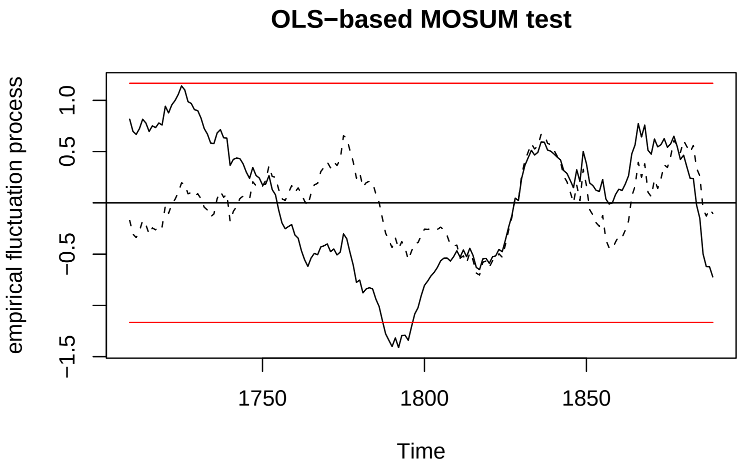

Figure 2: OLS-based MOSUM processes for minimal (—) and extended (- -) model

F test procedure as these breakpoints are given exogenously, i.e., this is essentially a model selection for the three factors `politics`, `morals`, `nuptiality` based on analysis of variance (ANOVA) methods. Finally, it is worth remarking that the MOSUM process for the extended model still exhibits some not significant but not uninteresting deviation from zero at the end of the 18th century. This will be explained further in the comparison at the end of this section.

4.2 Estimated Breakpoints

To estimate the breakpoints from the data the algorithm outlined in Section 3 is applied to the times series of the fraction of illegitimate births. As a trimming parameter of $h = 0.1$ is used (thus requiring a minimum segment size of 20 observations) the respective optimal breakpoints for models with $m = 0, \dots, 8$ breakpoints can be estimated (as the breakpoints in a 10-segment partition would be predetermined). This can be done in `strucchange` by

```
R> bp <- breakpoints(fraction ~ 1, h = 0.1)
```

A `summary` of the fitted object `bp` reports the breakpoints for $m + 1$-segment models with $m = 0, \dots, 8$ as well as the associated RSS and BIC. Table 2 reports the information derived from this `summary` as well as the AIC and Figure 3 shows the RSS and AIC for the various m-partitions.

Table 2: Summary for models with m breaks

m	estimated breakpoints								RSS	BIC	AIC
0									1.109	−460.8	−467.4
1					1826				0.876	−497.5	−510.7
2		1754			1821				0.685	−535.9	−555.6
3		1754			1823			1879	0.658	−533.2	−559.6
4		1754			1821		1856	1878	0.628	−532.2	−565.2
5		1753	1785		1821		1856	1878	0.602	−530.1	−569.6
6	1734	1754	1785		1821		1856	1878	0.592	−522.9	−569.0
7	1734	1754	1779	1800	1821		1856	1878	0.593	−511.7	−564.5
8	1734	1754	1778	1798	1818	1838	1858	1878	0.608	−496.1	−555.5

The `summary` tries (per default) to match the breakpoints of partitions with different m as these often differ slightly but not too much for practical interpretation. However, it happens that a breakpoint that is present in an m-partition is not close to any breakpoint in the $m+1$-partition. Here it can be seen for the Großarl data that the most significant break, in the sense of reducing the RSS, is around 1821 and the second most important around 1754. The BIC would choose this model with $m = 2$ breakpoints as it takes its minimum here. Usually, information criteria are a convenient possibility for model selection, which in this case means selection of the number m of breakpoints. Bai and Perron (2002) argue that the AIC usually overestimates the number of breaks but that the BIC is a suitable selection procedure in many situations. That is due to the fact that the BIC generally chooses very parsimonious models as it just includes the regressors that cannot be excluded, whereas the AIC rather includes all regressors that might be relevant and thus chooses larger models. But as we want to compare a model with exogenous

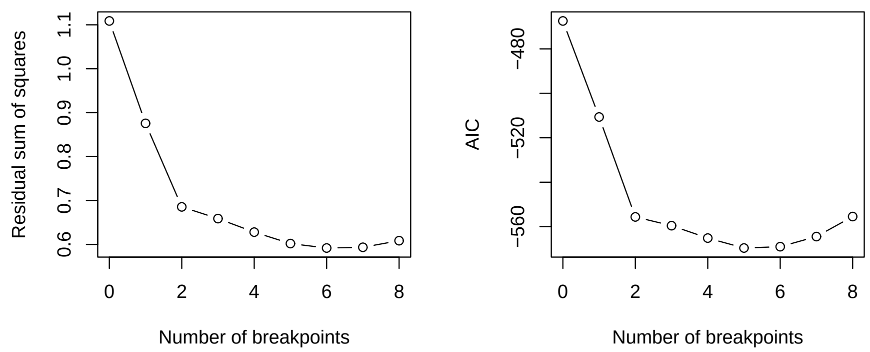

Figure 3: RSS and AIC for models with m breakpoints

breakpoints to a model with estimated breakpoints we have to overcome the problem that the information criteria penalize the estimation of the breakpoints and are likely to choose a smaller m than would be chosen if the breakpoints were known in advance. Therefore, we do not use the BIC but only the RSS and AIC, which are shown in Figure 3. The AIC would choose 5 or maybe 6 breakpoints and from the RSS it can be seen that the model with 6 breakpoints is the best model that can be achieved with an m-partition with trimming $h = 0.1$. Hence, the optimal partition with 6 breaks is extracted from the `bp` object fitted above

```
R> bp6 <- breakpoints(bp, breaks = 6)
```

4.3 Comparison of Exogenous and Estimated Breakpoints

To illustrate the difference concerning the breakpoints considered by the two different approaches Table 3 reports the breaks induced by the policy interventions on the one hand and contrasts them with those estimated from the data with $m = 6$ breakpoints. A graphical comparison of the two fitted models is given in Figure 4.

Table 3: Comparison of exogenous and estimated breakpoints

	breakpoints							
politics				1803		1816	1850	
morals	1736	1753	1771	1803				
nuptiality				1803	1810	1816		1883
estimated	1734	1754	1785			1821	1856	1878

From the comparison in Table 3 and Figure 4 respectively, a few interesting observations can be made: Although the end of the rule of the archbishops in 1803 was an important historic event and implied policy interventions affecting all three influence factors considered, it seems to have not affected the times series of the fraction of illegitimate births very much as it is not one of the estimated breakpoints. The moral regulation interventions are found rather exactly with the exception of the regulation in 1771. The political interventions and changes in marriage restrictions are also matched reasonably well. The estimated breakpoint corresponding to the change in 1816 seems to be somewhat shifted as the data reveal some implementation lag after 1816 (see Figure 4). The fraction of illegitimate births does not increase abruptly but over a couple of years until it has reached its new level. This would better be modelled by a term containing an additional slope. All in all, the results are very encouraging as both approaches result in very similar breakpoints and produce similar fits. However, there seem to be some changes within the data at the end of the 18th century and the beginning of the 19th century respectively, that are not described very well by the model with exogenous breaks. This can be seen both from the remaining (non-significant) shift in the MOSUM process mentioned above and the estimate 1785 that does not match 1771 very well. Veichtlbauer et al. (2002) describe changes during that time period in all demographical time series from Großarl, that cannot be explained very well by the considered model, e.g., there is an increase in the number of deaths and a decrease in the number of births around the turn of that century.

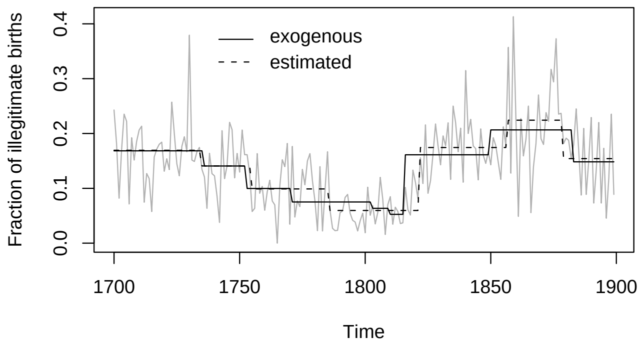

Figure 4: Fitted models with exogenous and estimated breaks

As Figure 4 illustrates, the models with exogenous and estimated breaks produce similar fits qualitatively, although the model with estimated breakpoints is of course a little bit better from a technical point of view as it is designed to minimize the RSS. But both models describe the decrease in the fraction of illegitimate births very well which corresponds to the moral regulations of increasing severity during the second half of the 18th century. Both capture the rapid increase in illegitimate births after the political changes 1816 and the decrease again after abolition of marriage restrictions in 1883.

5 Summary

To study the development of illegitimacy in the Alpine village Großarl in connection with the effects of policy interventions based on moral regulations and marriage restrictions during the 18th and 19th century two approaches from the structural change analysis framework are employed and compared. The first derives a set of explanatory variables coding exogenously known breakpoints from historical knowledge and evaluates their influence on the data. The second approach estimates the breakpoints in the time series from the data without using any further knowledge. Both lead to very similar results in terms of description of the data as the corresponding models capture the important changes in illegitimacy equally well. Both methods prove useful to gain insights about reproductive behaviour deviating from cultural norms.

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References

D.W.K. Andrews. Tests for parameter instability and structural change with unknown change point. *Econometrica*, 61:821–856, 1993.

D.W.K. Andrews and W. Ploberger. Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica*, 62:1383–1414, 1994.

J. Bai. Estimating multiple breaks one at a time. *Econometric Theory*, 13:315–352, 1997a.

J. Bai. Estimation of a change point in multiple regression models. *Review of Economics and Statistics*, 79:551–563, 1997b.

J. Bai and P. Perron. Computation and analysis of multiple structural change models. forthcoming, 2002.

P. Becker. Leben und Lieben in einem kalten Land. Sexualität im Spannungsfeld von ökonomie und Demographie. Das Beispiel St. Lambrecht 1600–1850. In *Studien zur Historischen Sozialwissenschaft Band 15*. Campus, Frankfurt/New York, 1990.

J.M. Chambers and T.J. Hastie. *Statistical Models in S.* Chapman & Hall, London, 1992.

Ch.-S.J. Chu, K. Hornik, and C.-M. Kuan. MOSUM tests for parameter constancy. *Biometrika*, 82:603–617, 1995.

A. Hunt. *Governing Morals. A Social History of Moral Regulation.* Cambridge University Press, Cambridge, 1999.

W. Krämer, W. Ploberger, and R. Alt. Testing for structural change in dynamic models. *Econometrica*, 56(6):1355–1369, 1988.

Ch.-M. Kuan and K. Hornik. The generalized fluctuation test: A unifying view. *Econometric Reviews*, 14:135–161, 1995.

B.S. Low. Occupational status and reproductive behaviour in nineteenth century sweden. locknevi parish. *Social Biology*, 36:82–101, 1989.

M. Mitterauer. *Ledige Mütter. Zur Geschichte unehelicher Geburten in Europa.* Beck, München, 1983.

Salzburger Landesarchiv. Geheimes Archiv Generale 35 1 / 2.

S. Scott and C.J. Duncan. Interacting factors affecting illegitimacy in preindustrial northern england. *Journal of Biosocial Sciences*, 29:151–169, 1997.

H. Siegel and K. Tomaschek. *Die Salzburger Taidinge.* Kaiserliche Akademie der Wissenschaften, Wien, 1870.

J.H. Sullivan. Estimating the locations of multiple change points in the mean. *Computational Statistics*, 17:289–296, 2002.

O. Veichtlbauer, E. Hanser, A. Zeileis, and F. Leisch. The impact of policy interventions on a pre-industrial population system in the austrian alps. Forthcoming, 2002.

G.N. Wilkinson and C.E. Rogers. Symbolic description of factorial models for analysis of variance. *Applied Statistics*, 22:392–399, 1973.

A. Zeileis, F. Leisch, K. Hornik, and C. Kleiber. `strucchange`: An R package for testing for structural change in linear regression models. *Journal of Statistical Software*, 7(2):1–38, 2002. URL `http://www.jstatsoft.org/v07/i02/`.

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