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Descriptive Finding

English fertility heads south: Understanding the recent decline

John Ermisch

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John Ermisch[1]

BACKGROUND
Fertility in England fell substantially during the past decade. The total fertility rate reached its historically lowest level in 2020.

OBJECTIVE
To improve our understanding of the decline in English fertility by using data on individual women during 2009–2020 from Understanding Society, which is a panel survey of the members of approximately 40,000 households.

METHODS
Estimation of a model of age and parity-specific birth rates on individual data, including year-effects, and cross-validation of it with external sources from registration data. Translation of the parameter estimates into more easily interpreted concepts such as period parity progression ratios and the total fertility rate (along with the standard errors for each).

RESULTS
The decline in first-birth rates appears to be primarily responsible for the decline in the TFR during the past decade, and women with an education below degree level experienced a larger fertility decline.

CONCLUSIONS
If recent period fertility patterns are sustained, England is embarking on a regime of a high level of childlessness not seen since that among women born in the early 1920s.

CONTRIBUTION
Individual-level panel data is used to estimate a model of parity-specific birth rates, which is cross-validated against registration data and used to provide insights into what lies behind the recent decline in English fertility.

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1. Introduction: Trends in English fertility

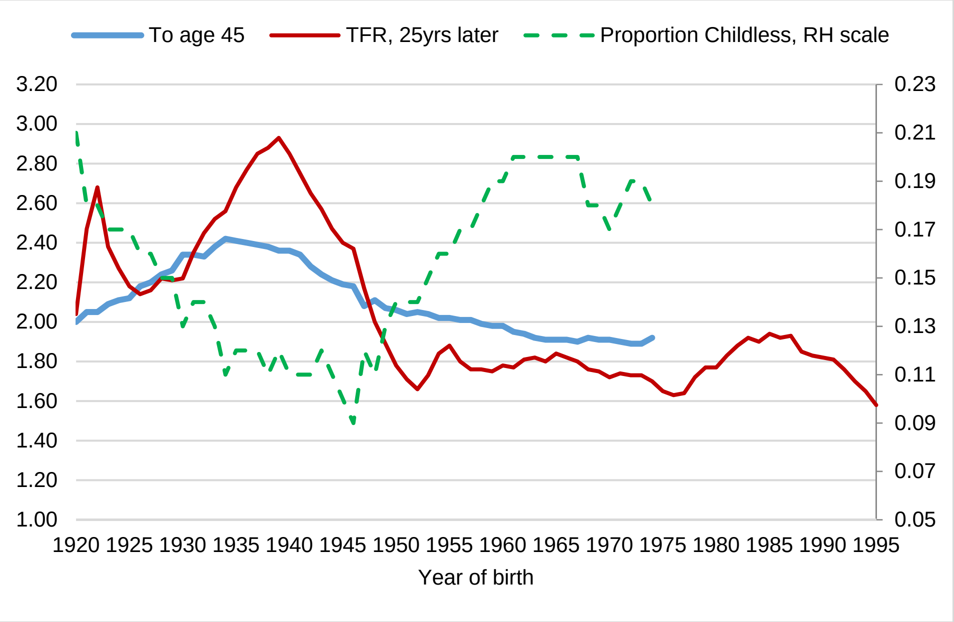
During the past decade, period fertility in England and Wales has fallen substantially, particularly since 2016. The Total Fertility Rate (TFR) declined by 0.35 children per woman, reaching 1.59 in England and 1.48 in Wales in 2020 (Office of National Statistics (ONS) 2021), placing England near the current level in Germany (1.60). Although the Welsh TFR is lower, it exhibits a correlation of 0.995 with the English TFR over 2010–2020. Most official statistics report English and Welsh fertility together, but because England usually produces about 95% of births it is called ‘English fertility’ for short.

The aim of the paper is to obtain a better understanding of recent changes in fertility. In England and Wales, birth registration data do not provide information on birth rates by birth order or for education groups. The paper’s main contribution is to use individual-level panel data over the last decade from the UK Household Longitudinal Study to estimate a model of parity-specific birth rates, to cross-validate the model against birth registration data, and to use it to provide insights into what lies behind the recent decline in English fertility, particularly its parity composition and education differentials. Estimates from the model are used to estimate period parity progression ratios (Henry 1953; Feeney 1983; Ni Bhrolchain 1987) and the TFR.

Figure 1 provides a long-term perspective, showing completed fertility by birth cohort along with the TFR 25 years after the cohort’s birth. The TFR has never been as low as it was in 2020. There have been declines and recoveries in the TFR before. For instance, between 1990 and 2001 the TFR fell from 1.84 to 1.63 and then recovered to 1.94 by 2011. This is because period fertility rates like the TFR reflect changes in timing as well as any change in completed family size. Cohort fertility since the 1920 birth cohort exhibits one wave, peaking at 2.42 for the 1934 cohort, and has been on a downward trend since then, reaching 1.92 for the 1974 cohort, which reached the end of its reproductive years in 2020.

In terms of age-specific birth rates (by five-year group), there have been declines since the mid-1960s for women aged under 30, accompanied by a rise among older women, particularly those aged 30–39, producing a later average age at motherhood (ONS 2020). Since 2016, rates have declined for all age groups under 40.

Figure 1: Cohort fertility, and TFR 25 years later, by birth cohort, England and Wales



2. Variation in fertility among women in Great Britain 2010–2020

Estimation of parity-specific birth rates during the past decade used information from Understanding Society, also known as the UK Household Longitudinal Study, which is a longitudinal survey of the members of approximately 40,000 households in the United Kingdom. Households recruited at the first round of data collection (2009–2011) are visited each year to collect information on changes to their household and individual circumstances. Annual interviews are conducted face-to-face in respondents' homes by trained interviewers. All members of the households selected at the first wave and their descendants, who become full members of the panel when they reach age 16, constitute the core sample and are followed wherever they move within the United Kingdom. All others who join their households in subsequent waves do not become part of the core sample, but they are interviewed as long as they live with at least one core sample member. Thus, the sample is refreshed with younger members annually. Understanding Society is designed to be representative of the UK population at each wave, representing all ages and all educational and social backgrounds (for more details see Understanding Society 2021a, 2021b). The analysis here used data during the first ten waves on women aged 16–45 born since 1970 and residing in England and Wales (the tenth wave was collected during 2018–2020). Fertility is measured by births between annual waves of the panel survey, and every pair of waves among this group is used in the estimation.

There is, of course, panel attrition (and re-joiners) between waves. After 25% attrition between the first two waves (Understanding Society 2019, section 2.3.4), about 90% of the target population of women in the present study were retained in the panel between subsequent pairs of waves. Whether attrition is ignorable for specific parameters and statistics based on them depends on specifics of the panel retention process in relation to fertility. This makes it important to cross-validate the estimated fertility model with registration data, which is done in section 2.3. In their analysis of British Household Panel Study data, the collection of which has very similar tracking and follow-up procedures to Understanding Society, Washbrook, Clarke, and Steele (2014) found that their substantive conclusions about the impact of covariates on residential mobility were not strongly affected by assuming that dropout is independent of mobility, even though movers were more likely to leave the panel.

2.1 Method

The main statistical method is the estimation of parity-specific functions for the annual birth probability. Each probability was assumed to depend on age, time since the last birth (other than parity zero), and interview year. The parity-specific equations estimated take the following form. For parities zero and one,

$$\ln\left(\frac{p_{itk}}{1-p_{itk}}\right) = \alpha_{0k} + \alpha_{1k} age_{it} + \alpha_{2k} age_{it}^2 + \delta_{1k} duration_{itk} + \delta_{2k} duration_{itk}^2 + \sum_{j=2010}^{2020} \mu_{jk} \quad k = 0,1 \qquad (1)$$

where p_{itk} is the probability of woman *i* at risk of a birth of parity *k* having a birth between waves *t-1* and *t*, *duration* is the years since the last birth for parities above zero (with δ_{10} and δ_{20} set to zero), *age* is the woman's age in years, and μ_{jk} are interview-year fixed effects.

For parities two and above,

$$\ln\left(\frac{p_{itk}}{1-p_{itk}}\right) = \alpha_{02} + \alpha_{12} age_{it} + \alpha_{22} age_{it}^2 + \delta_{12} duration_{itk} + \delta_{22} duration_{itk}^2 + \sum_{k=3}^{5} \gamma_k parity_k + \sum_{j=2010}^{2020} \mu_{j2} \quad k = 2,3,4,5 \qquad (2)$$

Thus, for parities three and above the equation allows for a different constant for each parity, but the other parameters are the same as for parity two. There are insufficient births at these parities (267, 77, and 35 at parities 3, 4, and 5 and above, respectively) to estimate the other parameters with any reasonable degree of precision. The impacts of this simplifying assumption on TFR estimates are mitigated by the small numbers reaching the risk set for such births.

The sample consists of up to nine pairs of consecutive years during which a birth could occur for each woman. There are no 'off-the-shelf' weights to assure the representativeness of such a sample to compute estimates of population means such as birth rates, but the sample can be used to estimate the model parameters on the assumption that these are constant across women and over the decade of analysis. The parameter estimates are therefore based on unweighted data. However, this can present a problem for the interpretation of the year-specific parameters μ_{jk}. They could reflect both sample composition effects and 'true' period influences. Overall, we observe 4,243 births during the period from 63,495 woman-year observations (from 14,354 women contributing between 1 and 9 waves of observation), of which 1,597 and 1,568 births are from parities zero or one, respectively, and 1,078 births are at higher parities.

2.2 Model parameter estimates

Parameters associated with the quadratics for age and duration were precisely estimated and produced the expected birth probability patterns. These parameters reflect the processes of partnering (particularly for first births) and of partnership dissolution, as well as births outside live-in partnerships. The parity-specific shift parameters for parities above the second (γ_k) are not precisely estimated. The hypothesis that these parameters are jointly zero cannot be rejected (p-value = 0.38).

The estimated year-effects are not precisely estimated for parities above zero, but for parity zero there is strong evidence of lower first-birth rates since 2013 compared to 2010: the average marginal effect (standard error) on the first-birth rate relative to 2010 ranges from –0.013 (0.008) for 2013 to –0.029 (0.008) for 2017, averaging –0.024 (0.004) for 2017–2020. This suggests that the recent decline in the TFR may reflect further postponement of motherhood in recent years. But, as noted earlier, the year-effects may also reflect compositional changes in the women interviewed in individual years. To explore this issue further, the next section reports on a cross-validation of the model with annual birth registration data.

2.3 Cross-validation of model

The cross-validation exercise is designed to gauge the extent to which the model of fertility behaviour estimated using the Understanding Society data is consistent with the TFR data for England and Wales. It was carried out in the following way. First, the model in Equations (1) and (2) was re-specified for parities higher than zero to a model without duration effects at each parity (the parity zero model is the same). This means that in terms of the parameters in Equation (1) the coefficient for age in the new model is $(\alpha_{1k} + \delta_{1k}) - 2\delta_{2k}age_{0itk}$ and the coefficient for age-squared is $(\alpha_{2k} + \delta_{2k})$, where age_{0itk} is the age at which a woman enters the population at risk for birth order k ($age_{0itk} = age_{itk} - duration_{itk}$). Estimation of the age coefficient in the new model in effect averages over age_{0itk}. According to the Bayesian Information Criterion (BIC), there is little to choose between the two models in terms of a characterisation of the parity-specific birth rates. Most importantly, estimates of this model produced similar year-effects to those based on Equations (1) and (2).

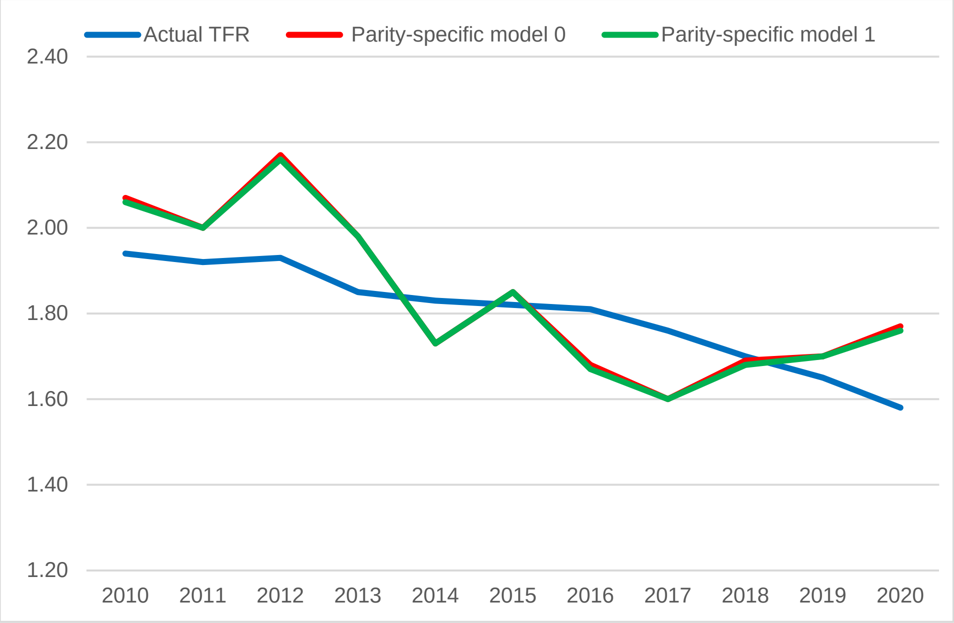
Next, the sequence of parity-specific fertility transitions was simulated using the parity-specific year-effects that apply in each year. The estimated transition rates imply period parity progression ratios (PPR) for each birth order j: PPR_j. From these the TFR is computed as:

$$TFR = PPR_1 + PPR_1PPR_2 + PPR_1PPR_2PPR_3 + PPR_1PPR_2PPR_3PPR_4 + \cdots \quad (3)$$

Two series of predicted TFRs for each year are shown in Figure 2 as parity-specific models 1 and 0, where the former includes the parity-specific parameters for parities two and higher and the latter does not. They are virtually indistinguishable. Their correlations of predicted and actual TFR are 0.725 and 0.720, respectively. The more parsimonious model 0 is used in the simulations that follow.

Heckman and Walker (1990: 1420) make the case that “tests of the time series properties of an aggregated micro model offer evidence on the fit of a model in a metric other than the one used to estimate the model”. One test is whether the differences between the TFR predicted from the micro model and the actual TFR (e_t) are serially correlated. If they are, then the model is misspecified. To carry out the test, as in Heckman and Walker (1990) the following regression is estimated: $e_t = \alpha + \rho e_{t-1} + u_t$, where u_t should be independently distributed over time (‘white noise’). One then tests whether ρ is significantly different from zero. This misspecification test supported the model (the p-value for the test that $\rho = 0$ is 0.24), and the intercept (α) was not significantly different from zero (p-value=0.64), indicating the model also predicts the level quite well. Also, the Ljung–Box (1978) Q test cannot reject the null hypothesis that the prediction errors (e_t) are independently distributed (a p-value of 0.15). Thus, the model performed well in replicating the TFR and its decline, suggesting that the year-effects mainly reflect real changes in fertility behaviour over the 2010–2020 decade, not just sample compositional effects.

Figure 2: TFR predicted by the parity-specific model and actual TFR, England and Wales



2.4 Statistical inference

Although it is more useful to think about the results from the fertility model in terms of PPRs and the TFR than parameter estimates, we need some idea of the precision of the estimates of these quantities, namely their standard errors (SE). These are not straightforward to calculate for the PPRs or the TFR other than via bootstrapping, which is what was done. Calculation of the SE for PPRs beyond the first is complicated by the fact that their PPR depends on the inflows into the population at risk from the previous birth order at each age, which is a function of the parameters from the previous order birth rate equations, as well as the parameters of the birth hazard for the particular birth order. This implies that bootstrapping for the estimate of $SE(PPR_j)$ must re-estimate parameters for all birth process parameters at each iteration.

The individual year-effects were not precisely estimated, even when rejecting the hypothesis that a particular year-effect (relative to 2010) is zero at the 0.05 level. Thus, for issues of statistical inference it is preferable to estimate grouped year-effects. Three sets of years are considered: 2010–2012, 2013–2016, and 2017–2020. The models take the following form for parities zero, one, two, and higher:

$$\ln\left(\frac{p_{itk}}{1-p_{itk}}\right) = \alpha_{0k} + \alpha_{1k} age_{it} + \alpha_{2k} age_{it}^{2} + \mu_{1k} year13\_16 + \mu_{2k} year17\_20 \quad (4)$$

where $year13\_16$ is a binary variable which is unity if the birth occurred between 2013–2016, and zero otherwise; similarly, $year17\_20$ equals unity if the birth occurred between 2017–2020 and zero otherwise. For instance, for first births (parity 0) the parameter estimates (robust SE) are: $\alpha_{00} = -15.052$ (0.566), $\alpha_{10} = 0.834$ (0.037), $\alpha_{20} = -0.0131$ (0.0006), $\mu_{10} = -0.307$ (0.060), and $\mu_{20} = -0.458$ (0.070).

Using the estimated model, estimates of the PPRs and the TFR (and their standard errors) for each time period are shown in Table 1. As for the TFR, the period PPRs reflect both tempo and timing effects. Note that these standard errors reflect sampling error in estimating the parameters of the model used to calculate the PPRs and are conditional on the model being a valid representation of the parity-specific birth processes, some evidence for which was provided in the previous section. The estimate of the SE of the TFR is calculated using the delta method using bootstrapped SEs and covariances for the individual PPRs. From Table 1 it is safe to conclude that the reduction in the estimated TFR between 2010–2012 and 2017–2020 of 0.41 is not entirely due to sampling variation.

The fall in the first birth rate since 2010–2012 indicated by the model is consistent with the sharp declines in the age-specific birth rates for woman aged under 30 since 2016. For example, if the age-specific rates under 30 had remained constant at 2016 values, then the TFR would have only fallen to 1.74 in 2020, rather than 1.58.

The counterfactual simulation of the model in the last column of Table 1, which sets the year-effect for 2017–2020 to zero for parities above zero, indicates that the decline in the TFR is almost entirely driven by the fall in the first birth rate. The age profile for first births with the 2017–2020 year-effect operating throughout ages 16–45 yields a median age at motherhood of 31 instead of 29 (for 2010–2012), and PPR_1 indicates that 21% (SE = 1.9%) would remain childless, which, if sustained, would take Britain back to the levels experienced for women born in the early 1920s, as illustrated in Figure 1.

Table 1: Simulated PPRs and TFR, England and Wales sample (bootstrapped SE[a] in parentheses)

PPR by birth order	2010–2012	2013–2016	2017–2020	Counterfactual[b]	Change 2010–2012 to 2017–2020
1	0.907 (0.010)	0.831 (0.012)	0.785 (0.019)	0.785 (0.019)	–0.122 (0.021)
2	0.797 (0.014)	0.775 (0.013)	0.725 (0.019)	0.749 (0.015)	–0.072 (0.024)
3	0.377 (0.015)	0.336 (0.013)	0.338 (0.016)	0.347 (0.014)	–0.039 (0.022)
4	0.327 (0.013)	0.295 (0.011)	0.302 (0.015)	0.309 (0.012)	–0.025 (0.020)
5	0.291 (0.013)	0.265 (0.012)	0.275 (0.016)	0.281 (0.013)	–0.016 (0.021)
TFR[c]	2.02 (0.043)	1.77 (0.038)	1.62 (0.055)	1.66 (0.053)	–0.398 (0.070)
Actual TFR	1.93	1.83	1.67		–0.26

Notes: [a]1,000 replications
[b]Assuming $year$_1720 = 1 for first birth rates only; other age-specific birth rates unaffected.
[c]TFR is the mean TFR over 1,000 replications; the estimate of SE uses the delta method with bootstrapped SEs and covariances for the PPRs.

3. Differential fertility decline

There is a vast literature documenting differences in fertility by a woman's educational attainment, both in timing and completed family size (e.g., Wood, Neels, and Kil 2014; Basten, Sobotka, and Zeman 2014; Impicciatore and Tomatis 2020). At least at some parts of the education distribution the education–fertility link may be causal (Fort, Schneeweis, and Winter-Ebmer 2016). Thus, it is an interesting differential to examine.

To explore how the recent fertility decline may have differed the sample was split into two education groups depending on whether or not the woman had a university degree (or equivalent) by her last interview in the panel. To establish a rough baseline for Great Britain, Understanding Society was used to estimate the difference in the number of natural children in the household (in their last panel interview) among women born in the 1970s (average age 43.6), who have virtually completed their childbearing. It will underestimate completed fertility because some children may have left home already, be living with their father, or may have died, and some women may still have another child. About half of women in these cohorts had a degree. Women without a degree had an average of 1.87 children, compared to 1.65 for women with a degree.

Separate parity-specific birth-rate models were estimated for women with (44% of the sample) and without a degree, thereby allowing for different age profiles and parity-specific time trends for the two groups of women. Using the same methods as earlier, the estimates of PPRs and the TFR are shown in Table 2.

Table 2: Simulated Period PPRs and TFR by woman's education, England and Wales sample (bootstrapped SEa in parentheses)

PPR	(1) 2010–2012 No degree	(2) 2017–2020 No degree	(3) 2010–2012 Degree	(4) 2017–2020 Degree	2010–2012 Ed. Diff.[c] (3) – (1)	2017–2020 Ed. Diff.[c] (4) – (2)
1	0.903 (0.014)	0.737 (0.032)	0.891 (0.015)	0.797 (0.022)	–0.012 (0.021)	0.061 (0.039)
2	0.772 (0.022)	0.647 (0.034)	0.785 (0.021)	0.745 (0.024)	0.014 (0.030)	0.098 (0.041)
3	0.409 (0.018)	0.350 (0.023)	0.292 (0.024)	0.261 (0.023)	–0.117 (0.030)	–0.090 (0.032)
4	0.353 (0.016)	0.311 (0.020)	0.225 (0.019)	0.205 (0.020)	–0.128 (0.024)	–0.106 (0.028)
5	0.317 (0.016)	0.287 (0.021)	0.185 (0.018)	0.171 (0.020)	–0.131 (0.024)	–0.116 (0.028)
TFR[b]	2.01 (0.061)	1.44 (0.082)	1.85 (0.055)	1.58 (0.060)	–0.167 (0.082)	0.141 (0.102)

Notes: [a]1,000 replications
[b]TFR is the mean TFR over 1,000 replications; the estimate of SE uses the delta method with bootstrapped SEs and covariances for the PPRs.
[c]SE is the standard error of the difference.

The most persistent and substantial fertility differences between women by education level are the lower PPRs for third and higher-order births among degree-educated women, which produced a lower TFR among them in 2010–2012. But, as documented in Table 3, there was a larger fertility decline among non-degree women than degree women in the subsequent period up to 2017–2020, reversing the education difference in the TFR, although the difference is not precisely estimated and may be small. The large decline in the overall TFR was driven by substantial declines in the PPR for the first three birth orders among lower-educated women and by a large decline in the PPR for first births among women with a degree. Similar TFRs during 2017–2020 by education group reflected higher PPRs for first and second births but lower PPRs for higher-order births among those with a degree compared to those without degrees (Table 2).

Table 3: Changes in PPRs and TFR by Women's Education, 2010–2012 to 2017–2020, England and Wales sample (SE^a in parentheses)

PPR	(1) No degree	(2) Degree	Diff in Change degree vs no deg. (2) – (1)
1	–0.166 (0.035)	–0.093 (0.026)	0.073 (0.044)
2	–0.124 (0.041)	–0.041 (0.031)	0.084 (0.051)
3	–0.059 (0.029)	–0.031 (0.033)	0.027 (0.044)
4	–0.042 (0.025)	–0.020 (0.028)	0.022 (0.038)
5	–0.029 (0.026)	–0.015 (0.026)	0.015 (0.037)
TFR^b	–0.571 (0.102)	–0.263 (0.081)	0.308 (0.131)

Notes: [a] SE is the standard error of the difference.

4. Conclusions

Four conclusions concerning recent fertility developments emerge from the analysis in the paper. First, whatever is driving the decline in first-birth rates appears to be primarily responsible for the decline in the TFR during the past decade. Second, if the recent period fertility pattern is sustained, England is embarking on a regime with levels of childlessness not observed since those of women born in the 1920s, although previous postponements of childbearing have been followed by some recovery in first births. Third, the analysis indicates a larger decline in fertility among women without a university degree than among degree-educated women, suggesting a compression of educational differentials. Fourth, the study illustrates the value of cross-validation of a model estimated on individual data with external sources, and of translating parameter estimates into more easily interpretable concepts such as period parity progression ratios and the total fertility rate.

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