Response to Edwards and Ogilvie

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Our paper on 'Late Marriage as a Contributor to the Industrial Revolution in England' is intended to show that the evidence is consistent with the European Marriage Pattern being a major influence on long run English economic development, through the accumulation of human capital broadly defined. Edwards and Ogilvie (EO) assert that our approach is inadequate because, they claim, we consider neither other influences on English industrialisation, such as non-familial institutions, nor other European economies where marriage age was high throughout the early modern period but where industrialisation came later. We do allow for other influences on English industrialisation in our model and the observation that some late industrialisers had later marriage than England does not refute our contention, which we test appropriately by simulating the model.

An objective of some of our simulations in section VI of the paper is to show how non-familial factors mattered and could alter 'why England was first'. For instance, in the 'German' simulation we take the estimated English economy model and data and run it with a small change in productivity, such as might be imposed by restrictive guild control in another European economy. The outcome reported in the paper is substantially delayed industrialisation – despite a late age at first marriage.

Structural differences between economies, such as captured by productivity measures θ_1 and θ_2 in F1 (Supplementary Information), can explain how a high marriage age, as found in some areas of Europe, need not be positively correlated with early industrialisation. The effects of the observed variation in marriage age can be more than offset by differences in other parameters. Lower productivity, generating lower wages that reduce the demand for children, predicts an inverse correlation between economic development and marriage age across Europe. Our model also allows that adverse shocks could raise marriage age while retarding economic development. Although we did not report it in the published paper, in the counterfactual 'Netherlands' scenario, marriage age remains higher almost throughout the seventeenth and eighteen centuries (**Figure 1**).

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Figure 1 Marriage Age and Adverse Economic Shocks
Source: See Foreman-Peck and Zhou, 'Late marriage', section VI.

EO's main thrust could be positively interpreted as pointing out that we do not have a cross-section or panel model, only one explaining a time series. Hence, we cannot and do not explain why for instance measurable human capital varied a great deal between societies in which late female marriage and servanthood were both high. We do not model the comparative weakness of the guilds, or the fewer entry barriers and mobility restrictions, that EO tell us allowed more female learning by doing in England than in other European societies. This is because institutions are highly persistent. Consequently, temporal covariation is not usually a suitable way of identifying their impacts. In the model of our paper institutional effects are implicit; in the national time series model institutions contribute to the accumulation process through the magnitudes of the parameters. International comparisons are more appropriate for identifying the role of institutions explicitly. But the simulations of section VI, discussed above, are intended to cast some light on the effects of institutional differences.

Bivariate correlations or single causes are rarely sufficient to understand the economic evolution of societies. To understand complexity, where there are many influences and in which variables can be both cause and effect, models that can support counterfactuals are necessary. EO assert that the informal human capital investment women could obtain through learning by doing in more skilled occupations was probably higher because of comparative weakness of the guilds, not because of the pattern of late marriage. The EO counterfactual then is that England could have had

early marriage but nonetheless, thanks to the weakness of the guilds, there would have been substantial informal female human capital investment. Our contention is that if women did not marry late, with the early onset of children, they would be less likely to be able to take advantage of more skilled work opportunities. In short, the outcome (female human capital investment) is dependent on more than one condition, a variable in our model, age at marriage, and a human capital productivity parameter, θ2, reflecting the comparative weakness of the guilds, among other influences.

It is true that as EO claim 'By construction … the accumulation of human capital has to provide a great deal of the proximate explanation of the rise in per capita output'. The essential questions of our paper are where does this human capital come from and what if anything does late marriage age contribute? EO's assertion is not true that our 'model, by construction, excludes any contribution from … other influences' than late marriage, or that we have run 'a race with one runner'. If it were we could not have written that 'The contribution of education by the family (0.6) is estimated to be greater than education outside the family in the wider society (0.4).' The relevant equation allows either the proportion of family or of non-family contributions to human capital to be close to zero. The proportions that we obtain are generated by the data. The simplified model in the diagram (fig. 3 of the paper) may convey the impression that there was no alternative to family accumulation (because only q is shown feeding in to H), but the text is supposed to do otherwise, with the discussion of apprenticeship and schools. The key equation is F3 in the Supporting Information. As the outline of the model in figure 3 suggests, this equation explaining the direct contributors to human capital accumulation, is part of a larger system. Many other components therefore contribute indirectly to the process.

$$Q_t = e^{x_t} H_{t-1}^{\epsilon} (Q_{t-2} q_{t-1})^{1-\epsilon} \qquad \text{....(F3)}$$

F3 describes how each generation's human capital level (Q_t) is formed. H_{t-1} is lagged aggregate human capital per capita, a weighted average of that of the three working generations. q is the target quality of children, defined as the ratio of children's, to parents' human capital. It is therefore multiplied by the parents' generational human capital to convert the bracketed expression to an absolute value of family-originating human capital. The parameter ε determines the balance between family and non-family sources of human capital accumulation; H includes both, the bracketed term does not. The larger is ε, the greater the proportion attributable to non-family accumulation and the smaller is the family contribution. If ε is one, generational human capital depends only on lagged aggregate human capital and aggregate human capital comes only from non-familial sources. The estimated size of ε is a test of the hypothesis on English historical data that family-originating human capital mattered for economic development.

We also report a test of the link, through the price of 'child quality', between this type of human capital and the marriage age. The test shows a substantial elasticity (η) of the price of quality with respect to the marriage age, even though the test (estimation and the model) allows for a zero effect. The price of 'child quality' equation depends upon wages and mortality rate variables, and several parameters as well as marriage age. So, the price of child quality in principle could be explained without any marriage age effect at all. However, the counterfactual of figure 5, setting η, the elasticity above, to zero, implies that the marriage age through the price of 'child quality' was important for long term real wages.

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References

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