Online appendix to:

The Feudal Origins of Manorial Prosperity:

Social Interactions in 11th-century England

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Contents

A Summary statistics of estimation sample

Table A1: **Summary statistics main variables**

Variable	**Mean**	**Median**	**Variance**	**10^{th} percentile**	**90^{th} percentile**
Value	5.0	2.0	93.7	0.5	12.0
Labor: non-slaves	14.4	9.0	355.5	2.0	31.0
Labor: slaves	2.1	1.0	12.8	0.0	6.0
Capital: ploughs	5.4	3.0	54.5	1.0	11.0
Land: ploughlands	5.8	4.0	62.5	1.0	12.0
Land: soil suitability	1.9	2.0	0.5	1.0	3.0

Table A2: **Main tenant-in-chiefs by number of manors**

Tenant-in-Chief	**Manors**				**Lords**	
	Number		**Value**		**Number**	**Share main (%)**
	Total	**Demesne**	**Total**	**Demesne**		
Count of Mortain	675	88	1,810.4	637.5	193	6.6
King William	470	359	8,379.7	6,156.1	149	1.0
Bishop Odo of Bayeux	328	23	2,121.2	506.9	145	7.9
Bishop of Coutances	226	25	755.5	194.9	116	27.1
Earl Roger of Shrewsbury	217	43	1,463.5	611.2	138	7.4
Count Alan	188	51	761.1	440.0	79	6.7
Baldwin the sheriff	167	19	340.0	127.9	90	5.3
Countess Judith	153	41	591.5	351.9	71	5.7
Henry of Ferrers	138	51	431.8	198.5	51	5.7
Roger of Bully	118	65	261.2	170.5	32	8.2
Robert of Stafford	110	15	217.1	73.1	67	4.3
Iudhael of Totnes	100	13	151.2	68.0	58	26.7
Bishop of Lincoln	98	19	730.3	312.6	78	7.0
Earl Hugh	97	20	516.6	133.8	38	11.9
Hugh of Grandmesnil	97	34	369.0	190.0	31	11.0
Average	15.8	6.7	81.4	47.5		

Note: The summary statistics for the lords are calculated under the assumption that these lords are all separate individuals.

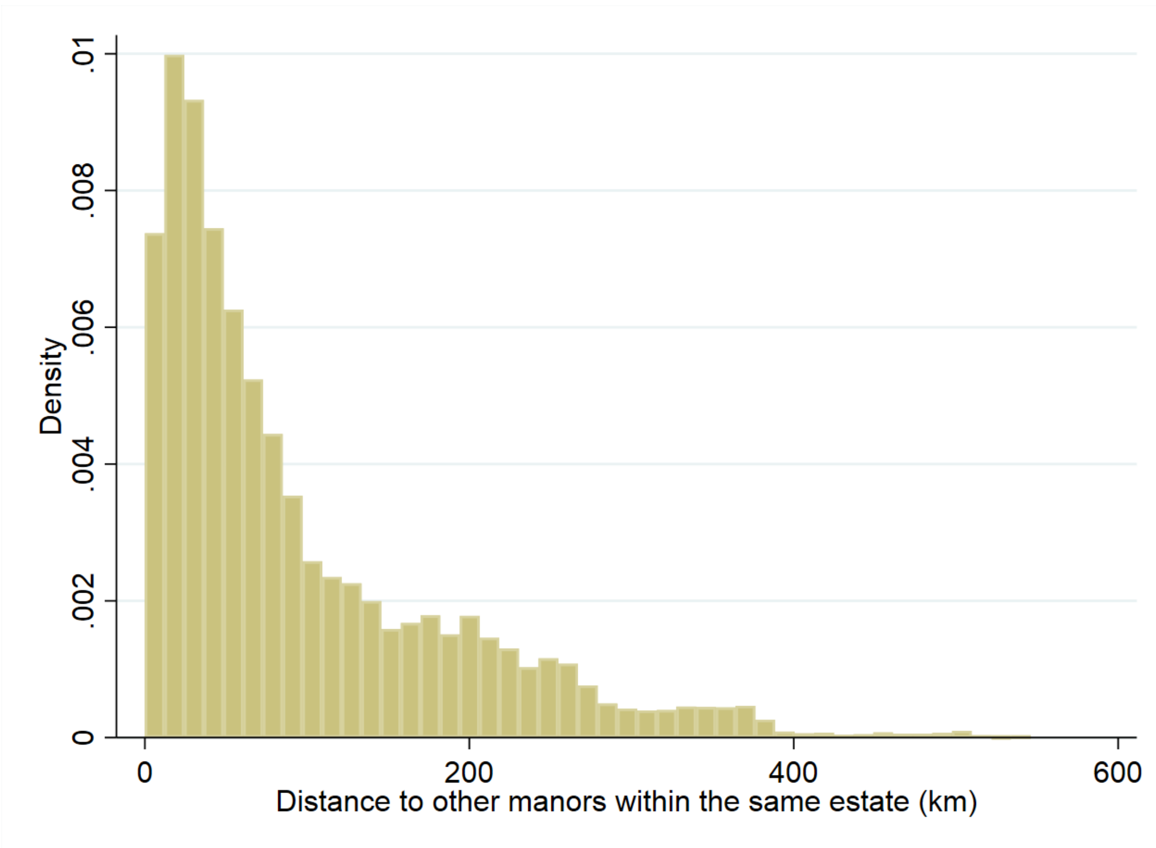
Table A3: **Main lords by number of manors (excluding demesne)**

Lord	**Manors**		**Tenant-in-chiefs**	
	Number	**Value**	**Number**	**Main (share in %)**
Drogo son of Mauger	70	80.7	2	Bishop of Coutances (98.6)
Reginald of Vautortes	48	71.8	1	Count of Mortain (100.0)
Ralph of Pomeroy	41	26.0	5	Iudhael of Totnes (40.9)
Alfred the butler	41	148.1	3	Count of Mortain (95.1)
Urso of Abetot	40	107.7	12	Abbey of Westminster (30.2)
Richard son of Turolf	36	40.1	5	Count of Mortain (82.1)
William of Keynes	35	96.1	3	Count of Mortain (91.9)
Wadard of Cogges	34	117.2	3	Bishop Odo of Bayeux (91.2)
Ilbert of Lacy	32	99.8	3	Bishop Odo of Bayeux (57.4)
Adam son of Hubert	28	239.4	1	Bishop Odo of Bayeux (100.0)
Nigel Fossard	28	28.9	1	Count of Mortain (100.0)
Hugh of Bolbec	27	122.5	3	Walter Giffard (78.8)
Reinbert the sheriff	26	85.3	2	Count of Eu (92.3)
Hamelin of Cornwall	22	21.9	1	Count of Mortain (100.0)
Turstin the sheriff	22	65.2	2	Count of Mortain (95.5)
Average including unidentified lords	1.6	9.9	1.1	(97.3)
Average excluding unidentified lords	3.2	16.9	1.4	(90.0)

Note: For manors that have multiple lords, the complete value of the manor was attributed to every lord. As a result, the values in this table should be interpreted as an upper bound.

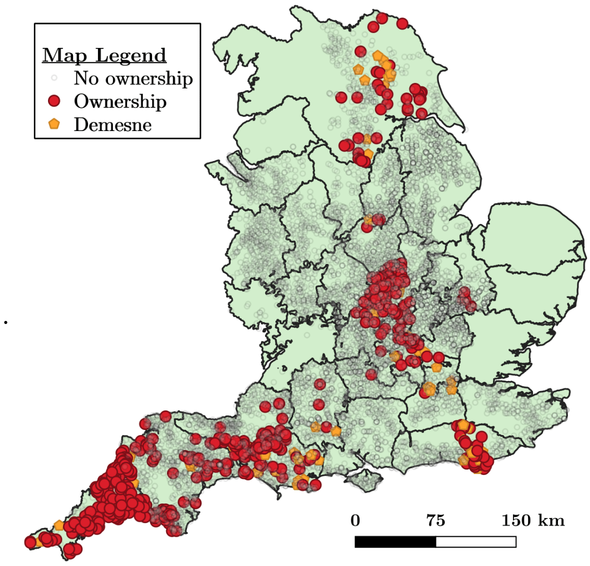
The average including the unidentified lords is calculated under the assumption that these lords are all separate individuals.

Figure A1: **Histogram of the distances to manors within the same estate**

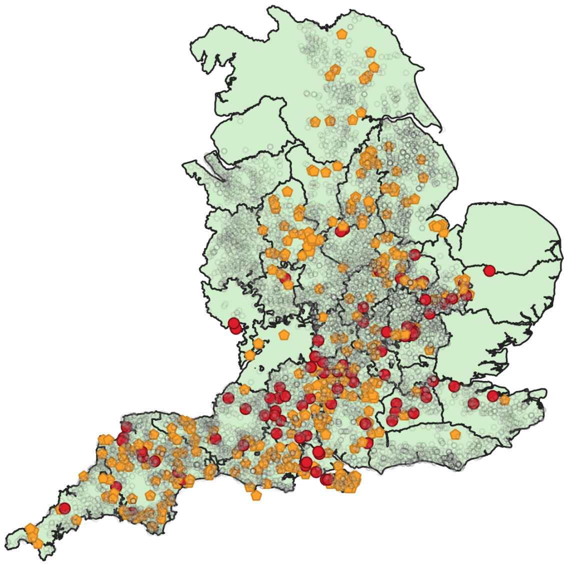


B Maps depicting manors of the main tenant-in-chiefs and lords

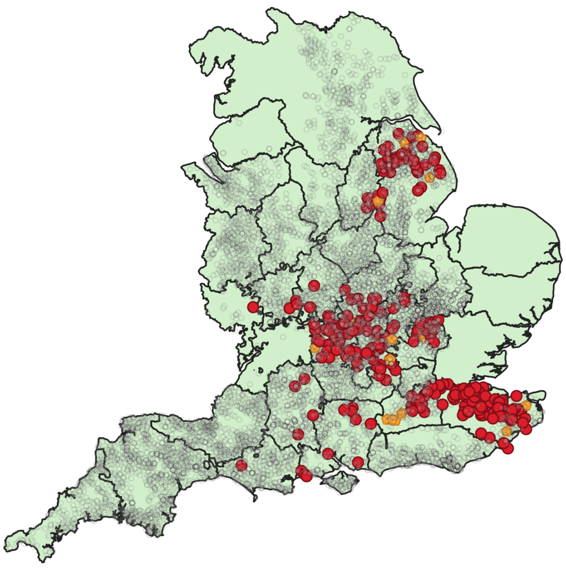
Figure A2: **Main tenant-in-chiefs by number of manors**



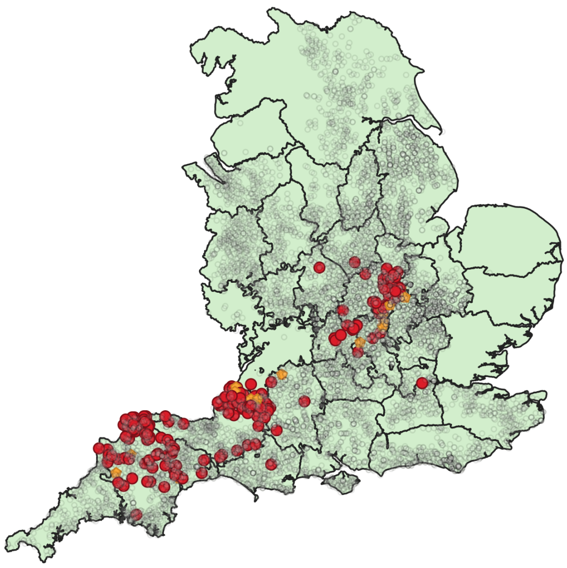
(a) Count of Mortain



(b) King William

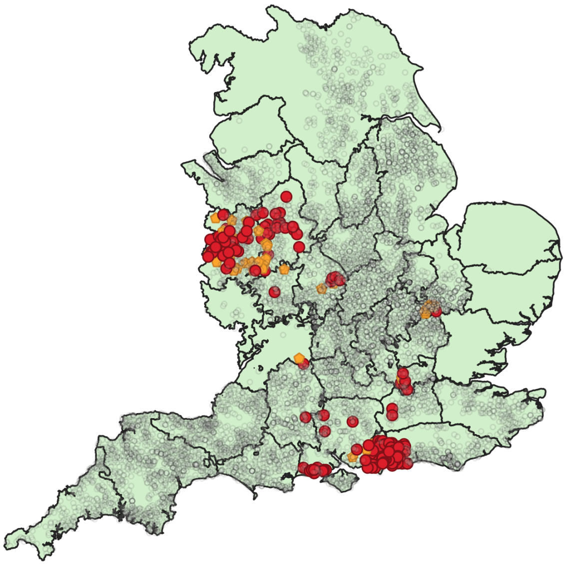


(c) Bishop Odo of Bayeux

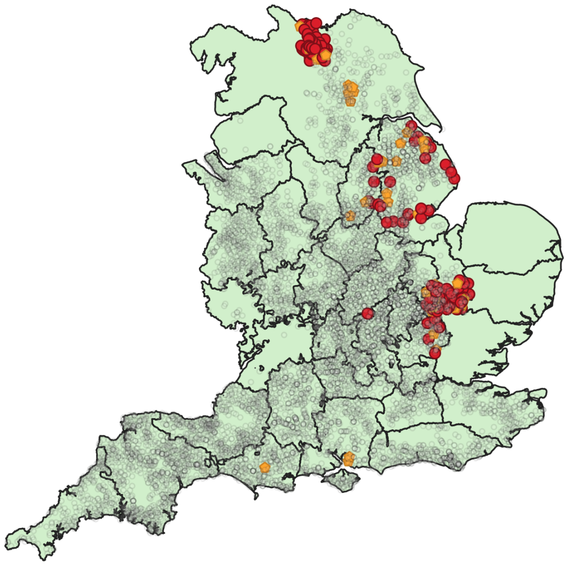


(d) Bishop of Coutances

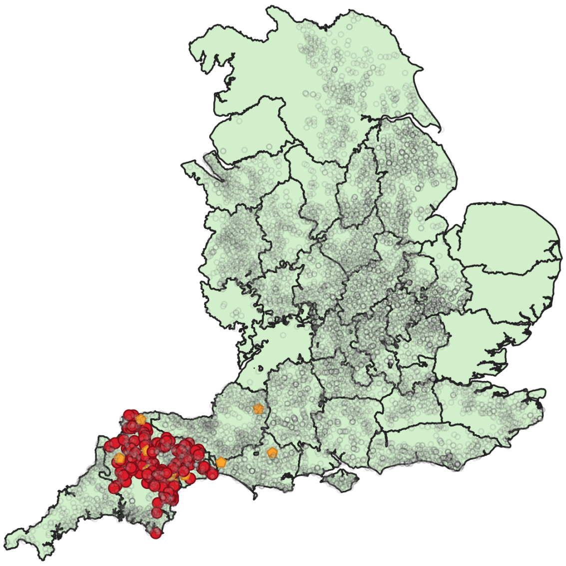
Figure A2: **Main tenant-in-chiefs by number of manors (continued)**



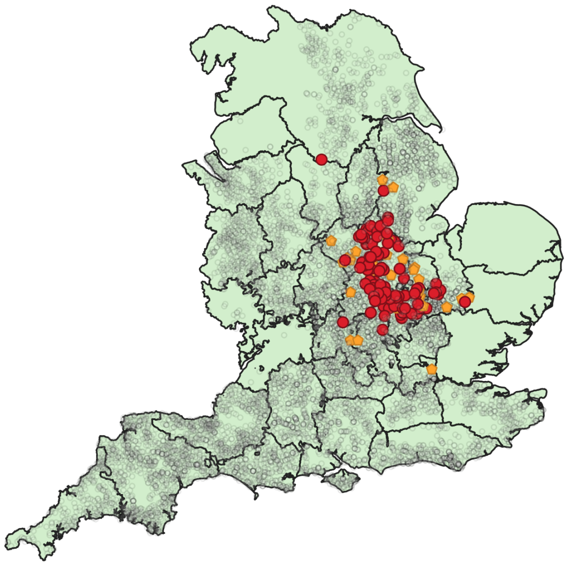
(e) Earl Roger of Shrewsbury



(f) Count Alan



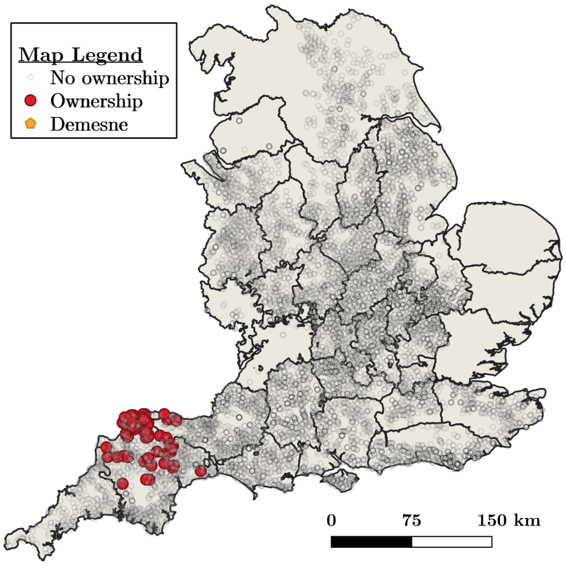
(g) Baldwin the sheriff



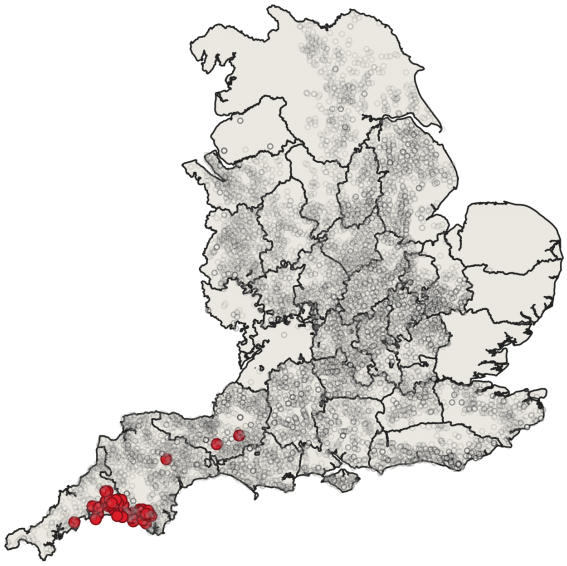
(h) Countess Judith

Source: Palmer (2010); historical county borders from Brookes (2017)

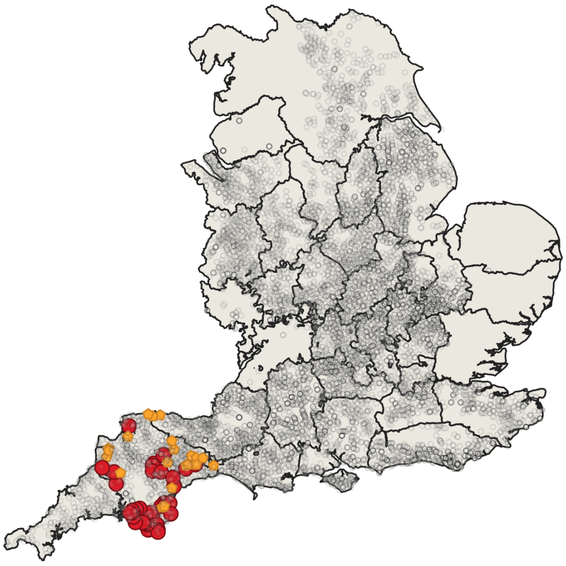
Figure A3: **Main lords by number of manors**



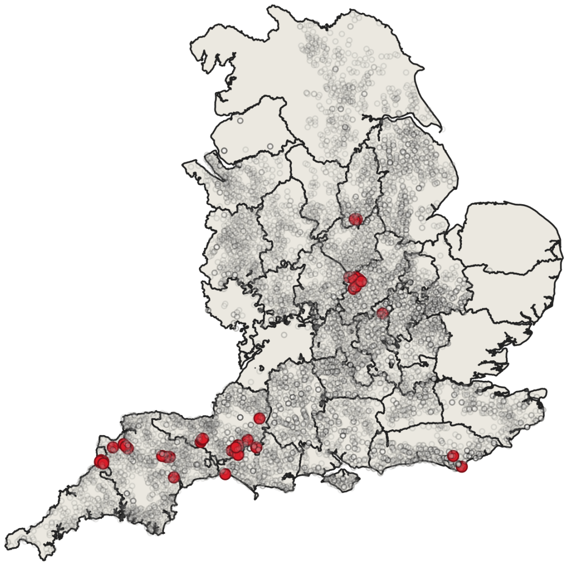
(a) Drogo son of Mauger



(b) Reginald of Vautortes



(c) Ralph of Pomeroy



(d) Alfred the butler

Figure A3: **Main lords by number of manors (continued)**

(e) Urso of Abetot

(f) Richard son of Turolf

(g) William of Keynes

(h) Wadard of Cogges

Source: Palmer (2010); historical county borders from Brookes (2017)

C Model with only productivity spillovers

As an alternative model, we consider the model that only contains productivity spillovers. Formally, we have

$$y_i = \alpha + \mathbf{x}_i\boldsymbol{\beta}' + \varepsilon_i, \quad \varepsilon_i = \lambda_F \frac{\sum_{f\in\mathcal{F}_i} \varepsilon_f}{|\mathcal{F}_i|} + \lambda_G \frac{\sum_{g\in\mathcal{G}_i} \varepsilon_g}{|\mathcal{G}_i|} + \eta_i, \quad E[\eta_i \mid \mathbf{X}, \mathbf{F}, \mathbf{G}] = 0,$$

in which $\boldsymbol{\beta}$ denotes the direct effect of the manor's resources. λ_F (λ_G) captures spillovers in productivity from feudal (geographic) neighbors.[1] Stacking observations, this model can be rewritten compactly in matrix notation:

$$\mathbf{y} = \alpha\boldsymbol{\iota} + \mathbf{X}\boldsymbol{\beta}' + \boldsymbol{\varepsilon}, \quad \boldsymbol{\varepsilon} = (\lambda_F\mathbf{F} + \lambda_G\mathbf{G})\boldsymbol{\varepsilon} + \boldsymbol{\eta}, \quad E[\boldsymbol{\eta} \mid \mathbf{X}, \mathbf{F}, \mathbf{G}] = 0, \tag{1}$$

where **F** and **G** are row-normalized interaction matrices as defined in the main text. As this model is a special case of our full structural model, it can also be estimated consistently and efficiently by using the generalized spatial two-stage least squares (GS2SLS) procedure, as proposed by Kelejian and Prucha (2010) and Drukker, Egger, and Prucha (2019).

Table A4 presents the estimates for this model. Overall, we find large positive and statistically significant results for the productivity spillover parameters in all specifications considered. The estimates are somewhat higher than those of the full model, although the overall qualitative assessment remains intact. The main takeaway from these estimates is that feudal peers' unobserved agricultural performance had a significant positive effect on a manor's value. This effect is sizeable, albeit smaller than the impact of a manor's geographic neighbors.

[1] A sufficient condition for this model to have a stable and unique solution is that $|\lambda_F| + |\lambda_G| < 1$.

Table A4: **Estimates baseline econometric model (GS2SLS)**

Parameter			**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Labor: non-slaves		β_1	0.19***	0.15***	0.15***	0.17***	0.15***	0.15***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Labor: slaves		β_2	0.11***	0.09***	0.09***	0.10***	0.09***	0.10***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Capital: ploughs		β_3	0.54***	0.60***	0.57***	0.56***	0.59***	0.57***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Land: ploughlands		β_4	0.13***	0.15***	0.15***	0.13***	0.14***	0.14***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant		α	-0.25***	-0.21***	-0.17***	-0.18***	-0.20***	-0.17**
			(0.02)	(0.03)	(0.03)	(0.03)	(0.04)	(0.07)
Productivity spill-overs	**F**	λ_F	0.81***		0.43***	0.55***		0.46***
			(0.01)		(0.07)	(0.02)		(0.02)
	G	λ_G		0.93***	0.71***		0.75***	0.63***
				(0.01)	(0.01)		(0.02)	(0.03)
County FE						YES	YES	YES
Soil FE						YES	YES	YES
Observations			9,084	9,084	9,084	9,084	9,084	9,084
ADE productivity spill-overs			1.08	1.04	1.04	1.02	1.02	1.04
ATE productivity spill-overs			4.06	5.65	10.71	2.17	3.44	8.90

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

D The role of within and between estate effects

Table A5: **Estimates of within and between estate contributions (GS2SLS)**

Parameter			**(1)**	**(2)**
Labor: non-slaves		β_1	0.15***	0.15***
			(0.01)	(0.01)
Labor: slaves		β_2	0.09***	0.10***
			(0.01)	(0.01)
Capital: ploughs		β_3	0.58***	0.57***
			(0.01)	(0.01)
Land: ploughlands		β_4	0.14***	0.14***
			(0.01)	(0.01)
Constant		α	-1.01***	-0.68***
			(0.03)	(0.05)
Productivity spill-overs	**F**	λ_{F_W}	0.21***	0.19***
			(0.02)	(0.02)
		λ_{F_B}	0.20***	0.19***
			(0.04)	(0.03)
	G	λ_G	0.63***	0.51***
			(0.02)	(0.03)
Scale spill-overs	**F**	δ_{F_W}	0.03***	0.04***
			(0.01)	(0.01)
		δ_{F_B}	0.08***	0.08***
			(0.01)	(0.01)
	G	δ_G	0.51***	0.28***
			(0.02)	(0.03)
County FE				YES
Soil FE				YES
Observations			9,084	9,084

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

E Test for network endogeneity

In this section, we conduct a graphical test for network endogeneity based on the discussion in Boucher and Fortin (2016). In the presence of homophily, one can test the null hypothesis of network exogeneity by means of the joint distribution of the errors of our structural model and the errors of a model of network formation.

We first extend our structural model as

$$\begin{aligned} \mathbf{y} &= \alpha \boldsymbol{\iota} + \mathbf{X}\boldsymbol{\beta}' + (\delta_F \mathbf{F} + \delta_G \mathbf{G})\mathbf{y} + \boldsymbol{\varepsilon} \\ \boldsymbol{\varepsilon} &= (\lambda_F \mathbf{F} + \lambda_G \mathbf{G})\boldsymbol{\varepsilon} + \boldsymbol{\eta} \\ \boldsymbol{\eta} &= \rho \boldsymbol{\zeta} + \boldsymbol{\xi}, \end{aligned} \tag{2}$$

in which $E[\boldsymbol{\xi} \mid \mathbf{X}, \mathbf{F}, \mathbf{G}] = 0$. Note that when $\rho = 0$, the model collapses to our main model. In a second step, we assume that the feudal links are formed by means of a dyadic model of network formation

$$f_{ij} = I\left(\kappa - \sum_k \varphi_k |x_{k,i} - x_{k,j}| + \tau g_{ij} - \mu|\zeta_i - \zeta_j| + \nu_{ij} \geq 0\right), \tag{3}$$

where ν_{ij} is an i.i.d. logistic error term.[2] When $\{\varphi_k\}_k, \mu > 0$, we say the network exhibits homophily, as manors that have similar observed characteristics $\{x_k\}_k$ and unobserved characteristics ζ are more likely to form links. When $\tau > 0$, manors that are close to each other are more likely to form feudal links.

Unless $\rho = 0$ or $\mu = 0$, the estimates of the structural model are biased, as unobserved characteristics ζ influence both network formation and productivity. However, in this setup endogeneity has some testable implications that can be exploited to test the null hypothesis of exogeneity. The graphical test is implemented as follows:

1. We estimate the structural model, assuming that $\rho = 0$. From the estimates of this model, we can calculate $\widehat{\eta}_i$ for all manors i. For every pair of manors (i, j), we define $\widehat{\eta}_{ij} = |\widehat{\eta}_i - \widehat{\eta}_j|$.
2. We estimate the dyadic model using logistic regression, assuming that $\mu = 0$. We denote the predicted value of f_{ij} as $\widehat{f}_{ij}$.
3. We estimate the joint distribution of $\widehat{\eta}_{ij}$ and $\widehat{f}_{ij}$ for the subsample of unlinked

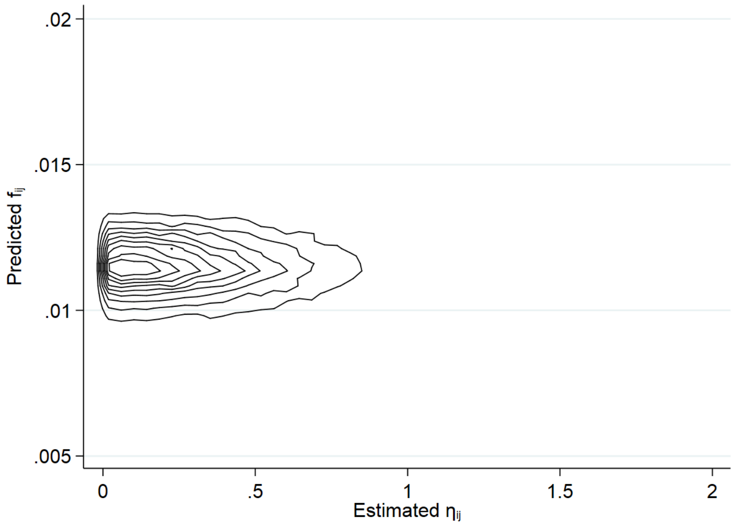
[2]Dyadic means that feudal links are formed independently.

manors, i.e. $f\left(\widehat{\eta}_{ij}, \widehat{f}_{ij} \mid f_{ij}=0\right)$, and for the subsample of linked manors, i.e. $f\left(\widehat{\eta}_{ij}, \widehat{f}_{ij} \mid f_{ij}=1\right)$, using nonparametric kernel density methods. If these joint distributions are similar, the null hypothesis cannot be rejected.

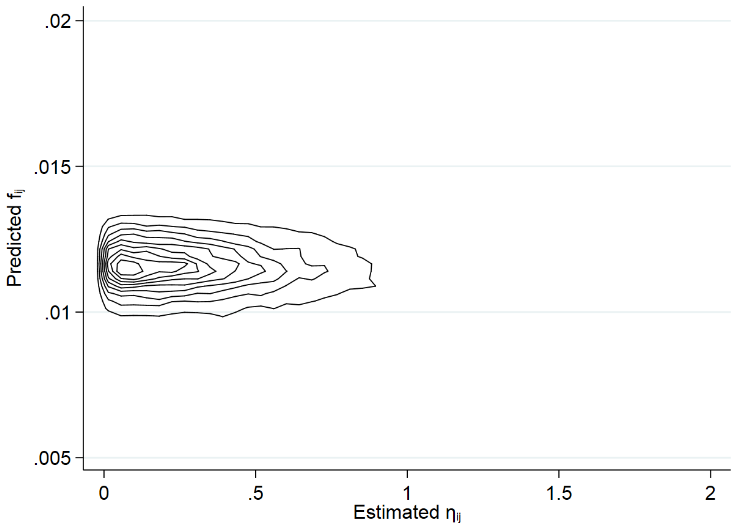
The underlying idea can be explained as follows. In the presence of endogeneity (i.e. $\mu, \rho > 0$), a pair of manors (i, j) that has a high predicted link value $\widehat{f}_{ij}$ but is unlinked in the data should have a large value for $|\zeta_i - \zeta_j|$ and hence for $|\eta_i - \eta_j|$. The opposite is true for pairs of manors that have a low predicted link value but are linked in the data. If there would be no endogeneity ($\mu = 0$ or $\rho = 0$), the residuals $\widehat{\eta}_{ij}$ would not provide any information on the probability that a link is created.

We inspect the joint distribution of $\widehat{\eta}_{ij}$ and $\widehat{f}_{ij}$ using nonparametric kernel density methods. Figure A4 provides estimates for both unlinked and linked pairs of manors. Since the joint distributions are rather similar, one might conclude that in our case, network endogeneity is not a substantial issue.

Figure A4: **Test for network endogeneity (KDE)**



(a) Kernel density plot for $f_{ij} = 0$



(b) Kernel density plot for $f_{ij} = 1$

F Robustness checks

Table A6: **Estimates of imputing IDs of unidentified lords (GS2SLS)**

Parameter	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Labor: non-slaves	0.19***	0.15***	0.15***	0.17***	0.15***	0.15***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Labor: slaves	0.12***	0.09***	0.09***	0.10***	0.09***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Capital: ploughs	0.55***	0.60***	0.58***	0.56***	0.59***	0.57***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Land: ploughlands	0.12***	0.14***	0.14***	0.13***	0.14***	0.14***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-0.34***	-0.47***	-0.91***	-0.29***	-0.49***	-0.62***
	(0.03)	(0.05)	(0.03)	(0.03)	(0.05)	(0.06)
λ_F	0.82***		0.39***	0.47***		0.38***
	(0.02)		(0.04)	(0.03)		(0.03)
λ_G		0.92***	0.65***		0.62***	0.51***
		(0.03)	(0.02)		(0.03)	(0.03)
δ_F	0.07***		0.10***	0.09***		0.10***
	(0.02)		(0.01)	(0.01)		(0.01)
δ_G		0.17***	0.44***		0.21***	0.25***
		(0.03)	(0.02)		(0.03)	(0.03)
County FE				YES	YES	YES
Soil FE				YES	YES	YES
Observations	9,084	9,084	9,084	9,084	9,084	9,084

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

Table A7: **Estimates when excluding manors with unidentified lords (GS2SLS)**

Parameter	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Labor: non-slaves	0.21***	0.16***	0.16***	0.18***	0.16***	0.16***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Labor: slaves	0.12***	0.09***	0.09***	0.10***	0.09***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Capital: ploughs	0.55***	0.60***	0.58***	0.56***	0.59***	0.58***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Land: ploughlands	0.12***	0.14***	0.14***	0.13***	0.14***	0.14***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-0.37***	-0.52***	-0.92***	-0.30***	-0.51***	-0.67***
	(0.03)	(0.05)	(0.04)	(0.03)	(0.06)	(0.06)
λ_F	0.76***		0.38***	0.42***		0.35***
	(0.02)		(0.04)	(0.03)		(0.03)
λ_G		0.89***	0.62***		0.54***	0.43***
		(0.03)	(0.02)		(0.04)	(0.04)
δ_F	0.08***		0.09***	0.09***		0.09***
	(0.02)		(0.01)	(0.01)		(0.01)
δ_G		0.19***	0.42***		0.22***	0.26***
		(0.04)	(0.02)		(0.03)	(0.03)
County FE				YES	YES	YES
Soil FE				YES	YES	YES
Observations	7,045	7,045	7,045	7,045	7,045	7,045

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

Table A8: **Estimates when including manors with multiple locations (GS2SLS)**

Parameter	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Labor: non-slaves	0.20***	0.16***	0.16***	0.17***	0.16***	0.16***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Labor: slaves	0.12***	0.09***	0.09***	0.11***	0.09***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Capital: ploughs	0.53***	0.59***	0.57***	0.55***	0.59***	0.57***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Land: ploughlands	0.13***	0.15***	0.15***	0.14***	0.15***	0.15***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-0.36***	-0.45***	-0.90***	-0.30***	-0.49***	-0.64***
	(0.03)	(0.05)	(0.04)	(0.03)	(0.05)	(0.06)
λ_F	0.80***		0.40***	0.47***		0.38***
	(0.02)		(0.04)	(0.02)		(0.03)
λ_G		0.93***	0.66***		0.63***	0.52***
		(0.03)	(0.02)		(0.03)	(0.03)
δ_F	0.08***		0.10***	0.09***		0.10***
	(0.02)		(0.01)	(0.01)		(0.01)
δ_G		0.15***	0.43***		0.21***	0.25***
		(0.04)	(0.02)		(0.03)	(0.03)
County FE				YES	YES	YES
Soil FE				YES	YES	YES
Observations	9,488	9,488	9,488	9,488	9,488	9,488

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

Table A9: **Estimates when using distances of 10km, 50km, and 100km (GS2SLS)**

Parameter	$d = 10$**km**	$d = 20$**km**	$d = 50$**km**	$d = 100$**km**
Labor: non-slaves	0.15***	0.15***	0.16***	0.16***
	(0.01)	(0.01)	(0.01)	(0.01)
Labor: slaves	0.10***	0.10***	0.10***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)
Capital: ploughs	0.57***	0.57***	0.57***	0.56***
	(0.01)	(0.01)	(0.01)	(0.01)
Land: ploughlands	0.14***	0.14***	0.14***	0.14***
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-0.43***	-0.63***	-1.07***	-1.09***
	(0.05)	(0.06)	(0.09)	(0.08)
λ_F	0.36***	0.36***	0.36***	0.40***
	(0.03)	(0.03)	(0.03)	(0.03)
λ_G	0.39***	0.51***	1.02***	1.81***
	(0.02)	(0.03)	(0.04)	(0.32)
δ_F	0.10***	0.10***	0.11***	0.10***
	(0.01)	(0.01)	(0.01)	(0.01)
δ_G	0.10***	0.25***	0.54***	0.56***
	(0.02)	(0.03)	(0.06)	(0.05)
County FE	YES	YES	YES	YES
Soil FE	YES	YES	YES	YES
Observations	9,084	9,084	9,084	9,084

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

Table A10: **Estimates when using binned distances (GS2SLS)**

Parameter	**(1)**
Labor: non-slaves	0.16***
	(0.01)
Labor: slaves	0.10***
	(0.01)
Capital: ploughs	0.57***
	(0.01)
Land: ploughlands	0.14***
	(0.01)
Constant	-0.28***
	(0.07)
λ_F	0.37***
	(0.03)
$\lambda_{G_{0-20}}$	0.50***
	(0.03)
$\lambda_{G_{20-50}}$	0.03
	(0.07)
$\lambda_{G_{50-100}}$	0.02
	(0.18)
δ_F	0.10***
	(0.01)
$\delta_{G_{0-20}}$	0.02
	(0.01)
$\delta_{G_{20-50}}$	0.04*
	(0.02)
$\delta_{G_{50-100}}$	-0.06**
	(0.03)
County FE	YES
Soil FE	YES
Observations	9,084

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

Table A11: **Estimates when excluding the ploughlands variable (GS2SLS)**

Parameter	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Labor: non-slaves	0.19***	0.17***	0.17***	0.18***	0.17***	0.17***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Labor: slaves	0.14***	0.11***	0.11***	0.13***	0.11***	0.12***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Capital: ploughs	0.64***	0.69***	0.67***	0.65***	0.68***	0.66***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	-0.34***	-0.52***	-0.83***	-0.25***	-0.50***	-0.64***
	(0.02)	(0.05)	(0.04)	(0.03)	(0.05)	(0.06)
λ_F	0.76***		0.41***	0.46***		0.40***
	(0.02)		(0.03)	(0.02)		(0.02)
λ_G		0.88***	0.64***		0.60***	0.50***
		(0.02)	(0.02)		(0.03)	(0.03)
δ_F	0.10***		0.08***	0.09***		0.10***
	(0.02)		(0.01)	(0.01)		(0.01)
δ_G		0.24***	0.42***		0.26***	0.30***
		(0.04)	(0.02)		(0.03)	(0.03)
County FE				YES	YES	YES
Soil FE				YES	YES	YES
Observations	12,222	12,222	12,222	12,222	12,222	12,222

Note: Standard errors are in parentheses.
$*** : p < 0.01, ** : p < 0.05, * : p < 0.1$

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